

December 2009, Issue 11

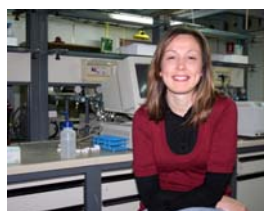
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ICCMR9 Prize

Rosalinda Mazzei, PhD student at ITM-CNR, has been awarded for the best oral presentation at 9th International Conference on Catalysis in Membrane Reactors (ICCMR9), held in Lyon, France, 28th June – 2nd July 2009.

The title of the work presented is: Biocatalytic membrane reactor to produce bioactive high value compounds from olive mill waste water: a kinetic study.

In this presentation biocatalytic membrane reactors using immobilized β -glucosidase from almond have been applied to implement the valorization of phenolic by-products, such as oleuropein, coming from olive oil processing.



Success stories in the materials field - A decade of EU-funded research



ITM-CNR has been an active partner in the Livebiomat project focused on the development of new polymeric biomaterials for in vitro and in vivo liver reconstruction (NMP3-CT-2005-013653) that is reported as one of the success stories in the FP6 in the publication of the European Commission "Success stories published by in the materials field - a decade of EU-funded research". The research activity performed by ITM-CNR has been coordinated by Dr. Loredana De Bartolo. As cited, project success were reached in:

Bioreactor construction. A small-scale bioreactor for primary hepatocyte cultures has been developed and characterised, capable of high throughput for in vitro pharmacological screenings. This system is being used to test the effect of the new polymeric biomaterials (polymeric membranes and peptide scaffolds) on the parameters for functional and genomic levels in primary rat hepatocytes.

Membrane trials. Semi-permeable polymeric membranes were prepared from a blend of modified polyether ether ketone (PEEK-WC) and polyurethane (PU), with regularly distributed 0.1 μ m surface pores. Primary hepatocytes cultured on this membrane surface exhibited higher metabolic rates than those in collagen cultures. The polymer is compatible with human hepatocytes, and is thus applicable as a substrate for the in vitro reconstruction of human liver tissue.

Surface modification. In order to optimise the membranes for biomolecule immobilisation, cell adhesion and expression of the hepatocytes' metabolic functions, various glow discharge plasma modification processes (pdAA, plasma deposition from acrylic acid, grafting of nitrogen groups from NH₃) were applied, followed by the immobilisation of biomolecules (RGD peptides, galactosamine). The pdAA-modified surfaces were also used as substrates to promote the self-assembly of a peptide coating (RAD16-I), without significant pore size alteration or structural change.

International Workshop on "Advances in Membrane Technology", Kolkata (India)

The international Workshop on "Advances in Membrane Technology for Water Treatment, Environment and Clean Energy" organized by Central Glass & Ceramic Research Institute (Council of Scientific & Industrial Research) was held from 7 to 8 of December in Kolkata (India). The Workshop was focused on innovative membrane technologies for clean energy and green environment, with particular attention to the recent developments involving liquid and gas separation. The most crucial problems of the modern Society where membrane engineering might offer a contribution to their solution have been also discussed.

The technical programme included invited lectures on the following topics:

- Remediation of Arsenic Contamination in Drinking Water
- Membrane Bioreactor and Wastewater Treatment
- Membrane Contactor and Carbon Dioxide Capture
- Membrane Reactor and Cleaner Technology
- Hollow Fibre and Capillary Membranes
- Zeolite and Dense Membranes.

A plenary lecture on "Integrated Membrane Operations and Water Treatment" was held by Prof. Enrico Drioli (ITM-CNR), Honor Guest of the Conference. Other two lectures on "Membrane Contactors" and "Arsenic removal by Membrane Process" were also held by him. Another lecture was held by Catia Algieri (ITM-CNR) on "Preparation and Characterization of Zeolite Membranes".

The event was also significant for strengthening the already existing bilateral S & T cooperation agreement between CGCRI Institute (India) and ITM-CNR (Italy) on "Membrane contactors for arsenic(III) to arsenic(V) conversion" which would help to find out the global status on environment and clean energy.



Summary:

ICCMR9 Prize	1
LIVEBIOMAT	1
Kolkata Workshop	1
Publications	2
Training Activities	2
Visiting Scientists	3
Short Visits	4
Focus	5
New Projects and Signed Agreements	6
Projects Meetings and	7
Seminars	8
Upcoming Events	8

New nanofibre self-assembling scaffolds prepared. Scaffolds were modified with peptide cell-instructive motifs (peptides), and their capacity to maintain liverspecific activities was tested and compared with that of the classical collagen culture model using primary rat hepatocytes cultured in a sandwich configuration.

http://ec.europa.eu/research/industrial_technologies/pdf/success-stories-in-the-materials-field_en.pdf

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Patents

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- Drioli, E., Cassano, A., Processo integrato a membrana per la concentrazione di succo di melograno, RM 2009 A000484

High Educational and Training Activities

PhD Defenses

Various doctoral students successfully defended their PHD dissertation for the Doctorate on "Chemical Engineering and Materials" at the University of Calabria for the Academic Year 2006-2009 (XXII Cycle):

Patrizia Cairo, Theoretical study of biocompatible membranes for pharmaceutical applications

Maria Concetta Carnevale, Application of membrane distillation on processes of industrial interest

Gianpiero Chiappetta, Catalytic membrane reactors

Carmela Conidi, Integrated membrane operations for the selective removal of bioactive compounds from juices and by-products of citrus production

Luana De Lorenzo, Molecular dynamics of "high performance" polymeric membranes for gas separation

Rosalinda Mazzei, Development and optimization of membrane bioreactors with enzymes and/or plant cells for the production and separation of bioactive molecules and biomass treatment

Emma Piacentini, Development of microstructured and multifunctional biohybrid membrane systems

Visiting Scientists (June - December 2009)



I am ASHRAF ISMAIL from Faculty of science, Cairo University, Egypt.

