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## EMCC5



The 5<sup>th</sup> Chemical Engineering Conference for Collaborative Research in Eastern Mediterranean Countries (EMCC5) was held on 24 - 29 May 2008 at the Grand Hotel San Michele in Cetraro (CS) - Italy.

The EMCC5 Conference aimed to bring together scientists from Eastern Mediterranean Areas and from USA. More than 60 speakers, among the major representatives of the Chemical Engineering area, have been invited for presenting their recent research activities with the scope of establishing collaborative research links and promoting scientific discussions on the various topics of specific interest.

Also, young researchers and PhD students participated to the meeting and to the discussions presenting posters (about 70) with new ideas and research progresses.

The Conference was organized by the Institute on Membrane Technology, ITM-CNR and chaired by Prof. Enrico Drioli.

The scientific program was structured in five Oral Sessions, focused on the following topics:

- Multiscale modelling: from molecular to process engineering; Sustainable and intensified processing; Chemical- and bio- engineering for energy; Biomaterials and bioprocesses for health care; Water purification, reclamation and reuse; Nanostructured and functionalised materials for products and processes.

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## New Visiting Scientists to ITM-CNR (Sept. 2007 - June 2008)

- ★ Corina-Petronela MUSTERET, from the "Gheorghe Asachi" Technical University of Iasi (Romania) is spending a two-months staying at ITM-CNR for conducting studies on the use of ultrafiltration in wastewater treatment as well as documentation and dissemination of existent research results in the field of sustainable and integrated water management.
- ★ Prof. May-Britt HÄGG from the Norwegian University of Science and Technology (Trondheim, Norway) was on sabbatical leave at ITM-CNR from March to May 2008. During this period Prof. HÄGG presented two Seminars on : Membranes in gas application with special focus on energy - Part I: Choices of materials and transport mechanisms and Membranes in gas application with special focus on energy - Part II: Membranes in energy production.
- ★ Dr. Pavel IZAK from the Department of Separation Processes of the Institute of Chemical Process Fundamentals (Rozvojová, Czech Republic ) gave a Seminar on "Recovery of acetone, butanol and ethanol from Clostridium acetobutylicum fermentation broth by pervaporation through supported ionic liquid membrane" on April 22, 2008.
- ★ Dr. Sudip CHAKRABORTY from the Jadavpur University (Calcutta, India) was admitted to the International Doctorate School "Pitagora" in Engineering, activated for the first time at the University of Calabria. Dr. Chakraborty will conduct his studies on Chemical and Materials Engineering, also at the Institute on Membrane Technology (ITM-CNR), in particular on Biosensor/Bio-Reactor Development and Membrane Based Separation Technology under the supervision of Prof. Enrico Drioli and Dr. Lidietta Giorno.
- ★ Dr. Piyush MITTAL from the Indian Institute of Technology Guwahati (Assam, India) will spend 3 months (May 6 - July 25) at the Membrane Laboratories of ITM-CNR, within the framework of the 2008 Summer Internship . During his visit, Dr. Mittal will participate to the activities of the Institute, attending Seminars and discussing on research project in progress in the area of membrane science and membrane engineering, particularly on hybrid membranes for gases separations, as H<sub>2</sub> or CO<sub>2</sub> purifications.
- ★ In the framework of the ERASMUS agreement between the İzmir Institute of Technology (İzmir, Turkey), ITM-CNR and the University of Calabria, Prof. Sacide ALSOY ALTINKAYA will spend six-days at the ITM-CNR. During this period, Prof. Altinkaya will give a series of lectures on:
  - Critical Review of Membrane Permeation Models;
  - Selectivity-Permeability Analysis for Membranes;
  - Applications of Membranes in Biotechnology/Biomedical Fields;
  - Modeling of Hollow Fiber Enzymatic Reactors;
  - Importance of Asymmetric Membrane Structures. Modeling of Asymmetric Membrane Formation by Dry-Casting Method.
- ★ Dr. Sophie CERNEAUX of the University of Montpellier (Montpellier, France) visited the ITM-CNR on March 18-20. Some membrane measurements on a tubular membrane were jointly carried out during her visit. The separative layer was grafted on a ceramic porous support.
- ★ Dr. Marius Sandru from the Norwegian University of Science and Technology (Norway) visited ITM laboratories on April 2008. The procedure necessary to utilize facilitated site carrier (FSC) membranes was discussed and utilized before the testing of membranes with concentration gradient method.



