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CO_2 capture by enzymatic bioconversion in a membrane contactor with task specific ionic liquids

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Separation of CO_2 from emission sources generated by power plants has been attracting much attention due to the enhanced greenhouse effect. Therefore, there has been a continuous effort to find energy efficient separation technologies for capturing CO_2 from post-combustion streams. Additionally, capture of CO_2 is also relevant for other applications, such as the removal of CO_2 from anesthetic gas streams, especially if expensive anesthetic gases are involved (e.g. Xenon).

The use of supported ionic liquid membranes has been regarded one of the most attractive approaches for CO_2 separation and recovery, due to: the low volatile character of ionic liquids (IL); 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 a thermo resistant enzyme, Carbonic Anhydrase, which is able to convert CO_2 in HCO_3^- in a IL environment, as can be observed in Figure 1 [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 TSIL, 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.

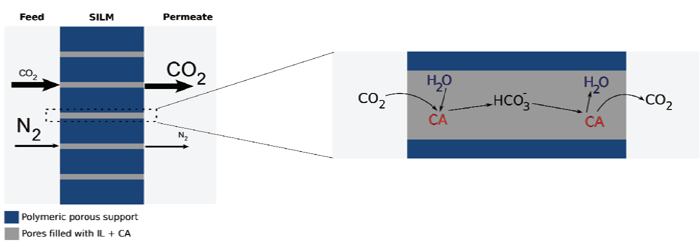

Figure 1. Schematic representation of the proposed concept.

Solubility and diffusivity coefficients of the pure gases CO_2, N_2 and CH_4 in different ionic liquids and one organic solvent PEG were determined at different temperatures between 30ºC and 100ºC. It was observed that for all these solvents, CO_2 presents a higher solubility coefficient when compared with other gases. High temperature stable supported ionic liquid membranes were also prepared by immobilizing different ILs and one organic solvent (polyethylene glycol, PEG) in a porous polymeric support. These membranes were found to be stable at temperatures up to 100 ºC and for a pressure difference up to 2 bar. The pure gas permeability towards the gases CO_2, N_2 and CH_4 was measured, and maximum selectivity values of 48 for CO_2/N_2 and 46 for CO_2/CH_4 separations were achieved for the lower temperature used.

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Solubility and diffusivity coefficients of the pure gases CO_2 and N_2 were also performed for the ionic liquids and organic solvent containing the carbonic anhydrase enzyme (concentration of $0.1 mg_{enzyme}/g_{solvent}$). Due to the fact that the biocatalytic activity is very sensitive to enzyme hydration, water activity of the solvent was also controlled. The results obtained showed that depending on the water activity of the solvents, the presence of enzyme increased the CO_2 solubility coefficient up to 30%, even for the low enzyme concentration used. In order to improve the selectivity and flux through the enzyme-solvent system, on-going work is focused on the evaluation of the performance of CO_2 task-specific ionic liquids, combined with higher concentrations of the carbonic anhydrase enzyme.

Future work is focused on testing this concept for the removal of carbon dioxide from anesthetic gas streams applications, where Xenon is present.

References

[1] L. A. Neves, C. Afonso, I. M. Coelhoso, J. G. Crespo, "Integrated CO_2 capture and enzymatic bioconversion in supported ionic liquid membranes", Separation and Purification Technology, (http://dx.doi.org/10.1016/j.seppur.2012.01.049)

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