I have visited ITM-CNR in the framework of my PhD studies on "Separation and concentration of some nitrated cellulosic derivatives from industrial waste water using inorganic membrane separation systems" in progress at Faculty of Science of the Cairo University.

Dr. Lidietta Giorno Director of the Institute hosted me for a short term study (3 months) starting from September 1st, 2009. During my staying I learned how to prepare and characterize membrane modules made by polymeric and ceramic membranes. I also carried out microfiltration and ultrafiltration experiments for the separation of polymers, such as cellulose, from wastewater.

I participated to the training activities in progress at the Institute including the IMeTI Workshop on "Membrane Applications in Agrofood" held on 18 - 20 October 2009 in Cetraro (CS) - Italy. I would like to express my sincere thanks to Prof. Drioli, Dr. Giorno, the researchers of Membrane Institute and all members of the (ITM-CNR), especially Ph.D student, Sudip Chakraborty from India for their kind cooperation and hospitality.

My name is Masoumeh Esmailinezhad (Massi) and I come from IRAN. I am working on solvent pervaporation using polymeric membranes, and collaborating with my husband (Sina Zereshki), to finalize his PhD thesis. Our research here in ITM-CNR is carrying out under kind supervision of Dr. Figoli, whom helped us a lot. ITM is a professional international research forum for researchers all over the world to gather, learn and exchange their information with each other and I suggest it to all researchers looking for such a place.

My stay here is for 6 months, till the end of January. It was a great opportunity and a valuable experience for me. I enjoyed being and learning from all researchers, staff, and friends here, with their very friendly relationships.

Thank you all for your kind help. I really appreciate it. I would like to give my special thanks to Prof. Drioli and Dr. Figoli who invited and accepted me, and also to Dr. Giorno the director of ITM. I wish the best for you.



I am Dr. SPAHIS Nawel from the University of Chlef (UHBC), Algeria. During my last training of one month (2009), I performed and characterized new polymeric membranes loaded with activated carbon under the supervising of Dr. Alberto

Figoli. I also considerably improved my skills on porous polymeric membrane characterization methods. I am thankful to everyone who helped me during my stay at ITM. Special warm gratitude goes to Prof Enrico Drioli for his support and kindness.

I am Dr. MAHMOUDI Hacene from the Laboratory of Water and the Environment located at the University Hassiba Ben Bouali of Chlef, Algeria. I have been visiting ITM for three times (2006, 2007 and 2009). My work consisted on the oxygen and carbon dioxide control by membrane contactors in reverse osmosis desalination process conducted under the supervising of Dr. Alessandra Criscuoli. I thank all the research team of ITM which helped me

during the period of my stay, especially Alessandra Criscuoli, Alberto Figoli, Lidietta Giorno, Mariella Liberti. Really it was a big opportunity for me to be surrounded by well experimented researchers and technicians. My entire recognizance goes to Prof. Enrico Drioli, who never saved efforts to help and orient me.



I visited the Istituto per la Tecnologia delle Membrane (ITM), Rende, Italy during November 26 to December 16, 2009 under CNR, Italy - CSIR, India Bilateral S&T Programme. I worked on the joint project 'Membrane contactors for arsenic(III) to arsenic(V) conversion' between Central Glass & Ceramic Research Institute (CGCRI), India and ITM-CNR, Italy. I am grateful to Dr. Alessandra Criscuoli, Senior Researcher and Coordinator of the project for inviting and giving me all kinds of facilities and advice to work with her research group in such an esteem research Institute in membrane science.

During my stay in ITM, I could learn on speciation of arsenic (III) and arsenic (V) mixture in aqueous samples. Experiments under various conditions on conversion of As(III) to As(V) using polymeric hollow fibre membrane contactor will have good impact on R&D activities of my Institute also. Literature survey was done for better

understanding of the reaction mechanism involved in the process. CGCRI activity on safe drinking water from arsenic contaminated ground using porous tubular ceramic membrane will hopefully be enriched from the present study. I appreciate Eng. Patrizia Bafaro for conducting experiments for all the days I was in ITM and I would like to thank also Prof. Enrico Drioli, Dr. Lidietta Giorno, Dr. Alberto Figoli, Dr. G. Barbieri and Dr. Francesco Galiano for the fruitful discussions. It was very good experience for me from scientific knowledge development point of view in the field of membrane science. Cooperation and assistance extended by the scientists, researchers, students and administrative personnel of this Institute were really amazing. Ganesh C. Sahoo

I am Said BEY, from BEJAIA University- Algeria, a PhD student working on: Preparation and Characterization of Modified Liquid Membranes: Studies and Applications.

My research activities at ITM are mainly devoted to:

- Preparation and characterization of hollow fibers membranes based on PEEKWC and PVDF polymer.
- Application to the extraction of arsenite (As(III)), arsenate (As(V)) and chromium (VI) by hollow fibers membranes contactors. A comparison study with commercial polypropylene hollow fibers will be investigated. In fact, the morphology and the type of polymer (hydrophobic or hydrophilic) will be considered.

My stay in ITM during 18 months was a very rich experience for me, which allowed me to improve my knowledge in membrane process in particular membrane (flat sheet, hollow fiber) preparation, characterization and their application.

Moreover, it was an opportunity to be in relationship with people all over the world working in membrane technology. It is a pleasure to me to spend this period in ITM-CNR for a simple reason of the professionalism of its workers, courteous and friendly.



Dr. Debora A. Nabarlantz from the Departament d'Enginyeria Química - Escola Tècnica Superior d'Enginyeria Química of the UNIVERSITAT ROVIRA I VIRGILI (Spain) spent the period of 21 - 28 October 2009 at the Institute of Membrane Technology (ITM-CNR) of the Italian National Research Council.

During this period Dr. Nabarlantz participated in some discussions on membrane emulsification and membrane bioreactors.

