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Sustainable Membranes Based on 2D Materials for H_2 Separation and Purification

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Abstract : Hydrogen as a fuel and environmentally pleasant energy carrier is part of this transition towards low-carbon systems. The extensive deployment of hydrogen production, purification and transport infrastructures still represents significant challenges. Independent of the production process, the hydrogen generally is mixed with light hydrocarbons and other undesirable gases that need to be removed to obtain H_2 with the required purity for end applications. In this context, membranes are one of the simplest, most attractive, sustainable, and performant technologies enabling hydrogen separation and purification. They demonstrate high separation efficiencies and low energy consumption levels in operation, which is a significant leap compared to current energy-intensive options technologies. The unique characteristics of 2D laminates have given rise to a diversity of research on their potential applications in separation systems. Specifically, it is already known in the scientific literature that graphene oxide-based membranes present the highest reported selectivity of H_2 over other gases. This work explores the potential of a new type of 2D materials-based membranes in separating H_2 from CO_2 and CH_4. We have developed nanostructured composites based on 2D materials that have been applied in the fabrication of membranes to maximise H_2 selectivity and permeability, for different gas mixtures, by adjusting the membranes' characteristics. Our proprietary technology does not depend on specific porous substrates, which allows its integration in diverse separation modules with different geometries and configurations, looking to address the technical performance required for industrial applications and economic viability. The tuning and precise control of the processing parameters allowed us to control the thicknesses of the membranes below 100 nanometres to provide high permeabilities. Our results for the selectivity of new nanostructured 2D materials-based membranes are in the range of the performance reported in the available literature around 2D materials (such as graphene oxide) applied to hydrogen purification, which validates their use as one of the most promising next-generation hydrogen separation and purification solutions.

Keywords : membranes, 2D materials, hydrogen purification, nanocomposites
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