

2^{ème} Congrès International FRANCOFILT



Techniques Séparatives et Procédés Membranaires: Concilier Progrès Techniques et Spécificités Locales

Organisé par



**Société Chimique
de Tunisie**



**Faculté des Sciences
de Sfax**

22-25 Septembre 2019

Hôtel Méhari, Yasmine Hammamet, Tunisie



**Résumés des Conférences et des Communications
Liste des Participants**

FrancoFilt 2019 - Programme Flash

<i>Dimanche 22 Septembre 2019</i>	
14.30	Accueil des participants et distribution des documents
<i>Lundi 23 Septembre 2019</i>	
9.00 - 9.30	Cérémonie d'Ouverture du Deuxième Congrès International FrancoFilt 2019
9.30 - 10.05	Conférence Plénière 1: <u>Roger BEN AÏM</u> <i>IFTS, IWA Distinguished Fellow</i>
10.05 - 10.40	Conférence Plénière 2: <u>Marc HERAN</u> <i>Montpellier University, France</i>
10.40 - 11.10	Pause café + Session Poster 1 (P1 - P15)
11.10 - 11.35	Keynote 1: Thameur JAOUADI Directeur de la valorisation des eaux usées traitées (ONAS), Tunisie
11.10 - 11.35	Keynote 2: Mahmoud HAFSI National Office for Electricity and Drinking Water (ONEE), Morocco
11.10 - 11.35	Keynote 3: Ludovic DUMÉE Swinburne University of Technology, Australia
11.35 - 12.55	Oral Communications - Session 1 : CO 1 - CO 12
13.00	Déjeuner
14.30 - 15.05	Conférence Plénière 3: <u>Ali AOUABED</u> <i>Université Saad Dahlab Blida-1, Algérie</i>
15.05 - 15.40	Conférence Plénière 4: <u>Mohsen KAABI</u> <i>Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE) / Division Contrôle Qualité de l'Eau, Tunisie</i>
15.40 - 16.00	Pause café
16.00 - 16.25	Keynote 4: Mohamed HACHICHA Institut National de la Recherche en Génie Rural, Eaux et Forêts, Tunisie
16.00 - 16.25	Keynote 5: Nachida KASBADJI MERZOUK Centre de Développement des Energies Renouvelables
16.00 - 16.25	Keynote 6: Raja Rekek BEN AMAR Faculty of Science of Sfax University of Sfax, Tunisia
16.25 - 18.05	Communications Orales - Session 2 : CO 13 - CO 27
19.30	Dîner

<i>Mardi 24 Septembre 2019</i>	
8.30 - 9.05	Conférence Plénière 5: <u>Hervé BUISSON</u> <i>Véolia</i>
9.05 - 9.40	Conférence Plénière 6: <u>Adham RAMADAN</u> <i>The American University in Cairo</i>

09.40 - 10.05	<i>Keynote 7: Soumana GAGARA</i> African Union- United Nations Hybrid Operation Mission in Darfur, Central Darfur, Sudan
09.40 - 10.05	<i>Keynote 8: Courfia K. DIWARA</i> Université Assane Seck de Ziguinchor, UFR Sciences et Technologies Ziguinchor, SENEGAL
09.40 - 10.05	<i>Keynote 9: Wojciech KUJAWSKI</i> Nicolaus Copernicus University in Torun, Faculty of Chemistry, Toruń, Poland
10.05 - 11.05	Communications Orales - Session 3 : CO 27 - CO 36
11.05 - 11.35	Pause café + Session Poster 2 (P 16 - P 30)
11.35 - 12.55	Communications Orales - Session 4 : CO 37 - CO 48
13.00	<i>Déjeuner</i>
14.30 - 15.05	Conférence Plénière 7: <u>Abdoulaye DOUCOURE</u> <i>Hollingsworth & VoseCompany, East Walpole (MA) USA</i>
15.05-15.40	Conférence Plénière 8: <u>Edward NXUMALO</u> <i>University of South Africa</i>
15.40-16.15	Conférence Plénière 9: <u>Hafedh SAIDANI</u> <i>NOVASEP PROCESS</i>
16.15 - 16.35	Pause café
16.35 – 17.00	<i>Keynote 10:</i> Boukary SAWADOGO Institut International d'Ingénierie de l'Eau et de l'Environnement Institut 2IE- Burkina Faso
16.35 – 17.00	<i>Keynote 11:</i> André DERATANI Institut Européen des Membranes, IEM, Montpellier, France
16.35 – 17.00	<i>Keynote 12:</i> Samia Mahouche-CHERGUI Institut de Chimie et des Matériaux Paris-Est (ICMPE)-UPEC, France
17.00 - 18.20	Communications Orales - Session 5 : CO 49 - CO 58
20.00	<i>Dîner</i>
Mercredi 25 Septembre 2019	
9.00 - 9.35	Conférence Plénière 10: <u>Saad Alami YOUNSSI</u> <i>University of Hassan II, Casablanca, Morocco</i>
9.35 -10.10	Conférence Plénière 11: <u>Woei Jye LAU</u> <i>Universiti Teknologi Malaysia, Johor, Malaysia</i>
10.10 - 12.30	Table ronde
12.45	Clôture du congrès
13.00	<i>Déjeuner</i>

La ponctualité est le principal facteur de succès d'un congrès

Avant-Propos



Nous accueillons en Tunisie Le 2^{ème} congrès international Francophone Francofilt 2019 sur la filtration et les techniques séparatives qui se déroulera du 22 au 25 Septembre 2019 à Hammamet. Il succédera au 1er congrès Francofilt qui a eu lieu du 29 au 31 Aout 2017 à Bordeaux qui a connu un franc succès. Ce congrès sera co-organisé par la Société Chimique de Tunisie, la Faculté des Sciences de Sfax, l'Université de Sfax (Tunisie), l'Université de Blida (Algérie) et l'Institut de la Filtration et des Techniques Séparatives (France). Le thème du congrès est consacré cette année sur les aspects spécifiques des techniques séparatives et des procédés membranaires portant sur l'adaptation des progrès techniques aux contraintes locales. Cet événement sera l'occasion de débattre et discuter des questions techniques, scientifiques et socio-économiques autour de la science et de la technologie des membranes et de découvrir les dernières avancées et les pratiques les plus innovantes en matière de séparation Solide/Fluide et des technologies membranaires.

Des échanges entre experts de la recherche et industriels, ingénieurs, exploitants et décideurs sur des thématiques pointues et spécialisées offriront des opportunités de réseautage et de socialisation.

Les techniques séparatives, essentiellement celles se basant sur la technologie membranaire sont en plein développement dans le monde, qu'il s'agisse du domaine de l'environnement, de la santé, de l'eau ou du domaine industriel.

Trois journées de Francofilt 2019 seront consacrées aux interventions techniques qui combineront des présentations orales, des interventions plénières et keynotes, une table-ronde et des posters scientifiques. Plusieurs participants des quatre coins du monde seront présents à cet événement, permettant des échanges fructueux. Les thèmes abordés traiteront des problématiques environnementales, énergétiques et sanitaires pour lesquelles les techniques séparatives sont en mesure d'apporter des solutions durables (Traitement des eaux, traitement de l'air intérieur, valorisation des eaux usées, Dessalement et énergies renouvelables, Filtration pour les applications biomédicales/biopharmaceutiques, Méthodes de caractérisation, Essais et techniques d'analyse).

Nous remercions nos collaborateurs, les différents sponsors ainsi que les participants qui contribuent à la réussite de ce congrès.

Rendez vous à Francofilt !

Pr. Raja BEN AMAR

Présidente du congrès FrancoFilt 2019

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Programme FrancoFilt 2019

Dimanche 22 Septembre 2019 - Accueil des participants et distribution des documents

<i>Lundi 23 Septembre 2019 (matin)</i>						
9.00 - 9.30	Cérémonie d'Ouverture du Deuxième Congrès International FrancoFilt 2019					
9.30 - 10.05	Conférence Plénière 1: Roger BEN AÏM <i>IFTS, IWA Distinguished Fellow</i> Comment les Technologies Membranaires Permettent de Valoriser les Effluents Industriels: Réutilisation de l'Eau, Récupération de Matière Premières et d'Énergie					Chairperson Hatem Ben Romdhane
10.05 - 10.40	Conférence Plénière 2: Marc HERAN <i>Montpellier University, France</i> Membranes et Procédés Biologiques: De la STEP vers la Station de Récupération des Ressources des Eaux Usées					
10.40 - 11.10	Pause café + Session Poster 1 (P1 – P15)					
Communications Orales - Session 1						
	<i>Room A</i> Traitement et valorisation des effluents industriels Chair person: Roger Ben Aim	<i>Room B</i> Techniques séparatives, Dessalement et potabilisation des eaux Chair person: Nizar Bellakhal		<i>Room C</i> Synthèse et préparation de membranes de filtration Chair person: André Deratani		
11.10 - 11.35	<i>Room A - Keynote 1: Thameur JAOUADI</i> Directeur de la valorisation des eaux usées traitées (ONAS), Tunisie La Réutilisation des Eaux Usées Traitées: Potentiels, Contraintes et Améliorations					
11.10 - 11.35	<i>Room B - Keynote 2: Mahmoud HAFSI</i> National Office for Electricity and Drinking Water (ONEE), Morocco The Pre-treatment: A Lever For Performances Optimization of Reverse Osmosis Desalination Plants Producing Drinking Water in Morocco					
11.10 - 11.35	<i>Room C - Keynote 3: Ludovic DUMEE</i> Swinburne University of Technology, Australia Super Flexible Carbon Nanofibre Membranes for Airborne Pollutant Removal					
11.35 – 11.55	CO-01	Tahri Nouha	CO-05	El Ghzizel Soufian	CO-09	Aloulou Hajer
11.55 - 12.15	CO-02	Bousbih Saida	CO-06	Gassara Sana	CO-10	Aloulou Wala
12.15 - 12.35	CO-03	Louhichi Ghofrane	CO-07	Anouar Islam	CO-11	Beqqour Donia
12.35 - 12.55	CO-04	Kitanou Sarra	CO-08	Gaetan Blandin	CO-12	Bouzid Rekik Sonia
13.00	Déjeuner					

Lundi 23 Septembre 2019 (après-midi)						
14.30 - 15.05	Conférence Plénière 3: <u>Ali AOUABED</u> <i>Laboratoire d'Analyse Fonctionnelle et des Procédés Chimiques, Université Saad Dahlab Blida-1</i> Réutilisation des eaux usées épurées en agriculture en Algérie					Chairperson Raja Ben Amar
15.05 - 15.40	Conférence Plénière 4: <u>Mohsen KAABI</u> <i>Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE) / Division Contrôle Qualité de l'Eau, Tunisie</i> Evaluation du facteur CT (Concentration et temps de contact) dans la désinfection par l'hypochlorite de sodium dans le procédé de traitement d'eau potable, Cas de GHDIR EL GOLLA.					
15.40 - 16.00	Pause café					
Communications Orales - Session 2						
	<i>Room A</i> Traitement et valorisation des effluents industriels <i>Chair person: Marc Heran</i>		<i>Room B</i> Techniques séparatives, Dessalement et potabilisation des eaux <i>Chair person: Béchir Chaouachi</i>		<i>Room C</i> Synthèse et préparation de membranes de filtration <i>Chair person: Ludovic Dumeé</i>	
16.00 - 16.25	<i>Room A - Keynote 4: Mohamed HACHICHA</i> Institut National de la Recherche en Génie Rural, Eaux et Forêts, Tunisie Research on the Use of Treated Waste water Towards a systemic approach to the use of TWW					
16.00 - 16.25	<i>Room B - Keynote 5: Nachida KASBADJI MERZOUK</i> Centre de Développement des Energies Renouvelables Critères de performance du couplage Dessalement - technologies renouvelables					
16.00 - 16.25	<i>Room C - Keynote 6: Raja Rekik BEN AMAR</i> Faculty of Science of Sfax University of Sfax, Tunisia Development of Low cost ceramic membranes for wastewater treatment					
16.25 - 16.45	CO-13	Dhifallah Asma	CO-18	Bouhria Mohamed	CO-23	Kammoun Med Ayman
16.45 - 17.05	CO-14	Chakraborty Sudip	CO-19	Tigrine Zahia	CO-24	Kecili karima
17.05 - 17.25	CO-15	Gharsallah Aménie	CO-20	Marzouk Trifi Ikhlass	CO-25	Mathaba Machodo
17.25 - 17.45	CO-16	Keniche Assia	CO-21	<i>Touir Jamal</i>	CO-26	Orfi Maryem
17.45-18.05	CO-17	Valat Mark	CO-22	Diop Saidou Nourou	CO-27	Ouammou Mohamed
19.30	Dîner					

Mardi 24 Septembre 2019 (matin)						
8.30 - 9.05	Conférence Plénière 5: <u>Hervé BUISSON</u> <i>Véolia</i> Filtration Membranaire pour le Traitement de l'Eau en Afrique, une Perspective Industrielle					Chairperson Abdoulaye Doucouré
9.05 - 9.40	Conférence Plénière 6: <u>Adham RAMADAN</u> <i>The American University in Cairo</i> Polymer-CNT Membranes for Water Desalination					
Communications Orales - Session 3						
	<i>Room A</i> Traitement et valorisation des effluents industriels Chair person: Latifa Latrous	<i>Room B</i> Techniques séparatives, Dessalement et potabilisation des eaux Chair person: Ali Aouabed	<i>Room C</i> Synthèse et préparation de membranes de filtration Chair person: Mohamed Lotfi El Efrif			
9.40 - 10.05	<i>Room A - Keynote 7: Soumana GAGARA</i> African Union- United Nations Hybrid Operation Mission in Darfur, Central Darfur, Sudan Waste water management improvement in the unamid headquarter in central Darfur, Zalingei, Sudan.					
9.40 - 10.05	<i>Room B - Keynote 8: Courfia K. DIWARA</i> Université Assane Seck de Ziguinchor, UFR Sciences et Technologies, Ziguinchor, SENEGAL Potabilisation de l'eau fluorée et salée au Sénégal : 17 ans de pratiques					
9.40 - 10.05	<i>Room C - Keynote 9: Wojciech KUJAWSKI</i> Nicolaus Copernicus University. in Torun, Faculty of Chemistry, Toruń, Poland Fabrication of PDMS and PTMSP based membranes with improved efficiency in hydrophobic pervaporation					
10.05 - 10.25	CO-28	Mahmoud Imen	CO-31	Khaled Hédia	CO-34	Tahri Nouha
10.25 - 10.45	CO-29	Yahia Asma	CO-32	Taky Mohamed	CO-35	Baya Sara
10.45 - 11.05	CO-30	Pontalier Pierre Yves	CO-33	Tigrine Zahia	CO-36	Ouraghi Mammar
11.05 - 11.35	Pause café + Session Poster 2 (P16 – P30)					
Communications Orales - Session 4						
11.35 - 11.55	CO-37	Mhiri Fadhel	CO-41	Chemini Rachida	CO-45	Oun Abdallah
11.55 - 12.15	CO-38	El Kateb Marwa	CO-42	Erragued Rim	CO-46	Derouiche Ghizlane
12.15 - 12.35	CO-39	Zaviska François	CO-43	Folaramni Gbenro	CO-47	Chamam Baha
12.35 -12.55	CO-40	Titchou Fatima Ezzahra	CO-44	Allaoui Safae	CO-48	Tijani Najib
13.00	Déjeuner					

Mardi 24 Septembre 2019 (après-midi)						
14.30 - 15.05	Conférence Plénière 7: <u>Abdoulaye DOUCOURE</u> <i>Hollingsworth&VoseCompany, East Walpole (MA) USA</i> Enhancing Indoor Air Quality by Filtration of Particulate and Gaseous Pollutants - (Advancing Educational and Professional Training in Africa)					Chairperson Hervé Buisson
15.05-15.40	Conférence Plénière 8: <u>Edward NXUMALO</u> <i>Nanotechnology and Water Sustainability Research Unit, College of Science, Engineering and Technology, University of South Africa</i> Relating Sulfonated Polyamide Thin-Film Composite Nanofiltration (TfCNf) Membrane Performance to Macrovoid-Free Pps/Spsf/O-Mwcnt Support Membranes Properties					
15.40-16.15	Conférence Plénière 9: <u>Hafedh SAIDANI</u> <i>NOVASEP PROCESS</i> Membranes céramiques présentation et analyse du marché et des applications - Focus sur les membranes KERASEP, du développement à la mise en œuvre industrielle.					
16.15 - 16.35	Pause café					
Communications Orales - Session 5						
	<i>Room A</i> Traitement et valorisation des effluents industriels Chair person: Courfia Diwara	<i>Room B</i> Techniques séparatives, Dessalement et potabilisation des eaux Chair person: Adham Ramadan		<i>Room C</i> Techniques d'extraction Chair person: Saad Alami Younssi		
16.35 – 17.00	<i>Room A - Keynote 10:</i> Boukary SAWADOGO Institut International d'Ingénierie de l'Eau et de l'Environnement Institut 2iE- Burkina Faso Traitement et valorisation des eaux usées industrielles par l'utilisation des procédés membranaires					
16.35 – 17.00	<i>Room B - Keynote 11:</i> André DERATANI Institut Européen des Membranes, IEM, Montpellier, France Solar Powered Desalination Units for Small Communities and Remote Locations: Case Study of Plants Located in Africa Using the Osmosun® Technology					
16.35 – 17.00	<i>Room C - Keynote 12:</i> Samia Mahouche-CHERGUI Institut de Chimie et des Matériaux Paris-Est (ICMPE)-UPEC, France Ultra small Metal Nanoparticles Based-Hetero structures: Design and Applications in Hybrid Catalytic Membrane Separation Processes					
17.00 - 17.20	CO-49	Ben Kraiem Nourhen	CO-52	Frikha Nader	CO-55	Didi Med Amine
17.20 - 17.40	CO-50	Tijani Najib	CO-53	Gabsi Slimen	CO-56	Angoy Alice
17.40 – 18.00	CO-51	Safiddine Leila	CO-54	Aoufi Boutheyna	CO-57	Mallek Myriam
18.00 - 18.20					CO-58	Zghal Imen
20.00	Dîner					

Mercredi 25 Septembre 2019		
9.00 - 9.35	<p>Conférence Plénière 10: <u>Saad Alami YOUNSSI</u> <i>Laboratory of Materials, Membranes and Environment, Faculty of Sciences and Technologies of Mohammedia, University of Hassan II- Casablanca,</i> Valorization of Natural Material in Development of New ceramic Membranes Application to Salts Rejection and Environmental Process</p>	Chairperson Hafedh Saidani
9.35 -10.10	<p>Conférence Plénière 11: <u>Woei Jye LAU</u> <i>Advanced Membrane Technology Research Centre (AMTEC), Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.</i> Feasible Strategies to Fabricate Thin Film Nanocomposite Membranes for Water Applications</p>	
10.10 - 12.30	Table ronde	
12.45	Clôture du congrès	
13.00	Déjeuner	



**Résumés
des Conférences
et des Keynotes**

COMMENT LES TECHNOLOGIES MEMBRANAIRES PERMETTENT DE VALORISER LES EFFLUENTS INDUSTRIELS : RÉUTILISATION DE L'EAU, RÉCUPÉRATION DE MATIÈRES PREMIÈRES ET D'ÉNERGIE

Roger Ben Aïm

IFTS, IWA Distinguished Fellow

Il y a une forte tendance à considérer les effluents industriels non plus comme un rejet qu'il faut traiter pour rendre son rejet possible dans le milieu naturel mais comme une source potentielle d'eau, de matières premières susceptibles d'être utilisées, d'énergie. Cette tendance est visible dans de nombreux secteurs industriels et conduit au concept de « ZLD » (Zero Liquid Discharge) ou de « dry plants » sites de production dans lesquels le recours à l'eau du réseau est très fortement réduit.

Dans cette approche, les technologies membranaires jouent un rôle primordial grâce à :

- Leur adaptabilité (conception modulaire)
- La facilité de combinaison avec d'autres procédés : c'est le cas du bioréacteur à membranes (aérobie ou anaérobie) auquel les industries ont recours pour la production d'une eau traitée capable d'être réutilisée. Mais c'est également des procédés physicochimiques (coagulation) ou électrochimiques.
- La qualité de l'eau produite adaptable selon les besoins de la réutilisation.

L'avantage des technologies membranaires doit être évaluée en tenant compte de la possibilité d'utiliser l'eau traitée sur le site même de production des effluents, limitant considérablement le recours à l'eau du réseau et l'utilisation du réseau d'assainissement.

Des exemples de cette approche seront présentés notamment en ce qui concerne l'industrie textile, les industries agroalimentaires (conserveries, huileries, etc.) A cette occasion, les développements récents des bioréacteurs à membrane aérobies et anaérobies en mettant l'accent sur les aspects énergétiques.

Mots clés : Effluents industriels, technologies membranaires, valorisation

MEMBRANES ET PROCÉDÉS BIOLOGIQUES : DE LA STEP VERS LA STATION DE RÉCUPÉRATION DES RESSOURCES DES EAUX USÉES

Marc Heran, Geoffroy Lesage, Francois Zaviska

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L'évolution de nos stations d'épuration suit les objectifs de développement durable (ODD de l'ONU) et d'économie circulaire dont les deux axes liés aux traitements des eaux usées sont :

- I. Sécuriser la production de matière première secondaire (réutiliser l'eau et valoriser les nutriments)
- II. Diminuer les consommations énergétiques.

Nos eaux usées urbaines sont une source alternative d'eau, de nutriments et d'énergie. La station de traitement des eaux usées du futur doit donc accompagner ce changement de paradigme et être conçue comme une STATION de Récupération des Ressources (STARR) en intégrant des procédés plus durables (Traitements innovants), une eau plus propre et des ressources valorisées.

Les besoins énergétiques de la STARR sont propres à chacune de ses opérations unitaires et, s'il est possible d'aller chercher de l'énergie thermique ou hydraulique dans les eaux usées, le développement des procédés anaérobies permet par la production de biogaz d'envisager une filière de traitement à énergie positive. Il reste ensuite à produire une eau usée traitée apte à une seconde vie. Cette seconde vie peut être à usage agricole ce qui implique (i) de fiabiliser la qualité sanitaire de l'eau produite (Niveau A) en développant des barrières stériques effectives (Membranes) ou robustes, mais aussi (ii) de préserver les nutriments indispensables aux plantes.

La présentation portera sur l'évolution, le choix et la définition des briques technologiques et de leurs enjeux scientifiques associés afin de produire une eau qui réponde aux usages en termes de risques sanitaires (microbiologique), et de valorisation agronomique. Ces exemples seront illustrés par des réalisations de démonstrateurs en Languedoc Roussillon et des actions de recherche associées.

Keywords : Membrane, valorisation des eaux usées, nutriments, station à énergie positive

RÉUTILISATION DES EAUX USÉES ÉPURÉES EN AGRICULTURE EN ALGÉRIE

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L'épuration de l'eau usée et son utilisation en irrigation est une option attrayante, en particulier dans les zones arides et semi-arides, car elle représente une source d'eau et éléments nutritifs additionnels renouvelables et fiables.

Cette réutilisation doit être gérée de manière rationnelle. En effet, ces eaux véhiculent des pollutions qui posent des problèmes de santé publique, de conservation des sols et de protection de l'environnement, qui ne doivent être ni exagérés ni sous-estimés.

Ces problèmes doivent être traités avec précaution par, le contrôle de la qualité de l'eau usée épurée, l'évolution de l'impact sur l'environnement et la prévision des conséquences de l'utilisation des eaux usées sur la santé humaine.

Dans ce contexte, notre étude s'intéressera particulièrement, aux l'effet de l'utilisation en irrigation des eaux usées épurées par la station d'épuration de Chenoua (Tipaza), sur l'environnement et la santé publique.

L'évaluation de cette faisabilité nécessite entres autres, la connaissance de la qualité physico-chimique et bactériologique de l'eau usée brute et épurée par des analyses effectuées dans une période bien précise.

Cette étude a, donc, pour objectif :

- D'apprécier la qualité des eaux épurées réutilisées pour l'irrigation ;
- De mettre en évidence l'impact des eaux usées sur les différentes composantes de l'environnement : sol et végétaux, en particulier la santé publique.

Cependant, en raison de l'origine et la composition de cette eau, la réutilisation, devrait être gérée d'une manière rationnelle et judicieuse, surveillée et contrôlée par des spécialistes dans l'objectif de maîtriser et de minimiser les risques sanitaires liés à cette pratique, d'où la nécessité de l'application des normes et de la réglementation est nécessaire pour une réutilisation durable sans risques sanitaires et environnementales.

Mots clés : réutilisation des eaux usées épurées- STEP Chenoua- Qualité physico chimique et bactériologique- irrigation- normes- santé publique- environnement.

EVALUATION DU FACTEUR CT (CONCENTRATION, TEMPS DE DU CONTACT) DANS LA DESINFECTATION PAR L'HYPOCHLORITE DE SODIUM DANS LE PROCÉDÉ DE TRAITEMENT D'EAU POTABLE CAS DE GHDIR EL GOLLA.