Marinus Sandru (NTNU), Francesco Scura and Adele Brunetti (ITM) - Discussion on the data measured at ITM on an FSC membrane supplied by NTNU

## PUBLICATIONS (from November 2007 to May 2008)

- ★ Barbieri, G., Brunetti, A., Tricoli, G., Drioli, E., An innovative configuration of a Pd-based membrane reactor for the production of pure hydrogen. Experimental analysis of water gas shift, *J. Power Sources*, 2008, in press
- ★ Barbieri, G., Scura, F., Brunetti, A., Mathematical modelling of Pd-alloy membrane reactors, in *Inorganic Membranes: Synthesis, Characterization and Applications*, 13, ISBN-13: 978-0-444-53070-7 (Membrane science and technology series, ISSN 0927-5193) 2008 – Elsevier B.V., Edited by R. Mallada and M. Menendez.
- ★ Basile, A., Gallucci, F., Iulianelli, A., Tereschchenko, G.F., Ermilova, M.M., Orekhova, N.V., Ti-Ni-Pd dense membranes - The effect of the gas mixtures on the hydrogen permeation, *Journal of Membrane Science* 310 (2008) 44–50
- ★ Basile, A., Iulianelli, Alternative sulfonated polymers to Nafion for PEM fuel cell, Chapter 3, in *Fuel Cell Research Trends*, L.O. Vasquez (Ed.), Nova Science Pub. Inc., 2007, ISBN: 1-60021-669-2, pp. 135-160
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- ★ Bernardo, P., Algieri, C., Barbieri, G., Drioli, E., Hydrogen purification from carbon monoxide by means of selective oxidation using zeolite membranes, *Separation and Purification Technology*, 2008, accepted
- ★ Buonomenna, M.G., Figoli, A., Spezzano, I., Davoli, M., Drioli, E., New PVDF microcapsules for application in catalysis, *Applied Catalysis B: Environmental*, 80 (2008) 185-194
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- ★ Chiappetta, G., Clarizia, G., Drioli, E., Theoretical analysis of the effect of catalyst mass distribution and operation parameters on the performance of a Pd-based membrane reactor for water gas shift reaction, *Chemical Engineering Journal* 136 (2008) 373-382.
- ★ Clarizia, G., Algieri, C., Regina, A., Drioli, E., Zeolite-based composite membranes: gas transport and surface properties, *Microp. Mesop. Mater.* 2008, in press.
- ★ Criscuoli, A., Carnevale, M.C., Drioli, E., Evaluation of energy requirements in membrane distillation, *Chem. Eng. Proc.*, accepted
- ★ Criscuoli, A., Drioli, E., Membrane contactors for gaseous streams treatments, in *Handbook of Membrane Separations: Chemical, Pharmaceutical and Biotechnological Applications* Eds. A.K. Pabby, A.M. Sastre, S.S. Rizvi. Production editor. K. Kwak, Marcel Dekker, Inc., in press
- ★ De Bartolo, L., Morelli, S., Rende, M., Campana, C., Salerno, S., Quintiero, N., Drioli, E., Human hepatocyte morphology and functions in a multibore fiber bioreactor, *Macromolecular Bioscience* 7 (2007) 671-680.
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- ★ De Luca, G., Di Maio, F.P., Di Renzo, A., Drioli, E., Droplet detachment in cross-flow membrane emulsification: Comparison among torque- and force-based models, *Chemical Engineering and Processing* 47 (2008) 1150 - 1158

## Patents

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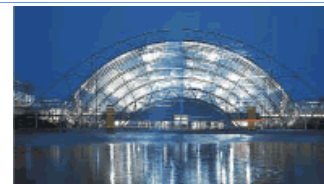
## INTERNATIONAL EVENTS

### World Filtration Congress WFC10, Leipzig (Germany)

The 10<sup>th</sup> World Filtration Congress was held in Leipzig (Germany) on April 14-18, 2008.

The WFC10 was structured in technical Short Courses presented by leading experts in the first day. Three and a half days were planned for the technical Congress and major Exhibition. More than 350 technical presentations with 7 concurrent sessions were presented and a major international exhibition featuring all relevant aspects of filtration and separation. It has been particularly interesting to realize as today membrane operations play a strategic role in the "Filtration World". More than 25 sessions at the WFC-10 have been in fact dedicated to this technology.

The Director of ITM was invited for giving a lecture on "Membrane Separation".



### PROMEMBRANE International Conference, Sfax (Tunisia)



In the frame of the (SSA) ProMembrane project, financed by the European Union, the ProMembrane International Conference took place in Sfax, Tunisia from 4 to 8 of May 2008 at the Centre of Biotechnology.

This International Conference constitutes the most relevant event held under the project ProMembrane and aims to contribute to ProMembrane objectives, which are:

- to support the current research activities in membrane technology for water treatment in the Mediterranean Region,
- to promote and facilitate the dissemination, transfer and exploitation of results of current and past research in the field,
- to encourage the permanent participation of young scientists in the field of membrane technology, and to promote the establishment of permanent communication links between research centres, universities and industry in the Mediterranean region, promoting the know - how exchange and expertise in relation to membrane technologies.

Two presentations were given by Prof. E. Drioli and Dr. A. Figoli on "Membrane Engineering in Desalination and Wastewater Reuse" and "Membrane Operations for Water Purification", respectively.

### NATO/SPS Pilot Project, Berlin (Germany)



The NATO/SPS Pilot Project on "Clean Products and Processes" 2008 Annual Meeting was held on 4-9 May 2008 in Berlin (Germany). The meeting was hosted by the Federal Environmental Agency, Germany and supported by the NATO Science for Peace and Security Programme and U.S. Environmental Protection Agency.

Clean Products and Processes Project enables tools for industrial sustainability, such as analytical and methodological tools for cleaner production, and metrics to measure progress toward cleaner production and sustainability.

