



# NanoMemPro

“Expanding membrane macroscale applications  
by exploring nanoscale material properties”

Newsletter of the Network of Excellence “NanoMemPro”

Year 1, Issue 2, October 2005. Contact person: Kitty Nymeijer (e-mail: [d.c.nijmeijer@utwente.nl](mailto:d.c.nijmeijer@utwente.nl))

Dear NanoMemPro partner,

In front of you, you have the second 6 month newsletter of NanoMemPro, Network of Excellence, subsidised by the European Union. After one year of NanoMemPro, I think we performed a tremendous amount of work and we currently have an extensive and clear overview of who-is-who, who-does-what, and what our common interests for research proposals are. Based on this information we should use the coming year to translate this knowledge into joint research proposals, projects and collaborations.

Another important aim of the Network of Excellence is the exchange of people within the network. Several exchanges were organized over the past months, as you shall read in this newsletter. But I think that we have to put more effort on this issue, to have people travelling and visiting the research institutes and laboratories of the NanoMemPro partners. In fact, the exchange of people contributes to a large extent to the aims of the network and allows the exchange of knowledge!

Kind Regards,

Kitty Nymeijer ([d.c.nijmeijer@utwente.nl](mailto:d.c.nijmeijer@utwente.nl))

## Upcoming NanoMemPro Events

### **Annual Meeting NanoMemPro**

October 11-14, 2005, CNRS (Montpellier - France). Organised by Gilbert. M. Rios (CNRS-IEM).

### **NanoMemPro meeting days (M18) (to be confirmed)**

Suggested dates: March 20-22, 2006, Vito (Leuven - Belgium). Combined with workshop about Solvent Filtration. Several workshops and meetings for the different work packages will be organized.

### **NanoMemPro meeting days (M24) (to be confirmed)**

Suggested dates: September 20-22, 2006, ITM-CNR (Taormina – Italy). Combined with Euromembrane. Several workshops and meetings for the different work packages will be organized.

NanoMemPro e-Newsletter. The internal news bulletin of the NanoMemPro Network of Excellence (RTD-Project 6<sup>th</sup> FP, NoE, Contract No. NMP3-CT-2004-500623). Contact Details: NanoMemPro, Dr.ir. Kitty Nymeijer. University of Twente - Membrane Technology Group. P.O. Box 217. 7500 AE Enschede - The Netherlands. Tel.: +31(0)53-4894185/2950. Fax: +31(0)53-489461. [d.c.nijmeijer@utwente.nl](mailto:d.c.nijmeijer@utwente.nl). Circulation and Distribution: All NanoMemPro partners. Electronic. Also available online at: [www.nanomempro.com](http://www.nanomempro.com)

## **Workshop on Back-design and mass production of membrane material (WP 10)**

ITM-CNR, Rende, April 4, 2005

*Lidietta Giorno*

On 04.04.2005 at ITM-CNR in Rende (Italy) was performed the first workshop on Work Package (WP) 10 *Back-design and mass production of membrane material*.

The main objectives of this work package are:

- To identify and provide indications of the optimal characteristics of the membranes and processes in specific applications of significant industrial interest.
- To translate the nano-material science concepts for new and optimized membranes into large-scale production processes.

Representatives of ten partners and three members of the Club of Interest attended the workshop.

The overall analysis confirmed that membrane operations are, in principle, among the most important technologies answering the process intensification concepts and requirements, since they offer various advantages in terms of improvements in manufacturing and processing, substantially decreasing the equipment-size/production-capacity ratio, energy consumption, and/or waste production and resulting in cheaper, sustainable technical solutions.

One of the main and rapidly growing applications is water treatment, which nowadays involves about 40% of the total use of membranes. The market moved from the classical modules to submerged systems because of their possibility to reduce overall costs.

Two main bottlenecks in the use of membrane technology in this field are: Fouling and Membrane breakage.