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La désinfection par la technique de chloration notamment par l'hypochlorite de sodium est une étape très importante dans le procédé de traitement des eaux potables dans le complexe de Ghdir El Golla qui assure la production et le stockage des eaux nécessaires pour l'alimentation du grand Tunis et le Cap Bon avec une capacité de production égale à 600.000 m³ /jour. L'objectif principal de ce travail, est d'étudier l'influence des paramètres physico-chimiques (turbidité, matière organique et pH) sur la désinfection et d'évaluer l'efficacité de cette étape sur l'eau traitée par l'hypochlorite de sodium « NaClO » vis à vis l'élimination des germes pathogènes (Coliformes totaux, Coliformes fécaux et Streptocoques fécaux) et son effet rémanent (chlore résiduel) sur la protection microbiologique de l'eau dans les réseaux de distribution. Les essais réalisés sur différentes turbidité ont montré que la quantité de chlore résiduel est plus importante pour des turbidités inférieures ou égale à 1 NTU. Au delà de cette valeur, les matières en suspension constituent des supports d'accrochage pour les germes, ce qui réduit l'efficacité de l'opération de désinfectants. L'étape de coagulation/floculation joue donc un rôle très important dans l'épuration des eaux potables. Elle permet, du plus du rabatement de MES, une élimination de 25% de la matière organique présente dans l'eau brute jusqu'à atteindre des valeurs inférieure à 5mg/l. L'injection de chlore à des doses supérieures à 1.5mg/l pour les eaux traitées provoque une diminution notable de la matière organique entraînant la formation des sous produits indésirables comme les TriHaloMéthanes. L'effet de la variation du pH sur la concentration de chlore résiduel est plus important pour des valeurs de pH entre 6.5 et 7. En effet, lors d'une désinfection au chlore, le pouvoir germicide de ce dernier, diminue à mesure que le pH augmente; ce qui est expliqué par le système acide hypochloreux/ion hypochlorite. L'acide hypochloreux est efficace dans l'élimination et la destruction des germes pathogènes. L'optimum de désinfection est enregistré pour un pH entre 6,5 et 7 (l'acide hypochloreux (HClO) est prédominant). Les différentes essais ont pu démontrer la relation entre la concentration et le temps de contact vis-à-vis l'abattement des germes pathogènes (totaux, Coliformes fécaux et Streptocoques fécaux). Une faible injection de chlore (0.25 mg. Cl₂/l) permet d'obtenir, après 20 minutes, un taux d'abattement optimal (100%) avec une faible concentration de chlore résiduel (0.04 mg. Cl₂/l). Tandis qu'une forte teneur de chlore résiduel (0.6 mg. Cl₂/l) et un abattement optimal sont obtenu après une injection d'une concentration peu élevée de chlore (1.25 mg. Cl₂/l) et avec un temps de contact peu réduit (15 minutes). Par conséquent, on peut déduire que le taux d'abattement et la quantité de chlore résiduel est largement influencé par le facteur concentration et temps de contact (C.T)

**FILTRATION MEMBRANAIRE
POUR LE TRAITEMENT DE L'EAU EN AFRIQUE,
UNE PERSPECTIVE INDUSTRIELLE**

Hervé Buisson

Véolia

POLYMER-CNT MEMBRANES FOR WATER DESALINATION

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Carbon nanotubes (CNTs) gained attention as possible additives to desalination membranes following molecular dynamics simulations which established superfast water flow inside the nanotubes [1,2]. In this respect, CNTs have been added to a variety of polymers, primarily for reverse osmosis (RO) applications. A more limited number of studies reported the use of CNTs as fillers in membranes used in forward osmosis (FO) applications [3,4].

This paper summarizes investigations conducted for the use of CNTs as nano fillers in RO cellulose acetate membranes, as well as in FO polysulfone/polyamide thin film membranes. CNTs, being hydrophobic, were carboxylated for a better dispersion within the polymer matrices used.

RO cellulose acetate membranes with dispersed CNTs were prepared by phase inversion [5], while the FO thin film membranes were prepared by interfacial polymerization of the polyamide rejection layer on top the polysulfone support layer. Different amounts of CNTs were incorporated in the polyamide rejection layer.

The incorporation of CNTs in the polymeric membranes significantly improved water permeation. While the improved water permeation in RO membranes showed a limited decrease in salt rejection, this was more significant for FO membranes. The change in membrane performance is believed to be associated with changes in membrane morphology and porosity.

The investigations demonstrate the promising use of CNTs as additives in polymeric membranes for the improvement of membrane performance, specifically water permeation, in water desalination applications in both RO and FO modes.

Keywords: Carbon nanotubes; Membranes; Desalination; Reverse Osmosis; Forward Osmosis.

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**ENHANCING INDOOR AIR QUALITY BY FILTRATION
OF PARTICULATE AND GASEOUS POLLUTANTS
(ADVANCING EDUCATIONAL AND PROFESSIONAL TRAINING IN AFRICA)**

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The urgency of addressing Indoor Air Pollution has become more pressing because of rising threats on global public health. The World Health Organization estimates that nearly 4 million people die prematurely each year because of household air pollution. Moreover 50% of deaths due to pneumonia among children under five are caused by airborne particulate matter [1].

Given the expansion of urban centers in Asia and Africa, the emergence of non-ventilated dwellings is expected to rise thus increasing the prevalence of illness associated with indoor air pollution [2]. Practices leading to poor air quality across the globe are linked to solid fuel burning (for cooking and energy generation), city transportation, power plant operation, and methane-triggered landfill fires [3, 4, 5]. Fine particles -both less than 2.5 μm , $\text{PM}_{2.5}$, and below 10 μm PM_{10} - are the biggest health concerns. Further, excessive exposure to Volatile Organic Compounds (VOCs), sulfur dioxide, nitrogen oxide, and formaldehyde gases also play a role in premature deaths [5].

In an effort to highlight mitigation strategies adopted by Western and Asian countries, we are introducing a tutorial describing several filtration standards and showcasing global commercial trends in the Room Air Purifier (RAP), Cabin Air and Heating Ventilation and Air Conditioning (HVAC) filtration markets. Steps to initiate joint academic-industry investigations in Africa will be discussed in order to build a framework seeking to mitigate key factors contributing to indoor air pollution on the continent.

Keywords : Indoor air quality - $\text{PM}_{2.5}$ and PM_{10} particles - Volatile Organic Compounds - alkaline gases - air filtration - adsorptive filtration

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**RELATING SULFONATED POLYAMIDE THIN-FILM COMPOSITE
NANOFILTRATION (TFCNF) MEMBRANE PERFORMANCE
TO MACROVOID-FREE PES/SPSF/O-MWCNT
SUPPORT MEMBRANES PROPERTIES**

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The study reports on the synthesis of sulfonated thin-film composite nanofiltration (TFC NF) membranes on polyethersulfone/sulfonated polysulfone/oxidized multi-walled carbon nanotube (PES/SPSF/O-MWCNT) ultrafiltration membrane supports via interfacial polymerization method.

During the deposition of the selective polyamide film layer, the aqueous phase solution consisted of a mixture of piperazine (PIP) and 2,4-diaminobenzenesulfonic acid (2,4-DABSA) and the organic phase solution consisted of trimesoylchloride (TMC). The deposition of the sulfonated polyamide thin-film layer was confirmed by ATR- FTIR, SEM, AFM, contact angle and zeta potential measurements.

The TFC NF membranes fabricated on PES/SPSF/O-MWCNT support membrane showed a 35% improvement in pure water flux with comparable salt rejections from those prepared on PES/SPSF support membranes. The addition of low monomer weight ratio of 2,4-DABSA in the amine mixture, led to the generation of a sulfonated TFC NF membrane with superior membrane performance in terms of pure water flux (30.2 L/m².h), monovalent/bivalent salt selectivity (NaCl/Na₂SO₄, 25.0) at low operating pressures (3 bar) and salt concentrations in the range of brackish water salinity. Moreover, sulfonated TFC NF membrane exhibited good antifouling properties against BSA, with FRR of 96.4% after 3 cycles of fouling and cleaning. The performance of the sulfonated TFC NF membrane remained fairly stable over a 10-day duration of pure water flux and Na₂SO₄ rejection testing. The use of a macrovoid-free PES/SPSF/O-MWCNT supports not only provided mechanical strength for the TFC NF membrane, but their open, cellular network structure, combined with high hydrophilicity and large surface pore sizes were beneficial in the reduction of polyamide layer thickness, and subsequently in the enhancement in TFC NF membrane performance in comparison to their pristine counterparts (PES/SPSF supports).

Overall, the fabricated sulfonated TFC NF membrane displayed promising features for low pressure desalination of brackish waters.

Keywords : membranes properties

MEMBRANES CÉRAMIQUES
PRÉSENTATION ET ANALYSE DU MARCHÉ ET DES APPLICATIONS
FOCUS SUR LES MEMBRANES KERASEP,
DU DÉVELOPPEMENT À LA MISE EN ŒUVRE INDUSTRIELLE.

Hafedh SAIDANI

NOVASEP PROCESS

Présentation générale des membranes céramique : Définition, structure et caractéristiques.

Analyse du marché des membranes céramique à l'échelle international : chiffres actuels et perspectives d'évolution à 10 ans, découpage du marché selon le type (tubulaire, plan), l'application (traitement de l'eau, biotechnologie, chimie...) ainsi que les régions (Europe, Asie, Amériques, Afrique..)

Challenges et opportunités pour le développement des membranes céramiques.

Focus sur les membranes KERASEP de Novasep : méthodologie de développement des problématiques de filtration industrielles, à partir des essais à l'échelle laboratoire, en passant par l'étude pilote, la preuve du concept, jusqu'à l'exploitation à l'échelle industrielle.

VALORIZATION OF NATURAL MATERIAL IN DEVELOPMENT OF NEW CERAMIC MEMBRANES APPLICATION TO SALTS REJECTION AND ENVIRONMENTAL PROCESS

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In recent years, various removal methods have been developed for the treatment of pollutants in wastewater, such as chemical precipitation, membrane filtration, adsorption, dialysis/electrodialysis... Among these methods, we choose to work with ceramic microfiltration and ultrafiltration membranes made from natural material : phosphate, clays..., due to its abundance in Morocco [1-5].

The filtration test of salts solutions, performed with different ultrafiltration ceramic membranes, shows that salt rejection depends on the charge of the ions, pH, salt nature and concentration. The rejection mechanism depends on the relative ratio of the coulombic, dielectric and hydration interaction between the material and the ionic species [6-7].

We will focus in this presentation on the elaboration and characterization of microfiltration and ultrafiltration ceramic membranes and their application to remove salts and textile dyes from water.

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Feasible Strategies to Fabricate Thin Film Nanocomposite Membranes for Water Applications

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Advancements in the performance of organic polyamide (PA) layer of thin film composite membrane modified by inorganic nanomaterials have improved the bare PA layer characteristics, overcoming the trade-off effect between water permeability and solute selectivity and improving the resistance against foulants attachment. Over the past decade, many nanomaterials such as carbon nanotubes, graphene oxide, zeolite, titania nanotubes and silver nanoparticles have been utilized to modify PA layer, producing thin film nanocomposite (TFN) membranes with different characteristics for nanofiltration (NF), reverse osmosis (RO) and forward osmosis (FO) applications. Although the potential of TFN membranes for water treatment process in particular has been demonstrated by many research groups, there remain several key challenges related to the TFN membrane fabrication. One of the main problems encountered is the uneven distribution and agglomeration of nanomaterials in the thin PA layer. In view of this, it is very important to have good strategies of embedding nanomaterials into PA matrix. Two approaches will be presented to address the problems of using nanomaterials with the aim of developing TFN membranes with improved surface integrity. A description of conventional interfacial polymerization technique for composite membrane preparation will be also be covered, along with the trends in the use of such membrane for water treatment.

KEYNOTES

LA RÉUTILISATION DES EAUX USÉES TRAITÉES : POTENTIELS, CONTRAINTES ET AMÉLIORATIONS

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Créé en 1974, l'office national de l'assainissement, (ONAS) a pour mission :

- La lutte contre les sources de pollution hydrique ;
- La gestion, l'exploitation, l'entretien, le renouvellement et la construction de tout ouvrage destiné à l'assainissement des villes dont la prise en charge est fixée par décret ;
- La promotion du secteur de distribution et de la vente des eaux traitées et des boues des stations d'épuration ;
- La planification et la réalisation des projets d'assainissement ;
- L'élaboration et la réalisation de projets intégrés portant sur le traitement des eaux usées et l'évacuation des eaux pluviales.

Le volume actuel des eaux usées traitées est de 274 millions m³ traitées dans 122 stations d'épuration dont les procédés de traitements sont très diversifiés.

L'objectif de l'ONAS est d'atteindre 50% de taux de réutilisation en 2020, ce qui nécessite la résolution de plusieurs contraintes dont l'amélioration de la qualité des eaux usées traitées, d'où le lancement des projets de réhabilitation de 55 stations d'épuration et la séparation des eaux usées industrielles des eaux usées domestiques par la réalisation de 09 station de traitement des usées industrielles.

La réutilisation des EUT doit concerner différents secteurs agricole, touristiques, industriels et services. Pour cela un plan directeur pour la réutilisation de cette ressource non conventionnelle est en cours d'élaboration pour définir les différentes stratégies de réutilisation.

Mots clés : réutilisation, ONAS, stations d'épuration

**THE PRETREATMENT
A LEVER FOR PERFORMANCES OPTIMIZATION
OF REVERSE OSMOSIS DESALINATION PLANTS
PRODUCING DRINKING WATER IN MOROCCO**

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Considered, for a long period, as a drinking water supply solution, exclusively, for the southern regions of Morocco, desalination is expanding steadily in the central and northern regions of the country, induced by the growing needs of the three sectors: drinking water, agriculture and industry.

In the field of drinking water production, several projects are carried out or underway on the Atlantic Ocean and the Mediterranean seaside, even if this region receives the highest rainfall rate in Morocco.

The Morocco water production, using desalination technology, of about 14 million m³/year, in 2016, will reach around 400 million m³ /year by year 2030. Reverse osmosis was adopted, thirty years ago, as giving the best option of desalination technology for Morocco.

Since the desalination has been implemented in Morocco for drinking water production, three kinds of raw waters are used as resources: sea water, brackish water, and surface water (river water), and two kind of membranes hollow fibers membranes and spiral membranes have been used. This diversity in raw water qualities has required, from operator, a wide know-how in waters treatment, in general, and specifically in pretreatment.

Although it is recognized that reverse osmosis membranes have achieved, in absolute terms, very high performance, the fact remains that the achievement of the expected performance of desalination projects, using these membranes, remains strongly dependent on the mastering of pretreatment by the operators.

Through the presentation of some ONEE's reverse osmosis desalination plants we will underline the complexity of the pretreatment of some waters, complexity which is not necessarily underlined during the design. The pretreatments adopted have concerned especially reduction of turbidity, reduction of biological fouling, physicochemical removal of iron, biological treatment of ammonia.... In some these cases the reverse osmosis has appeared as the simplest step of the process.

Thus, mastering of the pretreatment has proved to be the only lever available to the operator to optimize the operation of reverse osmosis systems. This mastery of pretreatment can't be reached without multidisciplinary approaches and scientific research approach.

Key words :Desalination-Demineralization –Reverse osmosis - Complexity of the pretreatment

SUPER FLEXIBLE CARBON NANOFIBRE MEMBRANES FOR AIRBORNE POLLUANT REMOVAL

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Viruses spread in the environment through solution and as aerosols, generating great risks of infection for exposed populations. The removal of viruses from water and air is a challenge due to their nanoscale dimension and high flexibility, allowing for their diffusion across complex surfaces and porous architectures. Viruses versatile chemistries and behaviours thus require remediation solutions encompassing both nanoscale controlled surface topography and chemical functionalities. Here, nano-composite electrospun nanofiber membranes were electrospun from tetraethoxysilane and Ammonium tetrathiomolybdate mixed within a Polyacrylonitrile / N, N-Dimethylformamide dope and carbonized to produced effect-free and highly interconnected porous structure.

The capture efficiency of the nano-composite electrospun based membranes for the Semliki Forest virus in solution and air borne testing was found to be largely related to the tuned fiber surface morphology and roughness as well as to the surface energy of the materials. The mechanically flexible and robust composite microfiltration membranes, with pore size distributions in the range of 0.8 to 3.1 μm and specific surface areas on the order of 45.6 m^2/g , exhibited virus removal efficiencies up to 98.91% and yet very high water permeation up to 28,000 $\text{L}\cdot\text{m}^{-2}\cdot\text{h}^{-1}\cdot\text{bar}^{-1}$. These hybrid membranes also yielded excellent photocatalytic performance thus allowing for continuous flow operation as continuous membrane reactors. These ultra-thin membranes, facile to mass-produce, offer opportunities to provide cost-effective and versatile water and air borne remediation strategies for low-energy requirement separation systems for the simultaneous capture and degradation of pathogens, and to self-cleaning materials.

Keywords :carbon nanofibres, non-woven, nanotextured membranes, air filtration, virus removal

RESEARCH ON THE USE OF TREATED WASTE WATER TOWARDS A SYSTEMIC APPROACH TO THE USE OF TWW

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Wastewater is currently treated in 119 plants that produced 266 Mm³ in 2017, of which only 40 Mm³ were used to irrigate 31 public and two private perimeters. The research work has made it possible to define the risks of using these waters. The adequate use of treated wastewater (TWW) is currently perceived by standardized quality, regulatory tolerated crops, appropriate water and soil management and periodic monitoring of water, soil, crops and farmers.

However, studies have shown the contamination of receiving environments, hence the need to review this form of use. The Cebala - Borj touil area located in the Lower Medjerda Valley has been selected. Analysis of irrigation shows poor management with high doses and irregular frequencies. Imperfect water treatment leads to a high load of suspended matter inducing deposition accumulation and the formation of a black crust on the soil affecting the hydrodynamic properties of the soil and decreasing water infiltration, water stagnation and salt concentration and decreasing biological activity.

Irrigation also affects soil pH, which declines slightly, and soil salinity, which rises under irrigation and the progressive accumulation of heavy metals. The quality of the groundwater and drainage water is also contaminated by heavy metals. The presence of metals and salts in drainage waters highlights the risk of contamination of the marine ecosystem. Thus, even if standards are met, the agricultural use of TWW triggers consideration of the long-term effect and the entire system from the plot to the final receptor, which is usually the sea.

Keywords: Treated wastewater, Heavy metals, Salinity, Soil, Drainage water, Groundwater

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Selon la banque mondiale, le déficit en eau augmente aujourd'hui de 50 Bm³ par an. Il atteindra 150 à 240 Bm³ d'ici 2050. Les pays les plus touchés par la rareté de l'eau, sont ceux situés dans la région MENA, (14 sur les 20 premiers dans le monde).

Toutefois, l'eau et l'énergie sont indissociables. Si l'eau est nécessaire pour la production d'énergie (forages pétroliers, extraction, fluide de refroidissement, ou autre), il en est de même pour l'énergie qui est indispensable à la production de l'eau potable et sa gestion, (extraction, transport, traitement et utilisation, ...).

En effet, on estime que la production d'eau potable consomme de 0,25 à 4 kWh par mètre cube d'eau potable à partir d'eau de surface et de 3.5 à 15 kWh par mètre cube d'eau douce produite par dessalement. Dans ce cas, la consommation énergétique dépend du mode de dessalement. La consommation énergétique des procédés thermique avoisine 15 kWh par m³ d'eau dessalée alors que pour l'osmose inverse elle est réduite à environ 3,5 kWh par m³, [1].

A la fin de 2014, les Nations Unies comptabilisaient près de 16 000 usines de dessalement, d'une capacité totale de production de 70 millions de m³ d'eau par jour. Au total, le dessalement absorberait près de 75 TWh/an, soit l'équivalent d'environ 0,4 % de la consommation électrique mondiale, [2].

Répondre à ce besoin énergétique par les énergies renouvelables semble une solution adéquate qui répond à la préoccupation mondiale liée au changement climatique et ses conséquences sur la planète. En effet, selon l'IRENA, la capacité installée en énergie renouvelable dans le monde a atteint 2350 GW, fin 2018 [3].

Toutefois, la performance du couplage du dessalement aux énergies renouvelables dépend de plusieurs critères. On peut citer la salinité de l'eau qui alimente le procédé, le type d'énergie renouvelable disponible sur le site, le type d'énergie requise mécanique ou électrique....

La présente conférence portera essentiellement sur l'identification des critères de choix pour une performance optimale du couplage des techniques de dessalement avec les énergies renouvelables.

Mots clés : Dessalement, Energie renouvelables, couplage.

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Development of Low cost ceramic membranes for wastewater treatment

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Porous ceramic membranes have many advantages, such as good thermal, mechanical and chemical resistances, long life time and ease of cleaning. These membranes are generally manufactured from inorganic compounds such as alumina (Al_2O_3), silica (SiO_2), zirconia (ZrO_2) and titania (TiO_2). To circumvent the issue of the high cost of these materials that results in high production cost of ceramic membranes, during the last years, many recent research activities have focused on the preparation of ceramic membranes from natural materials and from subproduct coming from the industry transformation of some natural materials, such as clay [1], phosphate [2], zeolite [3], sand [4], carbon [5], fly-ash [6] and mud of hydrocyclone laundries of phosphates [7].

In addition, there are various methods to prepare and/or functionalize ceramic membranes through surface chemistry approaches including the use of organosilanes and polymers in view of developing materials suitable for membrane separation processes which need hydrophobic membrane character such as gas separation, organics/water mixtures separation and desalination by membrane distillation [8, 9].

In the other hand, the preparation of a nanostructured ceramic membrane can be possible by using a dispersion of nanoparticles either in submicroscopic or nanoscopic size as an important precursor used for having tailor made pore size distribution in UF and NF membrane.

In this context, this presentation concerns several works performed in the field of new low cost ceramic membranes preparation to enhance the porous membrane structure as well as surface properties. The efficiency of these membranes in the fields of water treatment will be also shown.

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WASTE WATER MANAGEMENT IMPROVEMENT IN THE UNAMID HEADQUARTER IN CENTRAL DARFUR, ZALINGEI, SUDAN.

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This study, which focuses on conserving water and reducing the level of risk to personnel, local communities and ecosystems from wastewater management practices is part of the implementation of the new United Nations Secretariat's environmental management strategy through the Agenda 2030 for Sustainable Development adopted in 2015. It requires all UN agencies and peacekeeping missions to adopt good environmental management practices in order to leave a good footprint of the environment after the withdrawal of their operations on the ground.

The study, which is running since 01 January 2019 will continue up to 30 June 2020. It takes place in the UNAMID headquarter in Sudan in the locality of Zalingei in the Central Darfur region.

It is about the water and wastewater pillar which is part of the implementation of the UN new strategy on the environmental management policies.

The main results achieved by the study are: i) reduction of malaria cases; (ii) six (6) new wastewater treatment plants are installed and operational; (iii) sanitary facilities are improved; iv) enough recycled water is available for the drip irrigation within the camp. It has also led to an effective and lasting partnership between the Faculty of Agriculture at the University of Zalingei and the UNAMID Office Administration in Central Darfur.

Keywords: wastewater; UNAMID; waterborne diseases; water treatment; recycled water

POTABILISATION DE L'EAU FLUORÉE ET SALÉE AU SÉNÉGAL 17 ANS DE PRATIQUES

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Avec une estimation à 15 millions d'habitants, plus de 27% de la population du Sénégal sont exposés à une eau de boisson excessivement fluorée et salée entraînant des problèmes de santé tels que la fluorose dentaire et/ou osseuse.

Des résultats de laboratoires ont fait l'objet de plusieurs publications dans des revues scientifiques indiquant la possibilité d'élimination partielle du fluor dans l'eau par membrane de nanofiltration malgré sa taille d'ion très petit et d'une très forte électronégativité plutôt responsable d'une énergie d'hydratation élevée [1–7]. Cette situation entraîne l'organisation à Dakar d'un colloque international regroupant des universitaires, des industriels et des partenaires au développement [8]. La synergie développée lors de la rencontre aboutie à la conception et la mise en place en 2007 d'un module test en milieu rural dont la salinité dans l'eau de boisson varie autour de 2000 mg/L et le fluor entre 5 et 15 mg/L. C'est un module « Disc Tube™ » qui présente une forte résistance à l'encrassement, démontable puis réparable sur place et ne nécessite pas de prétraitement [9– 12]. Les résultats des tests obtenus ont permis l'installation d'une unité pilote en 2011 et de conclure sur la faisabilité et la fiabilité d'une production d'eau potable à partir d'eau très fluorée (73% d'abattement) et salée (48% d'abattement)[13]. Un nettoyage chimique est effectué après chaque 400 heures de fonctionnement du fait de la montée de la pression d'alimentation de 11 à 13 bars pour maintenir le même débit de perméat. Lorsque les 4000 heures sont atteintes, nous procédons plutôt à un lavage mécanique qui consiste à démonter tout le module et laver les membranes manuellement avec de l'eau du perméat permettant alors de retrouver efficacement la pression initiale de 11 bar.

La question du devenir du concentrât n'est pas abordée dans cette présentation. Ce travail, source de 4 DEA et 3 thèses est présentement à l'origine de 22 unités de production de 500 L/h d'eau potable chacune à un taux de conversion de 75%. Ces unités sont installées pour l'essentiel en milieu rural, permettent l'accès à une eau de qualité, créent des emplois durables et améliorent la qualité de vie.