She also participated in experiments on the preparation of oil-in-water and water-in-oil emulsions using membrane emulsifications, in co-operation with Emma Piacentini, under the supervision of Dr. Lidietta Giorno.

This visit took place in the framework of the Programme of Integrated Actions between Italy and Spain promoted and supported by the Ministry of Education, University and Research - MIUR in collaboration with the Spanish Ministerio de Ciencia y Tecnología.



My name is Qusay Fadhel, I am an Associate Professor Dr. working in Chemical Engineering College, University of Technology, Baghdad, Iraq. I am visiting the ITM-CNR for one month in order to follow-up the experimental work of my M.Sc. student Sufyan Fadhil. We are doing characterization of PVC hollow fiber membranes fabricated in our laboratory (i.e. Scanning Electron Microscope (SEM), Atomic Force Microscope (AFM), Permporometer and measure the Contact Angles, etc...). The PVC hollow fiber membranes fabricated for UF and NF as a base membrane. Here we are feeling as same as in our university in Baghdad. Finally, I would like to thankful the director of the ITM, Dr. Lidietta and Professor Dr. Drioli for supporting this visit. Also I would like to thankful all of the research team of ITM, especially Dr. Alberto Figoli and Dr. Silvia Simone for helping us with advice.

When I was ready to departure from Spain to Rende I did not have any idea what I would find. It is curious to compare the real images of a place with those that are built in our minds before to arrive to a new destination. When I arrived to the "Università della Calabria" in Rende it was a big surprise to find such a big infrastructure and buildings, and even more, I was surprised to find so many people working in membrane research and developments. It was something that really took my attention because in my university the quantity of groups working in membrane technology is smaller than in CNR-ITM. In fact, few but important groups of the Chemical Engineering Department at Rovira y Virgili University (URV) in Tarragona are involved to topics related to membrane. I am glad to belong to one of these groups as a PhD student under the supervision of Dr. Ricard Garcia-Valls and Dr. Daniel Montané. Once arrived to ITM-CNR it was easy for me to understand why the people of CNR-ITM have a big impact in membrane research not only in Europe but in the rest of the world. For this reason as representation of URV it was a big challenge for me to learn and to perform a good role during the days of my short stay.

I was pleased to work in CNR-ITM with the team of Dr. Angelo Basile. They have a lot of experience in the fascinating world of membrane reactors and his name is a huge reference in this field. For me was an honour to be part of his work group. Not only for the quality of the scientific work developed but also the people who work with him. I was here in order to perform high temperature permeation experiments of carbon molecular sieves membranes supported on ceramic supports and also to evaluate the performance of this membrane in steam reforming of methanol. The work I have been developing in my University was basically fabrication and characterization of those nanostructured materials. However, before my arrival, I did not test these membranes in real applications. It was then a big challenge to learn about construction of mini-plants and also manipulation of variables to study a chemical reaction. I learned a lot about how to build the plant and also how to do a right interpretation the data obtained. It was very important for me to work with people with so many years of experience. I remember to be surprised with solutions I had in the lab thanks to the help of my laboratory. They helped me to solve in few minutes a problem that I thought would take hours to be solved. For this reason I can say, the experience was a big enrichment from professional and personal point of view. The long days in front of the "impianto" were delightful and full of recompense after finishing my three months of stay.

I just want to say thank you to all ITM-CNR for opened the doors to do my short stay. I was received for excellent people who had all the welcome procedure organized to do a very good welcome to the foreign students. I have to say thanks to all the excellent team Dr. Basile have in the laboratory. In fact I told him: you have gold here! I am so glad I had the opportunity to learn so many things inside and outside of the laboratory. The only thing I could not learn was the Cosenza soccer hymn, but maybe in a future I will do a new attempt.
Kelly Briceño, PhD Student at Rovira y Virgili University, Spain



Dr. Daniela Ebrasu, from the National Institute for Cryogenics and Isotopic Technology, ICIT-Rm. Valcea (Romania), was involved in the 2009 for 11 months in the experimental activities of the ITM-CNR in the contest of a MIUR Project (N.9589), based on the "Preparation and characterization of polymeric membranes for proton exchange membrane fuel cell". As an expert on proton exchange fuel cells, Daniela Ebrasu developed the characterization of sulfonated PEEK-WC polymeric membranes paying attention to the most important behaviours of these kind of membranes as a potential alternative to commercial Nafion membranes.

Short Visits (June - December 2009)



From 21 to 25 September, Ms. Priscila Anadão, PhD student of the *Universidade de São Paulo, Escola Politécnica, Departamento de Engenharia Metalúrgica e Materiais*, was the guest of John Jansen and Franco Tasselli in the ITM labs. In the framework of her PhD studies, Priscila Anadão has developed new mixed matrix membranes with clay and other filler particles. Her visit to ITM served as a training in membrane preparation by the phase inversion technique and of membrane testing, focused especially on ultra- or nanofiltration applications.

Dr. Lubos Novak from MEGA a.s. and Mrs. Dana Cerninova from the Czech Membrane Platform (CZEMP) visited ITM-CNR on 24 and 25 October. They discussed on membrane activities in Czech Republic and on the organization of the Membrane Sessions in the next CHISA Conference to be held in Prague on August 2010.

Prof. Shokry Elmarsfy and Akila Ahmed from Cairo University and Supervisor of Mr. Ashraf Ismail visited the Institute on November 16 and 17 for discussing possible collaborations between ITM and Egyptian Research organizations.

Dr. Sibdas Bandyopadhyay from the Central Glass and Ceramic Research Institute (CSIR), Kolkata and Dr. Mili Bandyopadhyay from City Correspondence College, Kolkata, India visited ITM on 20 - 26 October for discussing the preparation of joint research proposals in the framework of the Bilateral agreement ITM-CNR/CSIR.



Focus on Research at ITM

Integrated membrane operations in fruit juice processing

Over the last decade different research activities at ITM have focused on the development of integrated membrane operations in the fruit juice processing. These activities have been devoted to the development of processed items with increased shelf-life able to retain the peculiarity of fresh fruit as well as colour, aroma, nutritional value and structural characteristics.

