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Title:

Novel hybrid membranes for post combustion CO_2 capture in power plant and industry.

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Abstract:

Membrane separation technologies are considered as energy-efficient and compact compared to conventional absorption–desorption technologies. In our project, hybrid membranes are composed of homogeneously interpenetrating polymeric and inorganic particle phases. Functionalised silica nanoparticles can be a valuable tool for improving properties of polymer composites. Hybrid membranes incorporating these materials have previously shown CO_2 permeance of 1 m^3(STP)/(m^2•h•bar) at CO_2/N_2 selectivity >100 [1].

With the aim to gain understanding of the transport phenomena in these hybrid membrane materials, membranes have been prepared with and without the addition of functionalised silica nanoparticles to polyvinyl alcohol (PVA) polymer layer. The thin PVA layer with a thickness in the range of 1-2 micron is supported by a PPO hollow fibre substrate. The membrane performance has been evaluated by varying CO_2 feed content and pressure. Different batches of functionalised silica nanoparticles in two different solvents (dimethyl sulfoxide (DMSO) and water were prepared in order to understand the impact of the solvent in the manufacturing process. DMSO gives the narrowest distribution of particle size**.**

The functionalised silica nanoparticles were synthesized by a controlled sol-gel process through hydrolysis and condensation of alkoxy silanes The hydrolysis can produce different structures and only a full control of the reaction leads to the desired structures. Such condensation reaction requires a full thermodynamic control to deliver highly define structures. As nanotechnology permits to obtain materials with high specific area (and hence high reactivity), our effort has been focused on optimizing the synthesis of functionalised silica nanoparticles and delivering nanoparticles with narrow size distribution. Ideally, a good dispersion of these particles in a continuous polymeric phase should efficiently help to promote the gas separation by facilitating the transport of CO_2 through the membrane.

Various preparation methods were investigated, including sonication effect and type of solvent, but surprisingly, no facilitated transport could be detected. Gas permeation results, using DMSO as a polymer solvent, shown a decrease in the selectivity and CO_2 permeance after incorporation of the nanoparticles. A change in the final appearance on the solution showed that the polymer became unstable after some period of time. Although DMSO gave a narrow distribution for nanoparticles, it was not a suitable solvent for PVA. Other solvents were tried out to prepare membranes with PVA alone and PVA with functionalized silica nanoparticles. It is of vital importance to understand the behaviour of the functionalized nanoparticles when embedded in a membrane for the purpose of facilitated the transport of CO_2.

In the case of water as a polymer solvent, functionalised silica nanoparticles in propanol were incorporated. First miscibility trials were made to assure any mixture problem. Gas separation results still not shown an important effect, both, selectivity and permeance were lower than expected. This could be due to a probable instability of the nanoparticles in water; since the reaction is made by hydrolysis some changes in the cage structure may be affecting the gas separation. Further study is need in this case.

In conclusion, the results show that there are large discrepancies with previously obtained results. The effect of the addition of amine functionalised silica nanoparticles has not been positive although the

theory for amine functionalized carriers indicates that facilitated transport should take place. Two theories about the CO_2 transport trough the membrane are currently being investigated: 1) The amine groups on the nanoparticle surface bind CO_2 very strongly, making release difficult and thus limiting CO_2 transport through the membrane by a facilitated mechanism, or 2) Incompatibility of the nanoparticles with the applied polymer phase. Agglomeration of the nanoparticles could result in a decrease in the effective number of active sites for facilitated transport.

The effect of the polymer phase will as well be studied. Other possible new candidates are blends of polyallylamine with PVA and triblock copolymers, such as poly[styrene-amine-propylene)-styrene [SAPS], PEBAX block copolymer tested with 6FDA-Durene Diamine as the glassy polymer with functionalised silica nanoparticles embedded.

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References
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