Presently, producers of NF and RO membranes are outside Europe. European companies are mainly end users not membrane producers and membranes available in the European market satisfy their

requirements. It was remarked that in Europe it is not possible to produce costs reducing membranes, whereas other countries -such as Japan or the USA- are already very advanced in this field. European companies cannot compete with the current prices of about \$10/m<sup>2</sup> and it is now probably too late to step into this market. The market still has some openings in temperature resistant RO membranes and in inorganic membranes applied in fields where polymeric membranes are not traditional (e.g. high temperature membrane reactors, certain solvent applications, membrane emulsification). It was also pointed out that RO membranes are basically still based on cellulose acetate as was the case 30 years ago and that new materials are necessary to have new developments.

Gas producers are not easily convinced to change technology. Highly selective membranes are required which give less than 0.1% of methane loss; removal of vapours from permeate may require vacuum, which is not easily accepted because of the risk of explosion in case of system leaks.

Wider acceptance of membrane processes requires a better understanding of this technology by the end user.

Concerning standardization of membrane properties, it was suggested to carry out an analysis of the state of the art in order to identify better the different parameters. Suggestions from the Club of Interest are expected to help carrying out such an analysis. Data given about membrane performance are often depending on the way they are obtained. For instance, Nominal Molecular Weight Cut Off (NMWCO) is not a measure of molar mass but of the hydrodynamic volume of the rejected species in the particular solution. This makes comparison of results difficult. Such results are often not a measure of performance. A better criterion would be for instance the virus removal efficiency of the membrane. Standardization is therefore desirable. A close interaction with other work packages dealing with these aspects will be considered (in particular WP 11.1, which deals with standardization of processes and WP 7, which deals with standardization of tools and methods).

## Workshop on Food quality: Safer production methods

### (WP 11.2)

ITM-CNR, Rende, April 5, 2005

Lidietta Giorno

On 05.04.2005 at ITM-CNR in Rende (Italy) was performed the first workshop on Work Package (WP) 11.2 *Food quality: safer production methods*.

The main objectives of this work package are:

- The development of new technologies working at molecular level starting from new concepts of biocatalytic membrane reactors, biosensors, affinity membranes, membrane contactors.
- The study of new and intelligent polymer membrane films for food packaging.
- The investigation of new ways to control food texture.
- Development of membrane technologies to obtain liquid food ingredients of higher quality.

Representatives of eight partners and three members of the Club of Interest attended the workshop.

The needs and challenges in today food production were analysed. Important aspects to be considered are:

- Quality (maintaining or improving flavour, colour, texture)
- Safety (at a microbiological and chemical level, it is mandatory that materials and methodologies used during processing and preservation do not induce the presence of hazardous compounds)
- Stability ("fresh food" with medium / long-term shelf-life)
- Convenience (that food be produced in easy-to-use forms)
- Waste prevention, minimization, valorization and recycling (prevention rather than afterwards cleaning up)
- Formulation (new products starting from new and enabling raw materials and processing)
- Sustainability (meeting today's needs without compromising the ability of future generations to meet their own needs).

To achieve these challenges, all the steps in food manufacturing have to be considered (e.g. where and how the food is produced, processed, packaged,

preserved, distributed, prepared and disposed of, consumed).

It was pointed out that sustainability in food production should start from a "*sustainable food consumption*", which means that in addition to developing new materials and technologies, new consumers' habits have to be developed.

Furthermore, to afford a sustainable growth, it is necessary to maximize mass and energy utilization as well as maximizing recovery and recycling. To achieve this, new raw materials new technologies have to be considered. Raw materials have to be abundant, non toxic, with the right properties to be processed ; they must have a high content of the wanted nutrients, few deteriorating compounds, that grow fast with low need for water and nutrients, etc. Genetic Engineering is one of the enabling technologies that has to be properly considered and integrated into processing technologies. The "a priori" refusal of GMO thus has to be overcome, and a multidisciplinary approach developed.

Europe must be aware of the fact that other (especially developing) Countries are and will develop and use GM technology and that the risk for Europe of losing knowledge and competitiveness is huge.