Figure 1 shows a general scheme of an integrated membrane process applied to the industrial transformation of red oranges. Concentrated juices with total soluble solids concentration of 65-70°Brix and high total antioxidant activity have been obtained by combining different membrane processes operating at low temperatures. Similarly, integrated membrane processes have been designed for the clarification and concentration of different citrus juices (mandarine, bergamot, lemon, blond orange), fruit juices (cactus pear, kiwifruit, pomegranate) and vegetable juices (carrot)^{1,4}.

The recovery of bioactive compounds from fruit juices and by-products of the fruit juice processing (such as flavonoids and anthocyanins from orange press liquors, polyphenols from bergamot juice) has been also investigated. In particular, a process for the selective extraction and the concentration of polyphenols from by-products coming from the working cycle of red oranges (press liquors coming from red orange peels) and, generally, from fruits containing anthocyanins, through the integration of adsorbent resins and membrane operations, has been patented⁵. The proposed extraction process is based on the use of adsorbent resins and membrane operations. These technologies permit to avoid the use of reagents or toxic materials or materials with a high environmental impact. Anthocyanins are isolated by minimising their instability towards degradation. The use of the final concentrate as natural food colorant is a valid alternative to the use of artificial colorants which, in the manufacture of beverages based on citrus juices, have been considered harmful to human health.

A method for obtaining a pomegranate juice concentrate, starting from the fresh juice, with high nutritional and organoleptic properties has been also recently patented⁶. The proposed method is based on the use of an integrated membrane process constituted by an initial clarification step of the juice through an ultrafiltration process, followed by a concentration step operated by osmotic distillation. Both operations, performed at temperatures close to 25°C, permit to preserve the dissolved solids (sugars, vitamins, polyphenols, etc.) and the aromatic compounds obtaining a product at high antioxidant activity, which can be employed for the formulation of pharmaceuticals, cosmetics and food products.

1. A. Cassano, E. Drioli, G. Galaverna, R. Marchelli, G. Di Silvestro, P. Cagnasso, *J. Food Eng.*, 57 (2003) 153-163.
2. A. Cassano, B. Jiao, E. Drioli, *Food Res. Int.*, 37 (2004) 139-148.
3. A. Cassano, C. Conidi, R. Timpone, M. D'Avella, E. Drioli, *J. Food Eng.*, 80 (2007) 914-921.
4. G. Galaverna, G. Di Silvestro, A. Cassano, S. Storza, A. Dossena, E. Drioli, R. Marchelli, *Food Chem.*, 106 (2008) 1021-1030.
5. A. Cassano, E. Drioli, R. Timpone, M. D'Avella, *Patent RM 2006 A000436*.
6. E. Drioli, A. Cassano, *Patent RM 2009 A000484*.

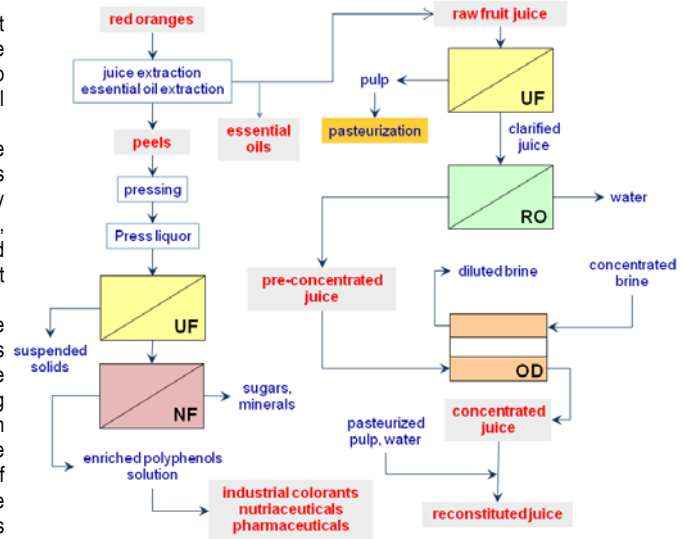


Figure 1 - Integrated membrane process in the industrial transformation of red oranges (UF=ultrafiltration; NF=nanofiltration; RO=reverse osmosis; OD=osmotic distillation)

Free volume in glassy perfluoropolymer membranes

The preparation of symmetric and asymmetric dense polymeric membranes and the study of their gas and vapour transport properties is one of the strategic research areas of ITM. This is witnessed by the involvement of ITM in various European research projects in this field, either as a participant (MultimatDesign, NanoGLOWA) or as the coordinator (DoubleNanoMem).

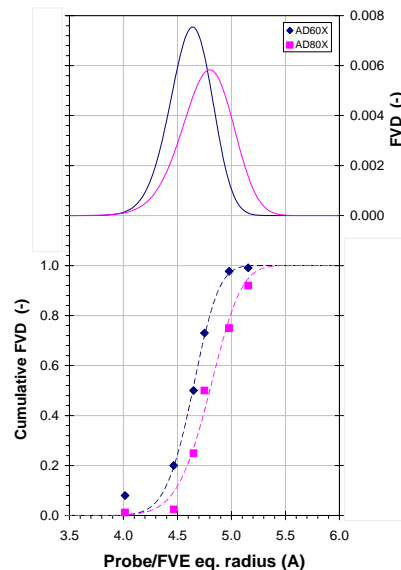


Figure 1. Free volume distribution curve of Hyflon AD (normal and cumulative) as a function of the equivalent sphere radius of the probe molecule or the free volume element. Data determined by photochromic probing.