FABRICATION OF PDMS AND PTMSP BASED MEMBRANES WITH IMPROVED EFFICIENCY IN HYDROPHOBIC PERVAPORATION

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Effective and selective transport in pervaporation requires the application of membranes possessing the best performance. Due to that fact, the membrane modification is often applied to achieve superior membrane properties. The modification of membrane structure can be performed either at the preparation stage or by the post-treatment [1]. Improvement of transport and separation properties towards the desired component can be achieved by using one of the following modification procedures [2-4]: i) surface membrane activation by plasma treatment with subsequent further modification, ii) salt method, iii) cross linking, iv) polymer blending.

The aim of this research was the preparation and modification of polymeric flat sheet membranes made from PDMS, and PTMSP, which should result in the improved separation and/or transport properties during hydrophobic pervaporation.

PDMS and PTMSP based membranes were prepared using various preparation and modification approaches (phase inversion, plasma treatment and subsequent grafting, salt method, incorporation of alumina oxide into polymer matrix). Material and surface properties of prepared membranes were investigated applying a number of instrumental techniques (AFM, FT-IR, DSC, SEM, CA). Finally, transport and separation properties of the elaborated membranes were determined during vacuum pervaporation (PV) experiments in contact with pure water and water-ethanol mixture at 30°C. The results were compared with efficiency of the native and commercial PDMS based membrane (Pervap™4060).

According to AFM results, the highest roughness (Rq) was obtained on the surface of PDMS_NaCl membrane. Other PDMS based samples possessed similar Rq value, which implies that applied modification procedures do not affect significantly the resulting membrane roughness. FT-IR results proved presence of hydroxyl groups in PDMS_plasma_C8 membrane structure, showing that not all -OH groups created during plasma treatment were modified with triethoxy(octyl)silane (C8). Additionally, -CH=CH2 groups were detected in the PDMS_NaCl membrane, indicating that polymer matrix was not completely crosslinked during preparation procedure using salt method. DSC results proved that modification procedures utilized in this study did not change temperatures of the membranes phase transitions.

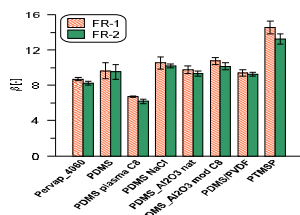


Fig. 1. Comparison of separation factor values obtained for elaborated membranes during pervaporation experiments performed in contact with water-ethanol system at two feed flow rates. FR-1=1.2 L/min; FR-2=0.1 L/min. Feed composition: 5 wt.% of ethanol.

The pervaporation results shown in Fig. 1 evidenced that PDMS membranes prepared by the salt method (PDMS_NaCl, =10.5) or by adding the hydrophobized alumina filler (PDMS_Al2O3_mod.C8, =10.8) to the poly(dimethylsiloxane) matrix allow to obtain improved membranes performance in pervaporation. Plasma treatment of PDMS sample caused reduction of hydrophobic properties of PDMS_plasma_C8 membrane, resulting in a much lower separation factor (=6.0). Except for PDMS_plasma_C8, all prepared PDMS based membranes possessed better separation properties towards ethanol than the commercial Pervap™4060 one.

Pervaporation results also proved that the most selective membrane during ethanol recovery from water-ethanol mixture was the PTMSP one (separation factor =14.5), however this membrane was not stable during the

separation process. PTMSP underwent compaction during pervaporation experiments. It was established that the thickness normalized water transport through PTMSP membrane fallen from 4.5 μm kg m-2 h-1 to 0.8 μm kg m-2 h-1 after 30 h of pervaporation process.

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**TRAITEMENT ET VALORISATION DES EAUX USÉES INDUSTRIELLES
PAR L'UTILISATION DES PROCÉDÉS MEMBRANAIRES :
COUPLAGE BIORÉACTEUR À MEMBRANE-NANOFILTRATION OU
ÉLECTRODIALYSE POUR LE TRAITEMENT D'EAUX USÉES DE BRASSERIE
SOUS CLIMAT SAHÉLIEN**

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Les industries de production de boissons génèrent quotidiennement des volumes importants d'eaux usées. Du fait des résidus de production mais aussi de l'utilisation de produits de lavage et de désinfection, ces rejets industriels, en plus d'être chargés en matière organique, contiennent des polluants minéraux indésirables comme le sodium. Différents pilotes de Bioréacteur à Membranes (BàM) couplés à des pilotes de nanofiltration (NF) et/ou électrodialyse (ED) ont été utilisés afin de valider la pertinence des technologies membranaires dans le contexte climatique sahélien pour une réutilisation des effluents de l'industrie de production de bières et de boissons gazeuses. Les résultats obtenus montrent que l'évolution des microorganismes dans le réacteur biologique est fortement influencée par les conditions opératoires comme le pH et la température. Ensuite la charge organique a directement influencé la production de boue, le temps de séjour des boues (SRT) a impacté le colmatage des membranes et les performances mécaniques ont joué sur la croissance des microorganismes. L'élimination de la pollution organique a été influencée par l'acclimatation de la biomasse et par la charge massique dans le réacteur. Des rendements d'élimination de la DCO compris entre 93 et 96 % ont été obtenus aussi bien en conditions aérobie qu'anaérobie. Lors du traitement des eaux usées réelles, le taux de conversion observé lors du traitement aérobie est de l'ordre de 0,166 kgMVS/kgDCO alors que le rendement moyen de production de biogaz avec le BàM anaérobie est estimé à $0,21 \pm 0,03$ L biogaz/gDCO éliminé pour un débit moyen journalier de biogaz de 89 ± 40 L/j. L'utilisation de la NF en post-traitement du BàM permet d'affiner le traitement aussi bien de la matière organique dissoute que des ions. Quant à l'ED, si elle permet une meilleure élimination de la salinité, la matière organique dissoute, elle n'est pratiquement pas impactée. Les concentrations de sodium dans les produits finaux de traitement avec la NF et l'ED sont inférieures à 150 mg/L autorisant ainsi une possible réutilisation des eaux traitées pour l'irrigation et un déversement sans risque dans l'environnement. L'amélioration du traitement par les technologies BàM-NF requiert un investissement estimé à 3,8 milliards de FCFA (5,7 millions d'euros).

Mots clés : bioréacteur à membrane, eaux usées industrielles, électrodialyse, industrie de production de boissons, nanofiltration

**SOLAR POWERED DESALINATION UNITS
FOR SMALL COMMUNITIES AND REMOTE LOCATIONS:
CASE STUDY OF PLANTS LOCATED IN AFRICA
USING THE OSMOSUN® TECHNOLOGY**

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This presentation focuses on the use of photovoltaic (PV) panels to power membrane desalination plant. The first part will be devoted to the specific constraints of this technology with respect to the fluctuations and intermittence of the solar irradiance and to the strategies that can be developed to smooth the energy variations. Population in many areas of Africa suffers of water shortage due to periodic and prolonged droughts that requires treating unconventional water sources such as desalination of seawater and of brackish water. Case studies of desalination plants for seawater and brackish water equipped with the Osmosun® technology from Mascara Renewable Water will be detailed in the second part. Depending on the energy supply environment, the plants can be operated in stand-alone or hybrid configuration.

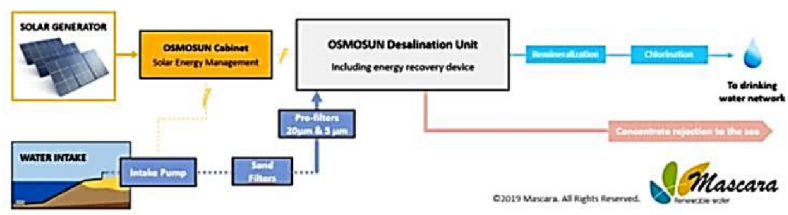


Fig. 1: Schematic diagram of the PV powered reverse osmosis desalination unit with the Osmosun® technology installed at Witsand, Hessequa, W. Cape Province, South Africa.

Keywords: Renewable energy, Membrane desalination, Stand-alone desalination unit, Seawater desalination, Brackish water desalination.

ULTRA SMALL METAL NANOPARTICLES BASED-HETERO STRUCTURES: DESIGN AND APPLICATIONS IN HYBRID CATALYTIC MEMBRANE SEPARATION PROCESSES

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The demand for novel efficient and affordable waste water treatment processes brought catalytic hybrid metal-based hetero structures/inorganic membranes into the focus.

In order to fully exploit the advantages originating from the hybrid reactors, a proper design of the final materials is imperative to control their morphology, surface area, porosity, metal nanoparticles size and distribution because all these characteristics are directly related to the functional properties.

Multifunctional hairy nanostructures consisting of chelating polymers grafted on clay, carbon nanotubes, graphene, or graphene-clay have attracted considerable attention in designing of effective metallic nanoparticles platforms. These metal NPs-based hetero structures exhibit remarkable potential in water purification due to their high surface area, catalytic activity and selectivity, stability, and reusability. Furthermore, one important advantage of such systems is that the metal nanoparticles are at highly dispersed/distributed state offering them a high efficiency in catalytic organic transformation. In this presentation, we report synthesis of a new series of nano hetero structures and some examples of their use as heterogeneous catalysts in the conversion of organic micro pollutants in batch mode.

The second part will be dedicated to the role played by these catalysts in terms of reduced membrane fouling and improved permeate equality when combined with ceramic membrane filtration.

Keywords : metal nanoparticles, hetero structures, heterogeneous catalysis, water purification, hybrid membrane systems



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<p>W. Aloulou, H. Aloulou, R. Ben Amar <i>FSS - Sfax</i> DEVELOPING OF TITANIA-SMECTITE NANOCOMPOSITEDOPED TIO₂ ULTRAFILTRATION MEMBRANE OVER ZÉOLITE BASEDCERAMIC SUPPORT</p>	<p>CO 10</p>
<p>A. Angov, M. Valat, P. Goupy, P. Ginisty, A. Sommier, C. Caris-Veyrat, F. Chemat <i>Université de Bordeaux, France</i> ECO-EXTRACTION DE MATIEREVEGETALE PAR MICRO-ONDES ET CENTRIFUGATION</p>	<p>CO 56</p>
<p>I. Anouar, R. Jouraiphy, H. Essallaki, S. Yousfi, H. Mazouz, T. Mahfoud, M.L. Bouamrani <i>Université Hassan II, Maroc</i> EVALUATION DES PERFORMANCES DE LA SÉPARATION SOLIDE-LIQUIDE POUR LA RÉCUPÉRATION DE P₂O₅A PARTIR DES BOUES D'ACIDE PHOSPHORIQUE</p>	<p>CO 7</p>
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<p>S. Bava, L. Messaoudi <i>Université Moulay Ismail, Meknes, Maroc</i> ELABORATION AND CHARACTERIZATION OF A LOW-COST CERAMIC MEMBRANE MADE OF NATURAL MOROCCAN CLAY AND STUDY OF THE PERMEABILITY OF THIS MEMBRANE</p>	<p>CO 35</p>
<p>N. Ben Kraiem, K. Zlaoui, D. Jellouli Ennigrou, K. Horchani Naifer <i>CNRSM - Borj Cédria</i> REMOVAL OF LANTHANUM (III) FROM AQUEOUS SOLUTIONS BY POLY(SODIUM 4-STYRENESULFONATE)</p>	<p>CO 49</p>

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<p>M. Bouhria, M. Breida, S. Alami Younssi, M. Ouammou <i>Université Hassan II, Casablanca, Maroc</i></p> <p>FILTRATION DES SOLUTIONS SALINES SUR DES MEMBRANES D'ULTRAFILTRATION EN ALUMINE GAMMA. APPLICATION A LA RÉTENTION DES CATIONS MÉTALLIQUES</p>	<p>CO 18</p>
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Résumés des Communications Orales

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EFFECTIVENESS OF USING NF AS POST-TREATMENT OPTION FOR THE HYBRID UF/ADSORPTION SEPARATION OF DYE FROM REAL TEXTILE WASTEWATER

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As water usage is a key operational part in most of the industrial processes, the production of wastewater is inevitable in a wide spectrum of industries. Textile industry is one of the most important industrial sectors of the world economy. Its main drawbacks are related to high water consumption and wastewater production. Among the different technologies that can be applied for the treatment of textile wastewater, the membrane-based processes represent the most promising technologies that offer a realistic solution to meet the increasingly strict discharge limits and to reuse the textile wastewater by providing treated water with good quality. Adsorption process with operability and economic feasibility is considered to be efficient and promising pretreatment of dyes containing textile industry wastewaters.

The present study is based on the investigation of the performance of a hybrid adsorption/membrane process for the removal of COD, salt and color from real textile wastewater using Tunisian natural clay (NC) and commercial activated carbon (AC) as adsorbents. UF process used alone and coupled with adsorption is employed as pretreatment to be an efficient approach to increasing effective removal of the compounds via membrane separation.

The application of continuous hybrid system (A/UF) using the optimal dose of adsorbent (150mg/L for AC and 200mg/L for NC) shows a better separation performances in comparison to the use of UF separately and revealed that the best adsorption efficiency was achieved in the presence of the NC. A quasi-total retention of color and turbidity was obtained while the retention of COD and salinity were of 52 and 33%, respectively. The integration of Nanofiltration membrane (NF) as post-treatment for the hybrid system, lead to a high quality of the treated effluent with retention of color, suspended matter, salt and COD respectively of 99.9%, 100%, 60% and 75%. The use of A/UF as a pretreatment prior to NF improves the treatment effectiveness by increasing the operating time and the permeate flux. NF permeate quality was satisfactory enough to be reused in dyeing baths.

Keywords: Hybrid treatment, Adsorption, Ultrafiltration, Nanofiltration, textile waste water

CLAY/PTFE MEMBRANE: APPLICATION TO THE TREATMENT OF TEXTILE EFFLUENT

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Membranes are used more and more in different fields thanks to several advantages such as facility of process, low energy requirement, high stability and efficiency [1,2]. Membrane processes represented by microfiltration, ultrafiltration, nanofiltration and reverse osmosis have shown excellent results in the field of water treatment, especially for the treatment of industrial effluents. The main materials used in membranes are the polymers thanks to the advantages they offer such as a good capacity of membrane formation, flexibility and lowcost. However, chemical, mechanical and thermal resistance limits the application of polymeric materials [3].

To overcome this limitation, the dispersion of inorganic nanoparticles at nanometer-level in a polymeric matrix, is one of the promising and used approaches studied in recent years [4,5]. In this context, a composite membrane obtained from the mixture of 50% natural clay and 50% PTFE at a temperature of 70 °C was prepared. The characteristics of this membrane have shown encouraging performance from mechanical resistance point of view with 24 MPa Young's modulus. The pore size was found in the range 0.1 - 0.14 µm indicating that this membrane works in the field of microfiltration.

The determination of the water permeability shows a value of 535 L.h⁻¹.m⁻². The application to the textile effluent treatment shows a good efficiency of this membrane. The permeate has a turbiditylessthanl NTU and shows a retention of Color and COD of 96% and 85% respectively.

Keywords : Kaolin, PTFE, composite membrane, microfiltration membrane, textile Wastewatertreatment.

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EFFICIENCY OF HYBRID PROCESS THROUGH ENZYMATIC TREATMENT AND MEMBRANE FILTRATION IN THE TREATMENT OF VEGETABLE OIL REFINERY WASTE WATER FOR WATER PURIFICATION AND RECOVERY

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Increasing growth of industries in the Mediterranean countries has led to excessive use of water resources in different processes and accelerated pollution in the environment. In Tunisia which mainly produces edible oil, there are 35 to 40 oil conditioning plants for local consumption and export and 13 oil refineries with a total refining capacity of 900 tonnes / day.

The process of edible oil refining requires the usage of high amount of water, in the other hand generates of highly polluted effluents. In view of sustainability, highly loaded wastewaters such as vegetable oily wastewater have been considered more as a resource for water, value-added products and even energy rather than a waste. This has driven many researchers toward developing useful treatment technologies including physical chemical and biological processes as well as various combinations of them to produce treated water suitable for reuse and/or recycling. An appropriate treatment system should provide efficient pollutant reduction uses less treatment time requires simple installation with the addition of little or no chemical compounds.

Therefore, this work aims to investigate the purification of Edible Oil Refinery. Wastewater using an innovative hybrid process combining enzymatic treatment and membrane separation via cross flow filtration.

Commercial Laccase catalysis was conducted under slow stirring at 150 rpm, pH values (3-8) of wastewater were established by adding buffer solutions. Batch reactions were carried out under different contact times (0-92h) using different Laccase concentrations (0 -100 U/L) under different temperature levels (25-50°C). When the reaction was concluded, the reaction medium solutions were incubated during 8 min at 100°C; under these conditions the enzyme was inactivated. Cross flow-filtration experiments were carried out at constant pressure of 3 bars. Volumes of 1L of enzymatic treated waste water were filtrated using flat membranes (UF and NF).

The optimal conditions for a enzymatic treatment were achieved under a pH solution of 6, at a temperature of 40°C using Laccase with a concentration of 60U/L; under these conditions COD and turbidity removals reached 50% and 52%. Enzymatic-catalyzed wastewater was subsequently treated via membrane filtration process using flat membrane of Ultra and Nanofiltration. The combination of Laccase catalysis with ultrafiltration process using a membrane with a molecular weight cut off of about 100 kDa enhance the enzymatic treatment efficiency with 97% and 100% of COD removal.

Keywords: OilyWastewater, Hybrid process, Enzymaticcatalysis, Cross Flow Filtration, COD removal.

MEMBRANE BIOREACTOR TECHNOLOGY FOR MUNICIPAL WASTE WATER TREATMENT AND REUSE

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Increasing interest in sustainable wastewater treatment has led a fundamental change in treatment System operation. A key aspect of improving overall sustainability is the potential for direct wastewater effluent reuse. However, membrane bioreactors (MBRs) have been identified as an attractive option for producing high quality and nutrient-rich effluents during the treatment of municipal and domestic wastewaters. Currently, the implementation of membrane bioreactors (MBRs) has increased due to their superior effluent quality and low plant foot print. MBR technology can be used as a technology to treat different types of wastewater and to produce effluent with a good and suitable quality for reuse.

The aim of this work is to evaluate the feasibility of ultrafiltration membrane bioreactor technology for municipale wastewater treatment and their suitability for irrigation reuse. The performance of the ultrafiltration membrane in treating wastewater was tested using low and high-strength municipal wastewaters and the performance system was continuously monitored to compare filtration characteristics and effluent quality. The results lead to conclude that in quantitative terms, the MBR outcome treatments how edhigher removal efficiencies (>97%) for TSS, COD, BOD and TN, while lower efficiencies (<87%) were observed for TP.

Thereby, membrane filtration removes biological pollutants, particulate materials, microorganisms, suspension impurities and elements such as iron, cooper and zinc. Furthermore, in terms of reuse, the excellent effluent quality of the treated wastewater was satisfying the legal standards for water irrigation reuse in Morocco.

Keywords: Municipal Wastewater treatment, Membrane Bioreactor, Irrigation reuse.

POTABILIZATION OF GROUND WATER BY NANOFILTRATION COUPLED WITH A PHOTOVOLTAIC ENERGY PRODUCTION AND STORAGE SYSTEM : SIZING AND TECHNICO-ECONOMIC EVALUATION

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Unconventional desalination technologies have become necessary for hydrological planning as is the case for conventional water resources. One of the main obstacles to the implementation and extension of a desalination plant is the high cost of the produced water, which is strongly impacted on the one hand by energy consumption (accounts for 50 -60% of the total cost) and secondly, by the operation cost, maintenance and investment.

Renewable energy systems, such as solar photovoltaic, are currently used as a source of energy for desalination systems. This coupling is a reliable and particularly promising process for remote areas where there is no access to the electricity grid and where water is extremely scarce.

The aim of this work is to design a stand-alone photovoltaic installation for the supply of electrical energy to a desalination plant for treating slightly brack is groundwater by nanofiltration. The purpose of this installation is to provide 3 L of drinking water /day/students for a high school of 2000 students in Sidi Taibi (Kenitra region, Morocco) and also provide some of its electricity needs. The energy requirements of the plant in terms of pumping and lighting are estimated at 74.7 kWh/day. This allowed calculating the number of photovoltaic panels, inverters, storage batteries needed as well as the charge regulators.

Based on the life time of 20 years, and the price of the various elements of the installation including maintenance and cost per kWh, the cost of drinking water produced is estimated, which is the ultimate measure of the economic feasibility of the autonomous system. The results of this study will be presented and discussed.

Keywords: Potabilization, nanofiltration, photovoltaicenergy, sizing, economic valuation.

OCEAN WAVE-POWERED STAND-ALONE ONEKA BUOY FOR DESALINATION OF SEAWATER

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Wave energy is considered as the most promising renewable source. It is more persistent and spatially concentrated than most renewable energy resources [1]. As example, wave power at a given site is available up to 90 % of the time, while solar and wind availability tend to be available just 20-30 % of the time [2]. Then, wave power density is at least 10 times higher than typical solar density and 5 times higher than wind offering the physical conditions for effective harvesting using relatively small devices [3].

Traditional methods (powerplants) and sustainable methods (e.g. solar and wind) have to undergo several energy conversion steps which is complicated, hard to maintain and costly. Wave power is a mechanical energy and easily convertible to high pressure seawater, hence a compatible match with reverse osmosis desalination. So Wave energy can be regarded as the best solution for water desalination in coastal regions where sea water is the only available water source.

Oneka Technologies develops Wave-powered desalination buoys to produce drinking water. The Oneka floating buoys doesn't require any land space and use the waves as unique source of energy to pressurize the sea water through reverse osmosis membranes with following the environmental guidelines (no harming the marine environment or carbon dioxide emissions).

This system provides a sustainable, economical and 100% environmentally-friendly supply of drinking water for coastal communities and remote lands that lack access to an electricity grid or that have precious and limited lands.

Keywords: Renewable energy, Seawater desalination, Stand-alone reverse osmosis unit, OceanWaveenergy

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EVALUATION DES PERFORMANCES DE LA SEPARATION SOLIDE-LIQUIDE POUR LA RECUPERATION DE P_2O_5 A PARTIR DES BOUES D'ACIDE PHOSPHORIQUE

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Le processus de la production d'acide phosphorique par voie humide génère des boues, qui augmente avec l'augmentation de la production d'acide phosphorique. Ce déchet extrait est l'une des problématiques très importantes de l'industrie du phosphate. En effet, les boues d'acide phosphorique sont générées en grande quantité, dépassant des centaines de m^3 par jour, contenant plus de 70% d'acide phosphorique à 54% en P_2O_5 , et qui se forment dans des conditions extrêmement défavorables ; (ex : faible taille de particules, milieu très visqueux, haute pression dans un décanteur statique...) et par conséquent, présentent des caractéristiques qui rendent leur séparation de l'acide phosphorique très difficile.

Le but de ce travail est donc d'étudier, par une technique de séparation physique, les différents paramètres qui régissent la récupération de l'acide exprimé en P_2O_5 à partir des boues d'acide phosphorique. Trois techniques ont été sélectionnées dans cette étude : filtration sous vide, centrifugation et filtration sous presse.

La comparaison reposait sur trois critères : le taux de séparation des solides liquides de chaque technique, la quantité de P_2O_5 récupérée et la teneur en solide de l'acide liquide. Les résultats ont montré que la méthode de séparation la plus appropriée est la filtration sur presse avec un rendement de récupération de 89%, suivie de la centrifugation à 80% et ensuite de la filtration sous vide à 70%.

Mots clés : Séparation solide/liquide, Boues d'Acide Phosphorique, Rendement, Récupération, P_2O_5 .

L'OSMOSE DIRECTE EN DESSALEMENT ET RECYCLAGE D'EAU. RETOURS D'EXPERIENCES ET FUTURS DEVELOPPEMENTS

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L'osmose directe (en anglais forward osmosis, FO) est une technologie membranaire émergente prometteuse qui utilise une membrane dense et le gradient osmotique comme force de perméation. Cette configuration spécifique a démontré un rejet élevé de tous les contaminants tout en ayant une faible propension à l'encrassement et ne nécessite pas d'énergie pour l'extraction de l'eau. Initialement développée pour le dessalement ou la production d'énergie (PRO), cette technologie n'est pas encore mature pour être compétitive dans un futur proche pour ces applications. Néanmoins, de nouvelles applications possibles et plus prometteuses ont émergées telles que pour le recyclage des eaux usées ainsi que pour les procédés de concentration (agroalimentaire, eaux usées, ZLD). Egalement des systèmes hybrides plus bénéfiques tels que la fertirrigation ou la combinaison de dessalement et recyclage d'eaux sont envisagés.

A l'heure actuelle, le développement de FO demeure limité par un manque de validation industrielle, la nécessité d'une meilleure compréhension des phénomènes d'encrassement et de transfert de masse ainsi que le besoin de développement de membranes et de modules plus performant et adaptés aux applications. Le projet Tecniospring+ Sub-FO entend contribuer à combler certaines lacunes actuelles en développant l'osmose directe immergée. Dans ce procédé, une membrane FO est immergée dans la solution à traiter, ce qui est d'intérêt pour le traitement des liquides visqueux ou chargés qui ne peuvent pas être pompés dans des modules.

