Reinforcement of hollow fiber membrane with nanoparticles

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In the membrane research group at NTNU, there has for several years been ongoing research on facilitated transport membranes[1-2].These membranes show promising results for CO2-capture, and will, in the current project, be coated on hollow fiber supports suitable for use in natural gas sweetening. The conditions for high-pressure natural gas separation require that the hollow fiber membrane is resistant to swelling, mechanical compression and be chemical inert to degradation. It must also posess low mass transfer resistance. For instance, the selective layer is made durable by choosing a high molecular weigth polymer or polymer blends with high intermolecular interaction, chemical crosslinking or mixed-matrix membranes with inorganic particles. The hollow fiber support can be made defect-free and mechanically strong by choosing a spinnable polymer in the casting solution and is fabricated without macrovoidal defects by operating with proper hollow fiber spinning conditions. For the FSC-membrane, investigations have shown that polysulfone (PSf) is a very good support material. However, great care must be taken not to increase its mass transfer resistance[3]. In order to increase the mechanical strength of the hollow fiber support without increasing mass transfer resistance, precipitating insoluble nanoparticles from salts in the coagulating polymer solution may be a possibility [4]. Incorporation of nanoparticles in hollow fibers is usually achieved by mixing them in the casting solution before the spinning procedure. However, the nanoparticles and the polymer tend to phase separate because of incompatibility, they may align in the solution flow because of shearing with the inner spinneret compartment or large stretching in the air gap from high take-up rates. This issue will be adressed in the project in order to avoid the problem. This will be a challenging task because the salts influence the casting solution, its thermodynamical state and phase-separation kinetics which are correlated to the successful hollow fiber spinning. Since the membrane is operating in humid conditions, the nanoparticles must also not dissolve in any water trapped in the pores. The precipitation of water-insoluble nanoparticles during the coagulation of the polymer solution, may also affect the polymeric chain packing, hence reducing the mass transfer resistance even more[5]. The system to be tested out will be a polysulfone/N-methyl-pyrrolidone (NMP)/-solution with selected salts coagulating in a water bath.

Polysulfone hollow fibers are already being spun with nice control of spinning parameters. New hollow fiber membranes will be made with and without nanoparticles. The fibers will be characterized with compression tests, pore size measurements, SEM-pictures and correlated to coagulation properties like cloud-point measurements and apparent diffusion measurements. The initial results will be reported in the presentation.

References:

1. Kim, T.-J., B. Li, and M.-B. Hägg, *Novel fixed-site–carrier polyvinylamine membrane for carbon dioxide capture.* Journal of Polymer Science Part B: Polymer Physics, 2004. **42**(23): p. 4326-4336.
2. Sandru, M., S.H. Haukebø, and M.-B. Hägg, *Composite hollow fiber membranes for CO2 capture.* Journal of Membrane Science, 2010. **346**(1): p. 172-186.

3. Pinnau, I. and W.J. Koros, *Relationship between substructure resistance and gas separation properties of defect-free integrally skinned asymmetric membranes.* Industrial & Engineering Chemistry Research, 1991. **30**(8): p. 1837-1840.
4. Xie, M., et al., *Alginate-controlled formation of nanoscale calcium carbonate and hydroxyapatite mineral phase within hydrogel networks.* Acta Biomaterialia, 2010. **6**(9): p. 3665-3675.
5. Merkel, T.C., et al., *Ultrapermeable, Reverse-Selective Nanocomposite Membranes.* Science, 2002. **296**(5567): p. 519-522.

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