Development of sustainable mixed matrix alginate membrane substrates for gas separations

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The growing demand for sustainable and efficient gas separation technologies has driven research into innovative materials. In line with green chemistry principles, there is a strong emphasis on reducing or completely eliminating hazardous materials. Therefore, this study aims to evaluate the potential of alginate, a natural, biodegradable, gel-forming linear biopolymer extracted from brown algae [1], as a viable and eco-friendly alternative to conventional polymeric substrates that utilize toxic solvents in gas separation processes, particularly for CO_2 capture and natural gas sweetening. To address the fragile nature of alginate and improve its low permeance, various carbon nanomaterials were integrated to enhance its gas permeation properties, resulting in a green and sustainable substrate while upholding environmental sustainability.

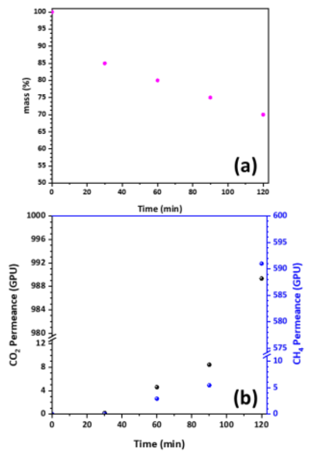

Figure 1: (a) Temporal variation of mass weight and; (b) corresponding changes in CO_2 and CH_4 permeance for the alginate/10 wt.% MWCNTs membrane substrate.

In this study, we developed several flat sheet membranes using alginate as the polymeric matrix, incorporating graphene nanoplatelets (GNPs) and multi-walled carbon nanotubes (MWCNTs) within the alginate. We optimized the filler content to achieve a balance between mechanical strength and permeance. This approach not only harnesses the eco-friendly properties of alginate, but also takes advantage of the selective adsorption capabilities of the fillers, leading to improved gas performance. As shown in Figure 1a, there is a continuous weight loss over time, indicating the presence of residual water or moisture in the membrane and suggesting that water gradually evaporates from its matrix. This moisture hinders gas permeation, reducing the initial permeance by making it difficult for CO_2 to pass through easily. Over time, the increase in CO_2 permeance, depicted in Figure 1b, is likely attributed to both structural changes within the membrane and the gradual evaporation of moisture. As CO_2 interacts with the alginate, it may cause slight swelling or plasticization of the polymer matrix, increasing the free volume or spaces between the polymer chains [2,3]. In addition, the membrane undergoes structural modifications, such as reduced hydration of the polymer chains, which further frees up diffusion pathways and enhances gas permeation.

The findings demonstrate that the development of a mixed matrix alginate substrate is feasible and offers significant potential for gas separation technologies, successfully merging sustainability with effective performance. This study contributes to the growing field of green materials by showcasing alginate-based membranes as a promising solution for efficient gas separation substrates, paving the way for further research in environmental applications.

References:

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