One of the crucial parameters which determine the permeability and the permselectivity of polymeric membranes is their overall free volume and their free volume size distribution. Recently, ITM researchers, in collaboration with the AV Topchiev Institute of Petrochemical Synthesis and the N. N. Semenov Institute of Chemical Physics (Moscow, Russian Federation) and with GKSS (Teltow, Germany), have analyzed the free volume distribution in two different grades of Hyflon AD (Solvay Solexis) [1]. This is an amorphous glassy perfluoropolymer with a moderately high gas permeability and with excellent chemical stability, and with a high resistance to solvents and vapours. This combination of properties makes these materials interesting for application as gas separation membranes that should operate under harsh conditions, for instance in the presence of reactive species or condensable vapours which would corrode or plasticize the commonly used polymeric membranes. Gas and vapour transport properties of Hyflon membranes have been studied previously [2,3].

The results of several experimental free volume probing methods (e.g. photochromic probing (figure 1), Positron Annihilation Lifetime Spectroscopy, Inverse Gas Chromatography, Xe-NMR) were compared with those of molecular dynamics simulation studies. The latter proved particularly powerful, providing a truly 3-dimensional view of the free volume distribution (see figure 2). Careful analysis of the differences between the various experimental methods provides deep insight into the fundamental aspects of each individual probing technique.

1. J.C. Jansen, M. Macchione, E. Tocci, L. De Lorenzo, Yu.P. Yampolskii, O. Sanfirova, V.P. Shantarovich, M. Heuchel, D. Hofmann, E. Drioli, *Comparative study of different probing techniques for the analysis of the free volume distribution in amorphous glassy perfluoropolymers*, *Macromolecules* 42 (2009) 7589-7604. DOI: 10.1021/ma901244d.
2. M. Macchione, J.C. Jansen, G. De Luca, E. Tocci, M. Longeri and E. Drioli, *Experimental analysis and simulation of the gas transport in dense Hyflon® AD60X membranes. Influence of residual solvent*, *Polymer* 48 (2007) 2619-2635. DOI:10.1016/j.polymer.2007.02.068.
3. J.C. Jansen, K. Friess et al., *ICOM2008 and Euromembrane 2009*.

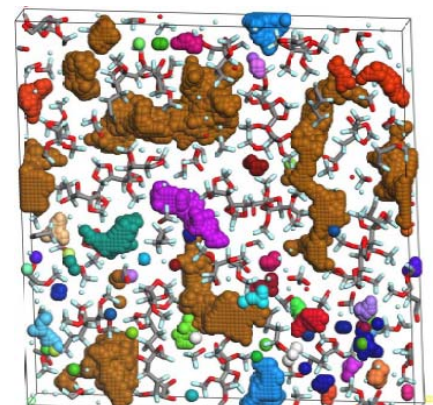


Figure 2. Distribution of the free volume elements in Hyflon AD glassy perfluoropolymer membranes, as obtained by molecular dynamics simulation studies.

New Projects Approved and New Signed Agreements

EURINDIA



ERASMUS MUNDUS

The Erasmus Mundus and External Cooperation Window project, EURINDIA, officially started on 4 August 2009. The project, funded by the European Commission and coordinated by KTH Royal Institute of Technology, Sweden, will have a duration of 4 years. EURINDIA provides scholarships for educational and staff exchange between European and Indian universities and research institutions. The consortium 'EURINDIA' will establish mobility of 201 individuals from reputed Indian Higher Education institutions and research centres to the European partner universities and vice versa.

There are 10 European [EGE University (Izmir, Turkey); Hochschule Karlsruhe (Germany); Institute of Chemical Technology (Prague, Czech Republic); Katholieke Universiteit Leuven (Belgium); Politecnico di Torino (Italy); TU Delft (Netherlands); Universitat de Girona (Spain); Universiteit Gent (Belgium); Universität Göttingen (Germany)] and 8 Indian partner institutions [Anna University (Chennai); Anugrah Narayan College (Patna); IIT Guwahati; IIT Roorkee; National Law University of India (Bangalore); Tamil Nadu Agricultural University (Coimbatore); University of Kalyani; University of Pune], as well as 1 associate partner in Europe (ITM-CNR) and 2 associate partners in India [CII - Sorabji Godrej Green Business Centre (Hyderabad, India); Mahratta Chamber of Commerce Industries and Agriculture (Pune, India)]. The person in charge of the scientific activities for ITM is Dr. Alberto Figoli.

The prioritized subject areas have a broad focus on sustainable development on all societal levels. The broad thematic expertise within the consortium enables applicants to select among several universities in Europe and in India. It is the aim of the partnership the participating institutions shall have ongoing mobility with as many partners as possible.

This mobility programme will only be the beginning of a long-lasting cooperation between the partners with the aims also to start-up joint research projects also including industry. More information is available at the following website: http://www.kth.se/om/internationalit/eurindia?!=en_UK

CapWa

CapWa - Capture of evaporated water with novel membranes

Funding Scheme: FP7 - NMP - Nanosciences, Nanotechnologies, Materials and New Production Technologies - FP7-NMP-2009-SMALL-3

Duration: 36 months

The project, funded by the European Commission (EC) under the FP7, brings together universities, industry and SMEs. It is focused on the development of gas separating polymeric membranes capable of capturing evaporated water in air streams. The objective of the project is the transfer from lab-scale to full scale production of selective water vapour separating membranes with the aim is to have commercially available membrane modules suitable for industrial applications which are competitive with existing technologies within 3 to 4 years.

Capwa is coordinated by KEMA (The Netherlands), while ITM-CNR covers different roles. In particular, it has the responsibility of the "central testing laboratory" of the membranes prepared by other partners devoted to the membrane development and it will also focus the activity on a modelling/simulation phase taking into account all significant/peculiar aspects of the related membrane systems in order to optimize the operating conditions for reaching a defined requirement.

Furthermore, the ITM-CNR research will be devoted on the development of microporous hydrophobic hollow fiber membranes for the selective removal of water utilizing a cheap, polymeric membrane as promoter and barrier for water condensation.