Delegates from thirty-one countries belonging to the North Atlantic Treaty Organization (NATO), Central and Eastern European partner countries, and Mediterranean Dialogue countries participate in this pilot study, promoting cleaner production and sustainable technologies through collaborative research projects. The Institute on Membrane Technology is the representative for the Italian side.

Two presentations on "New application of membrane contactors" and "An integrated membrane system for advances biogas production, recovery and valorisation" were given by Dr. Alessandra Criscuoli and Prof. Enrico Drioli.



### Korea – Italy Workshop on "Water and Wastewater Treatment and Reuse", Daejeon (Korea)

A Korea – Italy Workshop on "Water and Wastewater Treatment and Reuse", was held in Daejeon (Korea) on June 9 - 10, 2008. This event was sponsored by the Italian Embassy and the Italian Trade Office in Korea and jointly organized with the collaboration of ITM-CNR, the Korea Research Institute of Chemical Technology (KRICT) and the Seoul National University.

This initiative takes place in a sector of growing importance such as that of water and wastewater treatment and reuse in urban areas, where only strategic technical solutions can guarantee a good life quality. The Workshop was attended by leading experts coming from the academic and industrial world which will exchange their knowledge and experience with the aim of building strong relationships between the two Countries.

Dr. Kew- Ho Lee from KRICT was honoured by the Government of Italy with the title of Commander of the Star of Solidarity.

Prof. Enrico Drioli and Dr. Lidietta Giorno presented two lectures on "Water recovery and reuse and advanced products formulations with integrated membrane operations" and "Membrane bioreactors for water reuse", respectively.



### Pre-conference of the 14<sup>th</sup> International Congress on Catalysis (ICC 14), Dalian (China)



Prof. Enrico Drioli, as member of the International Advisory Board of the State Key Laboratory of Catalysis, has been invited to attend a meeting to be held in July 8-9, 2008, Dalian (China). In this meeting, scientists from the State Key Laboratory of Catalysis will present their recent research activities and the board members will discuss the future research directions for the laboratory.

Prof. Drioli has also been invited to the Nanocatalysis: Fundamental and Applications, which is a Pre-conference of the 14<sup>th</sup> International Congress on Catalysis, where he will give an oral presentation on "Catalytic membrane and catalytic membrane reactors: an integrated approach to catalytic process with an high efficiency and a low environmental impact".

This Pre-conference will be held in Dalian, China, July 9-12, 2008 and will mainly focus on fundamental issues and practical applications of nanocatalysis for understanding and defining the underlying concepts. It will also offer a unique blend of the various scientific disciplines (physics, chemistry, materials, and theoretical simulations) that play essential roles in understanding catalysis on the nanoscale.

## Training Summer School on Membrane Engineering, Weihai (China)

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A Training Summer School on Membrane Engineering will be held in Weihai (China) in early October 2008.

The event supported by the Chinese Government and the Shandong authorities will be jointly organized by the Harbin University, the Shandong University and ITM-CNR.

Main scope of the Training Summer School is to promote cooperation and scientific exchanges between China and European Union.

## NEW RESEARCH PROJECTS

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### IMeTI

The IMeTI (Implementation of Membrane Technology to Industry) Project has been approved and funded by the European Commission under the Marie Curie Actions -- Industry-Academia Partnership and Pathways (IAPP).

The IMeTI proposal aims to create a programme for implementation of membrane technology into industry based on experience and knowledge transfer between Academia and Industry. The project involves the integration of the invention of new membranes and applications in the University/Research Institute Partners with the subsequent development of the necessary membrane technology up to processing scale by the SMEs. A key feature of this project will be the interdisciplinary nature of the Partners, and the fact that they bring inter-sectorial competence to the network. The knowledge transfer and training programme involves Early Stage Researchers (ESR), at both university and industrial partners. IMeTI seeks to contribute to improving the European knowledge supply chain through this industry-academia programme of applied research aimed at developing engineers and scientists who are academically excellent and industrially experienced.

Prof. Enrico Drioli and Eng. Giuseppe Barbieri will serve as Principal investigators for ITM.

### NEMOPOUR

ITM-CNR is a partner in the NEMOPOUR (New Molecular Purification Technologies For Pharmaceutical Production) project, a Marie Curie Initial Training Networks (ITN) of the FP7-PEOPLE-2007-1-1-ITN call, recently approved. The NEMOPOUR consortium consists of 3 universities/research institutes, 2 technology SMEs and 4 end users. The coordinator is the Imperial College of Science Technology and Medicine (UK). Other partners are: University of Dortmund (Germany), Membrane Extraction Technology Limited (UK), MIP Technologies AB (Sweden), Hovione Farmaciencia SA (Switzerland), UCB Pharma SA (Belgium), GlaxoSmithKline Research and Development Limited (UK), Lonza Limited (Switzerland).

Main tasks of the NEMOPOUR project are:

Task 1 – Establish Model Purification Challenges and Genotoxic Impurity Analysis

Task 2 – Create New Generation OSN Membranes Through Templating

Task 3 – Create New Generation Technologies for MIP

Task 4 – MIP Film Composite Membranes

Task 5 – Combine Techniques and Business Cases

Task 6 – Proof-of-Concept at Large Lab Scale

Prof. Enrico Drioli, Dr. Lidietta Giorno, Dr. Alessandra Criscuoli and Dr. Enrica Fontananova will participate to the project.