MODIFICATION DE SURFACE D'UNE MEMBRANE DE MICROFILTRATION A BASE DE SABLE TUNISIEN PAR FLUOROALKYLSILANE

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Les performances de la séparation membranaire, en termes de sélectivité et du flux de perméat, dépendent de la texture de la membrane et de la composition chimique du matériau utilisé pour l'élaboration de la membrane. Les propriétés de surface de la membrane de microfiltration à base de sable Tunisien ont été modifiées chimiquement, afin de changer son caractère hydrophile en hydrophobe, par greffage d'une molécule de fluoroalkylsilane (C8) appelée 1H,1H,2H,2H-perfluorodecyltriéthoxysilane.

L'observation par microscopie électronique à balayage a montré une diminution de la taille des pores de la membrane greffée. Une analyse thermogravimétrique a été utilisée comme technique d'identification des groupes silane greffés. L'analyse IR a permis une identification qualitative de la présence des liaisons caractéristiques des silanes incorporés. La membrane initialement très hydrophile (angle de contact non détectable) avant le greffage devient hydrophobe après le greffage (angle de contact égal à 117°). La perméabilité à l'eau diminue de 1228 L/h.m².bar avant le greffage à 434 L/h.m².bar après la modification.

Cette nouvelle membrane hydrophobe semble être prometteuse dans le domaine de distillation membranaire.

Mots clés: Membrane de microfiltration; Greffage; Fluoroalkylsilanes; Hydrophobicité.

DEVELOPING OF TITANIA-SMECTITE NANOCOMPOSITE DOPED TiO₂ ULTRAFILTRATION MEMBRANE OVER ZÉOLITE BASED CERAMIC SUPPORT

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The high cost of ceramic materials is one of the major factors that contribute to the high production cost of ceramic membrane. Thus, various attempts were made to use natural low cost material such as clay, apatite as an alternatives to well-known other metallic oxides like alumina, silica, zirconia and titania. The goal is to fabricate ceramic ultrafiltration (UF) and microfiltration (MF) membranes.

The aim of this work is to develop UF low cost ceramic membrane from Nanoparticles (mixed clay sol-gel + TiO₂ with different percentage) as active layer and zéolite as a support. The composition of clay powder Nanoparticles which previously prepared by sol-gel methods contains different amount of Titanium dioxide (TiO₂): 95 % - 5 % (Nanoparticle 1) : 85 % 15 % (Nanoparticle 2) and 70 % - 30% (Nanoparticle 3). The UF active layer was deposited on the previously prepared zéolite support via the Layer-By-Layer approach. For this reason we use a suspension formed by a mixture of the Nanoparticle with polyvinyl alcohol solution (PVA) and water.

The morphology and properties of the resulting membrane sintered at 950°C for 3 h then characterized by BET and SEM. At the end the performances of those membranes were investigated by conducting pure water permeation and then application for the treatment of industrial waste water. It was observed that separation layers of the three membranes (Nanoparticle 1/Z, Nanoparticle 2/Z, Nanoparticle 3/Z) has homogenous structure without cracks with an average pore diameter of 22 nm, and 3<dp< 12 nm 5 nm respectively.

The water permeability was then determined and showed that the value varied from 1062 L/h.m² bar for the support before layer déposition to 95 L/h.m² bar after coating for the Nanoparticle /Z3 membrane. This value confirms that the membrane was suitable for operating in ultrafiltration domain. Finally, the application to the treatment of industrial effluents reveals an important decrease in turbidity, color and chemical oxygen demand (COD) while the permeate flux was maintained within acceptable value. The overall data suggest that the elaborated nanocomposite membranes can be an use for the remediation of industrial effluents.

Keywords: Nanocomposite clay, Titanium dioxide, mixed nanoparticles, Layer-By-Layer, ultrafiltration membrane, industrial effluent treatment.

EFFECT OF MICRONIZED PHOSPHATE ADDITION AND SINTERING TEMPERATURE ON THE PERFORMANCES OF POZZOLAN MICROFILTRATION MEMBRANE AND ITS APPLICATION FOR INDUSTRIAL WASTE WATER TREATMENT

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Flat ceramic microfiltration membrane was prepared from natural pozzolan and micronized phosphate. The low-cost membrane was obtained by dry uniaxial pressing process and sintering. The effect of sintering temperature (900-1100 °C) and of micronized phosphate addition (10-40 wt.%) on membrane properties such as porosity, microstructure, mechanical strength and permeability were investigated. Experimental results show that the increasing temperature remarkably improves permeability and mechanical strength and increases pore size up to 1050 °C but slightly affect porosity. On other hand, the incorporation of micronized phosphate in pozzolan membrane significantly minimizes the pore size and slightly increases porosity. However, the permeability and the mechanical strength decrease with micronized phosphate addition.

The optimized membrane (20 wt.% of micronized phosphate and sintered at 1050 °C) has a porosity of 32.07%, an average pore diameter of 1.33 μm and a water permeability of 1732.5 L/h.m².bar.

As application, optimized membrane efficiency was evaluated by microfiltration of aluminum chloride suspension and tannery waste water. Filtration results show that the membrane exhibits higher turbidity removal efficiency for both feeds (99% for aluminum chloride suspension and 97% for tannery wastewater). From these promising filtration results as well as its low-cost, the obtained membrane could be considered as an alternative membrane for clarification of industrial wastewater.

Keywords: Pozzolan; Micronized phosphate; Ceramic membrane; Microfiltration; Wastewater.

**PREPARATION AND CHARACTERIZATION OF
CHITOSAN/KAOLIN COMPOSITE MEMBRANES
WITH PEG 10000 AS A PORE FORMING ADDITIVE**

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A novel chitosan/kaolin composite membrane with high flux and enhanced hydrophilicity was prepared by casting of a dope solution containing polyethylene glycol (PEG) and evaporation process. The morphology of membranes was analyzed by scanning electron microscope and performance of membranes was evaluated in terms of pure water flux, water permeability, contact angle, tensile strength, and elongation at break.

Results show that PEG additive acts as a pore former and can improve the surface hydrophilicity of membranes. Highly porous membranes were obtained. Both size and density of the pores increased with increasing the PEG content in the casting solution.

Additionally, their mechanical, thermal and chemical stability showed a large improvement compared to the unmodified ones.

keywords: biopolymer; clay composite membrane; mechanical properties; filtration performance.

TEXTILE EFFLUENT TREATMENT WITH 13X ZEOLITE SYNTHESIS EDFROMA NATURAL ALGERIAN KAOLINS

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In this study, 13X zeolite was successfully synthesized from natural local kaolins DD1, DD2 and DD3 via alkali fusion followed by hydrothermal treatment. Fusion with NaOH, followed by hydrothermal reaction, kaolinite and halloysite in kaolin sample were converted into 13X zeolite. The Three kaolins DD1, DD2 and DD3 issued zeolite 13X were characterized using Xray diffraction (XRD), surface area measurements (BET method), and Fourier Transform Infrared Spectroscopy (FT-IR).

The adsorption experiments were done using the Bezanyl Yellow (BY), commonly used in the textile industry. The results show that the adsorption is efficient and feasible at ambient temperature on DD1 kaolin issued 13X compared to 13X zeolite synthesised by DD1 and DD3 with good discolouration efficiency with a percentage of 90 % and adsorption quantity of 45 mg/g. Experiments with real textile wastewater showed an improvement of physico-chemical characteristics (BOD, COD, MES, TOC) compared to the untreated effluent.

Keywords : Zeolite 13X, Kaolins, Benzanyl yellow, Kinetics adsorption, Real textile effluent

MEMBRANE BASED PROCESS INTENSIFICATION: HIGH VALUE PRODUCT FROM WASTE BIOMASS

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In recent decades, a great deal of attention has been paid to the exploration of alternative and sustainable resources to produce value added components from waste biomass. biofuels and valuable chemicals, with the aim of alleviating the reliance on depleting confined fossil resources, as well as emerging economic and environmental issues. The terms “Process intensification strategy” (PIS) is emerging as an interesting guideline to revolutionize various process industry in terms of reduction of system size, improved process efficiency, minimizing waste generation and lowering footprint to the environment including sustainability. Membrane technology has appeared as a strong candidate to implement PIS in most of the recent processes. The most significant progress has been observed in recycling the waste to get more value added components and reducing the waste generation, where substantial reduction in overall energy demand, environmental footprint, and process hazards has already been accomplished. Recent developments in membrane engineering are shaping the biomass industry into value added materials including production of several byproduct. In this current study most discussions of current and perspective role of membrane engineering in achieving the objectives of PIS in the field of recovering the value added component will be summarised. Case studies will be introduced starting from olive industry to fruit juice and more further to the dairy industry waste. Renewable fuel will be discuss briefly before concluding with opportunities for the production of value-added components from biomass that would economically and technically support the production of fuels and power in an integrated biorefinery and identify the common challenges and barriers of associated production technologies.

Keywords: Membrane Processes, Waste Valorization, Process Intensification, Waste minimization, Biorefinary

AMELIORATION DU TRAITEMENT DES EFFLUENTS TEXTILES PAR L'INTEGRATION DES PROCEDES A MEMBRANE.

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Les principaux polluants dans les effluents textiles sont de nature aussi bien minérale qu'organique. L'utilisation d'une station biologique classique par boue activée reste insuffisante pour produire une eau traitée conforme aux normes de rejet dans le milieu récepteur en termes de salinité essentiellement.

Ce travail concerne l'amélioration des performances d'une station biologique existante dans une entreprise textile localisée dans la région de Monastir par la mise en place d'un traitement complémentaire de séparation membranaire. Il s'agit d'étudier différentes alternatives formées par l'addition séparée d'une Ultrafiltration simple (UF), d'une Nanofiltration (NF) ou d'une Osmose Inverse(OI) puis en considérant le traitement combiné UF/NF, UF/OI.

Les paramètres suivants ont été évalués avant et après traitement : Couleur DCO, TDS, teneur en chlorures, en sulfate, en sodium. Etant donné que l'addition des procédés de filtration a amené à une qualité des eaux très compétitive à celle de l'eau de procès. Un traitement par UF/OI a abouti à une meilleure réduction de DCO de 99,04 %, TDS de 99,52% ainsi qu'une décoloration totale. Le prétraitement par UF en amont du dessalement a montré des résultats très prometteurs en termes de limitation de colmatage de la membrane, l'encrassement de la membrane a été estimé par la détermination du taux de récupération de flux (FRR) (FRR = 93,9% ; 97,8 ; 90,1% et 95,6 % respectivement pour NF, UF/NF, OI et UF/RO) et augmente le flux de filtration 57% pour l'UF/NF et 37% l'UF/OI.

Les échantillons d'eau traitée ont été testés dans deux différentes recettes de teinture soufre et réactive à l'échelle du laboratoire pour déterminer leur impact sur la qualité des produits textiles. Un test témoin avec l'eau de procédé est effectué en parallèle pour pouvoir comparer les résultats par spectrophotométrie. Les résultats ont été comparés à ceux colorés avec de l'eau de traitement (eaux adoucies). Il a été constaté que, les tests de qualité des produits avec les eaux usées récupérées ont donné des résultats très prometteurs. Par conséquent, les coûts d'investissement et d'exploitation ont été estimés pour une éventuelle usine de traitement et de valorisation des eaux usées à grande échelle dans l'usine de textile.

PHYTO-PURIFICATION OF COPPER FROM INDUSTRIAL WASTEWATER AND ITS RELATIONSHIP WITH WILSON'S DISEASE IN THE MAGHNIA REGION (ALGERIA)

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Copper is one of the most valuable and prevalent metals used in the industry. There are many techniques to treat different types of industrial wastewater that are contaminated with heavy metals such as copper. In this work, we are interested in the problem of the presence of copper in the region of Maghnia and its relationship with Wilson's disease, widespread in this industrial region.

We used seeds from the Moringa plant to highlight the potential of the Moringa olifera plant to purify industrial wastewater with copper concentrations. Our study is to develop a model in the laboratory to control the scrubbing power of Moringa from copper laden waters. The results have been promising, which opens up the possibility of exploiting it in the form of large-scale copper-laden water purification tanks.

Keywords: Copper, Moringa, Wilson's Diseases, Phytoremediation.

ETUDE EXPERIMENTALE DE LA FILTRATION ET DU DRAINAGE CENTRIFUGE DANS UNE ESSOREUSE PILOTE

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La filtration centrifuge est un procédé très répandu dans l'industrie. La description physique des phénomènes mis en œuvre au cours de la séparation a été abordée par de nombreux auteurs. L'étape d'essorage est particulièrement complexe puisqu'elle fait intervenir un écoulement diphasique dans un milieu poreux sous l'action de la force centrifuge. Le modèle de Wakeman et Vince (Wakeman and Vince, 1986) a été largement utilisé pour décrire le drainage centrifuge du liquide. L'équation de Darcy généralisée combinée à l'équation de conservation de la masse conduit à l'équation de Richards qu'il est possible de résoudre en saturation ou en pression liquide. Dans ce travail, nous montrons que la formulation en saturation (utilisée par Wakeman et Vince) ne permet pas de décrire correctement l'écoulement dans la zone saturée du gâteau et conduit à une surestimation de la cinétique d'essorage. La formulation en pression liquide conduit à des résultats physiquement corrects en amont et en aval du front de saturation et qui évoluent vers la solution d'équilibre imposées par les effets capillaires et centrifuge.

Par ailleurs, l'utilisation du modèle de Darcy généralisé nécessite d'introduire les relations entre pression capillaire et perméabilité relative d'une part et saturation liquide d'autre part. Le modèle original de Wakeman et Vince utilise le modèle de Brooks et Corey (Brooks and Corey, 1964). On des écueil à l'utilisation du modèle de Wakeman et Vince est que la détermination des paramètres associés aux phénomènes capillaires est expérimentalement ardue. Ici, nous proposons leur estimation à partir du résultat d'expérience dans une essoreuse. L'instrumentation d'un pilote a permis l'acquisition des paramètres clés de la séparation. Ceux-ci donnent accès, en particulier, à l'estimation de la saturation moyenne du gâteau en cours d'essorage. Les cinétiques d'essorage ainsi obtenues peuvent être utilisées pour ajuster les paramètres capillaires du modèle.

Des expériences ont été réalisées sur deux types de suspensions minérales (talc et spath ou fluorure de calcium). Bien que les distributions granulométriques des poudres de talc et de spath soient assez proches, les propriétés des gâteaux et les cinétiques d'essorage sont très différentes. Les données expérimentales permettent de suivre l'évolution du rayon d'anneau liquide au cours du temps, pendant la formation du gâteau. Au cours de l'essorage, la mesure de la masse de filtrat instantanée permet de suivre l'évolution de la saturation moyenne du gâteau. Une méthode est proposée pour déduire l'ensemble des paramètres du modèle à partir des données de l'expérience. Les valeurs ainsi obtenues donnent une estimation très cohérente et reproductible des propriétés du système (gâteau/liquide/air).

Mots Clés : pilote instrumenté, centrifugation, essorage, modélisation, capillarité.

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FILTRATION DES SOLUTIONS SALINES SUR DES MEMBRANES D'ULTRAFILTRATION EN ALUMINE GAMMA. APPLICATION A LA RETENTION DES CATIONS METALLIQUES

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De grandes quantités d'eau polluée sont souvent obtenues des processus de transformation chimique et qui nécessitent un traitement obligatoire avant de les réintroduire dans le milieu naturel. Les métaux lourds sont utilisés dans de nombreux procédés, de sorte que la récupération et/ou le recyclage de ces métaux dans les unités de réaction est essentiel.

Pour cela, diverses techniques classiques de purification sont utilisées. Néanmoins, à l'heure actuelle, le développement de technologies propres est de plus en plus souhaité afin de préserver l'environnement. Par ce présent travail, la filtration membranaire est présentée comme une technique utile pour éliminer / récupérer les métaux lourds présents dans les solutions aqueuses. La filtration de différentes solutions d'électrolytes, de cuivre (II), de chrome (VI) a été réalisée au moyen d'une membrane d'ultrafiltration en Al_2O_3 qui a un diamètre de pore de 5 nm. L'effet des paramètres de filtration tels que le pH, la pression appliquée et la concentration du sel sur la sélectivité et la perméabilité de la membrane a été étudié en utilisant des sels simples $\text{K}_2\text{Cr}_2\text{O}_7$, CuSO_4 , $\text{Cu}(\text{NO}_3)_2$ et des mélanges de sels ($\text{K}_2\text{Cr}_2\text{O}_7+\text{NaNO}_3$), ($\text{K}_2\text{Cr}_2\text{O}_7+\text{Na}_2\text{SO}_4$) et ($\text{CuSO}_4+\text{Cu}(\text{NO}_3)_2$).

Les résultats expérimentaux ont montré que la rétention du sel dépend fortement du pH de la solution, de la nature des sels métalliques et de la charge de la membrane. Le taux de rétention augmente avec l'augmentation de la pression, tandis qu'il diminue progressivement lorsque la concentration des cations métalliques augmente. La valence et le rayon hydraté des cations métalliques ont un effet majeur pour expliquer les rétentions observées.

Mots clés: Al_2O_3 ; Membrane céramique; Ultrafiltration; Cations métalliques; Filtration.

EXPERIMENTAL STUDY OF A NEW SOLAR STILL

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Desalination of ocean water via solar green house effect distillation was used at the turn of the 19th century to produce fresh water on a small industrial scale. The average daily output per distillation module was in the range of 3 liters per day per m². Since then, solar distillation has come a long way with the advent of new materials, new technologies and innovation.

This study presents design features of a new, enhanced output solar distillation prototype, outdoor performance data and a brief analysis of the kinetics of the solar distillation process. A new type of autonomous, stand alone, all solar distillation equipment achieved a maximum output of 13 liters per m² per day during the summer in June when days are hot and long.

Keywords: Distillation, Solar Desalination, Heat Storage, Desalination, Solar Distillation

REMOVAL OF PHOSPHATE BY DONNAN DIALYSIS COUPLED TO ADSORPTION ONTO ALGINATE CALCIUM BEADS

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In this study the removal of phosphates from solution by Donnan dialysis and by adsorption onto alginate calcium beads has been studied separately and then the coupling was performed. This hybrid process was conducted in order to benefit from each process and it is an original and new combination.

First, the Donnan dialysis process was performed with three anion- exchange membranes AMV, AFN and AMX. Then, adsorption effects initial concentration, pH and adsorbent dose were investigated according to a full factor design. Using the experimental results, a linear mathematical model representing the influence of the different parameters as well as their interactions was obtained; it shows that the initial phosphate concentration is the most significant parameter affecting the phosphates removal.

Finally, Donnan dialysis coupled to adsorption onto alginate calcium beads for the removal of phosphate was conducted. The hybrid process can be considered a solution to improve the contact time and the amount of phosphate removed.

Keywords: Donnan dialysis; Phosphate; Anion-exchange membrane; Adsorption; Alginate

NANOFILTRATION AND REVERSE OSMOSIS MEMBRANE FOR NITRATE REMOVAL: PERFORMANCE STUDY AND ECONOMIE EVALUATION

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Contamination of water with nitrates is a global problem that poses a serious threat to human health. In Morocco, a country characterized by limited water resources, ground water accounts for almost 32% of total resources. However, 6% of these water resources are estimated to have nitrate levels greater than 50 mg / L, the level recommended by the world health organization for drinking water (WHO) and in some areas of high agricultural activity the nitrate content exceeds 250 mg / L.

In the first part of this study, the performances of two commercial membranes, Reverse Osmosis and Nanofiltration membranes (Dow-FilmTec) are experimentally compared and assessed for nitrate removal by using real brackish water, containing 850-1100 mg/l of total dissolved solids (TDS) and 80-120 mg/L of nitrate. Moreover, the influence of operating conditions (pressure and recovery rate), water quality, solute-solute interactions, and membrane characteristics on nitrate removal were discussed. The salt rejection from each membranes and the energy consumption were also calculated to choose the best membrane for nitrate removal and drinking water production. The pilot used in this study (supplied by the French company TIA) is an industrial pilot plant having two modules equipped with various spiral commercial membranes with an area of 7.6 m².

The second part of this study estimates the total cost of the produced water by the application of the two studied membrane (NF and OI) for a plant of nitrate removal having a capacity of production of 24000 m³/d (100 m³/h) corresponding to a water consumption for 50000 capita following the Moroccan considerations in rural medium. The design of the plant was carried out based on the experimental results from the first part of the study corresponding to a recovery rate of 84%. The results of this study will be presented and discussed.

Keywords: Nanofiltration, reverse osmosis, nitrate, ground water.

**ELIMINATION DU FLUOR ET DE LA SALINITE PAR SYSTEME
MEMBRANAIRE EN MILIEU RURAL :
BILAN DE 02 ANS DE FONCTIONNEMENT DANS LE VILLAGE DE
KEURMARIAMA (KAOLACK, SENEGAL)**

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Au Sénégal, particulièrement dans le Sine Saloum la présence des ions fluorures à des doses excessives dans les eaux de consommation humaine est à l'origine d'un réel problème de santé publique. Parallèlement, la salinité des eaux de forages ne cesse de croître, à cause de leur surexploitation.

Notre étude porte sur la double possibilité d'élimination sélective du fluor et le dessalement partiel par OIBP de l'eau de boisson de Keur Mariama provenant des eaux souterraines.

Les résultats quantitatifs obtenus concernant le taux de rejet en conductivité montrent que ce paramètre diminue légèrement au cours des années. Cependant, la baisse relative qui n'est pas importante prouve que les membranes rejettent bien les ions et donc sont toujours performantes. Pour la pression de fonctionnement, elle augmente relativement d'année en année avec une valeur de 4 % entre 2012 et 2013 et de 2 % entre 2013 et 2014. Ce phénomène résulte de l'accumulation progressive des éléments colmatant. Par conséquent, les membranes s'encrassent de façon progressive d'année en année. Aussi, la perméabilité des membranes baisse d'une année à l'autre. On note une baisse relative de 7 % entre 2012 et 2013 et de 12 % entre 2013 et 2014. Cette diminution de la perméabilité est en parfaite corrélation au colmatage des membranes mais également à la baisse du taux de conversion.

Les résultats obtenus au bout de deux ans et demi de fonctionnement de l'unité de KeurMariama montrent que ce système reste performant malgré une légère baisse des taux de rejet en conductivité, de la perméabilité et du taux de conversion. Le respect des conditions de fonctionnement ainsi que des entretiens périodiques permettent d'avoir une durée de vie des membranes et de l'installation relativement longue.

Mots clés : fluor, salinité, colmatage, osmose inverse à basse pression, milieu rural

TEXTURING OF ULTRAFILTRATION MEMBRANES SURFACE FOR HYDROPHOBICITY CONTROL

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Generally, for the polymeric membranes, operating parameters and formulation of polymer solution strongly affect membrane morphology including sponge/bi-continuous, finger-like, cellular or nodular structure. General trends for the formation mechanism of these structures can be drawn from system thermodynamics (binodal and spinodal decomposition) and transformation kinetics of phase separation. Membrane surface plays a very important role in ultrafiltration (UF) since separation takes place at the top layer in this technology. Therefore it is important to have a good command of the surface micro-texturing governing the membrane performance. However, to our best knowledge, there is still a lack of investigations regarding the structuring of the surface and the interplay between membrane morphology and surface topography

A series of PSU flat sheet UF membranes with mean pore size of 7 to 13 nm were prepared. The thickness of the cast film was varied from 150 to 400 μm and the polymer concentration in the dope solution from 12 to 18 %.

AFM observation shows that membrane surface topography exhibits deformations with multi-scale texturing (micrometric and nanometric): a quasi-repetitive deformation in the form of undulation with a micrometric wavelength and a random deformation at the nanoscale. The effect of the membrane preparation conditions on the surface topography has shown that the polymer concentration as well as the cast solution thickness give surfaces with high roughness at the micrometric scale and pronounced undulations favoring the hydrophobicity of the surface.

Different morphologies were observed according to the same preparation conditions. It turns out that the topography of the surface is closely related to morphology at the micrometric scale. The phenomena involved in the texturing of the surface were determined on the two different scales.

Keywords: membrane preparation, surface topography, morphology, multi-scale analysis, hydrophobicity control

COMPARAISON DES PERFORMANCES DE DEUX MEMBRANES D'OSMOSE INVERSE BASSE PRESSION

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Pour s'adapter aux évolutions de la qualité de ses ressources en eau et aux renforcements de la réglementation relative aux eaux destinées à la consommation humaine, le Syndicat des Eaux D'Ile de France (SEDIF) s'est engagé dans une réflexion sur l'évolution à long terme des filières de production de Choisy-le-Roi et de Neuilly-sur-Marne. Plusieurs études sur la faisabilité technique d'intégration d'une étape de filtration sur membranes d'affinage ont été réalisées.

Ces études menées depuis 2009 au centre d'essais de Choisy-le-Roi ont porté sur des membranes de « Nanofiltration », elles ont permis notamment de définir la qualité d'eau d'alimentation, le type de membranes ainsi que les conditions de prétraitement optimales. Par la suite, la volonté du SEDIF d'améliorer la qualité de l'eau produite et d'anticiper l'émergence de nouveaux polluants a orienté les études vers des membranes capables de retenir plus de micropolluants et de sels monovalents « les membranes d'OIBP ». Dans un premier temps, un screening des membranes OIBP disponibles sur le marché a été réalisé et a permis la caractérisation de 14 membranes d'OIBP par le biais d'essais sur coupons en termes de performance hydraulique et de rétention de 35 micropolluants cibles. Cette étude a permis de choisir deux membranes (A) et (B) présentant un bon compromis entre performance hydraulique et rétention en micropolluants pour effectuer des essais à l'échelle 4 pouces sur des pilotes membranaires 3 étages.