Other partners: Israel Electric Corporation (Israel), Union Fenosa (Spain), Centre of Competence Paper and Board (KCPK) (The Netherlands), Membrana GmbH (Germany), European Membrane Institute (EMI) (The Netherlands), National Engineering School of Tunisia (Tunisia), Kwame Nkumah University of Science and Technology (Ghana), Brabat Water (The Netherlands), Cut Membrane Technology GmbH&Co (Germany), Papiertechnische Stiftung (Germany), Sappi Manufacturing Pty Ltd. (South Africa), Yodfat Engineers (1994) Ltd. (Israel).



LoLiPEM

LoLiPEM: Long-life PEM-FCH & CHP systems at temperatures higher than 100°C

Funding Scheme: Collaborative project, Co-funded by EU-FP7-Fuel Cells and Hydrogen Joint Undertaking (FCH JU) under the call FCH-JU.2008.1 - SP1-JTI-FCH-3.3: Degradation and lifetime fundamentals.

Duration: 36 months

The project is focused on the development of long-life SPG&CHP systems based on PEMFCHs working at temperatures $\geq 100^\circ\text{C}$. In particular, the research will be developed in two directions: the first one, devoted to the creation of improved polymeric electrolyte membranes and electrodes, fulfilling the requirements of long term durability for stationary fuel cell operation in air at temperatures by at least 20°C higher than that of the state-of-the-art. The second devoted to the realization development of a Modular multi-PEMFCHs system for Combined Heat and Power. Dr. Giuseppe Barbieri, researcher at ITM-CNR is the coordinator of the project. Other partners: University of Roma "Tor Vergata" (Italy), University of Provence (France); University of Saarbruecken (Germany); Edison Spa (Italy); Fumatech (Germany); MATGAS 2000 A.I.E. (Spain); Cracow University of Technology (Poland).



ILMC - IIF Marie Curie Fellowship

Next February will start a new Marie Curie Actions—International Incoming Fellowships (IIF), FP7-PEOPLE-IIF-2008, on "Preparation of ionic liquid microcapsule membranes loaded and their application in NMVOCs removal" coordinated by Dr. A. Figoli. The project will fund the grant of the post doctorate, Dr. *Shanthana Lakshmi Duraikkannu*, coming from India. The project will have a duration of 2 years.



APQ OLIO

APQ OIL - Design, study and development of technological systems for the recovery of water and the extraction of bioactive compounds for new applications from by-products of olive oil industry

Funding Scheme: PON-POR APQ Calabria

Coordinator: APOR (Gioia Tauro, RC)

Duration: 36 months

A National Research Project concerning the recovery of high added value products (such as polyphenols) from olive mill and vegetable waters has been recently approved. It is supported by Calabria Region and involves two small and medium enterprises (APOR and D.G.N. Olearia s.a.s.) and two research Institutes (Istituto Industrie Agrarie of University of Bologna and ITM-CNR). Prof. Enrico Drioli is the Scientific Responsible on behalf of ITM.

CNR Bilateral Agreements

Two Bilateral Scientific and Technological Bilateral Cooperation Agreements between the Italian National Research Council (CNR), Italy, and the Council of Scientific & Industrial Research (CSIR), India have been approved. The Agreements jointly promote the exchange of researchers from both Institutions.

The first one entitled "Membrane contactors for arsenic(III) to arsenic(V) conversion" started on September 2009. It is a three-year project coordinated by Dr. ing. Alessandra Criscuoli (from ITM) and Dr. Swachchha Majumdar (from the Central Glass & Ceramic Research Institute - CGCRI).

In the first months of activity, two Indian scientists were hosted by ITM-CNR: Dr. Sibdas Bandyopadhyay, who studied the performance of polymeric membrane contactors for water aeration and Dr. Ganesh Sahoo, who made experiments of arsenic oxidation on polymeric membrane contactors and investigated the reaction mechanism involved in the process. Prof. Enrico Drioli and Dr. Catia Algieri were also hosted by the Central Glass & Ceramic Research Institute (CGCRI) in India. In particular, Dr. C. Algieri analysed in details the methodology utilised by the Indian researchers in the preparation of the macroporous ceramic membranes and ceramic supports. The possibility to use these materials for the preparation of supported zeolite membranes utilising also the novel seeding procedure designed at ITM-CNR was considered.

The second one "Functionalized ZnO nano tubular membrane assembly for CO₂ capturing: design, fabrication and performance assessment studies" has been signed between ITM-CNR and the Sol-gel Nano Ceramics Section of Materials and Minerals Division of the National Institute for Interdisciplinary Science & Technology (NIIST). The project activities, focused on the preparation and characterization of functionalized ZnO nano tubular membrane for CO₂ capture, are already in progress and will end in 2011. In particular, the Indian partners will develop improved nanofunctionalized membranes, which will be tested by ITM-CNR. Furthermore, ITM-CNR will employ its knowledge for the analysis and simulation of gas separation processes also of industrial interest. The project is coordinated by Eng Giuseppe Barbieri for the Italian side and Dr. Solaippan Ananthakumar for the Indian side.

Projects Meetings and Related Activities

IMeTI Workshop



The IMeTI workshop "Membrane applications in Agrofood" was organized by the Institute on Membrane Technology (ITM-CNR) and was held at the Grand Hotel S. Michele, in the beautiful landscape of Cetraro, on the west coast of Calabria.

The event was attended by various representatives coming not only from partner institutions, but also from other universities, research institutes and industrial companies, which presented the results of their activities providing the basis for interesting conversations, exchange of ideas and experiences and for future collaborations.

The theme of international cooperation involving universities of different nationalities and industries was of central importance in the meeting. For this reason, a brokerage event was held during the poster session, which was also animated by novel ideas, being mainly performed by young scientists.

