Publishable executive summary

Contractors:

Name	Department	Type	Country
Bio Pure Technology Ldt.		SME	Israel
GMT Membrantechnik GmbH		Industry	Germany
Helsinki University of Technology	Dpt. Of Engineering Physics and Mathematics	University	Finland
CINVENTION AG (former Blue Membrane)		SME	Germany
SINTEF	Functional Ceramics Group	Research Center	Norway
Topchiev Institute of Petrochemical Synthesis	Laboratory of Synthesis of Selective Permeable Polymers	Research Center	Russia
University of Groningen	Material Science Centre	University	Netherlands
GKSS Forschungszentrum	Institute of Chemistry	Research Centre	Germany

Co-ordinator:

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project web site:

http://compose.gkss.de

Summary description of project objectives and work performed

COMPOSE aims at using nano technology in order to develop separation membranes with fluxes and selectivities beyond the state of the art. The project can be roughly divided into two approaches. One of them focuses on organic/inorganic hybrid materials. For example, sol-gel chemistry is used to produce inorganic particles which are incorporated in polymeric materials for applications in gas separation and nano filtration (or reverse osmosis). By changes in interfacial properties high selectivities and fluxes can be expected. So called mixed matrix membranes represent another kind of hybrid material. COMPOSE tries to align carbon molecular sieve flakes in order to obtain a better separation performance.

There are several important applications for gas separation in which COMPOSE wants to achieve improvements, e.g.: O_2/N_2 separation with a selectivity of 7 combined with an oxygen permeability of 50 Barrer; CO_2/CH_4 separation with a selectivity of 40 combined with a carbon dioxide permeability of 20 Barrer; butane/methane separation with a selectivity of 25 combined with a butane permeability of 30 Barrer. In the case of nanofiltration, rejections of more than 90% for solutes in the range of 200 - 500 Daltons are aimed at.

The second approach within COMPOSE is new and tries to utilise self-organised materials. Thereby nanostructures can be created which are investigated with respect to a potential application in separation processes.

Numerous polyacetylenes were synthesised by TIPS which exhibit very high permeabilities and provide selectivities of up to 40 when applied to butane/methane gas mixtures. It is one of the objectives of the project to improve these excellent properties even further by preparing membranes with incorporated nano particles. These particles were provided in different sizes and kinds by SINTEF. In the case of a commercial polyacetylene (PTMSP) it was possible to increase the permeabilities of most of the investigated gases. When applied to gas mixtures of butane and methane, it was possible to increase the selectivity in an amount of about 40%. There was also a small increase in an experiment with one of the polyacetylenes prepared by TIPS.. The final work will focused on the manufacturing of composite membranes with porous polyacrylonitrile as support membrane. The most promising membrane for technical application has been selected and fabricated into a module.

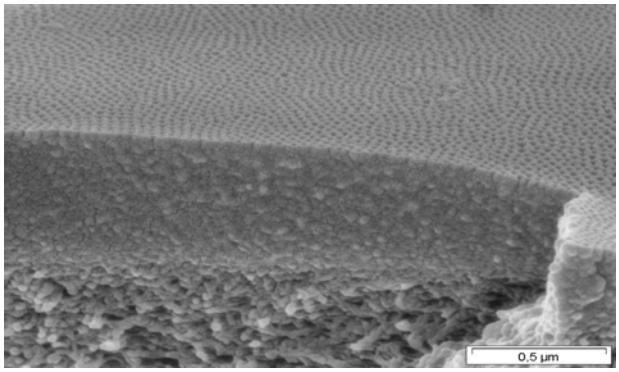
Nano particles were also used in combination with other (commercial) polymers. Changes in selectivities could be detected, but most of the investigated films and composite membranes revealed lower permeances when compared to unmodified membranes. Very attractive is a cellulose-based polymer, which has been modified with a nano-sized filler. The resulting membrane has excellent properties for oxygen enrichment and is now being tested by an industrial end-user.

Within the work on mixed matrix membranes, a layer-by-layer process is currently developed which allows the preparation of aligned flakes in a matrix of poly(dimethylsiloxane) rubber. It was possible to measure extraordinary high selectivities of helium and hydrogen over nitrogen.

For nanofiltration purposes, prototypes of organic solvent resistant membranes with a high rejection to organic solutes in the molecular weight range of 200-900 could be prepared and characterised successfully. This included the preparation of polymer-inorganic hybrid materials as well as the fabrication of a flat ceramic membrane support. In this context, also a bench type nanofiltration test unit has been established.

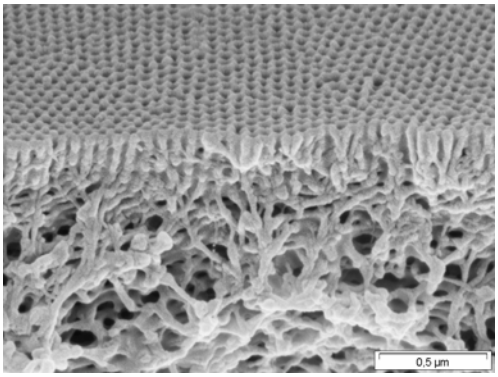
Concerning self-organised structures for separation purposes, it was possible to show that thin films of self-organising block copolymers can be made on top of conventional microporous supports.

On dense conventional substrates, it is possible to grow thin films with hexagonally ordered cylinders (or pores) orientated perpendicularly to the plane of the film. This structure is exceedingly interesting for membranes. With two block copolymers it was possible to transfer the coating process to microporous UF membrane. The figure below shows a layer of polystyrene-b-polyethylene oxide on top of a polyacrylonitrile UF-membrane.



SEM-picture of cross-section of a Polyacrylonitrile/polystyrene-b-polyethylene oxide membrane

Part of the work during the last project period focused on the combination of self-assembly and the classical membrane formation by non-solvent induced phase separation. It was possible to create an integral asymmetric membrane structure with a highly ordered self-assembled top-layer supported by porous non-ordered sponge-like support layer. A patent application for this new membrane formation process has been filed. The figure below shows obtained membranes structure made from the synthesized polymer polystyrene-b-polyvinylpyridine.



Main elements of the plan for using and disseminating the knowledge

As far as possible, the results of the project will be published in international scientific journals. 5 publications already appeared in high impact factor journals and about 4 more are in preparation. Since PhD students are participating in the project, the knowledge will also be disseminated in the framework of their theses. Furthermore, the contractors are encouraged to present their results as contributions at international conferences and courses, as has been already done in the first reporting period, too. 6 presentations based on work performed in Compose have been given at international conferences e.g. Euromembrane 2006.

It is also possible for the contractors to protect their inventions by patent applications. Two patent applications (GKSS) have been filed and another one is in preparation. One membrane type developed within Compose is currently in a long-term test at an end-users site.

The compose web site (http://compose.gkss.de) is online since December 2004.