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BioNexGen ID

Title

Development of the Next **Generation** membrane **Bioreac-**
tor system

Programme

Seventh Framework Programme, Collaborative Project

Duration

01/09/2010-28/02/2014

Main objective

BioNexGen is developing a new class of functional low fouling membranes for membrane bioreactor technology with high water flux and high rejection of organic matter with low molecular weight

Partner countries

Egypt, Germany, Greece, Italy, Syria, Tunisia, Turkey, UK

Editorial

Dear Readers,

Welcome to the second issue of the **BioNexGen** newsletter which will give you information about recent activities of the project. The ongoing project work is making advances in many ways. On 8th and 9th March the first workshop on „Membrane based water treatment and reuse“ was held at the partner institute Centre of Biotechnology of Sfax (CBS) in Sfax, Tunisia. Besides theoretical seminars and courses, this workshop was combined with visits at MBR plants on-site for becoming acquainted in-depth with relevant industrial membrane technologies for wastewater treatment. This workshop also fostered new contacts and collaborations between European and MENA water engineering experts, researchers, stakeholders, municipalities and companies.

In addition a PhD student from CBS paid a scientific visit to Karlsruhe University of Applied Sciences. Within her visit both partners exchanged fruitful information about pilot scale treatment of textile wastewater by membrane bioreactor technology.

With this issue we will also make you aware of interesting upcoming events such as the Euromembrane conference 23rd-27th September 2012 in London.

Moreover we warmly invite you to also regularly consult our project website under www.bionexgen.eu in order to be updated on the latest developments.

Yours sincerely,
BioNexGen consortium

Rejection and Permeability of CNTs:

a quantum mechanics and atomistic theoretical investigation

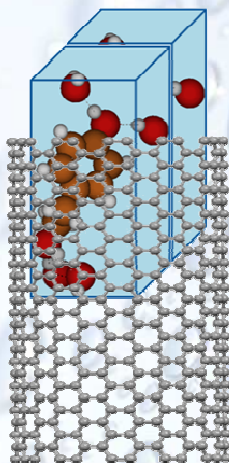
Removal of pollutants with low molecular weight represents a current challenge in the water treatment field in addition to high water permeability. Moreover, the recovery of valuable compounds present in industrial wastewater can bring significant benefits. To increase rejection and water permeability, particular attention should be given to the materials used in the membranes preparation. High rejection and water fluxes cause organic fouling and concentration-polarization effect. These aspects constitute the major limitations in the separation processes because in turn, these lead to a decrease in permeability. However, the physical-chemical resistance over time of membrane materials are equally important. The drawbacks related to material resistance are numerous: chemical and biological degradation, swelling and embrittlement, mechanical and thermal resistances.

The Carbon NanoTubes (CNTs) are known for their excellent mechanical and thermal features and for their amazing hydrodynamic property (very high water flux). In addition, their nano-metric diameters, easily tunable, allow to carry out an efficient rejection of low molecular weight solutes.

As a result, they can be considered good starting materials with regard to the aforementioned issues. However, it is also important to take into account the proprieties of the support in which the CNTs are embedded in order to not fall in the underlined drawbacks. However, to have an optimal efficiency of the Multi-Wall CNTs, their internal and external diameters should be optimized in order to get the best compromise between rejection and water permeability. In this way, the perm-selective properties of the CNTs are effectively exploited.

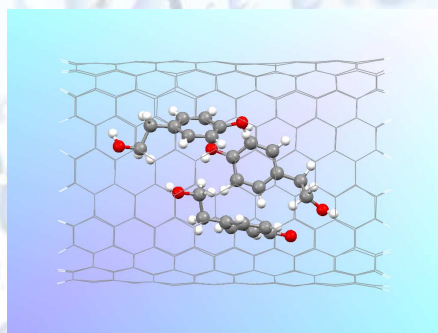
A study in this direction has been carried out by Dr. Giorgio De Luca, and PhD student Federica Bisignano (ITM-CNR partner), in the frame of the BioNexGen project. A computational investigation of the structures-properties relationship of

CNTs was conducted at a quantum mechanics and molecular mechanics level. The rejection of several important organic solutes by the CNTs as function of their diameters was analysed on the basis of topological study of the solute molecules. A handy criterion has been developed in order to define the diameter of the CNTs to be used to attain a rejection of the target solutes by a size exclusion mechanism. It is worth noting that no empirical or fitting parameter are used in the proposed criterion. In the frame of the implemented procedure, the trapping energies of solutes in the CNTs have also been evaluated at quantum mechanics level to understand if pore blocking or friction separation mechanism can also occur. Monte Carlo and Molecular Dynamics simulations, provided by Dr. V. G. Mavrantzas and E. Karahaliou (FORTH partner) were carried out in this study to investigate more accurately the solute packaging in the CNTs with different diameters.