The topic of the conference concerned the application of membrane technology in various fields of agrofood industry, such as the extraction of valuable/therapeutic compounds from fruits, plants or natural products as propolis, the treatment of matrices such as wine, beer, fruit juice and milk, and the production of emulsions. With the aim of extrapolating and resuming from the three days of lectures and discussions, the most interesting topics addressed during the conference were:

- "Classical" examples of membrane application in the food industry: treatment of milk and other dairy products, concentration/clarification of fruit juices, wine, beer etc...
- Membrane emulsification and its application in the food industry.
- High value natural compounds (HVNC), such as flavour and fragrance, dietary supplement/nutraceutical and pharmaceutically active compounds, recovery.
- Integration between different membrane operations, design of new membranes and implementation of new process with the aim of redesign the transformation cycles of fruits and vegetables, for improving the quality of the products, for recovering valuable compounds also from by-products and reducing energy consumption, production of waste and environmental impact.

The final lecture, held by Dr. Lidieta Giorno, Director of ITM-CNR, regarded the application of Biocatalytic membrane reactors (BMRs) for the production of functional food. Biocatalytic membrane reactors combine the advantages of a biological catalyst with the properties of a perm-selective membrane. BMRs find wide applications in the food industry such as in the processing of starch (production of cyclodextrines or oligosaccharides), oil and fat (ester synthesis to produce emulsifiers, aroma compounds, free fatty acids, mono- and diglycerides), fruit juice (pectin hydrolysis), milk and whey (hydrolysis of lactose and proteins to reduce problems connected to lactose intolerance and milk proteins allergy).

IMeTI Project Meeting



The IMeTI project meeting took place at CNRS in Montpellier, France on September 11, 2009.

All 7 partners (Imperial College, ITM-CNR, MET, University of Chemical Technology and Metallurgy, CNRS, Hyflux and GVS S. P. A.) gave a presentation on their scientific project achievements and the project management team reviewed the status and deliverables for the Work packages.

From ITM-CNR, Dr Alberto FIGOLI and Dr. Seung-Hak CHOI participated and presented the activities carried out at ITM.

Their presentations concerned the following topics.

- 1: Application of high temperature gas separation using inorganic membrane supplied by Hyflux.
- 2: Preparation and characterization of co-polyimide hollow fibres and modules for gas separation.
- 3: Membrane preparation and characterization for organic solvent nanofiltration (OSN).
- 4: Collaboration with industrial partner (GVS).

Dr. Seung-Hak CHOI will visit GVS in Bologna (Italy) for his secondment in industrial partner for three months from January 2010.

MEDINA in China



Three years ago the European Commission decided to boost the sustainable development of desalination processes through the financing of Membrane-Based Desalination: An Integrated Approach project (acronym MEDINA) within the scope of its 6th Framework Program.



The main aim of the project was to improve the overall performance of membrane-based water desalination processes by applying an innovative approach based on the integration of different membrane operations in the reverse osmosis (RO) pre-treatment and post-treatment stages accordingly to the philosophy of Process Intensification.

Now the project is going to its end (foreseen for January 2010). Therefore, a concrete dissemination policy has been started for the diffusion and discussion of the results of

potential interest for industrial exploitation.

The first dissemination activity concerned the organization of the EU-CHINA Workshop on MEDINA project in China. The event was co-organized by the MEDINA Consortium, the Ocean University of China, the China Desalination Association and Qingdao International Desalination Center. It was held at the Academic Exchange Centre of Ocean University of China (Qingdao, China) on September 4th -6th, 2009.

The goal of the workshop was to strengthen the exchanges and cooperation between China and Europe in seawater and salty water desalination, and to increase the communication between industry and academicians.

Representatives from Ocean University of China, Chia Nan University of Pharmacy and Science, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Nanjing University of Technology, Tianjin University, Tsinghua University, Harbin Institute of Technology, Nanyang Technological University (Singapore), Toray Industries, The Dow Chemical Company (China), and China Desalination Association have been present together with a very large number of MEDINA delegations which include representatives from Australia, Tunisia and Israel. Through Prof. Gary Amy, one of the MEDINA partner and today director of the new membrane centre at the King Abdullah University of Science & Technology, also Saudi Arabia was present.

Moreover, representatives from other European projects (MEDESOL and ASDECO) also attended the workshop and had the possibility to participate to the discussion and to present their results.

Interesting and fruitful speeches were made by experts and professionals focusing on the policy, the progresses and the results reached in the projects. The possibility of trans-nation research and cooperation between MEDINA and other countries, especially with China, was discussed.

2009 China-EU International Summit on Membrane Engineering, Weihai (China)



The China-EU Summit on Membrane Engineering in Water Treatments and Reuse that took place 1-3 November in Weihai, China was organized by Noppen (Shanghai) Co., Ltd, Harbin Institute of Technology, and National Engineering Research Center of Urban Water Resources; and co-organized by Weihai Foreign Exchange Center of Science and Technology, ITM-CNR, Membrane Industry Association of China, China Urban Water Association and China-EU Membrane Technology Research Institute.

The aim of the conference was to promote a common platform for scientific exchanges between Chinese and European researchers on latest research works in the field of membrane engineering in water

treatment and reuse. Members of the European Society contributed to the meeting.

The scientific program of the Conference included from the European side: Enrico Drioli, Lidieta Giorno and Alfredo Cassano from ITM; Kang Li, Professor at Imperial College of London, Department of Chemical Engineering; Frank Lipnizk of Alfalfaval; Immaculada Ortiz, Professor at Universidad de Santander (Spain); Dr. Suzana Pereira Nunes, GKSS Research Centre (Germany); Prof. Bart Van der Bruggen, Katholieke Universiteit Leuven (Belgium); Dr. Pierre Aimar, Université Paul Sabatier-Toulouse 3 (France).

Different topics in the area of membrane technology application in wastewater treatment, industrial application of membrane technology, nanofiltration and pervaporation in waste water treatment, polymeric membranes, and cooperation at the Sino-EU Membrane Technology Development and Research Center (Weihai) were covered.



