Synthesis of Fine Chemicals in Zeolite Membrane Microreactors

Wai Ngar Lau, Siu Ming Kwan and King Lun Yeung
Department of Chemical Engineering, the Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, P.R. China.

Fine chemicals and pharmaceuticals are high value, seasonal products that are produced in modest quantities. They are usually customer specific and have a short shelf life. These characteristics usually place a significant constraint in their production, such that it is not uncommon to see labour intensive batch processes being used. This often led to waste generation during the scale-up from the laboratory to production scale. In addition, the use of hazardous and often toxic homogeneous catalysts makes the product purification and waste disposal important issues. Microchemical systems offer a new paradigm for meeting these challenges. They represent a cheap alternative way for the production of specialty chemicals and pharmaceuticals by a continuos process, allowing simpler process optimization, rapid design implementation, better safety and easier scale-up through replication. This enables rapid product deployment to the marketplace and thus ensuring a significant competitive edge.

Two types of membrane reactors, the packed-bed membrane reactor (PBMR) and catalytic membrane reactor (CMR) were successfully miniaturized. Zeolites were incorporated as catalyst for reaction and membrane for separation. The membrane microreactors were tested for Knoevenagel condensation reaction between benzaldehyde and ethyl cyanoacetate to produce ethyl 2-cyano-3 phenylacrylate. Supra-equilibrium conversion and high product purity were obtained from selective removal of water during the reaction. Catalytic membrane reactors often perform better than PBMR, but are more difficult to prepare since the membrane must exhibit both good catalytic and separation properties. A simple computational model was developed to simulate the reaction in the multichannel membrane microreactor using kinetic data from batch reaction, correlated data from membrane separation and published transport data. The influence of reactor geometry (i.e., channel width and membrane location), membrane separation and catalyst properties were evaluated and the results compared well with experimental data. The information provided by the model suggests several ways of improving the reactor performance.