Sol-gel synthesis, functionalisation and characterisation of molecular sieve silica (MSS) membranes

Professor **Joe DA COSTA**

FIMLab – *Films and Inorganic Membrane Laboratory*, School of Chemical Engineering,
The University of Queensland, Brisbane, Australia

The sol-gel process is a versatile tool in pore size tailoring, particularly in the ultra micropore range ($d_p < 5$Å). There are several important industrial applications of materials at this pore size range, generally called molecular sieves. One avenue to control the pore size construction is to inhibit the condensation reactions using silica precursors, thus forming amorphous silica thin films for membrane application. As a result, the concentration of silanol groups (Q^2 and Q^3) increases, leading to the formation of weakly branched fractal systems. These fractal structures tend to interpenetrate each other, and form dense films with smaller pore size, contrary to full condensation reaction which results in the higher concentration of siloxane bridges (Q^4) and larger pore sizes. Using gases of different kinetic diameters as molecular probes, MSS membranes delivered selectivity ratios close to 1000 for the separation of He and CH_4.

The problem here is that industrial gas streams contain water vapour. Silanol groups are hydrophilic and react with water, causing change in the pore structure and greatly reducing the capability of the membranes to selectively separate gases. Hence, silica membranes require functionalisation. One approach is by employing templates in the sol-gel process. Here we show that the carbonisation of the surfactants embedded in the silica matrix conferred hydrostable properties, yet the membrane was still hydrophilic. In some cases, the surfactant carbon chain, or the amount of carbon in the silica film affects selectivity in other application, such as the removal of salts from sea water. Lately, we have shown that metal doping of silica films provides a much more robust film structure; in addition to a high precision pore size tailoring, thus delivering selectivities of 5000 for the separation of He and N_2. These issues forms the basis of the work to be presented which shows an improved understanding of the relationship between microstructure and synthesis process associated with separation properties of MSS membranes.