The analysis of the solute shape and packaging in CNTs permitted to define the aforementioned handy criterion. However, since rejection and water flow are coupled, once optimized the diameters of CNTs as a function of the rejection capability, the analysis of the water flow in the same nanotubes was carried out using a slip-modified Hagen-Poiseuille. In particular, the number of CNTs, which must be trapped in a defined support, for example in a porous polymeric membrane, to have a water flow greater than the flow of the unmodified membrane was evaluated. The simulations show that the internal and external diameters of the CNTs must be chosen carefully in order to obtain an appreciable rejection of solutes and at the same time a significant increase of the water flow.

Authors: Dr. Giorgio De Luca and PhD students working in quantum mechanics modelling



Nano4water Cluster



The nano4water cluster is a coalition of research projects, funded by the European Commission following a Joint Call on nanotechnologies for water treatment (FP7-ENV-NMP-2008-2).

The aim of this action is to support research and technological development in the field of water treatment by applying developed or adapted nano-engineered materials to promising separation, purification and detoxification technologies. Hence, 6 projects have joined the cluster, representing a broad spectrum of competencies and expertise. Their cooperation enables the exchange of knowledge and gives visibility to the different approaches they focus on to meet their common challenges.

In the field of water, nanotechnology has the potential to contribute to long-term water quality, availability, and viability of water resources such as through advanced filtration that enables sustainable water reuse, recycling or desalination. Aiming for more efficient water treatment the projects of the nano4water cluster focus on process intensification through

- the development of nanomembranes and
- the use of nanomaterials in catalytic reactors.

The production of nanomembranes comprises both the incorporation of nanomaterials into the membrane matrix or the deposition of nanoparticles on the membrane surface. The cluster projects mainly utilise known nanomaterials

such as carbonnanotubes, titanium dioxide and silver to alter membranes (e.g. projects Nametech, CleanWater, New ED). Molecular imprinting is another method applied to design membranes with defined retention capacities by creating molecule-specific receptor sites in the membrane (e.g. project WATERMIM).

These types of modification will result in functionalised membranes with

- improved selectivity for specific target compounds
- reduced fouling propensity
- higher water flux
- catalytic properties.

In catalytic reactors nanomaterials aid to accelerate degradation reactions (project MONACAT).

In view of the obvious common interests of Nano4water cluster and BioNexGen, our project coordinator was kindly invited to take part in the joint nano4water cluster workshop which took place in Thessaloniki on 24th-25th April 2012.

This was a good occasion for BioNexGen to present its ambition and current progress, and to create synergies with other related projects.

This 2-day workshop was the final conference for some of the nano4water cluster projects that presented results and raise new research questions.

To get more information about the cluster and the individual projects, please click on the following link: <http://nano4water.eu>



BioNexGen Membrane Developers

Basically, BioNexGen team is divided in two groups, i.e. membrane developers and membrane testers. We have chosen to present you both groups more closely so that you can better know who is behind our project, i.e. what professionals and expertise will enable the successful development of BioNexGen membrane. In this issue, we are presenting you our membrane developers, i.e. our partners involved in the theoretical and experimental activities on membrane preparation. Don't miss the testers in the next newsletter!

FORTH, Greece



Dr. Vasilis Burganos

Role in the project: Modeling and simulation

Background: PhD in Chemical Engineering, Univ. of Rochester, USA (1988)

Current position: Research Director at FORTH/ICE-HT since 1999. Member of the Scientific Council of FORTH/ICE-HT

Major research interests: Modeling and simulation of micro-structure and transport phenomena in porous materials.



Prof. Nikos K. Karamanos

Role in the project: Assessment of potential health and safety issues of nanoparticles and carbon nanotubes developed for the project

Background: PhD in Chemistry (Biochemistry), University of Patras, Greece (1988)

Current position: Professor at the Department of Chemistry, University of Patras, since 2003. Collaborative Faculty Member of FORTH/ICE-HT

Major research interests: Matrix pathobiology. Cell signaling. Molecular targeting and *in vitro* Pharmacological evaluation and



Dr. George A. Voyiatzis

Role in the project: Coordination of FORTH group

Background: Physico-Chemist, Université de Paris VII, France - PhD of Chemical Engineering, University of Patras, Greece (1992)

Current position: Research Director since 2010/11. Member of the Scientific Council of FORTH/ICE-HT since 2001

Major research interests: Advanced modified polymeric materials. Specialty spectroscopic probes.



Professor Jannis K. Kallitsis

Role in the project: Introduction of functional groups on the carbon nanotubes surface

Background: PhD in Chemistry, Univ. of Patras, Greece (1985)

Current position: Professor at the Department of Chemistry, University of Patras, since 2000. Collaborative Faculty Member of FORTH/ICE-HT

Major research interests: New proton conducting polymeric membranes for use in PEM fuel cell operating at high temperatures. Amphiphilic block copolymers and hybrids with biocidal or antifouling properties. Development of new semiconducting block and brush copolymers and their hybrids with carbon nanostructures.