The technologies involved have to be clean, safe, low energy consuming ; they shall preserve properties of products and co-products, and allow new product formulation.

All participants agreed on membrane operations being among the most suitable technologies for food processing (they allow to carry out concentration and separation without using heat; innovative formulation strategies; equipments flexible, needing small space, and easy to scale-up -they are enabling technologies and answer well to the process intensification strategy- ; operating costs are low; little energy is used ; products are high quality; so are co-products (which is very important for by-product valorization, waste prevention and minimization).

Members of the CoI underlined the convenience of converting wastes into added value components or into non harmful compounds, rather than separating them from one phase to another.

In food industry membrane technology was dominated by the application in treatment of whey and milk, whey protein concentration, followed by beverages, wine, beer, juices.

New applications of membrane technology in food processing (mainly carried out at lab scale) concern:

- Fractionation of vegetal proteins (for their use as nutraceuticals)

- Biocatalytic membrane reactors (to improve processability, to transform deterioration components, to valorize co-products)
- New product formulation (encapsulation, emulsion)
- Food packaging, in particular the preparation of aseptic (bio)packaging with controlled atmosphere (to increase the non-refrigerated shelf-life and availability of fresh and perishable food).

The general perception concerning research priority on membranes in food, within the present work package, was that research efforts should focus on:

a) The functionalization of membranes for:

- enzyme immobilization (biocatalytic membrane reactors)
- antibody and/or biomimetic selectors immobilization (affinity membranes)
- cell/biomolecules repulsive surfaces (to control biofouling)
- membrane hydrophobicity enhancement for MC application
- bioreactive and/or biomimetic-reactive molecules immobilization (biosensors)
- biomolecules immobilisation on biofilms to detect the presence of harmful substances (e.g. accidentally or voluntarily introduced during storage and distribution chain) (Bio-packaging/sensor)
- the improvement of films biocompatibility (food packaging).

b) BioPackaging able to

- keep an aseptic and controlled atmosphere
- activate and control the release of bacteriostatic biomolecules
- show improved biocompatible and biodegradable properties.

c) The improvement of food texture by formulation of new encapsulated and emulsified food ingredients. For example, (inorganic) membranes with a pore size of a few nm, uniform size distribution, geometric and uniform disposition on the surface are needed in order to obtain stable emulsions that could limit or avoid the use of emulsifiers.

e) Optimization of integrated processes (including MF, UF, NF, RO, MC, PV, submerged MBR) to maximize production, minimize wastes, valorize co-products, purify and recycle water within the same production cycle.

In order to complete the analysis with inputs from the other members of the Club of Interest not present at the workshop, it was decided to prepare a schematic questionnaire and circulate it among them.

This was considered important also in view of the fact that the next dead line for IP and STREP proposals within the "Thematic Priority 5: Food Quality and Safety" is October 2005, and that the "interest" and "needs" of the Col members active in food industry should be the main driving force for proposals development.

## Exchange of people within NanoMemPro

### University of Twente (Netherlands) → Imperial College (United Kingdom)

Last July, Tymen Visser, a Ph.D. student in the Membrane Technology Group of the University of Twente visited Imperial College for a period of one week to carry out experiments with high pressure infra red spectroscopy. Tymen currently studies the plasticization behavior of glassy polymer membranes used for gas separation. Standard experimental techniques available in his own lab (e.g. gas permeation, sorption, dilation) to analyze CO<sub>2</sub>-induced plasticization effects generally give one-sided and indirect information, whereas infra red spectroscopy can give information about the solubility of CO<sub>2</sub> and simultaneously information about the dilation of the glassy polymer exposed to CO<sub>2</sub>.

### GKSS (Germany) → University of Twente (The Netherlands)

Karen Gerstandt (GKSS) visited the University of Twente to use Scanning Electron Microscopy to elucidate the structure of several membranes prepared at GKSS.