### NAPOLYNET

On April 1<sup>st</sup> the Project entitled "NaPolyNet - Setting up research-intensive clusters across the EU on characterization of polymer nanostructures", a Coordination Support Action focused on Theme 4 "Nanoscience, Nanotechnologies, Materials and New Production Technologies" has been approved. The project is supported by the European Commission under the 7<sup>th</sup> Framework Programme and completely fall within the general objective and scope of the call NMP-2007-2.1-3 Characterisation of nanostructured materials.

NaPolyNet is a 36-month project involving 15 partners from 10 European countries. The objectives are to network at regional, national and international level with experts on the characterization of polymer nanostructured materials in the field of packaging, textiles and membranes, bridging the gap between scientific and engineering approaches for the improved understanding of the structure-performance correlation in polymer devices. Another objective is to facilitate transnational access to important and unique equipment and to train young scientists and SMEs technologists. The coordinator is Dr. Clara Silvestre of the Institute of Chemistry and Technology of Polymers – ICTP-CNR. Other participants are: Institute on Membrane Technology – ITM-CNR, Italy, Bulgarian Academy of Sciences Central Laboratory of Physico-Chemical Mechanics- Bulgaria, Polymer Physics Group - Institute of Physics - University of Rostock – Germany, Department of Physics and Polymer Science Centre University of Reading – UK, National Technical University of Athens Department of Physics – Greece, Romanian Academy "Petru Poni" Institute of Macromolecular Chemistry-Romania, SOPRA-SA- France, Dep. of Macromolecular Physics, Fac. of Mathematics and Physics, Charles University, Prague- Czech Republic, GVS- Italy, University of Surrey- UK, SciTe B.V. – The Netherlands, NanoBioMatters Ltd. – Spain, Department of Chemistry, University of Napoli "Federico II"- Italy Spain, DIN – Germany and Inotex - Czech Republic.

Dr. Elena Tocci will serve as principal investigator, for the ITM Team.

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## MEDIRAS

ITM - CNR is involved in the project Membrane Distillation in Remote Areas (MEDIRAS) which is in the approval phase by the European Commission within FP7 (Type of funding scheme: Collaborative Project; Work programme topics addressed: ENERGY.2007.4.1.3: Small distributed systems for seawater desalination).

Countries involved in the project are: Germany, Italy, Tunisia, Belgium and Spain.

Main tasks for ITM-CNR are the development of brine disposal units and brine cooler and the design of membrane distillation units

Prof. Enrico Drioli and Dr. Alessandra Criscuoli will serve as principal investigators for the ITM team.

## TIME

The Calabria Region in the Framework of "POR Calabria 2000-2006 – Misura 3.7- Azione A – Tirocinio di ricerca" approved the research training projects "TIME – Tirocini in operazioni innovative a membrana, di interesse anche industriale, per separazioni selettive ed a basso impatto ambientale (Apprenticeship in innovative membrane operations, also of industrial interest, for separations selective and with low environment impact)" promoted by the ITM-CNR in the field of membrane science and technology.

The Imperial College London (UK), the GKSS (Germany), the University of Athens (Greece), the GVS SpA (Italy) are the hosting Institutions or Companies where the young researchers have to spent few months as foresaw by the call.

The selected young researchers are Iolanda CIMIERI, Fabio BAZZARELLI, Carmen SANCINETO, Maria RENDE, Patrizia CAIRO, Carla CAMPANA.

## PROJECTS MEETINGS AND RELATED ACTIVITIES

### NanoMemPro: Semi-Annual Meeting - 19<sup>th</sup> - 20<sup>th</sup> March 2008, Paris



The Semi-Annual Meeting of the NanoMemPro project took place on March 19 and 20 in Paris. The event started on March 20 with the presentations of the activities of the different Work Packages; Dr. Lidietta Giorno, as leader of Work Package 11.2 : Food Quality: Safer Production Methods, gave an overview of WP11.2 Progress & Main Results M36-M42.

In the following day, the industrial aspects of the projects were also analyzed in order to make a step towards an effective integration of research activities, training, equipment and R&D.

Successively, the Executive Committee, the Integrated Management Team and the Governing Board have been also assembled for discussing on the 3<sup>rd</sup> EC review report, for promoting dissemination activities and for setting up the strategies of the European Membrane House (EMH), the new created legal entity.

### NanoMemPro: NanoMemFood Workshop - 21<sup>st</sup> March 2008, Paris

The Institute on Membrane Technology (ITM-CNR), as leader of the WP11.2, organized the NanoMemFood Workshop on "Membrane Processes in Food: safe and sustainable production methods" which was held in Paris on 20 March 2008 at ENCPB - Ecole Nationale de Chimie, Physique et Biologie.