Nanoglowa - Second meeting of 3rd year

The second meeting of the 3rd year of the NANOGLOWA project was held on 2-4 November in Enschede (The Netherlands). This project, funded by the European Commission (EC) under FP6, brings together universities, power plant operators, industry and SMEs. 26 organisations from 14 countries throughout Europe join the NANOGLOWA-consortium for developing optimal nanostructured membranes and installations for CO₂ capture from power plants. In particular, this meeting was focused firstly on the results achieved by testing the membranes in a real power plant (Israel) and secondly, on the design and development of membrane modules in hollow fibres and flat sheet configuration. Since the membranes had some problems related to the SO₂ content in the flue gas stream, a deep discussion was conducted on the possibility of using pre-treatment of the stream before feeding the membrane module. Furthermore, wide attention was paid on the membrane module configuration in order to avoid problems such as preferential paths or pressure drops. In order to foresee the membrane module performance and to prevent some drawbacks in the pilot plant tests which will be carry on in the fourth year, a new set of operating conditions for the testing on big-lab-scale level was defined. These tests will be performed by the partner from Poland which will add also SO₂ in the simulated flue gas stream.

The ITM-CNR which has the responsibility of the "central testing laboratory" of the membranes prepared by other partners devoted to the membrane development will continue the testing on other several membranes supplied by the WP1-WP5 and it will also focus the activity on a modelling/simulation phase with which will analyzes the single or multi- membrane stages performance on CO₂ removal from flue gas streams." www.nanoglowa.com

Seminars

On September 30, Dr. Enzo Menna of the *University of Padua, Italy*, gave a seminar entitled "Chemistry of Carbon Nanotubes". Dr. Menna, expert in the functionalization of carbon nanotubes for a variety of applications, is an associate researcher of the ITM section of Padua. His visit to the ITM laboratories was related to his involvement in the FP7 project DoubleNanoMem, coordinated by ITM, in which carbon nanotubes will be used to tailor the transport properties in hybrid polymeric membranes. In his seminar Enzo Menna focused on the different ways to functionalize CNTs with the aim to improve CNT dispersion in the polymer matrix, to facilitate their alignment and/or to modulate their transport properties.

Brandon W. Rowe of the *University of Texas, Austin, USA*, gave a lecture on "Physical aging behavior of ultra-thin glassy polymer films" on October 9. Brandon Rowe, who recently obtained his PhD degree under the supervision of Prof. Don Paul and Prof. Benny Freeman, discussed in particular his work on the depth profiling of the Free Volume in polymeric membranes by Positron Annihilation Lifetime Spectroscopy. Such information is important for the understanding of the transport properties of dense polymeric membranes for gas and vapour separations, as witnessed also by a recent publication of ITM researchers (Jansen et al., *Macromolecules* 2009) on the free volume probing in glassy perfluoropolymers (see publications list elsewhere in this newsletter).

Upcoming Conferences and Scientific Events

In combination with the IV Italy- Korea Forum on Science and Technology to be held in Naples (Italy) on June 3-4, 2010 and sponsored by the Italian Ministry for Foreign Affairs, the VI Italy- Korea Workshop on Membranes will be carried out on June 4-5, 2010.

The Forum is aimed to provide an ideal venue of exchanging information and opinions among experts and government officials on the recent status of research and development both in Italy and Korea in sectors of mutual interest ranging from S&T Policy and the more advanced technologies. A Session on "New Selective Transport Processes in Biotechnology" will be chaired by Prof. Enrico Drioli from ITM-CNR:

The Workshop will be addressed to 'Membranes for Green Technology' and co-organized by ITM-CNR and the Korea Research Institute of Chemical Technology (KRICT). As well as in the previous editions, the aim of the Italy-Korea Workshops is to promote the discussion on membrane science and technology in the two Countries and in particular on the fundamentals and applications of membranes for a clean environment and energy saving, providing excellent opportunities for researchers from academia and industries to be informed on the recent developments in membrane research and development, to get a perspective on the novel and emerging technologies and to meet leading experts and industrialists.

NanoMemCourse on Nanostructured Materials and Membranes for Food Processing, Cetraro - Rende, 15 - 24 Sept. 2010

The NanoMemCourse is a series of training courses funded under the scheme "Marie Curie Conference and Training Courses Action" designed to deliver to young researchers the most relevant state of the art knowledge on nanostructured materials for a career development in line with the scientific, industrial and societal needs and challenges. One of these courses will be organized by ITM-CNR and will be entirely devoted to "Food Processing".

<http://www.nanomemcourse.eu/new/site/courses/EA3/index.htm>

ECI Conference on Advances in Science and Engineering for Brackish Water and Seawater Desalination, Cetraro, May 9-12, 2010

Water stress is becoming a major problem worldwide which negatively affects the overall quality of life and industrial development. Reclamation of new alternative water sources like sea-brackish water desalination and the necessity to reuse purified wastewater represent an important part of the water supply in many areas of the world, particularly in Europe, the U.S., Australia and Japan. The reclaimed/reused water can help meet the increasing municipal, industrial, and agricultural demands for water. Moreover, water management (production - treatment - distribution) can be completely redesigned in order to alleviate water shortages in modern, advanced city planning.

The ECI conference on "Advances in Science and Engineering for Brackish Water and Seawater Desalination" will address advances in seawater and brackish water desalination, water purification and their strong relation to new technologies and process intensification strategy.

Topics of the Conference will be:

Membrane Engineering for Process Intensification; Membrane engineering in desalination and water treatment; Progress in thermal desalination and water purification processes; Desalination and the Environment; Wastewater treatment and reuse; Membrane contactors and new desalination technologies; Worldwide efforts for the improvement of Water Problem: The MEDINA project and other projects in progress. <http://www.engconfintl.org/10ag.html>



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The ITM News is published by the **Istituto per la Tecnologia delle Membrane (ITM-CNR)** del Consiglio Nazionale delle Ricerche

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