### LUT (Finland) → CNRS-Institut Européen des Membranes (France)

Samantha Kiljunen (Plat) visited the CNRS-IEM to work on the *NanoFlux* simulation program provided by CNRS-IEM to model data provided by Lappeeranta University.

### LUT (Finland) → Imperial College London (United Kingdom)

Samantha Kiljunen (Plat) visited the Imperial College to work on the solvent stability of nanofiltration membranes. Imperial College has a great deal of expertise in solvent transport through nanofiltration membranes, while Lappeeranta University has a strong background in the interaction of solvents with membranes. By combining the expertise, it is possible to get a better understanding on how to improve the membrane manufacturing (important for Imperial College since they also make membranes) so that the membranes are more stable in solvents.



## Seventh "Network Young Membrains"

June 22-24, 2005

Enschede, Netherlands.

84 Young Membrains working all over Europe took part in the Network Young Membrains 7 (NYM7) in June 2005. The goal of this event is to help young membrane researchers (under 35) create a network early in their career. The host for this year's meeting was the Membrane Technology Group of the University of Twente in Enschede, Netherlands.

Professor Matthias Wessling (University of Twente) opened the NYM 7 by talking about the importance of such a network for the future of a researcher's career. He also described the present research topics within the Membrane Technology Group. The participants were then split into groups to talk about their own field of interest (Knowledge Diffusion session). The presentations every participant gave of his/her research topic were a good starting point for many lively discussions during the whole event. The discussions were shared with the whole group during the Knowledge Network session.

On Friday, Professor Thomas Melin (RWTH Aachen) started with a lecture about research on membrane modules. Dr. Kitty Nijmeijer (University of Twente) gave an overview of the goals and possibilities of NanoMemPro. Many participants had not heard of this network of excellence before and were very intrigued about its possibilities. The rest of the day was spent in the labs of the Membrane Technology Group and at Vitens, a water purifying company.

It is the combination of "formal" lecture sessions and informal social interaction during the meals, sports activities and lab tour/company visit that made the NYM a perfect setting for the creation of a membrane network. The NYM7 was made possible thanks to the financial support of NanoMemPro, the European Membrane Society and several sponsoring companies. The organizing committee would like to thank them all very much for the faith they have in the next generation of membrane scientists.



Presentations Knowledge Network



Barbeque

See you all in Italy in 2006 for NYM 8!

### Information from the partners of NanoMemPro

#### University of Zaragoza (Spain)

The University of Zaragoza has acquired a new XPS (X-Ray Photoelectron Spectroscopy) equipment. *Dr. Silvia Irujo*, one of the researchers working in the NanoMemPro network is currently taking care of the start-up. The new equipment is suitable for the characterization of the chemical composition in the surface of membranes (or any other material). In addition to the normal XPS experiments, this equipment includes an electron gun, to obtain deep profiles and an Auger accessory.

The XXII EMS Summer School was held at Jaca (Spain), September 5-9, 2005. With the participation of 26 students from all around Europe, the course covered the main subjects on Inorganic Membranes. The speakers were researchers from universities and research centres participating in the NanoMemPro network, as well as from industries (Membraflow and Mast Carbon) participating in the Club of Interest of the network.

## Institut Européen des Membranes - CNRS-IEM (France)

### New equipment or facilities

Single-crystal diffractometer Xcalibur III (Oxford Diffraction). Its main use is the collection of single-crystal X-ray diffraction data to determine the atomic structure of (supra)molecular precursors for new hybrid organic/inorganic membrane materials. Actually operating with molybdenum radiation, a second copper radiation source is foreseen for next year making it possible to collect data on smaller and/or badly scattering crystals. The diffractometer is equipped with a large CCD camera in order to perform data collections on a reasonable time scale (2-16 hours).

Contact Person: Arie van der Lee ([vdlee@iemm.univ-montp2.fr](mailto:vdlee@iemm.univ-montp2.fr)).