The Workshop was organized in the framework of the European Network of Excellence on Nanoscale-based Membrane Technologies NanoMemPro" (Coordinator: Gilbert Rios, IEM-CNRS) and particularly within the activities of the Work Package 11.2 Food Quality: Safer Production Methods (Leader: Lidietta Giorno, ITM-CNR) who served as Chairperson of the event and also gave a presentation on "Membrane Technologies Development in Food". Aim of the Workshop was to set the state of the art and breakthrough advances needed in membranes and membrane processes in food industry.

To this regard, various members of the Club of Interest together with academic experts operating in the agro-food sector have been invited for discussing and identifying sustainable research strategies.

## Exchange of people within NanoMemPro Project

Since June 2007, Dr. **Karel Friess**, senior researcher of the Laboratory of Membrane Separation Processes of the Institute of Chemical Technology in Prague (ICTP), is hosted by the ITM-CNR in Rende. The aim of this exchange is two-fold: first of all, it is a first step to establish a long term cooperation between the two laboratories in the area of gas/vapour sorption and permeation in polymeric membranes. Secondly, the visit is aimed at an exchange of scientific expertise. Dr. Friess, expert in the sorption of gases and vapours in polymeric membranes will train students and young researchers in this discipline and will contribute to develop short and medium term research plans. At the same time Dr. Friess will have the possibility to perform gas permeation measurements at the time-lag setup available in the ITM laboratories to establish standardized procedures.

In particular, the attention is focused on transport of gases and vapours through dense amorphous perfluoropolymer membranes. Perfluoropolymers have an extraordinary chemical and thermal stability and they are traditionally known as solvent-resistant. However, some amorphous glassy high-free-volume perfluoropolymers appear to be remarkably permeable to a select number of vapours, offering perspectives for certain gas/gas, gas/vapour and vapour/vapour separations under demanding conditions where traditional polymers may not resist due to chemical degradation, plasticization etc.. Therefore this study is aimed at the determination of structure/permeability relationships and at a detailed analysis of the transport parameters (sorption as well as diffusion coefficients) in these materials. Such information is important for acquiring knowledge of the fundamental transport phenomena in these remarkable materials, necessary for an evaluation of their future potential in industrial separation processes.

After the return of Dr. Friess at ICTP, the activities will be continued at both laboratories with sorption measurements (ICTP) and with permeability measurements and free volume analysis (ITM). Developed procedures lead to results that will be in part presented at the Chisa conference and in scientific publications (in preparation). The benefit of this cultural and scientific exchange of Karel Friess not only consists in the above mentioned work, but also in reciprocal skill and knowledge transfer, and in planned future cooperation. The latter should be consolidated in common research projects, as in the framework of FP7.

## NanoMemPro Demonstration, Rende (Italy)

ITM-CNR is preparing on 23 and 24 of June 2008 a practical demonstration on the production and use of porous hydrophobic membranes for application as membrane contactors. This two-day activity will take place in the ITM laboratories in Rende, Italy, as one of the activities of the 6<sup>th</sup> Framework Program's Network of Excellence "NanoMemPro". The program is spread over two days where various aspects of membrane contactors will be discussed. The demonstration is open to all NanoMemPro members and to members of the club of interest.

## Promembrane, Cetraro (Italy)

The Promembrane Specific Support Action (FP6-EU project) is ending in August 2008 and ITM-CNR will host the final meeting of the project in Cetraro (CS) on 20-21 July 2008. The project has the aim of supporting the current research and development activities in membrane technology focused on water treatment in the Mediterranean area. During the meeting, the results accomplished in the two years project will be discussed and the possibility of encouraging and promoting further research activities in membrane technologies among Mediterranean partners will be also considered.

## CAMERE, Cetraro (Italy)

The Third Annual Meeting of the project CAMERE (FIRB-RBNE03JCR5) "Nuove membrane catalitiche e reattori catalitici a membrana per reazioni selettive come sistemi avanzati per uno sviluppo sostenibile" will be held in Cetraro (CS) on September 4-5, 2008.

This research project focuses on the development of new catalytic membranes and catalytic membrane reactors for selective reactions as advanced systems for an industrial sustainable development in the logic of the process intensification strategy.

During the meeting, all the activities carried out by the different Partners will be discussed, and also the future activities will be presented.

## MULTIMATDESIGN, Teltow (Germany)



Project logo

The research project "Computer aided molecular design of multifunctional materials with controlled permeability properties – MULTIMATDESIGN" has ended on the 29th of February after 36 months of activities (march 2005 - february 2008). The project has been supported by the European Commission under the 6th Framework Programme and has contributed to the implementation of the NMP programme (Contract NMP3-CT-2005-013644). Total cost EUR: 3.591.617, Commission funding EUR: 2.100.000, web page <http://multimatdesign.gkss.de/>

Under the coordination of Dr. Dieter Hofmann of the Institute of Polymer Research, GKSS Research Center (Germany), for MULTIMATDESIGN project 11 partners from 8 European countries have been involved: National Centre for Scientific Research "Demokritos" (Greece), L'Air Liquide (France), Institute on Membrane Technology – ITM-CNR (Italy), Accelrys Ltd. (United Kingdom), Universiteit Leiden (The Netherlands), MatSim GmbH (Switzerland), TIPS - A. V. Topchiev Institute of

Petrochemical Synthesis (Russia), Politecnico di Milano (Italy), Alma Mater Studiorum - Università di Bologna (Italy), Culgy (The Netherlands).