Depuis 2018, les deux membranes (A) et (B) ont été mises en fonctionnement sur les pilotes 3 étages avec des membranes 4 pouces pour une comparaison. Un suivi de la cinétique du colmatage en termes de perméabilité hydraulique, de perte de charge longitudinale et de la qualité d'eau produite ainsi que la rétention en micropolluants a été mis en place.

En conclusion, les résultats de cette étude ont montré que ces deux membranes présentent des performances hydrauliques et une qualité d'eau produite sensiblement équivalentes. En revanche, la membrane (A) présente une meilleure résistance au colmatage que la membrane (B) remettant en cause ainsi la viabilité de cette dernière pour une application industrielle sur l'usine de Choisy le Roi.

Mots clés : Membranes, colmatage, Osmose Inverse Basse Pression, Comparaison.

EFFECT OF CHITOSAN'S DEGREE OF DEACETYLATION ON THE PERFORMANCE OF PES MEMBRANE INFUSED WITH CHITOSAN

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Membrane technology has emerged as alternative technology over conventional treatment methods and has since been utilized extensively in many industrial wastewater treatment applications. Nevertheless, broader employment of membrane technology is hindered due to membrane fouling phenomenon.

To overcome this challenge, most attention was geared towards membrane modification to increase membrane resistance to fouling. Chitosan has emerged as one of the most promising modifying agent due to its high hydrophilic property and numerous functional groups which could act as binding sites to contaminants. Chitosan is a naturally occurring, biodegradable and non-toxic polymer which is obtained from chitin by deacetylation process. Degree of deacetylation refers to a number of free amino groups exposed on the polysaccharide. This paper studies the effect of chitosan's degree of deacetylation on the PES membrane modified with chitosan during the treatment of acid mine drainage.

The hydrophilic chitosan was blended within the PES membrane support. The hydrophilicity of PES membrane was significantly improved with increasing chitosan's degree of deacetylation. This was due to high number of amine groups available on the chitosan molecule which enhanced water transport through the membrane. Membrane permeability and rejection was enhanced with increasing chitosan's degree of deacetylation.

Keywords : Polyethersulphone, Chitosan, Degree of deacetylation, Acid mine drainage

EFFICIENCY OF SUPPORTED NANO GOLD CATALYST COMBINED WITH TiO₂-COATED CERAMIC MEMBRANE FOR DECOLORIZATION OF METHYL ORANGE DYE

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Due to the growing interest in the use of natural and local resources for environmental remediation, clay and zeolite minerals have attracted particular attention as natural building-blocks in the development of new advanced materials.

In this contribution, on the one hand, we report a practical and efficient synthesis of highly active, stable, selective and regenerable heterogeneous catalysts based on finely dispersed nanoscale gold particles on clay-containing polyethylene imine nanocomposite. On the other hand, rational design of nanostructured membranes-based on zeolite ceramic flat support coated with an ultrafiltration TiO₂ layer will be detailed.

A series of batch experiments using the as-prepared uniform-sized small gold NPs decorated MMT-PEI nanocomposites alone and continuous flow catalytic membrane tests made by combining the later nanocatalysts suspended in solution with the TiO₂-coated ceramic membrane will be deeply discussed. A special attention will be focused on the effect of the experimental synthetic conditions on the kinetic of the conversion of methyl orange.

The results revealed that the hybrid catalytic membrane showed improved performances compared to the corresponding nanostructured ceramic membrane.

Keywords: hybrid membrane systems, supported gold NPs, heterogeneous catalysis, dyes, clay

PRÉPARATION AND CHARACTERIZATION OF $\text{TiO}_2/\text{ZrO}_2$ NANOFILTRATION MEMBRANE ON LOW COST BENTONITE SUPPORT FOR FILTRATION OF DYES AND HEAVY METAL SOLUTIONS

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The wastewater of industries is more and more progressively growth in terms of quantity and contamination degree due to development and extension of these industries over the world. In textile industries, it should be just reported that annual world production of dyes is estimated to be more than ten thousand tons and around 15% of this amount is lost during industrial transformation. Membrane separation technology has been recommended as a practical alternative advanced process for wastewater treatment. Various membrane processes especially ultrafiltration (UF) have been proven to be the most effective for treatment of textile wastewater.

The purpose of this work is the preparation and the characterization of $\text{TiO}_2/\text{ZrO}_2$ nanofiltration membrane. The membrane layer was deposited on bentonite support using spin-coating method. The optimized membrane has water permeability of $4.5 \text{ L/h.m}^2\text{.bar}$ and maximum rejection of 99.36 and 94.2% respectively for methylblue and methyl orange and more than 96.7% for heavy metals (Pb, Cd, Co).

Based on promising filtration results as well as the low cost of prepared membrane, industrial applications for treatment of wastewater particularly colored wastewater generated from textile industries may take place.

Keywords: Nanofiltration membrane ; Bentonite ; Spin-coating; Dyes removal; Heavy metals.

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**Programme du
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PHARMACEUTICAL WASTEWATER TREATMENT USING ULTRAFILTRATION PROCESS: FOULING STUDY OF NON-MODIFIED MEMBRANES & SOLUTIONS

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Water is an important natural resource used for drinking and other developmental purposes in our lives. According to world health organization (WHO) 80% diseases are water borne and drinking water in various countries does not meet WHO standards: 3.1% deaths occur due to the unhygienic and poor quality of water. Nowadays, a specific scientific challenge is addressed to water-quality problems caused by pharmaceutical micropollutants.

In this work, the first experimental part consists in characterizing, on the one hand, the pharmaceutical effluent supplied and, on the other hand, the (unmodified) ultrafiltration membranes used with several analytical techniques. The second part concerns the improvement of the performance of the membranes in terms of limiting the clogging phenomenon and improving the quality of treated wastewater through steps of modification of their active surfaces.

The membranes used in this work are polyamide-polysulfone ultrafiltration membranes SEPA- GH and SEPA-GK with MWCO 1 KDa and 2 KDa respectively.

Membrane performance and efficiency was quantified at different operating conditions such as transmembrane pressure, we can conclude that increasing transmembrane pressure has slightly improved the physicochemical parameter.

Fouling is one of the key barriers preventing a more widespread adoption of energy-efficient membranes for industrial applications. Contaminants in the feed water may deposit and accumulate on the membrane surface, this phenomenon named external fouling which would dramatically decrease water flux, for UF membranes, the contaminants may even block the internal pores.

The application of the model of the resistances in series to the membranes used allowed to evaluate the main cause of permeate flux decline observed during effluent treatment.

The determination of the series resistances of the membranes shows that polarization of concentration is the principal cause of decline in permeate flux, in the case of GK membrane. In fact, the resistance due to polarization of concentration (R_{cp}) was about 61% for UF GK membrane and represents only 17% in the case of GH membrane. However, UF GH is more sensitive to the clogging phenomenon, this can be confirmed by percentages, in the case of GH membrane, the resistance due to the clogging (R_{col}) represents 26% of the total resistance and 19% for GK membrane.

One effective strategy to mitigate membrane fouling is to enhance antifouling properties by surface modification. In this vision, green synthesis of silver nanoparticles (AgNPs) was carried out using fresh clean leaves of thymus vulgaris.

There for there is great interest in grafting or coating this plant into the membranes, this can be seen in the next results of the physicochemical properties of the permeate treated by the modified membranes.

Keywords: Pharmaceutical wastewater, ultrafiltration, membrane fouling, surface modification.

OPTIMIZATION AND MODELING OF TANNERY WASTEWATER TREATMENT BY ELECTROCOAGULATION COMBINED TO NANOFILTRATION PROCESS

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Throughout the world, tanneries are recognized as high-level waste generating industries. The leather processing that takes place in the tanneries involves a series of chemical treatments and mechanical operations for attaining the prescribed characteristics. The wastewater used in this study was collected from a homogenization tank from an operating tanning factory in Tunisia. Our work deals with optimization and modeling of a physical-chemical treatment which is electrocoagulation (EC) as second treatment and nanofiltration (NF) as tertiary treatment.

With the aim of suggesting an efficient treatment for this industrial effluent, we proceed to an optimization of EC process using experimental design. Several operating parameters such as thickness of the aluminum electrodes, number of pairs, density of current, distance between 2 electrodes, reaction time, mixing rate. We opt for a screening with 18 experiments, to identify variables which have more influence on the followed responses (Turbidity, salinity, COD). Once the most influent parameters are fixed we proceed to the modeling with a Box-Behnken matrix composed with 12 tests to obtain best conditions to work with. The construction of the matrix of experimental design was established using Statistica 8.0 software and all graphic study were designed by Nemrodw. The optimum conditions were subsequently determined using the response surface plots and contour plots for all significant parameters.

Although the effluent quality improvement after electrocoagulation process, it has been noticed that conductivity, salinity and chloride concentration exceed the tolerated limits. Hence, it was also proposed in our study to integrate nanofiltration process as a tertiary treatment.

We used a polyamide/polysulfone membrane (osmonics DK) with a plane geometry and an active surface of 140 cm². The transmembrane pressure was varied from 3 to 6 and results are given in terms of retention rates of the followed parameters which are firstly conductivity, salinity and chloride concentration for which EC has not a big impact and subsequently turbidity, COD which have a good abatement with EC and have been improved with nanofiltration process.

The results show that all retention rates exceed 70% and that the best performances were obtained for an optimal transmembrane.

Keywords: tannery effluent, Experimental design, Electrocoagulation, Nanofiltration

MEMBRANE FILTRATION AND CHROMATOGRAPHY APPLIED TO THE FRACTIONATION OF LIGNOCELLULOSIC RESIDUE EXTRACTS

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Fractionation of the lignocellulosic residues is of crucial importance for the replacement of many oil products. The only industrial development for the valorization of these biomasses has turned to extraction by acid hydrolysis, which leads to the production of monomers of sugars (xylose and glucose) which are valorized by fermentation for the production of ethanol. But these biomasses are rich in sugar and phenolic polymers, which can be used as a basis for the production of many plastics, bio-fuels, resins or solvents as a replacement for oil products. The extraction of these valuable molecules can be managed in sub-critical water or under alkaline conditions. In all cases, the main difficulty is that the extraction leads to the production of a complex extract containing mainly sugar and phenolic oligomers and monomers such as xylose, glucose or coumaric acid. The objective of this study is to evaluate how it is possible to separate this type of extract in to different recoverable fractions, containing sugar oligomers, phenolic oligomers and phenolic monomers, by combining purification steps such as membrane and chromatographic processes.

The work was carried out on sugar cane bagasse and wood residues. The extraction under basic condition was managed from conditions defined as optimal in the literature. Extraction under subcritical conditions was defined based on results obtained in a previous study. The objective of these extractions was to produce model extracts for the study of the fractionation of the molecules they contained. Extraction on bagasse led to the production of an extract containing a mixture of sugar oligomers of different sizes, with phenolic oligomers and a mixture of acidic (vanilla, coumaric, ferulic) and neutral (vanillin) phenolic monomers. Extraction under subcritical conditions on wood residues led to a mixture containing mainly phenolic compounds and tannins.

The ultrafiltration tests were carried out with organic hollow fiber polyether sulfone membranes with a molecular weight cut-off (MWCO) between 1 kDa and 100 kDa, under different pressure and tangential velocity conditions. The results show that the permeate flow is similar for both extracts although the wood extract contains only a few hemicelluloses. Filtration is limited by the appearance of a polarization layer whose influence depends on the membrane MWCO. Filtration does not allow separation between sugar oligomers and phenolic oligomers, regardless of the cut-off threshold used, but allows the production of an oligomer-concentrated extract while the phenolic monomers are found in the permeate. Chromatography tests were performed on cationic resins by injecting 20% dry weight concentrated extract and then eluting with water. The results show that it is possible to separate acidic (coumaric acid) and neutral (vanillin) phenolic monomers.

However, it is not possible to separate the oligomers obtained in the ultrafiltration retentate. The separation between phenolic and sugar oligomers was carried out on adsorption resins by elution chromatography. Phenolic oligomers are preferentially fixed by the resin and then recovered by eluting a hydroalcoholic mixture.

Keywords: membrane filtration and chromatography

**MODELISATION ET SIMULATION DE LA PRODUCTION DE L'ENERGIE
PAR DEGRADATION BACTERIENNE DE LA MATIERE ORGANIQUE :
APPLICATION AU DESSALEMENT DE L'EAU**

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L'eau est l'un des plus grands défis auxquels l'humanité est confrontée, en raison de la poursuite de la croissance démographique, du développement économique, de la sécheresse fréquente et d'autres ce qui a augmenté considérablement la demande en eau douce et a provoqué un épuisement des ressources en eau inquiétant. Pour faire face à cette crise mondiale en eau potable, le recours au dessalement des eaux des mers et saumâtres en utilisant les énergies renouvelables constitue une solution prometteuse. Parmi les systèmes innovants, on trouve la Cellule de Dessalement Microbien (CDM) qui a montré une bonne aptitude à traiter les eaux usées et générer en même temps de l'énergie en utilisant un concept d'électrodialyse incorporé dans la CDM.

Une modélisation et une simulation numérique de la dégradation de la matière organique dans la Cellule de Dessalement Microbien a été faite en utilisant le logiciel MATLAB. Cette simulation nous a permis de montrer une production considérable d'énergie pour le dessalement ce qui diminue le cout de production de l'eau potable en comparaison avec les procédés classiques.

Mots-clés: Eau de mer, Dessalement, CDM, Production d'énergie, Dégradation, Matière organique.

COMBINATION OF NANOFILTRATION AND ELECTROCHEMICAL WATER DISINFECTION PROCESS SUPPLIED WITH RENEWABLE ENERGIES FOR DRINKING WATER PRODUCTION: FEASIBILITY STUDY AND OPTIMIZATION

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In 2014, the first nitrate removal plant, using Nanofiltration (NF) coupled to an electrochemical disinfection system, supplied with renewable energies (Photovoltaic and windenergies) was realized at Al Annouar high school of Sidi Taïbi (Kenitra, Morocco).

This project was designed to supply the 1200 students of the school with potable water, based on the production capacity of 500 L/h (3L/Day/student). The local underground water, which is slightly brackish and nitrated, wastreated by Nanofiltration, using a hybrid renewable energy system, photovoltaic and wind; just before the distribution, an electrochemical disinfection setup was used to disinfect the nanofiltrated water.

In the first part of this work, the feasibility of the processes combination (Nanofiltration- electrochemical water disinfectionstep) is verified by assessing the main factors which have determined the electrolysis performance (Volumetric flow rate, temperature, chloride concentration, energy ...). This part of the study is carried out during 2 years of operation (from April 2014 to February 2016).

The second part focused mainly on the optimization of a new membrane treatment plant. The purpose of this installation is two fold; firstly, the objective was to correct the concentration of chloride ions at the inlet of electrolysis. Secondly, it was meant to avoid the quality deterioration of the produced water (nitrates in particular). The results of this study will be presented and discussed.

Keywords: Electrochemical disinfection, Nanofiltration, demineralization plant.

Experimental study on sustainable desalination by membrane process: Renewable energy powered reverse osmosis in Algeria

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Water desalination by reverse osmosis (RO) is the most technology to meet water scarcity in Algeria. Drinking water is produced from seawater for coastal area and brackish water in the arid regions where it the only available supplies. In Algeria, all desalination plants which produced water needs are powered by electricity derived from fossil fuels. In fact, the burning of fossil fuels particularly results in faster depletion and also causes a harmful impact on the environment by affecting the carbon cycle.

The present work deals with the reverse osmosis (RO) desalination coupled with renewable energy system has emerged as a cleaner alternative while eliminating green house gas missions. This photovoltaic (PV) developing technology is most appropriate to supply small desalination plants in remote and arid regions due to the high-solar irradiation and in the areas where no public grid electricity is available with limited water resources.

Renewable energy powered desalination allows to produce water at costs relatively competitive with that of conventional electricity grid powered desalination plants. The small-scale RO-PV system used for water treatment can be most cost competitive with other technologies where the costs of PV have declined strongly in recent years.

We present a small desalination RO unit coupling with a stand-alone solar PV system with energy storage. In fact, the high-pressure pump system requires direct energyelectric to operate a small-scale RO. The feasibility study is carried out for different pressures using salt concentration of the feed water that contains a mass salinity between 1 and 35 g/L. The influence of the main parameters such as operating pressure, salinity and feed flow rate on the performance of a reverse osmosis system are investigated.

The ability of PV system for developing a small size desalination plant under local conditions of Bou-Ismaïl site is studied. The economic feasibility of a PV-powered RO plant is evaluated. We found that the total cost of water treatment from brackish water PV-RO is considerably less than sea water desalination.

Keywords: Desalination, Membrane, Reverse Osmosis, Solar Energy, Seawater.

NEW APPROACH FOR THE PREPARATION OF MICROPOROUS CERAMIC MEMBRANE BASED ON CARBON MATERIAL

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Production of industrial membranes relies on the use of a limited choice of raw materials and generally involves a high temperatures intering step for ensuring strong bonding between membrane and support. While development of polymeric membrane is progressing in a steady pace, ceramic membranes have also gained a growing interest. Crucial requirements for using ceramic membranes are high permeability, long life time and selectivity and a very wide range of pore sizes from microfiltration to nanofiltration and even down to the sub-nanometer range depending on the materials of choice and synthesis conditions.

Today, the trend is towards the use of low-cost materials and if possible, to the recycling of by- products arising from industrial activities with the aim to reduce cost and to develop green processes. The use of low-cost materials of natural origin such as natural clays, mineral coal, sand and phosphate sub-products, have been proven to be very promising for the fabrication of low-cost ceramic membranes for wastewater treatment and desalination.

This work focuses on the development of microporous carbon membranes based on mineralcoal and phosphate sub-productsusing a new approach consisting of layer-by-layer method. The layer-by-layer method is the most suitable approach to correct defects and controlled porosity in order to obtain an appropriate selectivity for the desired separation, especially in the treatment and recycling of textiles effluents.

The carbon/carbon UF membrane show the better performances with an average pore size of about 4.8 nm and thickness 20.5 pm compared with the UF-based mud/carbon membrane which has an average pore size of 11nm and a thickness equal to 17.8 pm.

The application of these membranes to the treatment of industrial textile wastewater has shownpromisingresults in terms of permeate flux and pollutantretention (COD (72%), salinity (45%)). It was found that the treated wastewater could be recycled into the textile industry or can be discharged into the municipal sewerage in compliance with Tunisian legislations.

Keywords: Low-cost materials, Microporous membrane, Layer-by-layer method, Textile wastewater.

ELABORATION AND CHARACTERIZATION OF A LOW-COST CERAMIC MEMBRANE MADE OF NATURAL MOROCCAN CLAY AND STUDY OF THE PERMEABILITY OF THIS MEMBRANE

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This work describes the elaboration of tubular ceramic membrane based on natural Moroccan clay.

Before its use, the material was dried, crushed and sieved using a sieve of 63 μm . The clay is characterized by various experimental techniques such as X-ray fluorescence, X-ray diffraction, Infrared spectroscopy, thermogravimetric and thermogravimetric analysis (ATD and ATG) and BET.

The support was elaborated by wet route as follows: the powder was homogeneously mixed with organic additive, clay and water, the obtained paste was then extruded to elaborate a porous tubular structure.

The pieces were dried at room temperature during 5 days and then sintered in furnace using a well-defined temperature program. The fired supports present an excellent mechanical strength and a good chemical resistance in basic and in acid solution.

The water permeability of the sintered support at 1000 °C/2 h was 775, 30 L/h m² bar. The microfiltration layer was also prepared from TiO₂, water and a polyvinylalcohol solution. The water permeability of the sintered microfiltration membrane at 900°C/2 h was 410, 51 L/h m² bar.

Keywords: clays, thin layers, elaboration, sintering, membrane, permeability.

INVESTIGATION DES PROPRIETES STRUCTURALES ET MECANQUES DE SUPPORTS MEMBRANAIRES : EFFET SYNERGETIQUES DES CONDITIONS D'ELABORATION

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Dans ces dernières années, les travaux de recherche sur les matériaux membranaires ont connu un essor considérable, lié à la diversité et l'élargissement des domaines d'applications de cette classe de matériaux (traitement des eaux, agroalimentaire....

Effet, la demande du monde industriel s'est portée sur les membranes inorganiques et/ou hybrides, dépassant nettement les membranes organiques, car ils présentent des propriétés thermiques, thermomécaniques et chimiques intéressantes qui permettent leurs utilisations dans des applications mettant en jeu des milieux réactionnels spécifiques en termes de pH, toxicité et composition chimique.

Dans ce contexte s'inscrit notre contribution qui porte, essentiellement, sur l'élaboration de nouveaux supports membranaires, utilisant une argile naturelle Algérienne, en vue de leurs applications dans le traitement des eaux usées. Pour ce faire, plusieurs formulations ont été employées, faisant varier le taux des agents plastifiants et de porosité dans le mélange (2%, 4%, 6% et 8% en pds) ainsi que la température de frittage (800-950 °C). La structure et la morphologie des différents supports élaborés ont été examinées par diffraction des rayons X (DRX) et microscopie électronique à balayage (MEB).

De manière intéressante, le traitement thermique des supports conduit à la formation de différents oxydes mixtes dont la composition et le pourcentage dépendent de la température de frittage employée. A titre d'exemple, le diffractogramme du support membranaire traité à 800°C révèle la présence des oxydes mixtes suivants: SiO₂, Mg₂SiO₄, FeO et Ti₃O₅. Par ailleurs, un traitement à 850°C conduit à la formation du SiO₂, MgO, MgSiO₃, FeO et TiO_{1,04}. Sachant que les propriétés physiques du matériau dépendent de sa structure, les propriétés thermiques et mécaniques des différents supports préparés ont été examinées en fonction de la température de frittage ainsi que du taux des additifs dans le mélange et la synergie entre la structure du support et ses propriétés thermomécaniques a été élucidée. Des résultats encourageants portant sur le traitement d'une eau contaminée par des colorants issus de l'industrie textile à savoir: le vert de malachite et le méthyle violet ont été obtenus.

Mots clés : argile, membranes, morphologie, propriétés mécanique, synergie, colorants

CONSTRUCTED WETLAND CAPACITY TO TREAT DIFFERENT WASTEWATER

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In Tunisia, the discharge of wastewaters represents a serious problem particularly when it is done in the environment without depuration. For this reason, it was been necessary to adopt techniques which are simple in use and maintenance and economic in energy such as wetlands. The first treatment plant functioning as a wetland has been set up in 2004 and is in experiment now. It treats rural wastewaters of a small village of 800 inhabitants for Jougar Village in Zaghuan. The aim of this paper was to investigate the performance of this constructed wetland treating domestic rural wastewaters and the capacity of the system to treat different wastewater.

The plant is composed of a primary treatment pond followed by two planted basins with systems of vertical surface-flow (130 m²) then horizontal subsurface-flow (230). First basins contribute to pollution charge reduction in order to prevent clogging of forward filters. Second and third basin was planted by: *Phragmites australis* (reeds) and *Typha latifolia* (cattails). The plants were rooted in an artificial medium composed by different size layers of gravel. Treated waters are finally discharged into a little brook.

Results (Table 1) show high ratios of pollution removal (organic matter, nitrogen and phosphorus) (more than 95% except for N: 85%). This shows the importance of physical (settlement) and biological (degradation) phenomena occurring in the wetland. The efficiency of the phytodepuration appears also in effluent high quality, except for TKN and TP rates. A lot of experiments are in progress in CITET to study the capacity of constructed wetland to treat wastewater for agro food industries or leachate or phyto-remediation.



Fig 1 : Treatment plant for Jougar village

Table 1. Wetland treatment performance and treated water quality.

Parameters	Reduction of pollutants (%)	Treated water quality (mg L ⁻¹)	Tunisian standards (mg L ⁻¹)
BOD5	99	2.5	40
COD	> 97	< 30	160
SS	95	26	40
TKN	85	27	5
TP	96	0.61	2
pH		7.42	6.5 < pH < 9
T (°C)		20	<25

Keywords: Constructed Wetland, wastewater, macrophysics, high performance

MINERALIZATION OF NANOFILTRATION CONCENTRATE OF LANDFILL LEACHATE BY ELECTROCHEMICAL ADVANCED OXIDATION PROCESSES

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The objective of this study was to implement electrochemical advanced oxidation processes (EAOPs) in order to mineralize nanofiltration (NF) concentrate from land fill each at initially pre-treated in a membrane bioreactor (MBR). An undivided electrocatalytic cell using either a conventional carbonfelt (CF, for homogeneous EF) or a Fe^{II}/Fe^{III}-LDH/CF (for heterogeneous EF) cathode and either a Pt or a sub-stoichiometric titanium oxide (TiO₇) anode was employed to carry out the treatment of a real effluent. A particular attention was given to the understanding of mineralization mechanisms by using various analytical tools. Excellent mineralization of NF concentrate was achieved by heterogeneous EF with Pt anode after 8h of electrolysis, while homogeneous EF with external addition of catalyst (Fe²⁺) and adjustment of pH at 3 achieved lower mineralization rate. Comparative studies at low current density using Ti₄O₇ anode led to higher mineralization rate with limited energy consumption compared to Pt anode.

