Research project for a PhD student from China Scholarship Council

Title: Innovative composite polymer materials with high selectivity and separation ability

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Description:

The versatility of materials chemistry presents rich opportunity for tailoring membranes with unique transport and separation characteristics. Separation membranes have found applications in a variety of processes, as nitrogen separation from air, CO_2 separation from natural gas, and also as polymer electrolytes in fuel cells. If improved membrane materials could be developed, this technology would be used more widely in the existing applications and in many others as well. The search for these better membrane materials has spurred a huge effort by many research groups, but for the most part, the results have been disappointing [1, 2]. However, the polymer membranes are of particular commercial interest due to their low material cost and ease of large-scale manufacture.

The objective of the present PhD project is to design stable hybrid membranes with high selectivity properties suitable for environmental application. These multifunctional systems are intended for a wide variety of applications, involving membranes used for the separation, purification and dehydration of volatile organic compounds (VOC) [2] or for clean power devices (fuel cells) [3]. The membranes will consist of a network of spherical or lamellar inorganic particles (native and modified) introduced in polymer matrix (poly(amide-b-ethylene

oxide, polysulfone and/or polybenzimidazole) which will be also chemically modified by sulfonation reaction. This type of hybrid membrane should provide both high water sensitivity and better retention while maintaining high ionic conductivity at temperatures above 90°C. The structural, functional and transport properties will be studied and optimized according to the membrane preparation conditions, the charge content, their modification and their stabilization within the matrix.

Incorporation of an ionic liquid into the membrane will be considered to enhance ionic conductivity and/or vapor selectivity. The obtained results will be adjusted to mathematical models in order to determine the influence of the ionic liquid presence on the electrical parameters of the composite membranes. This will enable us to design membranes with the desired ionic conductivity and long-term stability (up to 5 000 h). Finally, the results of transport measurements (oxygen and hydrogen permeability) will be analysed and interpreted by using the transport models developed for the supported liquid membranes.

Keywords:

polymer hybrid membrane, separation, conductivity, selectivity

Applicant profile:

The project requires strong skills in organic and macromolecular synthesis, and in polymer physico-chemical characterization. A decent background in electrochemistry will be an additional advantage. The applicant must be fluent in english (or in french).

[1] Baker R.W., Low B.T., Macromolecules 2014 (47) 6999-7013.

[2] Rall D. et al., J Membr Sci 2019 (569) 209-219.

[3] Rahman S.N.A. et al., Ren Sustain En Rev 2016 (66) 137-162.