Izmir Institute of Technology, Turkey



Prof. Dr. Sacide Alsoy Altinkaya

Role in the project: Preparation and characterisation of nanoparticles

Background: PhD of Chemical Engineering, Pennsylvania State University, USA

Current position: Professor in Chemical in Engineering since 2007

Major research interests:

Modeling of diffusion controlled polymer processes, development of polymeric drug delivery systems, development of antimicrobial and antioxidant food packaging materials, development of polymeric membranes for environmental, biotechnology and biomedical applications, modeling of porous membrane formation by phase inversion technique, modeling of transport rates through enzyme immobilized membranes.

Nanothinx, Greece



Dr. Katerina Kouravelou

Role in the project: Preparation and characterisation of CNTs

Background: Chemical Engineer, University of Patras, Greece

Current position: R&D Manager of Nanothinx S.A. since 2010

Major research interests: Production and characterization of carbon nanomaterials with exceptional properties, and their realization in a variety of applications.



Theodoros Karachalios

Role in the project: Preparation and characterisation of CNTs

Background: Chemical Engineer, University of Patras, Greece

Current position: Production Manager of Nanothinx S.A. since 2006

Major research interests: Chemical Vapor Deposition (CVD), Reaction Engineering, Process Control and Optimization, Thin Films, Carbon Nanotubes (CNTs), Nanomaterials Production and Processing.

Central Metallurgical R&D Institute, Egypt



Prof. Dr. El-Sayed Ali Abdel-Aal

Role in the project: MBR Field testing with textile wastewater and preparation and characterisation of silver nanoparticles

Background: PhD Inorganic Chemistry, Faculty of Science, Cairo University, Egypt, 1989

Current position: Since July 2010, Head of Chemical and Electrometallurgy Division, Central Metallurgical Research and Development Institute (CMRDI)

Major research interests:

Preparation, characterization of advanced nanomaterials including but not limited to: metals (Ag, Ni), oxides (ZnO, SiO₂), and hydroxyapatite, preparation and coating of hydroxyapatite on titanium alloy for biomedical implant applications, continuous processing of phosphate for phosphoric acid production, crystal habit modification of phosphogypsum, gibbsite, calcium oxalate, etc., chemical processing on laboratory and pilot plant scales of ores, e.g. ilmenite, bauxite, clay, magnesite, bentonite, etc., studies for purification of phosphoric acid by different techniques, solvent extraction, ion exchange and precipitation, studies in the field of lignin separation for environmental protection, purification of industrial waste water and desalination of seawater.

CNR-ITM, Italy



Dr. Giorgio De Luca

Role in the project: Modeling and simulation

Background: PhD degree in chemical sciences

Current position: Researcher since 2001 at ITM-CNR

Major research interests: Study by means of quantum and molecular mechanics approaches of structure-property relationships of material used in membrane preparation



Dr. Alberto Figoli

Role in the project: Preparation and characterisation of membranes

Background: PhD degree at Membrane Technology Group, Twente University (NL)

Current position: Researcher since 2011 at ITM-CNR

Major research interests: membrane technology, particularly in membrane preparation, characterization and application in environmental field



Dr. Mauro Carraro

Role in the project: Preparation and characterisation of nanoparticles

Background: PhD degree in Organic Chemistry at University of Padova

Current position: Since 2004, assistant professor of Organic Chemistry at the Department of Chemical Sciences, University of Padova

Major research interests: preparation of hybrid organic-inorganic molecular materials (gels, polymers, membranes, nanoparticles), mainly based on the use of polyoxometalates functionalized with organic groups. Exploration of their applications in the fields of energy conversion, environmentally friendly catalytic processes, nanomedicine and materials science

Project events

12 months partner meeting in Swansea, United Kingdom

On 5th and 6th October 2011 BioNexGen project partners came together at Swansea University, United Kingdom for the third partner meeting of the project.



The two-day meeting was organised and hosted by Prof. Dr. Nidal Hilal (Swansea University).

The meeting, marking the 12th month of the BioNexGen project, was taken as an opportunity to look back at the progress that has been jointly made and to clearly take in focus the challenges and opportunities that lie ahead for the several partners and the consortium as a whole. In-depth presentations of the partners' completed research work and planned future activities not only provided the consortium with an excellent basis for the evaluation and discussion of past accomplishments but also sparked fruitful discussions about future efforts in the coming six month period.

First Training Workshop on "Membrane based wastewater treatment and reuse", March 8th & 9th 2012 in Sfax, Tunisia

This first two-day training workshop organised within the frame of BioNexGen focused on basic principles and state-of-the-art of "Membrane based Wastewater treatment and reuse".