The project aimed at an improved understanding and the knowledge-based design of multi-functional polymeric materials, i.e. membranes, that combine controlled permeability to selected small molecules with various other properties needed to ensure processability, durability and multiple end-uses.

This aim has been pursued by the development and extensive application of multiscale computer-aided material design (CAMD) methodology, complemented with computer-assisted evaluation of end-use performance of the membranes in question. Simulation results have also been validated against experimental data. The main idea of the MULTIMATDESIGN workplan has been that to combine efforts of leading European CAMD software developers/providers, experimentalists and users of CAMD and other modelling software to demonstrate that breakthrough solutions are possible for the design of multifunctional materials membranes with key permeability related properties.

In this framework the ITM effort has been devoted to the design by using MD simulations of different types of membrane materials, i.e., polymer/polymer composites and glassy high free volume membranes for applications in technical separation processes. Bulk and interface models of a block poly(ether/amide) membranes, PEBA@2533, formed by soft blocks of poly-tetramethyleneoxide (PTMO, 80%) interspersed with hard segments of poly[imino(1-oxododecamethylene)] or Nylon12 (PA, 20%), also with different amount, from 10 to 70% w/w, of the additive o/p-N-ethyl-toluensulphonamide (KET). The models have been investigated concerning the diffusion gases and of water molecules in the polymer matrix and the influence on transport in function of different additives. A quantum - mechanical approach in combination with experimental infrared analysis and MD simulation, has also been used for the establishment of the mechanism that controls the water sorption in modified Pebax membranes. To provide useful property – structure relation, perfluorinated high free volume membranes, i.e., Hyflon AD60 and Hyflon AD80, have been studied concerning the relation between free volume distribution and their gas transport properties.

In cooperation with l'Air Liquide and GKSS researchers, a methodology composed out of several computational methods combining atomistic modelling of models of polymer membrane materials with MD calculations as well as transition state theory (TST) simulation of transport properties of small gas molecules in the "old" models followed by Quantitative Structure Activity Relationship (QSAR) analysis for the design of new polymer materials has been proposed.

Simulation results have been validated against experimental data. In parallel to the theoretical effort, experimental characterisation of the influence of solvent type, film casting and drying, membrane thermal treatment on permeability (solubility, diffusivity) of membranes of glassy perfluorinated polymers and on polyamide copolymers, for permanent gases and vapours, has been performed. As a result an innovative method to evaluate the size distribution of free volume elements in Hyflon AD membranes by photochromic probes has been developed.

The researches have been spread out in national and international congress and 9 articles have been published on international journals.



Kick-off Meeting in Teltow (March 2005)

## WP2 and WP5 MEDINA Meetings, Toulouse (France)

Membrane-Based Desalination: An Integrated Approach (acronym MEDINA) is one of the research project funded by the European Commission within its 6th Framework Program. The project started on 15th October 2006, it had its First Annual Meeting in Banyuls (FRANCE) on 8th – 9th October 2007 and is scheduled for seventeen more months. This multinational and multidisciplinary project is led by a consortium of 13 research teams of proven and complementary expertise whose aim is to develop a work programme for improving the current design and operation practices of membrane systems used for water desalination. ITM researchers are active as sub-contractors in MEDINA.

In the first year of the project, a relevant coordination activity has led to a strong interaction between partners strengthened by the frequent reunions during several specific work packages meetings, conference calls and the annual project meeting. A fruitful exchange of information and scientific results there was also during the WP2 and WP5 semi-annual meetings on April 29th – 30th, 2008, held at INSA Toulouse (FRANCE).

Within WP2 meeting, different conventional processes and novel methods of pre-treatment for SWRO desalination have been compared in term of SDI, MFI and NOM removal. The objective is to improve the selection and optimisation of pre-treatment upstream of desalination membrane processes in order to lead to a more robust and sustainable operation of desalination systems. It is undoubted, in fact, that the improvement of specific operation practices related to premature membrane fouling leads to the minimisation of shut-down times and membrane replacement needs, thereby reducing the operating costs.

MEDINA project team also proposes innovative solutions to reduce the volume of concentrate streams usually discharged by the desalination plants. This is the research matter in the framework of WP5. To that end, the members suggest the introduction of the avant-garde and pioneering Membrane Distillation, Membrane Crystallization and WAIV evaporation techniques in order to recover the salts usually dissolved in the concentrated streams of the desalination plants and to increase the recovery factors of desalination plants. This also leads to the reduction of brine volumes to be discharged in the environment and, therefore, to the minimization of desalination plants environmental impacts. In order to realize this goal, WP5 research members are considering different design alternatives whose performance is evaluated in term of membrane fouling, produced salts, trans-membrane flux, fresh water recovery factor and control of the process.

In the opinion of the MEDINA research team, the development of these new techniques and the improvement of operation practices (e.g. optimized membrane pre- and post-treatment processes) will contribute to a more widespread use of membrane technologies for water desalination and, consequently, to more secure and cheaper water production systems.