Respirometric analyses under similar conditions than in the real MBR emphasized the possibility to recirculate the NF retentate towards the MBR after partial mineralization by EAOPs in order to remove the residual biodegradable DOC and improve the global cost effectiveness of the process. Further analyses were also performed in order to better understand the fate of organic and inorganic species during the treatment, including acute toxicity tests (Microtox[®]), characterization of dissolved organic matter by three dimensional fluorescence spectroscopy, evolution of inorganic ions (ClO₃⁻, NH₄⁺ and NO₃⁻) and identification/quantification of degradation by-products.

Keywords: Electro-Fenton; NF concentrate; Mineralization; Biodegradability.

**COUPLING ELECTRODIALYSIS AND NANOFILTRATION FOR THE
TREATMENT OF SURFACE WATER CONTAMINATED WITH
PESTICIDES AND SALINITY INTRUSION:
EXPERIMENTAL MODELLING AND PROCESS OPTIMISATION**

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Mekong Delta (MkD) (Vietnam) represents an abundant surface water resource on which important population activities (mainly agriculture) are depending on. However, since these last decades, the quality of the MkD has been strongly worsened due to salinity intrusion (climate change) and high pesticide concentration (development of intensive agriculture). The simultaneous presence of pesticides and high salinity makes this water complex and requires advanced water treatment processes in order to reach the Vietnamese Guideline.

The aim of this work was to investigate a hybrid process coupling electro dialysis (ED) and nanofiltration (NF) to treat surface water in the coastal areas of the MkD. Integration of NF and ED processes was studied by using the experimental design methodology to optimize the water treatment in terms of salt and pesticide removal efficiency taking into account energy consumption. A Box Behnken design has been selected as response surface design for this application in order to describe and optimize the hybrid process in terms of efficiency and energy consumption. Operating parameters such applied voltage (V), diluate volume (L) and treatment duration (min) for the ED stage and applied pressure (bar), feed concentration (mg/L) and treatment duration (min) for the NF stage were investigated.

Keywords: Nanofiltration; Electrodialysis; pesticide; salinity; experimental design methodology

APPLICATION DU PROCÉDE D'ELECTROCOAGULATION EN MODE BATCH DANS LE TRAITEMENT DES COLORANTS DE TEXTILES

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La production mondiale des eaux usées contenant des colorants reste un problème écologique important en raison de la stabilité des composés, de leur faible biodégradabilité et de leur caractère cancérigène [1]. L'industrie textile consomme de grandes quantités d'eau, et génère des quantités considérables d'eaux usées colorées. Cette industrie est impliquée dans plus de 20% de la pollution totale de l'eau [2], d'où la nécessité de rechercher des stratégies efficaces et peu coûteuses pour traiter ce type d'effluent industriel.

Parmi les méthodes de traitement, le procédé d'électrocoagulation représente un moyen simple, fiable, et rentable pour le traitement des eaux usées sans addition de produits chimiques supplémentaires, et donc sans la production de pollution secondaire. Par conséquent, Il réduit également la quantité de boues à éliminer. Il utilise une source de courant, une anode sacrificielle et une cathode. Le coagulant est produit par dissolution de l'anode dans les eaux usées à traiter [3].

Dans ce travail, l'élimination d'un colorant de textile a été étudiée par le procédé d'électrocoagulation. Différente combinaison d'électrodes (Fe-Fe, Acier-Acier, ...) a été utilisée. Les paramètres étudiés sont la concentration initiale du colorant, les concentrations des sels de fond, le pH initial, le courant appliqué et la quantité de boue formée. Les performances du traitement sont testées en termes d'élimination de la couleur, d'élimination de la DCO et de la consommation d'énergie électrique.

Mots clés : Electrocoagulation, Décoloration, Colorants, Effluents textiles, Boue.

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OPTIMIZATION OF CHEMICALS IN THE DE-OILING STATION

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The oily water treatment plant reduces or eliminates contaminants in the effluent before it is released into the environment. The main objective of this work is to optimize the chemical treatment of waste water by the coagulation- flocculation process.

Experiments were performed at different concentrations of the chemicals, sodium silicate Na_2SiO_3 and sulfuric acid H_2SO_4 in dilution water such as service water and fresh water, to prepare the activated silica to be injected into the de-oiling station.

Several pollution indicators were measured such as suspended solids, turbidity, hydrocarbons, pH before and after injection of the coagulants-flocculants, in order to obtain an optimal dosage to treat the petroleum effluent and meet the standards of rejection in the environment.

The use of a chemical compound (5% Na_2SiO_3 + 1.2% H_2SO_4) diluted in the service water at a rate of 20 ml/l reduces the suspended matter from 130 mg/l to 22 mg/l, the turbidity from 135 NTU to 24 NTU, as well as the hydrocarbon content of 56 mg/l to 3.5 mg/l.

A mixture of 4% Na_2SiO_3 and 1% H_2SO_4 diluted in fresh water corresponding to 24 ml/l decreases the suspended solids from 153 to 5 mg/l, the turbidity from 114 NTU to 1 NTU and the hydrocarbon content of 14 mg/l to 3.5 mg/l.

Dilution of chemicals with fresh water for the preparation of activated silica gives a better quality of treated water at the outlet of the de-oiling station. The quantity of activated silica is lower than that used with the service water.

Keywords: coagulation, flocculation, activated silica, de-oiling, wastewater

**PRODUCTIONS OF OLEUROPEIN CONCENTRATE EXTRACT
FROM *OLEA EUROPAEA* LEAF
BY USING MEMBRANE SEPARATION TECHNOLOGY**

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Membrane separation technology, for bioactive compounds separation, gained great attention lately. Our main goal in this work was to produce an oleuropein concentrate. The water extract of olive leaves has been subjected to a screening on the basis of molecular size. Two types of synthetic membranes UF (zeolite, the mud of phosphate), characterised by different molecular weightcut-off (MWCO) (400, 500 Da) and commercial NF membrane (300Da) were tested. Concentrates and Permeate fluxes of ultrafiltration and nanofiltration were investigated and analyzed.

Experimental results indicated that a large portion of phenolic compounds were recovered in the permeates fractions of the UF process. The nanofiltration retentate showed high polyphenol and flavonoid contents. Based on the content of solute in feed and retentate fractions of NF membrane, oleuropein was concentrated approximately 4 times to reach 6, 8 g/100 g extract. In addition, this fraction demonstrated high antioxidant capacities monitored by DPPH and ABTS radical scavenging capacity assay.

Keywords: Olive leaf, polyphenolrecovery, oleuropein, ultrafiltration, nanofiltration

HYDROPHILIC IMPROVEMENT OF ACTIVATED CARBON FOR ELECTROSORPTION BY CAPACITIVE DE-IONIZATION PROCESS : A COMPARATIVE STUDY OF AC AND AC/GO COMPOSITE

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Capacitive deionization (CDI), a water desalination technology based on the electrosorption of salt ions in porous electrodes; it is considered a simple, non-energy intensive method to produce clean water from salted and brackish water of which the performance is mainly governed by the electrode materials. In the present study, a composite of carbon electrode was fabricated by a simple blending method in order to enhance the hydrophilic property and ions diffusion pathways of the electrode leading to an enhanced desalination performance. The electrochemical properties of the prepared electrodes were characterized by cyclic voltammetry. The structural and physical properties were also studied by Scanning electron microscopy (SEM), X-ray diffractometry (XRD), Raman spectroscopy and water contact angle.

Depending on the operating conditions, the salt removal capacity of the composite at operating window of 1V is as high as 5.70 mg/g at 400 mg/L of salt initial concentration and a capacitance of 111 F/g at 2 mv/s in comparison to AC which has 3.74 mg/g and 85 F/g at the same condition. It has been found that the AC with 15% GO shows an excellent electrosorption capacity. This paves a new way to produce a highly hydrophilic carbon based electrode material for capacitive deionization (CDI).

Keywords : electrosorption, carbon materials, hydrophilicity, desalination performance.

REMOVE OF PLYPHENOLS FROM OLIVE MIL WASTEWATERS BY MEMBRANE

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The olive industry, which mainly produces olive oil, generates during the crushing of olives particular liquid discharges called waste waters. These waste waters are very polluting because of their high organic loads which are weakly biodegradable and highly toxic (polyphenols). The aim of this work is to study the waste water depollution with a low cost membrane based on Rhassoul hydro talcite (GHTM).

We have developed the Rhassoul clay support, by forming the synthesized layer based on hydrotalcite of magnesium and aluminum HT-MgAlCO₃ with a molar ratio equal to 3 (Mg/Al=3). This latter was characterized by DRX, IR, BET, SEM The physic chemical analyzes results have shown that the olive mill wastewaters (raw) studied, coming from the Fez-Meknes region (Morocco), is heavily loaded with organic pollutants, especially suspended matter (200g/L), COD (81.88g (O₂)/l), BOD₅ (29g (O₂)/l) and in the major factor is due to the high content of polyphenols (24g / L).

After dilution, there is a decrease in concentrations of almost all physic chemical parameters. The diluted waste water has a concentration of polyphenols of the order of 0.300g/L. Microfiltration tests using GHTM leads to a polyphenol permeate of the order of 0.116 g/L after 2 hours of filtration at 1 bar and at ambient temperature. In light of these results, it can be concluded that the membrane (GHTM) is able to reduce polyphenols with a percentage of 61 and reduction of COD and BDO₅.

Keywords: olive mill, waste waters, polyphenols, membrane, hydrotalcite, Ghassoul

SILVER/GOLD BIMETALLIC NANOPARTICLES DECORATED CLAY-BASED NANOCOMPOSITES FOR ENHANCED NITRO AROMATICS CATALYTIC REDUCTION

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In this study, we report a new type of effective hybrid heterogeneous nanocatalysts based on bimetallic (silver/gold) nanoparticles immobilized on poly(glycidylmethacrylate)-grafted clay layers. The preparation involves covalent surface-modification of montmorillonite (MMT) clay layers by 3-(trimethoxysilyl)propyl methacrylate followed by grafting photo-polymerization of glycidyl methacrylate (GMA), and subsequent hydrolysis and oxidation of the pendant epoxide groups of the PGMA chains into carboxylic acid chelating functions. To generate Ag/Au bimetallic nanoparticles on the MMT-PGMA nanocomposite, chelated Ag(I) cations were first reduced via sodium borohydride into Ag NPs and then gold(III) chloride trihydrate gold added to the MMT-PGMA-AgNPs suspension and subsequently reduced to Au⁰ using sodium borohydride.

The surface modification of the of clay layers was confirmed by FT-IR, XPS, TGA, and XRD analyses. The presence of ultrafine spherical Ag/Au bimetallic nanoparticles homogeneously dispersed on the surface of the clay-based nanocomposite was revealed by SEM and TEM.

The resulting bimetallic silver/gold nanoparticles decorated MMT-g-PGMA showed high catalytic activity toward the reduction reaction of both p-nitrophenol and pendimethalin nitro pesticide in the presence of an excess of sodium borohydride. Also, the nanocomposite catalyst could be readily recycled by a simple filtration and reused for five successive cycles without significant loss of activity. It was shown that Ag/Au bimetallic nanoparticles provided higher catalytic activity than Ag monometallic nanocatalyst suggesting a synergistic effect between silver and gold atoms.

The work in progress aims at developing a hybrid system combining adsorption/heterogeneous catalysis via MMT-PGMA-Ag/Au NPs with filtration process using ceramic membranes for waste water treatment in continuous flow conditions.

Keywords: Metal-organic-clay composites, chemical grafting, silver/gold nanoparticles, nitro-aromatics degradation, membrane reactor.

PERFORMANCES OF A NEW TUBULAR ULTRAFILTRATION MEMBRANE OF POLYPYRROLE. APPLICATION IN SALTS REMOVAL

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The present study consists in the development of composite membrane by deposition of polypyrrole polymer layer on a tubular microfiltration support based on carbone-ZrO₂. In order to evaluate its performance, this membrane was applied to eliminate sulfate and chloride from salt solutions. The selection of polypyrrole polymer is due to several characteristics such as high conductivity and fast oxidation reaction. In addition, the polypyrrole is insoluble in solvents, chemically resistant and easy to synthesize.

The polypyrrole membrane was successfully developed using the interfacial polymerization process. A thin layer of polypyrrole was synthesized on the support surface by the chemical polymerization of the pyrrole. The polypyrrole was prepared by mixing pyrrole solution (of 0.05M) with ultrapure water, followed by the addition of FeCE (0.1M) as oxidizing agent. This preparation was kept unagitated for 24 hours to achieve decantation of polypyrrole powder.

The morphology and hydrophobicity of polypyrrole layer have been investigated using the scanning electron microscopy and contact angle methods, respectively. These analyses show that the elaborated membrane has a typical ally cauliflower-like shape. The layer thickness could be estimated to be around 3.7 μm, and it has a high hydrophobicity surface (138°).

The sulfate, nitrate, fluoride and chloride ions dissolved in water were removed by the polypyrrole membrane. They were investigated under the influence of pressure (3-6 bar), pH of solution (3.5-10.5) and initial salt concentration (20-100 ppm). This study proved that the percentage of salts retention increases with the increase in operating pressure. At higher pH and lower concentration, the polypyrrole membrane can remove up to 92 and 58% of sulfate from Na₂SO₄ and MgSO₄ solutions respectively, 49% of nitrate from NaNO₃ solution, 42% of fluoride from NaF solution and 35% of chloride from NaCl solution.

Keywords: polypyrrole; membrane; ultrafiltration; salt; wastewater.

NANOCOMPOSITE MEMBRANES PVDF-Pb DOPED ZNO: SYNTHESIS, CHARACTERIZATION AND APPLICATION FOR TEXTILE EFFLUENT

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In recent years, nanotechnology has been successfully integrated in different processes of waste water treatment. Nanocomposite membranes are a promising modified version of traditional polymeric membranes for water treatment, with main characteristics of enhanced permeation and improved rejection.

In this study, a novel polyvinylidene fluoride (PVDF) ultrafiltration membrane was successfully fabricated via phase inversion method for the filtration of the textile dye Reactive black 5 (RB5). The membrane matrix was supplemented with ZnO doped Pb nanoparticles.

Filtration-sorption experiments, contact angle (CA) measurements, scanning electron microscope (SEM) /energy dispersive x-ray spectrometer analysis (EDX), permeability and porosity tests were conducted to characterize the membranes. The experimental results indicate that the implantation of nanoparticles on the membrane matrix improves that the resulting morphology shows higher permeability, porosity and water flux performances. Color removal from synthetic textile effluent reaches more than 90%.

Keywords: Nanocomposite membrane, Sorption-filtration, Textile dye, Color removal

PRÉPARATION AND CHARACTERIZATION OF Y-FAUJASITEZEOLITE MEMBRANE DEPOSITED ON CLAY SUPPORT FOR THE TREATMENT OF HEAVY METALS

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The use of ceramic membranes is becoming increasingly important in many areas of modern technology, particularly in membrane separation techniques.

This study describes the development and characterization of membrane supports based on local clay from the Meknes region. The clay undergoes crushing, grinding and sieving in order to control its particle size using screens standardized according to AFNOR, techniques of XRD, FTIR, BET, DTA, TGA were used for the characterization of the powder obtained.

The supports of 40 mm in diameter and 2 mm thick were prepared from the sieved powder. The raw supports thus obtained are sintered at 1000°C., then characterized by SEM scanning electron microscopy and tested by flow measurement on the front filtration pilot.

A deposit of the membrane of zeolite Y-Faujasite was made by the hydrothermal method on the supports developed. The application of the membrane developed in the filtration of synthetic solutions containing heavy metals has shown an abatement rate of about 92% for Cd²⁺ and 99% for Pb²⁺ and Co²⁺.

Keywords: Y-Faujasitezeolite, clay, membrane, heavy metals, filtration.

REMOVAL OF LANTHANUM (III) FROM AQUEOUS SOLUTIONS BY POLY(SODIUM 4-STYRENE SULFONATE)

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The increased use of rare earth elements in variety commercial applications has led to the release of these elements into the environment. These rare earth elements have adverse effects on aquatic and terrestrial organisms as well as on humans.

Polyelectrolyte assisted ultrafiltration (PAUF) has been shown to be promising for removal of lanthanum. The principle of this process is based on the coupling of a complexation of lanthanide ions by a polyelectrolyte and a membrane.

In this work, particular attention has been given to the retention of Ln (III) in the presence of sodium poly (4-styrenesulfonate) (PSS) using a regenerated cellulose membrane with molecular weight cut-off of 10 kDa.

Several parameters have been optimized, such as transmembrane pressure, PSS concentration and pH solution to improve La (III) ions retention and permeation flux.

Experimental results indicate that the retention of lanthanum ions increases respectively with applied pressure and polyelectrolyte concentration. A better retention was observed at 10^{-4} mol.L⁻¹ PSS concentration and 2.5 bar transmembrane pressure. The study of pH effect on lanthanum ions revealed a maximum retention around 90% at pH 6.

Keywords : Lanthanum(III), poly (4-styrenesulfonate de sodium) (PSS), Removal, Polyelectrolyte assisted ultrafiltration.

RÉTENTION OF HEAVY METALS BY NAAZEOLITE MEMBRANE DEPOSITED ON CLAY SUPPORT

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Several industries namely chemistry, petrochemistry, tanneries... produce various effluents, the treatment of which requires the development of specific processes. Membrane processes are involved in many areas, such as waste water treatment and liquid effluents, because of their good thermal stability, high mechanical and chemical resistance, and efficiency over traditional processes.

In this study, we have developed flat microfiltration supports based on local clay from the Meknes region, XRD, FTIR, BET, DTA, TGA techniques have been used for the characterization of clay. The membrane supports were prepared by uniaxial pressing after that sintered at 1000 °C, and then these supports were characterized by SEM scanning electron microscopy and the water permeability test.

A membrane layer of ultrafiltration zeolite Na-A (LTA) was deposited on the support developed by the hydrothermal method.

Filtration tests of solutions containing heavy metals including Pb^{2+} , Co^{2+} , Cd^{2+} , Zn^{2+} and Cr^{6+} were carried out by the zeolite membrane on the pilot adapted for frontal filtration leads to very promising abatement rates.

Keywords: Na-A zeolite, clay, membrane, heavy metals, filtration.

ELIMINATION OF CARBOXYLIC ACIDS IN INSULATING OILS FOR TRANSFORMERS BY MEMBRANE TECHNIQUE

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Transformers play a very important role in the transmission and distribution of electrical energy. They rank among the most expensive equipment. So it's fundamental that they work correctly for many years yet the main feature of its reliability is the quality of its insulation system which is mainly made up of dielectric liquid (insulating oil). However, insulating oil is submitted to different constraints and stresses during its exploitation. As a result we witness the formation of aging products which causes the electrical properties to be less important and the cooling efficiency to decline. Among the most critical oxidation products are carboxylic acids which have an important impact on cellulosic material aging and metal parts corrosion in transformers. Treatment or replacement of this acidulated oil is necessary for the retention of the equipment in service.

In this study, our study aims at showing that the process of physical treatment coupled with membrane filtration could be very advantageous for both the technical aspect as well as for the environmental one. It also allows the quality of the product to be maintained in terms of efficiency and pollution of insulating oil charged with carboxylic acids. We study retention of acids by microfiltration which presents the particularity of being species of negative charges.

The efficiency of membrane separation has been characterized and physical and chemical oil properties have been evaluated. The methods of separation and analyses by adsorption specter ultraviolet-visible, and Fourier transform infrared spectroscopy (FTIR) have been evaluated and identified for illustrating the elimination mechanism of functional grouping of aging and purifying insulating oil.

The results show that membrane process RC confirms the retention of one rate of 83% of carboxylic acids cumulated in dielectric oil.

Keywords: carboxylic acids, insulating oil, purified, RC membrane, FT-IR.

STUDY OF THE PRODUCTIVITY OF DIFFERENT SOLAR MEMBRANE DISTILLATION SYSTEMS

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Today, humanity faces great challenges on energy, economy and environment. So, there is a strong need to better design, analyze and evaluate energetically processes, systems and applications. Well-established energy research in desalination has helped in the decrease of water treatment costs. On the other hand, the lack of fresh water is considered as a serious problem that is constantly increasing, due to the population growth and changes in weather conditions.

Desalination using solar energy coupled with membrane technology is considered an attractive alternative to the production of drinking water. Membrane distillation (MD) is a new technology that combines distillation and membrane separation. MD is characterized by a lower operating temperature than the typical distillation and lower operating hydrostatic pressures than the pressure-driving process. Furthermore, the operating temperature of the MD process is in the range of 60-80°C, at which the thermal solar collectors perform well.

In this work, we are interested in VMD technology, which is an evaporative process using a hydrophobic porous membrane, whose function is to separate a liquid phase from a gas one.

We compare the performance of a desalination system coupling the membrane module with three different solar technologies: the flat solar collector, the cylindro-parabolic collector and the solar pond. A model describing the operation with the three solar technologies has been proposed. The model was established on the basis of material and transient heat balances. From this model, we have developed a simulation program that evaluates and compares the performance of different configurations. This study also quantified the production of the system with and without retentate recycling.

The following figure shows the operating principle of the studied system.

The models developed are able to determine the temperature evolution and the distillate flow during the time and for any day of the year during the day. The comparison of the performances of the different configurations studied showed that the CPC is the most efficient solar collector. Indeed, with 70 m² of catchment area we estimate an annual production of about 31.8 m³ per m² of membrane. In addition, the study showed that retentate recycling increases production by a remarkable amount. In fact, recycling makes it possible to recover the sensible heat of the retentate, thus making it possible to reach temperatures at the inlet of the relatively high module.

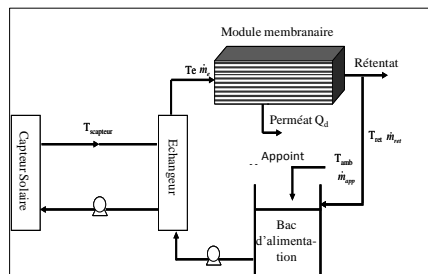


Figure 1: Principle of operation of the system studied.

STUDY OF PVDF HOLLOW FIBER MODULE USED FOR VACUUM MEMBRANE DISTILLATION COUPLED WITH SOLAR ENERGY

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Desalination using solar energy coupled with membrane technology is considered an attractive alternative for the production of drinking water especially in rural and arid areas. Tunisia offers great opportunities for the development of solar applications through the exploitation of solar energy. Several papers deal with membrane distillation of seawater and mainly focus on the choice of membranes and comparison of this technique with other desalination techniques, but there are very few studies that quantitatively estimate the potential of this technology coupled with solar energy.

A model describing the operation of a membrane module used in a desalination plant coupled with solar energy is established. The model is based on balance equations of mass and heat under transient conditions. From the model, we developed calculation programs on the software MATLAB and this in order to simulate and study the functioning of the unit. This program has allowed us as a first step to achieve steady-state simulations, which allows to evaluate the flow of distillate depending on operating parameters (temperature and feed flow, applied vacuum pressure and salinity). A parametric study showed that the vacuum pressure and salinity are two factors greatly affecting the productivity of the membrane and the increase of the feed rate will improve the production of the module.

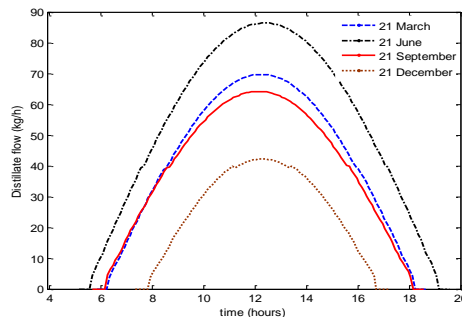


Figure 1: Variation of the distillate flow versus time for different year days.

Since solar energy is intermittent, we performed in a second stage of transient simulations. These simulations take into account the evolution of the solar flow and supply temperature over time. These simulations allowed us to study the performance of the membrane module according to the time. Simulations proved that pilot plant is able to provide average permeate flow ranging from 250 L/j to 21 December to 753 L/j to 21 June.

Keywords: membrane distillation, solar energy, modelling

REMOVAL OF LANTHANUM WITH POLYAMIDE NANOFILTRATION MEMBRANE

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In this study we tested the ability of polyamide nanofiltration membrane to extract the ion of lanthanum (III). A three-level factorial design and response surface methodology was used to evaluate the effects of parameters: pH (3-9), pressure (6-7 bars), concentration (10-100ppm).

The results showed that the retention is quantitative (100%) for 10 ppm at pH = 6 with pressure equal to 6 bars.

The study confirmed the high lanthanum extraction using polyamide nanofiltration membrane.

Keywords: Nanofiltration, Lanthanum, Extraction.