Besides theoretical seminars and courses, this workshop was combined with visits at MBR plants on site for becoming acquainted in-depth with relevant industrial membrane technologies for wastewater treatment.

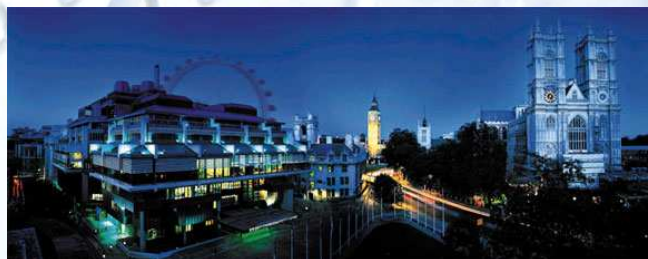
This workshop also aimed at fostering new contacts and collaborations between European and MENA water engineering experts, researchers, stakeholders, municipalities and companies.



Another interesting event

Euromembrane Conference, September 2012, London, United Kingdom

On **23-27 September 2012** the **Euromembrane 2012** conference will be held at the Queen Elizabeth II Conference Centre in Westminster, **London**, continuing the Euromembrane conference series first held in 1995.

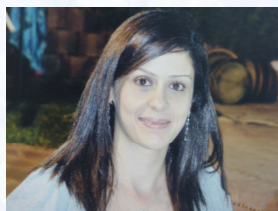


The aim of the Euromembrane Conference series is to bring together academic and industrial scientists from the field of membrane science and technology to stimulate contacts and to exchange new ideas on their research work. The conference will cover all types of membrane and related work including membrane materials, membrane fabrication and characterisation, modelling and simulation, membranes for process intensification, and application. The conference will be organized by the **European Membrane Society** and **Imperial College London**.

Visit the website at: <http://www.euromembrane2012.com>

Student Exchanges: Fostering students' advancement and cooperation between universities (2)

In each issue of our newsletter, we will try to present you an example of a successful stay of a student at a foreign university for research purposes. This time, we would like to introduce you Ing. Msc. Inès Friha. This young Tunisian PhD student describes us her experience at Karlsruhe University.



I am a PhD student at the CBS-Laboratory of Environmental Bioprocesses, Sfax (Tunisia). I am doing my PhD on the application of membrane technology for the treatment of industrial wastewater

which is conducted under the kind supervision of Pr. Sami SAYADI. I was at Karlsruhe University (Germany) last year for one month. It was an exchange in the framework of the BioNexGen Project in order to learn how the partner HSKA is dealing with the MBR trial with synthetic textile wastewater. It was an interesting stay, I was really impressed by the MBR they are working with, the system is computer-controlled and different measurements were analyzed online. I wish I had more time to learn how to manipulate the software. I also learnt how they defined the synthetic composition of the textile wastewater and I had the opportunity to be involved in the trial and do some analysis. I was happy to meet new and awesome friends and

especially exchange experience with students involved in the same project. I really had a nice stay and it was a great opportunity to visit Germany for the first time.

The difference worth mentioning is that we are working with the real textile wastewater and it was all new for me to see how they defined the synthetic composition and how the system behaved in the presence of such composition.

Doing a PhD in the frame of a European project such as BioNexGen project has many advantages and the most important one is the added value brought by the expertise of the different partners involved in the project. Moreover, such projects generally focus on the acquisition of new knowledge thus the ideas are always innovative and may lead to creative, novel and high impact products. For these reasons I encourage all the students when intending to do a PhD to look for PhD positions in the framework of national and European projects, to be highly motivated and they will enjoy the benefits of being involved in such projects.

BioNexGen Partners

The project is carried out by **7 European, 1 Turkish and 3 MENA partners**, namely two partners from North Africa and one from the Middle East.

The consortium has been carefully selected to ensure a multidisciplinary approach which is necessary to realise this innovative concept. It consists of academic and industrial partners and of technology transfer institutions. They ally their competences and play different roles towards the project's successful realisation.

- **Technology transfer:** Coordinator, Karlsruhe University of Applied Sciences (Germany), Steinbeis-Europa-Zentrum (Germany)
- **Membrane's development:** Institute for Membrane Technology at Italian National Research council (Italy), Foundation for Research and Technology, Hellas (Greece), Izmir Institute of Technology (Turkey), Swansea University (UK), as well as Microdyn Nadir (Germany) and Nanothinx (Greece), as European leaders in innovative MBR membrane technology and carbon nanotubes' manufacturing
- **Demonstration and field test activities:** Centre de Biotechnologie de Sfax (Tunisia), Central Metallurgical Research and Development Institute (Egypt) and Al Baath University (Syria)

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Al Baath University:	Prof. Adnan Ghata - ghatasyr@scs-net.org
CMRDI:	Dr. El-Sayed Ali Abdel-Aal - eabde@yahoo.com
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