### New staff

- **Matthieu RIVALLIN** since the 1<sup>st</sup> February 2005 at CNRS-IEM as Assistant Professor (*Ecole de Chimie de Montpellier*) in chemical engineering and inorganic chemistry. Thesis in Chemical Engineering at the "*Ecole des Mines de Paris*" (2003) on the synthesis of titanium oxide nanometric sols by sol-gel route. Post-doctoral stage at the "*University la Sapienza*" in Roma (2004) on the dextrose nucleation.

### New Post-doc Students

- **Laetitia BRUNEL**, (1<sup>st</sup> September 2005-30<sup>th</sup> June 2006), "*Elaboration of electrode for biofuel cell*". Engineer in Agronomy, specialisation in food Science, ENSA Montpellier, France. PhD Thesis in collaboration with Cognis, laboratoire de Génie Microbiologique et Enzymatique, UMR IR2B, Montpellier, France "*Candida parapsilosis lipase/acyltransferase : heterologous overexpression, structural characterization trials, immobilization and use in fixed bed bioreactor*". Post-doctoral stage at the IEM (7<sup>th</sup> February - 7<sup>th</sup> August 2005) on "*Elaboration of electrode for biofuel cell*".
- **Tania GUMI**, (1<sup>st</sup> May 2005 – 30<sup>th</sup> April 2007), "*Development and Characterization of Functionalized Membranes*". Doctorate in Chemistry, "*Universitat Autònoma de Barcelona*". Pre-doctoral research stays at "*University of Ottawa*" (Prof. T. Matsuura), "*Universidade Nova de Lisboa*" (Prof. J.G. Crespo),

"*Parc Científic de Barcelona*" (Ass. Prof. Cristina Minguillon) and "*Universitat Rovira i Virgili*" (Ass. Prof. Ricard Garcia-Valls).

- **Andreea PASC-BANU**, (1<sup>st</sup> September 2005 - 31<sup>st</sup> August 2006), "*Entrapping enzyme in functionalized mesoporous membranes*". PhD at *Paul Sabatier University* of Toulouse (France) and Post-doc at *Technische Universität München* (Germany).

### New Ph.D. Students

- **Rémy Caraballo** (Marie Curie Grants): Hybrids Materials – Molecular Imprinting, (Dr. Mihai Barbiou in collaboration with Dr. Olof Ramström - Stockholm University).
- **Florina Dumitru**: Adaptative hybrid materials for selectives membranes and biosensors (Dr. Mihai Barbiou, thesis co-director).
- **Jalal DWEIK**: Molecular modelling of nanoporous membrane transport (Dr. John Palmeri, thesis director).
- **Laurent FERTIER**: Biosensors for electrochemical detection (Dr. Marc Cretin, thesis director).
- **Samuel HENG**: Membrane Reactor for wastewater treatment (Dr. Anne Julbe, thesis co-director).
- **Géraldine MERLE**: Biofuel cell (Dr. Christophe Innocent, thesis director).
- **Gihane NASR**: Dynamic polymeric materials for adaptative membranes (Dr. Mihai Barbiou, thesis director).
- **Rosa Isela ORTIZ BASURTO**: Valorisation of natural vegetal products by membranes processes: example of "agave" juice (Dr. Marie Pierre Belleville and Prof. Gérald Pourcelly, thesis directors).
- **Mihaela-Dana SERB**: Combinatorial adaptative nanomaterials, (Dr. Mihai Barbiou, thesis co-director).

### Leaving NanoMemPro

**Lara PERRIN**, (WP09) finished her post-doc at CNRS-IEM on 31<sup>st</sup> August 2005. She has since started a new Post-doc : "Self-assembly of block copolymers for making nanostructured and functionalized materials for membranes applications", at "*Laboratoire de Chimie et Procédés de Polymérisation*" (CNRS-Lyon, France).