## MISCELLANEOUS

### European Roadmap for Process Intensification

A European Roadmap has been prepared by an international team of experts for identifying the potential benefits of Process Intensification and to illustrate the actions that are recommended for the acceleration of PI implementation in the process industry.

The PI Roadmap has been developed for the following sectors:

PETCHEM – Petrochemicals, bulk chemicals

FINEPHARM – Specialty chemicals, pharmaceuticals

INFOOD – Food ingredients

CONFOOD – Consumer food

Various of the research projects in progress at ITM-CNR have been indicated in the report as areas of interest and priorities (e.g. membrane reactors, membrane distillation, membrane crystallizers, etc. and in general membrane engineering.

[http://www.senternovem.nl/mmfiles/Report%20%27European%20Roadmap%20for%20Process%20Intensification%27\\_tcm24-258503.pdf](http://www.senternovem.nl/mmfiles/Report%20%27European%20Roadmap%20for%20Process%20Intensification%27_tcm24-258503.pdf)

### Working Party on Nanotechnology and Clean Water

The Organization for Economic Co-operation and Development (OECD) Committee for Scientific and Technological Policy (CSTP) set up a new Working Party on Nanotechnology (WPN) in March 2007. The overall objective of the WPN is to advise on emerging policy-relevant issues in science, technology, and innovation related to the responsible development of nanotechnology.

The work of the WPN focuses on issues related to the development of indicators, assessments of nanotechnology impacts on companies and business environments, international R&D collaboration, outreach and public engagement, and contributions to global challenges. The WPN also seeks to involve companies in order to secure industry relevancy and the promotion of nanotechnology applications and commercialization.

Prof. Drioli has been invited to serve as an expert in the panels of the OECD project "Nanotechnology and clean water".

Website: [www.oecd.org/sti/nano](http://www.oecd.org/sti/nano)

### BIO NANO INSIDER Newsletter

Last Fall, the Bio-Nano Insider Newsletter was published by the Italian Trade Commission of Los Angeles with the aim of providing news about Italy's up-and-coming bio-nano sectors, and bring the potential readers up-to-speed on the latest collaborations and investment opportunities.

An article on the research in membrane technology performed at ITM appeared in the Fall 2007 issue. In particular, with their ability to filter chemicals on a nano-scale, membranes have the potential to solve many of today's most pressing ecological problems, from cleaning waste waters to producing the purest hydrogen for fuel cells.

Website: <http://www.zangani.com/node/1010>

## Memorandum of Understanding

During a recent visit of Prof. Drioli at Gwangju Institute of Science and Technology in Gwangju, Korea, for attending a Specialist Seminar on Seawater Desalination Technology, a Memorandum of Understanding on Research Cooperation has been signed between ITM-CNR and the Center for Seawater Desalination Plant (Gwangju, Korea) in order to promote research collaborations between the two Institutions.

## Masters, PhDs, Trainings performed at ITM - CNR laboratories

In the framework of the collaboration with the University of Calabria, the ITM-CNR laboratories accommodate students for performing researches related to their master and PhD theses and training activities. The following PhD students of the Doctorate in Chemical Engineering and Materials defended their theses on Feb. 14, 2008.

**Adele Brunetti**, Integrated membrane plant for hydrogen production for PEM-FC

**Francesco Scura**, Engineering of membrane gas separation

**Gianluca Di Profio**, Advanced processes of molecular separation for chemical, environmental, agro-food, pharmaceutical and polymeric application: membrane contactors

**Enrica Fontananova**, Development of new polymeric and composite membranes for application in catalysis and fuel cell

During 2007, 19 students mainly in Biology, carried out their requested period of experimental training in the ITM Laboratories.

About 22 students, moreover, in Chemical Engineering, in Chemistry and in Pharmaceutical Technology, in Pharmacy, and in Biology have been working in ITM Laboratories for their experimental master theses, under the supervision of ITM researchers in the academic year 2006-2007.

## Catalogue of ESF Best Practices

The National Project "FOREME - Formazione di ricercatori ed esperti nel settore delle operazioni a membrana, anche integrate, in processi di interesse industriale" funded by the Ministry of Education, University and Research and carried on by the ITM-CNR has been recently enclosed in the National Catalogue of ESF Best Practices. The "National Catalogue of Best Practices related to the ESF, Programmes and Community Initiatives and implemented in Italy in 2000-2006 period" is a project promoted by the Ministry of Labour and Social Security - Directorate General for Guidance and Training Policies within the national System Actions with the intent to foster the transfer and dissemination of Best Practices as a strategic instrument for their innovation, dissemination, valorisation and mainstreaming.

The main criteria for qualifying projects as best practices are as follows: availability of clear, standard, reliable and synthetic information on carried out initiatives; initiative efficacy; innovation; implementation adequacy to the programming plan of actions when available; level of replication and transfer able to guarantee the absence of insuperable obstacles; long-term sustainability according to costs; capacity of horizontal and vertical mainstreaming; the presence of cues to be a lesson for the goals of 2007-2013 programming.

