



## Contribution of Pervaporation in Eco design of Processes

Oleksandr DIMITROV<sup>1</sup>, Evelyne NEAU<sup>1</sup>, Isabelle RASPO<sup>1</sup>, Pierrette GUICHARDON<sup>1\*</sup>,

Alfred TESTA<sup>2</sup>

*1 Aix Marseille Université, CNRS, Centrale Marseille, M2P2 UMR 7340, Technopôle de Château-Gombert,  
38 rue Frédéric Joliot-Curie, 13451 Marseille, France ;*

*2 INNOVACLEAN, 73, rue du Douard, F-13685 Aubagne, France*

*\*Corresponding author: pierrette.guichardon@centrale-marseille.fr*

### **Highlights**

- Dehydration of organic solvents by pervaporation
- Pervaporation data treatment using solution-diffusion approach coupled with an accurate vapor-liquid equilibrium model
- Comparison of pervaporation and distillation efficiency in terms of separation and energy consumption

### **1. Introduction**

In the modern conditions of constantly growing market demand and product consumption, the world leading industries shift progressively towards the eco design approach. That means a production with an attentive consideration for the environmental impacts of a product during its lifecycle, low material and energy resources consumption and using of the environmentally friendly solutions. Chemical engineering is not an exception. The situation becomes especially sensitive in separation technologies as the chemical waste treatment and recycling remains one of the most important problems of the humanity. For example, in the alcohols and organic solvents dehydration, robust and durable processes, such as distillation, are mainly used. Regardless of its durability and high product output, the overall results obtained by distillation may be far from expected. Its separation efficiency may be limited by the vapor-liquid equilibria (azeotropes, relative volatility etc). The modified processes such as azeotropic or extractive distillation are able to deal with these drawbacks generally at the expense of increased complexity and operational costs. Moreover, one should not ignore the high energy consumption of distillation.

The pervaporation, a membrane separation process, can be an excellent alternative to distillation. Though it is a relatively young technology, the attention of industries towards it increases every year mainly due to its low energy consumption and high separation performance. The main advantage of pervaporation is that the separation efficiency is independent of vapor-liquid equilibria and is only limited by the membrane material and operating conditions. A large number of researches on membrane materials have significantly decreased the costs of membrane modules which makes pervaporation even more attractive for separation of liquid mixtures.

The aim of our work was to emphasize the new horizons of solvent dehydration technology and mark the contribution of pervaporation in process eco design. We have experimentally and



theoretically studied the pervaporation applied to a dehydration of an aqueous mixture of three glycol ethers which are widely used in different chemical industries all over the world. The interest was mainly pointed towards the separation efficiency and energy consumption. The results were compared to those of distillation for the same mixture. The modeling of both processes was also performed in order to optimize operating conditions and increase the efficiency.

## **2. Methods**

A mixture of three organic solvents and containing 10%wt of water was dehydrated by pervaporation using commercial dense membranes with a cross-linked polyvinyl-alcohol (PVA) active layer. The pervaporation was carried out at 30, 50 and 70°C. The permeate fluxes were measured by weighing and the permeate composition was determined by a gas chromatography method. The membrane permeances were calculated by the solution-diffusion approach coupled with accurate liquid-vapor equilibria data. The energy consumption of the process was determined as well.

A dehydration of the same mixture by distillation was carried out in parallel at the pressures of 1.013 bar, 0.2 bar and 0.05 bar. The modeling of the distillation process was made using ProSim Pro software.

## **3. Results and discussion**

Results obtained were encouraging. The permeate analysis has indicated the presence of only pure water which means that the membrane is 100% selective to water and no solvent passed through it. The process was compared with the distillation in terms of separation efficiency and energy costs. While the distillation has offered high product flows, the separation was much less efficient because of the limit in vapor-liquid equilibrium; moreover, the energy consumption was very important.

## **4. Conclusions**

In this work we have shown the potential of pervaporation to replace classic separation methods such as distillation while dehydrating organics. A highest separation rate and low energy expenses were achieved. An ideal permeate flux can be obtained by choosing a membrane module with an appropriate working area. Experimental and modeling results were used for further development of an industrial-scale applied process.