## University of Twente (The Netherlands)

### New people

- **Walter van der MEER** is appointed as part-time professor of the Membrane Process Technology group of the University of Twente. Walter van der Meer studied chemical technology ; his Ph.D thesis dealt with a mathematical modeling of NF and RO membrane filtration plants and modules. He currently works as research director at Vitens, one of the largest water supply companies in The Netherlands. As professor of the Membrane Process Technology Group, he will mainly focus on the application of membranes for drinking water and waste water treatment.
- **Geert-Henk KOOPS** was responsible for the European Membrane Institute Twente (EMI Twente). He left our group and accepted a position as director R&D at Zenon Membrane Products in Toronto, Canada. Antoine Kemperman and Kitty Nymeyer, both already working in the Membrane Technology Group of the University of Twente, have been appointed as his successors and shall continue the work of the EMI Twente. Our group has agreed on a significant effort in the valorization of its knowledge (see Figure on next page). We distinguish (a) long-term academic research to establish new knowledge and new principles and (b) short term application research. Long-term research will be carried out by Ph.D. students and PostDocs. Short-term research, which addresses specific industrial issues and is hence confidential, is carried out by employees working at the European Membrane Institute (EMI) Twente. Its function is to act as interface between academia and industry. The Institute was founded in 1995, so as to offer industry and public organisations a platform where short-term research and development projects in the field of membrane science and technology could be carried out. The length of the projects, which also include literature studies and marketing assessments, varies from a few days up to three years.
- **Wika WIRATHA** started working in September 2005 as a technician at the European Membrane Institute, Twente
- **Piotr DŁUGOŁĘCKI** (Ph.D student): research topic: Reverse Electro Dialysis
- **Srivatsa BETTAHALI** (Ph.D student): research topic: Tissue Engineering
- **Matías BIKEL** (Ph.D student): research topic: Microfabrication
- **Sandra BRUINENBERG** (Ph.D student): research topic: Biofouling

### Promotions

- **Ronald JANSEN** (May 20, 2005): Ozonation of humic substances in a membrane contactor.
- **Ines FRENZEL** (June 3, 2005): Waste minimization in chromium plating industry.
- **Laura VOGELAAR** (July 8, 2005): Phase separation micro molding.

### Graduations Master students

- **Jurgen OOMS** (January 13, 2005): Membranes for direct methanol fuel cells.
- **Bisani RANGANADH** (May 19, 2005): Flue gas dehydration by membrane technology.
- **Tanya TEERLING** (June 16, 2005): Modelling of mixed-matrix membrane adsorbers modules.
- **Peter KOEL** (June 20, 2005): Star-shaped hollow fiber ultrafiltration membranes.
- **Bouke ANKONÉ** (July 4, 2005): Fabrication of thin porous microfluidic chips.
- **Imam AKBARSYAH** (July 13, 2005): Fabrication and characterization of polymeric microsieves.
- **Raghavendra SUMBHARAJU** (August 19, 2005): Asymmetric bipolar membranes for reduced salt leakages.
- **Nayeli Masetto ORTIZ** (September 9, 2005): Cellulose acetate asymmetric membranes for gas separation.
- **Koray ULGER** (September 15, 2005): Preparation of thin film multi-layer membranes for gas separation.

### Upcoming events

October 27, 2005: NMG Poster day of the Dutch Membrane Society organized by the EMI Twente. Location: Conference centre De Reehorst, Ede (The Netherlands). For more information contact Antoine Kemperman ([a.i.b.kemperman@utwente.nl](mailto:a.i.b.kemperman@utwente.nl)). This event is partly sponsored by NanoMemPro.

January 2006: Honory meeting for the 75<sup>th</sup> birthday of **Prof. C.A. Smolders**. Location: Membrane Technology Group, University of Twente.

## **Papers and Patents (UTwente)**

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- L. Vogelaar, R.G.H. Lammertink, J.N. Barsema, W. Nijdam, L.A.M. Bolhuis-Versteeg, C.J.M. van Rijn, M. Wessling, Phase separation micromolding: A new generic approach for microstructuring various materials, *Small* 1 – 6 (2005) 645-655.