**AN EFFICIENT CLOUD POINT EXTRACTION
USING AN IONIC LIQUID AS EXTRACTANT:
SEPARATION OF THE BLUE BEMACID DYE FROM AQUEOUS SOLUTION
IN SALINE MEDIUM AND OPTIMIZATION
THROUGH FACTORIAL DESIGN METHODOLOGY**

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This study concerns to the cloud point extraction of Blue Bemacid dye from an aqueous solution sulfate medium using di-(2-ethylhexyl) phosphoric acid (D2EHPA) ionic liquid as extractant in the presence of anionic surfactant (Triton X-100). A two-level factorial design and response surface methodology was used to evaluate the effects of parameters affecting extraction efficiency: pH (4.0–8.0), mass% of Triton X-100 (2%–10%), Na₂SO₄ (8%–10%) and blue Bemacid dye concentration (10–100 ppm).

Mathematical model has been developed to predict the effect of each variable and their interactions in the response (dye removal). A comparison between the predicted values using the model equation and the experimental values showed correlation coefficients higher than $R^2 > 0.998$. The response of factorial design (dye removal) showed a high elimination of dye removal with a yield of elimination of 96%.

Keywords: Blue Bemacid dye; Cloud point extraction; Triton X-100; Ionic liquid; Sulfate medium.

ECO-EXTRACTION DE MATIERE VEGETALE PAR MICRO-ONDES ET CENTRIFUGATION

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Un pilote instrumenté à l'échelle semi-industrielle a été développé pour implanter des micro-ondes dans une machine tournante. Dans un contexte d'Eco-extraction et de valorisation de co-produits végétaux, il a ensuite été modifié et adapté pour l'extraction de molécules à haute valeur ajoutée à partir de matrices végétales. Ce pilote combine un chauffage micro-ondes et une centrifugation ; ces deux effets mécanique et thermique semblent avoir des effets favorables permettant d'intensifier l'extraction à partir de végétal pour des molécules d'intérêt sans ajout de solvant. Le couplage des effets mécanique et thermique offre de nombreux avantages : investissement réduit, productivité améliorée et utilisation optimisée de l'énergie.

L'objectif de ce travail a été, dans un premier temps, d'adapter et de modifier le pilote pour les différentes techniques d'extraction (ajout de vapeurs d'eau dans le système, convection forcée, montée en température élevée, étanchéité...). Dans un second temps, l'optimisation des conditions optimales de couplage chauffage micro-ondes/centrifugation grâce à un plan d'expérience a été étudiée pour maximiser les rendements en métabolites d'intérêts. Les données de consommation énergétique ont été collectées dans l'optique de comparer ce nouveau procédé à un procédé conventionnel déjà utilisé en industrie.

Enfin, un modèle numérique est également en cours de développement pour décrire les mécanismes physiques de l'extraction par combinaison de chauffage micro-ondes et compression mécanique due à la force centrifuge appliquée à une matrice végétale. Afin d'évaluer l'efficacité d'extraction de ce nouveau dispositif, des matrices végétales ont été choisies comme la salade et les écorces d'oranges contenant, respectivement, des polyphénols et des huiles essentielles potentiellement valorisables pour les industries concernées. L'extraction par le pilote instrumenté est comparée à une méthode de référence permettant de recueillir le maximum de composés phénoliques (extraction par solvant) analysés par chromatographie liquide, ou d'huiles essentielles (hydrodistillation) analysées en chromatographie en phase gazeuse.

Le pilote est efficace pour l'éco-extraction comme le montrent les premiers résultats obtenus sur l'extraction des polyphénols de la salade. L'influence de la vitesse de rotation est positive pour intensifier la collecte d'extrait et permet d'éviter les points chauds en homogénéisant le traitement thermique lié au champ électromagnétique. La matrice végétale, récoltée en fin d'extraction, est sèche et a subi une diminution de volume d'environ 80%. Par rapport à une extraction conventionnelle, le pilote permet d'extraire environ 50 % des polyphénols. Le pilote est encore en cours d'optimisation pour augmenter le rendement.

Les extraits sont valorisables par plusieurs secteurs industriels comme l'industrie pharmaceutique, la cosmétique, l'agroalimentaire et de la parfumerie. L'application de ce couplage mécanique / thermique au domaine de l'éco-extraction semble être une véritable innovation, et pourrait permettre l'intensification de l'extraction de produits à haute valeur ajoutée avec des rendements élevés.

Mots clés : pilote instrumenté, extraction, micro-ondes, centrifugation, combinaison, procédé innovant.

**A POLYDIMETHYLSILOXANE ROD EXTRACTION-BASED METHOD
FOR THE DETERMINATION OF PHARMACEUTICALS AND TRICLOSAN
BY LIQUID CHROMATOGRAPHY IN WATER SAMPLES**

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A new analytical method for the determination of naproxen, ketoprofen, diclofenac, carbamazepine, and triclosan in water samples by liquid chromatography is developed and validated. The method is based on the extraction of the analytes by a polydimethylsiloxane (PDMS) rod. The different parameters affecting extraction, such as the addition of salt, pH, initial volume, extraction and elution times and elution solvent, as well as the application of sonication, are studied. The results showed that the detection limits are all in the 0.47 to 1.02 $\mu\text{g.L}^{-1}$ range except for carbamazepine (3.4 $\mu\text{g.L}^{-1}$) with relative standard deviations in the range of 0.4–9.7%. The method developed, which was validated by analysing spiked surface water samples at trace levels, gave recoveries of between 84.8 and 111.2%. The application of the developed method to the analysis of real water samples has demonstrated its feasibility in the determination of the target analytes in river water.

THERMAL DECOMPOSITION OF CERIUM TRIETHANOLAMINE COMPLEXES.

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Cerium(IV) oxide (ceria), CeO₂ possesses good mechanical, chemical and thermal stability. Ceria has been extensively used as catalyst[1], electrolyte for solid-oxide fuel cells[2], oxygen sensors[3], UV-protecting coating[4], anticorrosion coating in metals abrasive chemical-mechanical polishing and as buffer layer for coated superconductor architectures.

Thermal decomposition of cerium triethanolamine complexes to cerium oxide, CeO₂, in inert and oxidative atmospheres has been investigated by thermogravimetry combined with infrared evolved gas analysis; the main volatiles formed during thermal decomposition have been identified. Intermediates and final products have been characterized by infrared spectroscopy, X-Ray diffraction and elemental analysis.

Several overlapping steps occurring along decomposition path have been identified and plausible reaction pathways are presented. It will be shown that decomposition starts around 200°C independently of the atmosphere, but the end set temperature depends on the gas composition: the more inert the atmosphere the higher the end set temperature.

Keywords: CeO₂, Thermal decomposition, TGA-EGA, triethanolamine metal complex.

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**Résumés des
Communications
par Poster**

STUDY OF ELIMINATION DRUGS FROM HOSPITALS WASTEWATER BY PHOTODEGRADATION AND COMPLEXATION WITH CD

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Hospital wastewater (WWs) represents a particular type of effluent, in compared with the urban waste water. Hospitals generate on average 750 L of waste water by bed and by day so they are 2-5 times higher than urban flow rates, which refer to one inhabitant equivalent (typically included in the interval 120-250 L). This significant quantity of water per day, for the different purposes and services depending on the activities which take place within the structure.

In our work, we proposed two methods; the first one is the complexation with CD for treatment of drugs from Hospital WWs, which makes solid precipitate that can be filtered later. Our second method; is the photodegradation of most drugs found in Hospital WWs with a known UV lamp and time for each type of drug elimination.

Keywords: drugs, Hospital effluents, Photodegradation, inclusion complex.

FRACTIONATION OF TUNA BY-PRODUCT BY ULTRAFILTRATION AND NANOFILTRATION PRODUCE AQUACULTURE FEED INGRÉDIENTS

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Given the importance of by-products, many efforts have been made. The fish protein hydrolysates (FPH) are of increasing interest due to their potential applications as a source of bioactive peptides fractions. In this case a waste product of tuna heads from the canning industry was hydrolysed. Using a commercial protease “Alcalase” and “flavourzyme” enzymatic hydrolysis was investigated in a 200 ml batch reactor according to an experimental design varying pH, T° and hydrolysis time (exoprotease). The influence of the process variables was studied with regards to obtain a rate of degree of hydrolysis DH% with a maximum content of free amino acids and small peptides while assuring a maximum solubility rates. A degree of hydrolysis up to 32.18% was obtained after optimization of hydrolysis conditions (temperature 45 °C, pH 8.5 and 180 min of hydrolysis reaction using flavourzymes).

Under The rate of parameter response obtained, we carried out a Statistical model for the degree of hydrolysis and a statistical model for the content of free aminoacids. In our case, after the hydrolysis treatment, a membrane separation such as ultrafiltration (UF) and nanofiltration (NF) can be used to increase the specificactivities of the FPH. The performance of the combined process associating ultrafiltration and nanofiltration membranes was evaluated for fractionation of produced hydrolysate in order to isolate fractions (0,3-3 KDa) enriched in interested peptides. The peptide fractions produced have a high nutritional quality which can be used for applications in aquaculture diets assuring a maximum of survival rate and weight gain.

Keywords : Fish proteinhydrolysis, Enzyme, fractionation, amino acids, aquaculture

DESALINATION USING MEMBRANE TECHNOLOGY: APPLICATION TO THE PRODUCTION OF DRINKING WATER

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Desalination of seawater and brackish ground water, for drinking water production, is often the way to deal with the water crisis. In addition to reverse osmosis (RO), several research works indicate that nanofiltration (NF) is also a promising technology to deal with salinity removal, e.g. brackish water treatment. Herein, a study on commercial NF and RO membranes was performed in terms of their productivity through experiments of hydraulic permeability, and their performance regarding salts rejection according to different operating conditions of synthetic solutions (pH, ionic strength, water matrix, etc.).

This work should lead to a better prediction of the possibilities of using nanofiltration process as means of brackish water desalination with the optimal operating conditions.

Keywords: Desalination, Drinking water, Reverse osmosis, Nanofiltration

EFFECT OF CONCENTRATION ON THE REMOVAL OF NITRATE FROM WATER BY NANOFILTRATION MEMBRANES

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The treatment of water contaminated by nitrates is the problem of the day in the entire world where a large population consumes water containing high concentration of this compound. The concentration of nitrates in drinking water must not exceed 50 ppm.

Nanofiltration is a technique in which hardness and nitrates can be simultaneously or partially eliminated, and the treatment is done in one step. In the present study, we started by the calculation of the hydraulic permeability of nanofiltration membranes NF270, NF20 and NF90.

Knowing the characteristics of each membrane, we have studied the retention of nitrates in different concentrations with the selected membranes. The results obtained confirm the effectiveness of the nanofiltration technique for the treatment of nitrates.

Keywords: Nitrate, Nanofiltration, Membrane.

Elaboration et Caractérisation des Membranes Zéolithiques Type Sodalite Octahydrate et Zéolite Y pour la Rétention des Métaux Lourds

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L'utilisation des zéolithes naturelles et synthétiques dans différents domaines tels que la purification des eaux industrielles, les détergents, le piégeage de l'humidité dans les doubles vitrages.

Ces dernières décennies, les zéolithes ont été utilisées dans les techniques membranaires, en particuliers dans la filtration des effluents liquides industriels pollués. Notre travail de recherche est orienté vers l'élaboration et la caractérisation des zéolithes type sodalite octahydrate et zéolithe Y en tant que membrane de microfiltration. En effet, la synthèse des zéolithes a été effectuée par la méthode hydrothermale en utilisant des précurseurs à base d'aluminate et de silicate du sodium. Les deux zéolithes synthétisées ont été caractérisées par différentes techniques telles que la DRX, l'IRTF, l'ATD, l'ATG, la BET avant d'effectuer un dépôt membranaire sur des supports en argile locale (région de Fès, Maroc).

Des solutions contenant des métaux lourds ont été filtrées en utilisant les deux membranes montées dans un pilote de microfiltration pour déterminer leurs rétentions.

Mots clés : caractérisation, membrane, zéolithe sodalite octahydrate, zéolithe Y

SYNTHESE ET CARACTERISATION DE MEMBRANES D'ULTRAFILTRATION A BASE D'ARGILE SUR SUPPORT DE ZEOLITE POUR L'ELIMINATION DES METAUX LOURDS DES EAUX USEES

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Le coût élevé des matériaux est l'un des principaux facteurs qui limitent l'application de membranes en céramique. Ainsi, diverses tentatives ont été faites pour utiliser des matériaux naturels à faible coût, tels que l'argile, l'apatite, zéolite en tant qu'alternatives aux autres oxydes métalliques bien connus tels que l'alumine, la silice, la zircone et l'oxyde de titane. Le but de ce travail est de développer de nouvelles membranes céramiques d'ultrafiltration (UF) à faible coût, composées de nanoparticules de smectite préparées au préalable par la méthode sol-gel. Les membranes composites UF ont été obtenues par dépôt sur un support de zéolite préalablement préparé par la méthode Layer-By-Layer. Des supports microporeux tubulaires en zéolite naturelle ont été élaborés par extrusion. Quatre membranes Sm/Z4, Sm/Z5, Sm/Z6 et Sm/Z7 différant par le nombre de couches déposées sur le support ont été préparées. Ces membranes correspondent respectivement à quatre, cinq, six et sept couches.

La morphologie et les propriétés de membranes obtenues frittées à 900 ° C pendant 3 h ont été déterminées par BET et SEM. Les valeurs de diamètre de pore mesurées (dp) se situent dans les plages suivantes: 3 nm <dpSm/Z4 <13 nm, 2 nm <dpSm/Z5 <11 nm et 3 nm <dpSm/Z6 <5 nm et 60 nm <dpSm/Z7 < 100 nm.

Des essais d'UF ont été réalisés à l'aide d'une pilote de filtration à une température de 25 ° C une pression transmembranaire (TMP) comprise entre 3 et 7 bars. La perméabilité à l'eau variait de 1218 L / h.m² bar pour le support de zéolite avant le dépôt de la couche à 73; 65 ; 59 et 115,80 L/h.m².bar après revêtement, respectivement pour les membranes **Sm/Z4**, **Sm/Z6**, **Sm/Z6** et **Sm/Z7**. Ces membranes sont également utilisées pour le traitement des eaux usées contaminées par des métaux lourds provenant de l'industrie Sopal. Les résultats révèlent une diminution importante de la turbidité (<1 NTU), de la rétention de la demande chimique en oxygène (DCO) (supérieure à 96% pour **Sm/Z6**) et de la rétention du chrome (supérieure à 89% pour **Sm/Z6**). Les données globales suggèrent que les membranes nanocomposites élaborées peuvent être utilisées pour la dépollution des effluents industriels contaminés par des métaux lourds.

Mots-clés: Smectite nanocomposite, support de zéolite, Layer-By-Layer (LBL), membrane céramique UF, métaux lourds, traitement des effluents industriels.

CHARACTERIZATION OF NANOFILTRATION MEMBRANES EXPOSED OZONE

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Membrane technology is now well established in water treatment and demand in membranes is increasing. The main types of membrane processes are pressure-driven, including microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO).

Numerous NF membrane systems have already been implemented in the drinking water sector and surface waters. Owing to its smaller pore size compared to UF, NF can achieve a much greater removal of organic matter substances. In addition, it has been widely recognized as a promising technology for the removal of organic components that act as precursors for disinfection by-products, problematic compounds such as hormones, pharmaceuticals, pesticides, etc.

Despite the efficient rejection performance of NF, membrane fouling is a complex process in which organic and inorganic compounds accumulate on the surface of the membrane causing a significant increase in the hydraulic resistance, which leads to the reduction of the membrane permeability and a substantial increase in operating and maintenance costs.

Some studies have focused on preozonation of the feed solutions to limit membrane fouling. However, there is very little work reporting on the impact of ozone on membrane materials.

The aim of this study was thus to evaluate the impact of ozone on the surface properties of NF membranes. Several types of polyethersulfone and polyamide membranes were exposed to ozone under various conditions (10 ppm of dissolved ozone, pH 3 and 7). The surface charge properties and the zeta potential of the various membranes were characterized by streaming current measurements. Water contact angle measurements were performed to point out the impact of ozone on the hydrophilic/hydrophobic features of the membrane surfaces. Eventually, chemical modifications induced by the reaction between ozone and the membrane materials were probed by Fourier transform infrared (FTIR) spectroscopy in the attenuated total reflectance (ATR) mode. All membranes were impacted by contact with ozone but polyethersulfone membranes were found to be more resistant than polyamide membranes.

Keywords : Nanofiltration, Ozone, Zeta Potential, FTIR-ATR, contact angle, polymer membranes

**ETUDE DU PHENOMENE DE POLARISATION DE LA CONCENTRATION
DANS UN PROCEDE D'ELECTRODIALYSE :
INFLUENCE DE LA VITESSE LINEAIRE ET DE LA CONCENTRATION INITIALE
DE LA SOLUTION A TRAITER SUR LA DENSITE DU COURANT LIMITE**

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Les techniques séparatives à membranes suscitent d'importants efforts de recherche et de développement. Parmi les procédés membranaires les plus utilisés dans les domaines de traitement et de dessalement des eaux, on peut citer les techniques d'osmose inverse et l'électrodialyse.

Dans le présent travail nous nous sommes intéressés à l'étude du procédé d'électrodialyse. Plusieurs travaux antérieurs ont montré que cette technique souffre d'un phénomène appelé « polarisation de concentration ». C'est un phénomène très grave qui est considéré comme l'une des limitations les plus importantes de ce procédé.

Ce phénomène sera étudié plus profondément à travers la détermination de la densité du courant limite (LCD). Un paramètre qui se manifeste suite à l'apparition du phénomène de polarisation de concentration. Comme c'est indiqué dans la littérature, plusieurs facteurs peuvent avoir une influence sur ce paramètre. Des travaux ont montré que la concentration en sel et le débit de la solution à traiter sont les paramètres les plus influents sur la LCD.

Le but de ce travail est de trouver une relation empirique entre ces deux facteurs et la densité du courant limite et de développer un modèle explicite pour estimer la densité du courant limite dans un procédé d'électrodialyse lors de traitement de solutions d'eau saumâtre. Pour aboutir à ce résultat nous nous sommes servi de la méthodologie des plans d'expériences à travers l'étude des plans des surfaces de réponses et plus précisément les plans composites centrés.

Un nombre relativement faible d'essais expérimentaux était nécessaire pour trouver une relation entre la LCD et les deux paramètres étudiés. Le modèle mathématique proposé est simple. Sa qualité a été évaluée par analyse de régression et ANOVA.

Les tracés de surface de réponse tridimensionnelle ont montré que la densité de courant limite dépend étroitement des deux paramètres. À une concentration initiale fixe en sel, le LCD augmente en augmentant la vitesse d'écoulement linéaire de la solution à traiter.

Pour les solutions ayant une très faible concentration initiale en sel (inférieure à 0,01 M) et traitées avec une faible vitesse d'écoulement linéaire, la valeur du LCD est presque nulle. D'autre part, pour les solutions avec une concentration initiale en sel comprise entre 0,01 et 0,05 M traitée à une faible vitesse d'écoulement, le LCD est également faible. En conséquence, la polarisation de concentration peut être atteinte avec un courant appliqué relativement faible.

Keywords: électrodialyse, polarisation de concentration, densité de courant limite, plan d'expérience

AMELIORATION DE LA FILIERE DE TRAITEMENT DES LIXIVIATS ISSUS DES DECHETS MENAGERS ET ASSIMILES

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Les lixiviats issus des centres d'enfouissement techniques des déchets sont des effluents très complexes, particulièrement du fait de leur potentielle toxicité pour le milieu, leur salinité élevée et une DCO dure (difficilement biodégradable) présente à de fortes concentrations comme de nombreux métaux toxiques. Leur traitement est donc très difficile par les procédés conventionnels. A cet effet le bioréacteur à membranes (BRM) associé à une nanofiltration répond parfaitement à ce critère d'effluent chargé, en combinant un traitement biologique et une filtration membranaire, ce procédé permet d'atteindre une qualité d'eau conforme aux normes de rejet, en permettant particulièrement une rétention poussée des matières en suspension (MES) et la matière organique. En revanche, son essor économique est fortement limité par le colmatage des membranes d'ultrafiltration et de nanofiltration qui est dû principalement à la matière organique dissoute.

L'objectif premier de ce travail est le suivi en fonction du temps de la variation des paramètres globaux de la matière organique (DCO, COT, DBO5) dans les lixiviats de la filière de traitement de l'EPIC-GECITALE de la wilaya d'Alger composée d'un réacteur biologique membranaire (BRM) associé à une étape de nanofiltration. Dans un deuxième temps une Coagulation/Précipitation à l'aide de ferrates de sodium synthétisés in situ dans des conditions optimales a été envisagée.

A cet effet, la fluorescence 3D (3DEEM) a été utilisée pour identifier et suivre les fractions de la matière organique dissoute issue du BRM d'une station de traitement des lixiviats. Les résultats de cette étude ont démontré que l'ajout des ferrates de sodium dans les lixiviats pour un pH variant entre 7 et 8 a permis de réduire la concentration de molécules fluorescentes, tel que les type humique (AH), fulvique (AF) et les produits solubles microbienne (PSM).

D'autre part une Coagulation/Précipitation/Oxydation à l'aide de ferrates de sodium synthétisés par un procédé électrolytique dans des conditions optimales a été effectuée sur le perméat du BRM a permis un abatement des phosphates non retenus lors de l'étape du traitement par le BRM., ainsi qu'une élimination importante des espèces métallique tel que le Cobalt, le Nickel, l'Arsenic et le Baryum.

Mot clés : Lixiviats, BRM, Matière organiques, Ferrate de sodium, 3DEEM,

UV-ASSISTED ELECTROCHEMICAL DÉGRADATION OF CHLORAMPHENICOL ON A THIN-FILM BORON-DOPED DIAMOND (BDD) ELECTRODE

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In this work, the electrolysis, photolysis and photo-electrolysis with diamond electrodes of chloramphenicol (CHL) solution were investigated in the context of the search for technologies capable of removing antibiotic from liquid wastes. Accordingly, we studied the influence of the main process variables (temperature, pH, current density and chloride concentration) on CHL degradation.

The results showed that CHL is completely degraded and mineralized by electrolysis, in both chloride and sulfate media. Besides, the efficiency of degradation is higher in the presence of chloride. The effect of the current density and temperature on mineralization efficiency is relevant, which may be related to the role of mediated oxidation. Irradiation by ultraviolet light waves does not produce a synergistic effect on the mineralization of CHL solution. This behavior indicates that the massive formation of radicals, during the combined processes, can favor their recombination to form stable and less reactive species.

Keywords: Anodic oxidation; Diamond electrodes; UV irradiation; Chloramphenicol.

ADSORPTION OF PHENOL EXTRACTED FROM MARGINE INTO INDUSTRIAL ACTIVATED CARBON AND MODIFIED ACTIVATED CARBON

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Tunisia is a Mediterranean country in which a part of the economy is based on olive culture and the production of olive oil. It has been subjected to numerous difficulties in the disposal of olive mill waste-water produced after trituration. This waste causes large-scale environmental problems. The organic fraction includes sugars, tannins and polyphenols.

In this present work, polyphenols were extracted from Tunisian margine using diethylether. The removal of polyphenols by adsorption into activated carbon and modified activated carbon was studied. The two carbon materials were characterized using FTIR spectroscopy, measure of pH_{PZC}, ATD-ATG and SEM. The obtained results showed that activated carbon possessed a high adsorption capacity to remove polyphenols from aqueous solution. Based on the results of this study, Langmuir is the best isotherm model describing adsorption of polyphenols onto carbon-based materials, as it gave the maximum R^2 value.

Keywords: olive mill waste-water, activated carbon, modified activated carbon, polyphenols, adsorption.

EFFECT OF CHITOSAN'S DEGREE OF DEACETYLATION ON THE PERFORMANCE OF PES MEMBRANE INFUSED WITH CHITOSAN AND COATED WITH POLYAMIDE LAYER

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PES membrane was modified with chitosan and polyamide as co-polymers and was evaluated for the treatment of acid mine drainage. Chitosan was blended within the PES membrane and polyamide was coated layer on the membrane surface. Chitosan having various degrees of deacetylation was blended within the PES membrane to evaluate the effect of deacetylation on the performance of the modified membrane. The membranes were characterised by FTIR, SEM, contact angle and porosity measurement.

The performance of the membranes was evaluated using a Dead-Filtration system using synthetic AMD. The membrane flux and removal percentage of the modified membrane was improved with increasing chitosan's degree of deacetylation. The membrane modified with chitosan having high degree of deacetylation exhibited high metal rejection due to more amine group available as binding sites. Coating polyamide layer on top enhanced the membrane selectivity even more although the flux was low compared to PES modified with chitosan alone.

This was attributed by the polyamide material which is normally used to fabricate reverse osmosis membranes. Results obtained show potential of PES membranes modified with chitosan and polyamide to remove metal ions from acid mine drainage.

REVERSE OSMOSIS PERFORMANCE IN WASTE WATER TREATMENT

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This study describes a release of heavy metals (Cr, Cd, Pb, ...) from a hard chromium plating unit, using the commercial reverse osmosis membrane (XLE-2540).

The pH effects of the discharge and the allowed pressure were explored. The results obtained showed that by a suitable choice of experimental parameters: pH= 7.0 and pressure 6 bar the retention is: Pb (51%) <Cd (93%) <Cr (100%), and at pH = 5.1 and pressure 6 bar Pb (37%) <Cd (77%) <(99%) Cr.

