Design and Characterization of Novel Membranes with Ionic Liquids for CO_2 Capture

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This work aims the design and characterization of novel membranes for different applications: the efficient removal of CO_2 from anaesthetic gas circuits using liquid membranes with Ionic Liquids (ILs) and a very efficient enzyme (Carbonic Anhydrase); and the CO_2 capture from flue gas in post-combustion processes at high temperatures using mixed matrix membranes with ionic liquids (MMMs-ILs);

Regarding the removal of CO_2 from anaesthetic gas circuits, an innovative process is proposed using supported ionic liquid membranes (SILMs) that combine the ability of ILs to solubilize CO_2 with the use of the enzyme carbonic anhydrase. The use of SILMs has been regarded as one of the most attractive approaches for CO_2 separation and recovery due to the low volatile character of ILs, the high solubility of CO_2 in ionic liquids when compared with other gases, specially when CO_2 task-specific ionic liquids are used, and the high diffusivity of gases in liquid membranes when compared with solid materials. Although supported ionic liquid membranes present high CO_2 selectivity values, this work proposes to enhance it further by the inclusion of an enzyme, Carbonic Anhydrase, which is able to convert CO_2 in HCO_3^- in a IL environment, as can be observed in Figure 1. These membranes combine the advantages of an efficient CO_2 bioconversion with the high affinity of task-specific ionic liquids for CO_2. Therefore, in addition to the increased uptake of CO_2 by the selective IL, the extra mechanism of enzymatic conversion to HCO_3^- will enhance the driving force for the CO_2 transport and greatly improves the total CO_2 mass transfer.

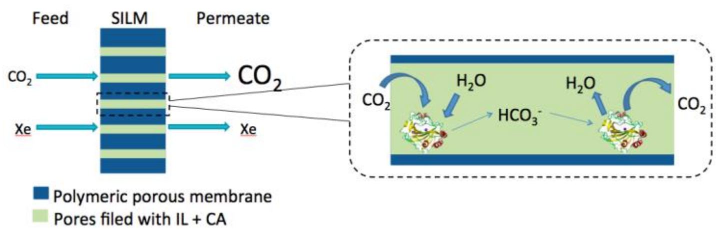

Figure 1. Schematic representation of the proposed concept.

For CO_2 capture from flue gas in post-combustion processes, amine-based solvent systems are used for scrubbing CO_2. However these conventional absorption technologies are rather energy intensive and present technical problems, such as corrosion and degradation of the absorbing amines. The separation and capture of CO_2 with minimum energy used is essential, and thus membrane-based processes show clear advantage relatively to other absorptive methods. Polymeric membrane-based separation processes have proved to be an energy-saving and cost-effective alternative to absorption or pressure swing adsorption processes for CO_2 separation. The efficiency of this technology depends mainly on the selection of the membrane materials, their properties, and the permeation mechanism. Even though membranes are already used for CO_2 capture, their performance is still compromised by membrane selectivity and permeability. The approach proposed is to design novel membranes combining a polymeric membrane with hybrid materials selective to CO_2, such as Metal Organic Frameworks (MOFs). These new membranes, designed as mixed matrix membranes (MMMs), will join the superior CO_2 permeability and selectivity of MOFs with the flexibility and ease of preparation of polymeric membranes. Additionally, MMMs may also incorporate ionic liquids, to further increase CO_2 permeability and selectivity.