## Focus on Researches at ITM

### NANOGLLOWA

The most currently used technology for CO<sub>2</sub> capture and separation is via absorption that requires huge energy consumption and installations costs. The application of nanostructured membranes for CO<sub>2</sub> capture and separation brings down the energy penalty and installation demands. In this logic, NANOGLLOWA project, funded by the European Commission (EC) under the 6th Framework Programme, brings together universities, power plant operators, industry and SMEs. 26 organisations from 14 countries throughout Europe join the NANOGLLOWA-consortium for developing optimal nanostructured membranes and installations for CO<sub>2</sub> capture from power plants.

The ITM-CNR has the responsibility of the "central testing laboratory" of the membranes prepared by other partners devoted to the membrane development. This is an important role because the information obtained from testing, in fact, will be fundamental for the successive designing of the membrane units.

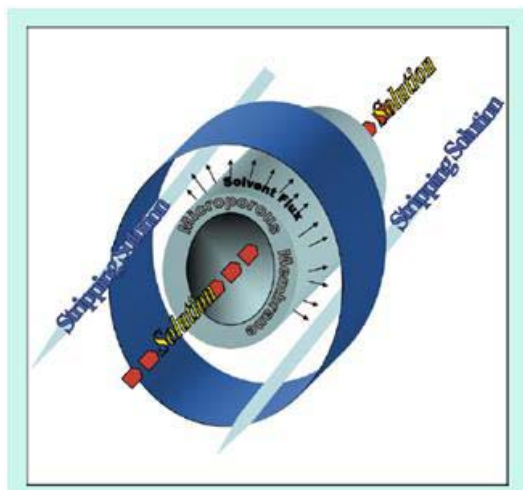
The membrane properties (permeance and selectivity) are measured for single gases (N<sub>2</sub>, CO<sub>2</sub>, O<sub>2</sub>, etc.) or gas mixtures at set operating conditions (temperature, pressure, relative humidity, etc.), with different methods such as pressure drop, concentration gradient and constant volume.

The activity of the first year of the ITM-CNR regarded the testing of several membranes of the various partner. In particular, the FSC membrane supplied by NTNU, the PEBAX1074 with and without carbon nanotubes loading supplied by the University of Twente and the ceramic membranes of ENSCM were tested. The preliminary results showed good membrane performances both in terms of permeance and selectivity, measuring a CO<sub>2</sub>/N<sub>2</sub> selectivity ranging from 30 to ca. 100 (FSC membrane by NTNU) in dependence of the operating condition. Furthermore, in this first year, the continuous exchange among the central testing laboratory and the different partners, stimulated the improvement in the membrane preparation for achieving better membrane performance. In fact, new membranes of different materials and with different configuration (i.e. hollow fiber) are already and will be under testing in next year.





## Polymorph control: past, present and future



The microporous membrane separates two isothermal solutions. Appropriate choice of the outer solution, the stripping solution, leads to the progressive concentration of the inner solution. This method is able to control accurately the rate of solvent transfer which affects the morphology, the crystallinity and the polymorph of the product. By controlling the rate of concentration change, thermodynamic or kinetic control can be achieved. At low solvent transfer rates, the amount of supersaturation is low and the more stable polymorphs have time to grow at the expense of the less stable forms. At high solvent transfer rates, the amount of supersaturation is high and this induces nucleation, favouring the appearance and growth of a metastable polymorph. In Di Profio et al.'s paper [97] the fine control of the solvent exchange rate through the membrane allowed the formation of either the g-glycine polymorph or the a-glycine polymorph, as required.

In a recent review which appeared on Drug Discovery Today, the studies on membrane crystallizers at ITM have been discussed with particular attention. (*Antonio Llina` s and Jonathan M. Goodman, Drug Discovery Today, Volume 13, Numbers 5/6, March 2008*).

The appearance and disappearance of polymorphs is no longer a mysterious and inexplicable process. Although methods for polymorph control are still imperfect, there is a large army of methods that can be used to tackle this important and challenging problem. We survey the methods and their successes over the last few years.

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### Crystallization using microporous membranes

Microporous membranes have recently been used in the development of a new method of crystallisation. The membrane acts as a physical support separating two isothermal solutions, and allows solvent to move between them [92]. This method has the advantage of being able to control the rate of solvent transfer accurately and this affects the morphology and the crystallinity of the product obtained [93], in both inorganic [94] and organic materials [95,96]. Di Profio et al. [97] have shown how this technique can be applied to the generation of specific polymorphs of glycine. The kinetics of nucleation is related to the width of the metastable zone, which can be increased by adjusting the solvent transfer rate. By controlling these parameters thermodynamic or kinetic control is achieved. At low solvent transfer rates the more stable polymorph has time to grow at the expense of the less stable form; high solvent transfer rates induce nucleation at higher values of supersaturation, favouring the appearance and growth of metastable polymorphs. Lee and co-workers [98,99] have investigated the effect of the solvent evaporation rate on the polymorph distribution of a- and b-glycine. In Di Profio et al.'s paper [97] the fine control of the solvent transport rate through the microporous membrane always yielded the g-glycine polymorph. In static membrane crystallization experiments, careful control of the concentration of the stripping solution inside the membrane always produced the a-glycine polymorph. It is too early to fully assess the value of this approach to the pharmaceutical industry, but the application of this technique could have a big impact in polymorph selection and production.

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