Keywords: treatment, Reverse osmosis, Heavy metals, Purification

REMOVAL OF LANTHANUM WITH POLYAMIDE NANOFILTRATION MEMBRANE

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In this study we tested the ability of polyamide nanofiltration membrane to extract the ion of lanthanum (III). A three –level factorial design and response surface methodology was used to evaluate the effects of parameters: pH (3–9), pressure (6-13.5 bars), concentration (10-100 ppm).

The results showed that the retention is quantitative (100%) for 10 ppm at pH= 6 with pressure equal to 6 bars. The study confirmed the high lanthanum extraction using polyamide nanofiltration membrane.

Keywords: Nanofiltration, Lanthanum, Extraction.

A SIMPLE METHOD FOR DETERMINATION OF DYE IN WASTEWATER BASED ON CLOUD POINT EXTRACTION AND SPECTROPHOTOMETRIC DETECTION

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A study on the phenomenon of clouding and the applications of cloud point technology has been thoroughly discussed. The phase behavior of clouding and various methods adopted for the determination of cloud point of various surfactant systems have been elucidated. The system containing nonionic surfactant (Triton X-100) has been reviewed with respect to their clouding phenomena and the effects of variation in quantity of the surfactant systems have been incorporated. Additives of various natures control the clouding of surfactants.

Electrolytes, nonelectrolytes, organic substances as well as ionic surfactants, when present in the surfactant solutions, play a major role in the clouding phenomena. The review includes the morphological study of clouds and their applications in the extraction of dye. The temperature of turbidity of aqueous solutions (2% Triton X-100) decreased in presence of Sodium salts up room temperature with Na_2SO_4 , contrary in presence of potassium salts. In addition, when a surfactant is supposed to be used at temperatures above its cloud point, the surfactant system and additives are valuable.

The results showed, without contribution of energy (ambient temperature), the removal dyes (>97 %) in a single Cloud Point extraction using optimum conditions. In this work, effluents from textile industry containing Blue Bemacid dye were treated by Cloud Point extraction, the methodology used is based on the formation of dyes complexes soluble in a micellar phase of non-ionic surfactant, these complexes are then extracted into the surfactant rich phase, at ambient temperature.

Keywords: Cloud point Extraction, surfactant (Triton X-100), Red Bemacid dye

EFFECT OF THE DISTANCE BETWEEN THE COLD SURFACE AND THE HOT SURFACE ON THE PRODUCTION OF A SIMPLE SOLAR STILL

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The aim of this work is to study the effect of the distance between the cold condensing surface and the hot steam generation surface in order to optimize the geometric characteristics of a simple solar still. To do this, a modeling of heat, mass and coupled transfer has been done.

Subsequently, a theoretical simulation of the operation of this device was made using a program developed on Matlab software that allowed us to evaluate the production of this system as a function of the distance separating the two surfaces. The obtained results show that when this distance is greater than the distillate flow decreases hence an optimization of the geometric and thermal characteristics to have a compact and productive system is necessary.

Keywords: Solar Distiller, cold surface, hot surface, inter-surface distance, modeling, simulation

RECUPERATION DU PLOMB PAR MEMBRANE LIQUIDE EMULSIONNEE

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Le problème de la pollution des eaux par les substances organiques et inorganiques est aujourd'hui très préoccupant pour les pays émergents, surtout pour certaines espèces toxiques non biodégradables comme les métaux lourds tels que (le plomb, cadmium, mercure..) [1].

De multiples activités humaines en sont responsables de cette pollution et la principale source est d'origine industrielle (métallurgie, tannerie, galvanisation). Bien que ces effluents puissent être traités avec des procédés physico-chimiques de séparation conventionnels comme adsorption, échange d'ions, précipitation et la séparation par membrane. Ces derniers, qui sont actuellement les plus employés dans les techniques des traitements, peuvent être inefficaces à cause de la haute consommation d'énergie et les couts élevés de ces procédés.

La technique de membrane liquide émulsionnée (MLE) permet la séparation sélective d'ions métalliques et d'opérer en continue sans besoin de régénération fréquente, associée à un bas impact chimique et à une consommation en énergie minimale [2].

L'objectif de notre travail est d'étudier l'élimination du plomb(II) à travers la membrane liquide émulsionnée par un extractant acide ; le di (2-éthylhéxyl) phosphorique (D2EHPA) comme transporteur et le triton X-100 comme tensioactif. Les paramètres expérimentaux étudiées sont: Rapport D2EHPA/TritonX-100 ; nature du diluent, vitesse de formation de l'émulsion ; concentration en acide d'épuration ; temps d'équilibre d'extraction ; concentration du plomb, Les résultats ont montré que le Pb(II) est extrait à 100%.

Mots clés : Membrane liquide émulsionnée ; Plomb ; D2EHPA ; TritonX-100

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ELIMINATION DE L'ARSENIC DES EAUX DES RESIDUS MINIERES AURIFERES DE LOULO PAR ADSORPTION SUR UN SUPPORT NATUREL, LA LATERITE

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L'adsorption de l'arsenic sur un support naturel, la latérite est étudiée. Trois échantillons de latérite prélevés sur le site aurifère de Loulo ont été caractérisés. Ils sont riches en Fe_2O_3 (42%) et en Al_2O_3 (4,64%). Ils ont ensuite été réduits à différentes granulométries respectivement de 0,177 mm à 10 mm.

Différents facteurs influents le taux d'élimination de l'arsenic des eaux de synthèses et celles des résidus miniers aurifères sur ces échantillons de latérite ont été investigués, il s'agit principalement du diamètre, de la masse d'adsorbant, du temps de contact, le pH et de l'ajout des ions ferriques.

Les résultats obtenus montrent que les isothermes d'adsorptions obtenues suivent les modèles de Langmuir et Freundlich. Les taux d'élimination de l'arsenic à 28°C sur les échantillons de latérite atteignent plus de 98% surtout pour le diamètre 0,177 mm ainsi que pour des concentrations en arsenic de 5 à 20 ppm. Des taux d'éliminations en arsenic de plus de 98% ont également été obtenus en ajoutant de l'ion ferrique Fe^{3+} (FeCl_3) au soluté. Des taux de réduction de plus de 94 % de l'arsenic ont été aussi obtenus en milieu très acide pour des pH variant de 1,7 à 2,40.

Mots clés : adsorption - latérite- arsenic - eaux des résidus miniers.

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FILTRATION PERFORMANCE OF TUBULAR CERAMIC MEMBRANE MADE FROM LOW COST NATURAL MATERIAL

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This paper discusses the development of a low cost ceramic membrane prepared from kaolin clays for filtration application to produce clear water from high turbidity waste waters.

In a first stage, tubular porous ceramic membranes were prepared by extrusion of a plastic paste prepared from clay powder mixed with organic additives and water. The obtained microfiltration membrane exhibited high properties in terms of mechanical resistance, porosity and chemical stability. It was used to treat real waste waters coming from textile-company and sea product industry.

Then, an ultrafiltration membrane was prepared by a simple and one-step deposition of a micrometer- thick clay layer on the internal surface of the tubular-shape macroporous support with an aqueous colloidal suspension of clay particles. This membrane can be used for cross flow ultrafiltration.

Keywords: Tubular ceramic membrane, Filtration performances, Active layer, waste water treatment.

DEVELOPMENT OF ASYMMETRIC ULTRAFILTRATION MEMBRANES FROM NATURAL ZEOLITE APPLIED TO WASTE WATER TREATMENT

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In this study, performance evaluation of tubular ultrafiltration (UF) zeolite membranes developed from natural zeolite materials during treatment of two industrial effluents is reported. These membranes were prepared via the slip casting process and supported on low cost natural zeolite supports of average pore size 0.55 μm . After sintering at 880°C for 3 h, the average pore size values of the membranes reduced to 8-11 nm. Morphology of the membranes was checked using scanning electronmicroscopy.

The membranes were applied for the treatment of industrial waste water coming from cuttle fish processing and electroplating containing basically (turbidity and COD) and (COD and salts) respectively. It was found that the water permeability of the membranes ranged from 118-176 L/h.m² bar and that they displayed good performances for the treatment of industrial waste water with a permeate flux maintained at interesting values higher than 74 /L.h.m² at 3 bar.

All the prepared membranes show good pollutants retention in term of COD (> 85%). Among these membranes, the membrane prepared using modified zeolite MZ/Z, characterized by positively charged surface displayed iron rejection of 90 %.

Keywords: Ultrafiltration membrane, Slip-casting, natural zeolite, iron removal, Industrial effluent.

TITANIA ULTRAFILTRATION CERAMIC MEMBRANE: PREPARATION, CHARACTERIZATION AND PHOTOCATALYTIC ACTIVITY

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The development of new membranes with improved separation properties, high mechanical and thermal stability using inexpensive and naturally abundant materials is of utmost importance for sustainable development and environmental applications. Ceramic materials due to their high chemical, mechanical and thermal stability in combination to their facile surface functionalization have inspired material scientists to design innovative low-cost ceramic-based membrane supports. A mesoporous photocatalytic titania (TiO_2) membrane on mud support is successfully fabricated via the spin coating method. The coated layer resulting was performed by a suspension made of a mixture of the titania powder, water and polyvinyl alcohol solution (PVA), then heated at 450 °C. Several techniques such as X-ray diffraction (XRD), TGA, N_2 - sorption, and SEM are utilized to investigate the optimized processing parameters and their influence on the final properties of the developed membrane. The permeability and photocatalytic properties of the titania membrane were measured.

KEYWORDS: Ceramic membrane, Ultrafiltration, Titania, Photocatalytic activity.

**DESIGN, CONSTRUCTION AND OPERATION
OF A *SCHMUTZDECKEAU* PILOT PLANT IN THE TECHNOLOGICAL VILLAGE
OF IPR/IFRA OF KATIBOUGOU, MALI**

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Access to potable water remains a major challenge to numerous households in rural communities in Africa. In this study, a design, construction and operation of a slow sand filtration-based *SchmutzdeckEau* Pilot Plant (SEPP) was performed in the Technological Village of the IPR/IFRA Katibougou, Mali.

The structure is made of a filtration basin with characteristics of 1.5 X 1.2 m² in surface for a total depth of 1.62 m of which the filter bed has a thickness of 0.84 m. The filter bed is made of fine sand sizes ranging from 0.4 to 0.7 mm. Fine to coarse gravels layer of 20 cm lays underneath the sandbed. Filtered water is collected by a drilled well PVC pipe strainer 140/152 be neath the layer of gravels. A metal frame carries a 200-liter plastic drum which is used as inletraw water source to feed the filtration basin through a piping system with a flowrate control valve. Also, the flow on the sand be disdirected on a metal board serving as energy breaker to prevent the bed burrowing by the inflow of raw water.

The treated water is collected out of the pipe strainer through a pipe assembly with a flow control valve. The SEPP has a production capacity of 200 liters of potable water in 6 hours of operation and can be increased to as much as 1 000 liters since the system operated only intermittently. Initial analyses of the produced treated water were performed.

The results of the microbial tests showed a reduction of more than 99.9% of all strains of microorganisms tested. The physicochemical quality of the produced water meets the requirement of potable water based on WHO guidelines. The total cost of the pilot station amounted to 524.70 euros for a construction duration of 20 days. Further studies are needed to determine the overall performance of the SEPP in the long-term to underpin the reliability of the technology for drinking water supply for communities in peri-urban and rural Africa.

Keywords: Slow sand filtration, design, *SchmutzdeckEau*, physicochemical, microbial, potable water.

MODELING OF THERMODYNAMIC PROPERTIES OF MIXTURES CONTAINING COMPOUNDS DERIVED FROM BIOMASS

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Biomass is any organic matter that is renewable over time. More simply, biomass is stored energy. During photosynthesis, plants use light from the sun's energy (light energy) to convert carbon dioxide and water into simple sugars and oxygen.

Fossil fuels are hydrocarbon deposits, such as petroleum, coal, or natural gas, derived from organic matter from a previous geologic time. They are essentially fossilized bio-mass and differ from present-day biomass in that they come from organic matter created millions of years ago, which has been stored below ground. In other words, the key difference between biomass and fossil fuels is age!

Fossil fuels contain carbon that was removed from the atmosphere, under different environmental conditions, millions of years ago. When burned, this carbon is released back into the atmosphere. Since the carbon being released is from ancient deposits, and new fossil fuels take millions of years to form, burning fossil fuels adds more carbon to the atmosphere than is being removed.

Biodiesel is nowadays in Europe the most used biofuel for road transportation. During its production, different separation and purification processes are required for the glycerol rich streams such as the recovery of the unreacted alcohol and the removal of water. The adequate design of the recovery and purification steps requires the knowledge about the vapour-liquid equilibria data for water + glycerol and alcohol + glycerol systems that are surprisingly scarce.

In this work we modeled the thermodynamic properties of experimental data existing in the literature of binary systems (glycerol+ water+ methanol and ethanol) using perturbed-chain statistical associating fluid theory (PC-SAFT), the equation of state is used in purely predictive and semi-predictive mode, the model parameters for the pure fluids and the binary interaction parameter k_{ij} were determined by a simultaneous fitting to pure-glycerol densities, the results shown indicate that such an approach can serve as an interesting modern thermodynamic tool for representation of thermodynamic data for these systems,

Additionally, Cubic-Plus-Association Equation of State (CPA EoS) has been applied successfully to correlate the experimental vapor data for the three investigated systems.

Keywords: Biomass, CPA EoS, PC-SAFT, Biodiesel and correlation.

SYNTHESIS AND CHARACTERIZATION OF NANO MAGNETIC MATERIAL BASED ON (CARBON NANOTUBES / γ -FeOOH): APPLICATION FOR THE REMOVAL OF CONGO RED OF DYE FROM CONTAMINATED WATER

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Water pollution by dyes has been a worldwide problem. Colour is the first contaminant to be recognised in wastewater. Dyes are used in different industries such as paper, plastics, food cosmetics, leather, pharmaceutical dyes tuffs textiles etc. to colour the product.

Various techniques have been developed for decontamination purposes. However, adsorption process seems to be among the most effective methods yielding therefore to remove dyes from aqueous environments [1], while several studies have already been done in this field using several materials as adsorbents. Indeed, the performance and the efficiency of this adsorption technique depend generally and preponderantly on the nature of the support used as adsorbent.

Synthetic γ -FeOOH is one of the most important phases of iron oxides because of its application as an adsorbent for various toxic cations and anions due to chemical reaction occurring at specific surface sites. In another side of view, double walled carbon nanotubes shows good mechanical, electrical properties and especially a large surface area [2]. Prior to this, carbon nanotubes are nanomaterials which have undergone considerable development in recent years due to their remarkable potential for nanoscale applications, with a fibrous form, large external surface accessible, and a well-developed mesopore. As a starting point as an hypothesis, the combination of magnetic properties and adsorbent properties within the same material is an interesting challenge that could overcome the problems of recovery of adsorbents loaded with pollutants.

The synthesis of (DWNTCs / γ -FeOOH) by refluxing process. Herein, the synthesized adsorbent was characterized via Fourier Transform Infrared Spectroscopy (FTIR), X-ray diffraction (DRX), BET, zeta potential and transmission electron microscopy (TEM), where the adsorption of congo red on (DWNTCs / γ -FeOOH) has been carried out by studying the adsorption kinetics, pH, mass and the initial concentration. The results indicated that the maximum adsorption rate is 16 mg.g⁻¹ at pH 7 with 100 mg of (DWNTCs / γ -FeOOH), and an initial orange methyl concentration of 10 mg.l⁻¹. In addition, the adsorption process describes a second-order kinetic model, where the modeling of adsorption isotherms showed that the Freundlich one seem to be the adequate model describing the adsorption process with R² = 0.97.

Keywords: Carbon nanotubes, α -FeOOH, methyl orange

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REMOVAL OF CHROMIUM FROM ELECTROPLATING INDUSTRY EFFLUENT USING SYNTHETIC TITANIA-CLAY NANOPARTICLES AND COMMERCIAL TITANIUM DIOXIDE

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The nanoparticle Titania-clay powders (NP) was obtained by using a colloidal route method and used as adsorbent to remove chromium from industrial effluent. The synthetic nanoparticle powders (NP) were characterized by X-ray diffraction (XRD), Fourier transform infrared (FTIR) spectroscopy, Scanning electron microscopy, EDX analysis (SEM-EDX) and Brunauer-Emmett-Teller (BET) method. The effect of adsorbent dose, contact time and temperature on adsorption performances of chromium onto synthetic nanoparticle Titania-clay powders (NP) and commercial Titanium dioxide (TiO₂) was determined in batch experiments. Chromium concentration, initially of 80 mg/L can be reduced to 25 mg/L at optimal dose of 1.2 g/L and 27 mg/L at optimal dose of 1.6 g/L using NP and TiO₂ respectively given an adsorption capacity of 20.83 mg/g and 16.87 mg/g under the optimum condition (time = 75 min and T= 293K). The capacity of chromate adsorption over synthetic NP was greater than over commercial TiO₂ due to the high adsorption capacity of clay and the fine particle size of NP.

KEYWORDS: Adsorption, Chromium, Industrial effluent, nanoparticle Titania-clay powder, Titanium dioxide.

TREATMENT OF OILY WASTEWATER EFFLUENTS FROM ELECTROPLATING INDUSTRY USING NOVEL CERAMIC MEMBRANE

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This study aimed to assess the performance of two ceramic membranes in the treatment of electroplating industry effluents using a cross-flow filtration through new ceramic membranes based on natural zeolite: Zeolite/Zeolite Microfiltration membrane (Z/Z) and Clay/Zeolite Ultrafiltration membrane (Sm/Z). These membranes of tubular geometry were prepared using slip casting process by deposition of a coated layer on preexisted support. After sintering, the pore size value of Z/Z and Sm/Z membranes were 0.18 μm and 18 nm respectively. The pore size of the zeolite support sintered at 900°C / 3 h has been 0.55 μm . The determination of the water permeability for both membranes shows a value of 534 and 80 L/h.m² bar respectively for Z/Z and Sm/Z membranes.

These membranes have displayed good performances for the treatment of oily industrial wastewater. The permeate flux value obtained after 60 min of filtration was of 100 L/h.m² at 25°C and 150 L/h.m² at 60°C for MF membrane at 1 bar and of 46 L/h.m² at 25°C and 144 L/h.m² at 60°C for UF membrane at 3 bar.

Keywords: New Ceramic membrane, Slip-casting, natural zeolite, Smectite nanoparticle, oily wastewater, Microfiltration, Ultrafiltration.

POLYELECTROLYTE COMPLEXATION FOR WASTEWATER TREATMENT

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Polyelectrolytes are increasingly used in wastewater treatment because of their ability to form complexes with contaminants such as dyes and heavy metals. A polyelectrolyte is defined as a macromolecular material that has repeating units and dissociates into a highly charged polymeric molecule after its solubilisation in a polar solvent such as water, to form either a positively or a negatively charged polymeric chain and counter ions of opposite charge. The electrostatic attraction between cationic and anionic macromolecules or between anionic macromolecules and cationic contaminants such as cationic dyes and metal cations, leads in general to the formation of macroscopic precipitates, or more rarely to stable colloidal complexes. Some researchers studied the assembly of weak polyelectrolytes such as poly (acrylic acid) (PAA) and poly (ethyleneimine) (PEI) for the complexation of metal cations, and then proceeded with ultrafiltration, thereby inhibiting the passage of the complexed contaminants through the membrane thanks to steric effects (M. Awal Abdil Ali et al., 2015). This process is called polyelectrolyte-enhanced ultrafiltration (PEUF) and it is the subject of an increasing number of papers in the field of membrane science.

In our case, we are interested in the study of the complexation of strong polyelectrolytes like poly (styrenesulfonate) (PSSNa) and poly (diallyldimethyl ammonium chloride) (PDADMAC) for the removal of cationic dyes as a function of different physicochemical parameters (chain length, charge density...). We started by evaluating the complexation between cationic dyes like methylene blue, toluidine blue and safranin t with PSSNa (anionic polyelectrolyte) using the spectrophotometric method. We found that the complex formation of the three cationic dyes with PSSNa is characterized by the appearance of a new metachromatic band having a blue-shifted absorption compared to the monomeric band, indicating the formation of H-aggregates. Furthermore, the stoichiometry of polyelectrolyte-dye complexes, determined using the ratio method, is 15:1 for all the cationic dyes. On the other hand, the addition of increasing amounts of PDADMAC (cationic polyelectrolyte) on the complex PSSNa-dye induces the disappearance of the metachromatic band and the reappearance of the monomeric band, indicating the formation of a new complex formed by the two oppositely charged polyelectrolytes, substituting the initial polyelectrolyte-dye complex.

Keywords : polyelectrolytes, ultrafiltration, cationic dyes, metal cations, polyelectrolyte complexes...

DEVELOPMENT AND APPLICATION OF NEW CERAMIC MICROFILTRATION MEMBRANE FROM NATURAL ZEOLITE MATERIAL

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Ceramic microfiltration membrane from zeolite natural material has been successfully elaborated on planar macroporous support by dip coating process. The main steps of support preparation and microfiltration layer deposition have been detailed. The zeolite support sintered at 900°C for 3 h has exhibited high properties in terms of mechanical resistance, porosity and chemical stability. Scanning electron microscopy analysis has shown smooth surfaces and cracks-free membranes for a sintering temperature of 850°C during 3 h. The water permeability values of the support and the membrane have been 1230 and 454 L/hm²bar, respectively. The application of the microfiltration membrane to the treatment of textile wastewater effluent has shown good performances in terms of permeate flux and efficiency in terms of turbidity and COD retention.

KEYWORDS: Zeolite Membrane; Microfiltration; Textile wastewater; Treatment; performances.

USE OF TA TO ANALYSE THERMAL EXPLOSION: APPLICATION TO Ce TRIETHANOLAMINE COMPLEX.

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Knowledge of the conditions that must be met to predict the occurrence of thermal runaway is pertinent for a large number of applications [1]. The occurrence of thermal runaway is controlled by two competing phenomena: the exothermic reaction that tends to increase the local temperature, and heat dissipation that lowers the temperature through heat conduction [1]. Any thermal runaway must be initiated by a so-called “ignition” event. Two different igniting modes are considered [2].

In the “self-propagating high temperature” mode, ignition is created locally by an external and localized energy source [3]. Recently, a critical condition has been derived that takes into account reactant consumption, realistic geometries and constant heating conditions. Therefore, the occurrence of thermal explosion can be predicted provided that the system parameters are known: mass, container geometry, activation energy, thermal conductivity, heat capacity, heat of reaction and density. In this poster, we will show that thermal analysis (TA) allows to determine the parameters related to heat generation and dissipation. In addition, TA allows detecting the occurrence of a thermal runaway during different temperature programs and sample masses.

In particular, we will apply TA to analyse thermal explosion in a Ce triethanolamine complex.

Keywords: Triethanolamine, ignition, thermal explosion, self-propagating high temperature.

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TRANSFERT ET INNOVATION TECHNOLOGIQUE AU CITET

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Projet: valorisation énergétique des déchets organiques du marché de gros de Bir Le Marché de Gros de Tunis rejette 25 T déchets Organiques/jour :

- frais de transport et de mise en décharge
- diminution de la durée de vie de la décharge
- Perte définitive de cette biomasse.

Proposition CITET : Transformation de ces déchets organiques en sous produits sources d'énergie (biogaz riche en méthane, fertilisant et eau d'irrigation) par biométhanisation

Projet : Assainissement rural et adoption de nouvelles technologies (traitement par macrophytes)

- * Le rejet des eaux usées pour les petites agglomérations en région rurale constitue une problématique majeure sur le plan sanitaire et environnemental.
- * Le CITET a réalisé une station pilote de traitement des eaux usées par macrophytes au niveau de la localité de «Jougar» Gouvernorat de Zaghuan.
- * En 2005 le CITET a obtenu le meilleure prix d'invention au concours BSB de l'ATI pour les inventeurs et a enregistré son brevet d'invention.

Projet : Traitement des Margines

Les eaux résiduaires des huileries (marges ou encore eaux de végétation) sont des résidus liquides de couleur noirâtre et d'odeur désagréable. elles sont presque 200 fois plus chargées que les eaux domestiques et elles sont riches en matière organique (composés phénoliques, lipides, sucres, protéines...) et en sel minéraux de potassium, sodium, magnésium.

Plusieurs technologies ont été testées au CITET :

- * Traitement biologique à trois étages (aérobie-anaérobie-aérobie)
- * Épandage des margines
- * Compostage avec des éléments structurants

Réseaux technologiques- CITET :

- 1- *Réseau Technologique des Cimenteries pour l'Environnement RTCE*

- Instaurer un partenariat entre les cimentiers, les organismes publiques, les centres de recherches, les bureaux d'études, les laboratoires, etc...
- Répondre aux problèmes posés par les industriels et les sociétés du secteur.
- Élaboration d'un guide environnementale du secteur cimentier en Tunisie.
- Élaboration d'une feuille de route pour la Co-incinération des déchets dans les cimenteries.

2- *Réseau Technologique de l'Environnement des Conserves de Fruits et Légumes*

- Diagnostic environnementale des usines de Tomate Concentré
- Action pilote pour le traitement des rejets hydriques des deux unités industrielles de la branche.
- Mise en place d'un plan de gestion des déchets solides et de traitement des eaux usées
- Élaboration d'un guide pratique pour l'industrie de Tomate.



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