# Hybrid facilitated transport membranes containing GO-based nanoplatelets for $CO_2$ separation

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## Introduction

Amine-based fixed-site carrier membranes transport $CO_2$ through reactional pathway in addition to solution diffusion under humid conditions. Poly-amine blends with other film forming polymers have been proven to conveniently transcend the Robeson upper bound that denotes the trade-off (Deng et al. 2009). However, $CO_2$ plasticisation at high pressure in the case of $CO_2/CH_4$ separation and poor mechanical stability under humid conditions are often common problems in polymeric facilitated transport membranes (Ansaloni et al. 2015). A well-known approach to address this issue is the incorporation of various fillers to result in hybrid membranes. The fabricated hybrid membranes synergistically inherit individual properties of both polymer and filler phase with properties that arise due to their interaction. Anisotropically shaped thin nanosheets triggers nanoscopic changes in polymer chain packing, resulting in enhanced permeation performance at very low loading when compared to conventional fillers like Zeolites, MOFs (Park et al. 2017). Additionally, incorporation of 2D nanofillers like graphene oxide have been found to improve both selectivity and permeability due to the molecular sieving effect while reducing $CO_2$ plasticisation (Park et al. 2017). As a novel approach, the current study aims at combining the aforementioned two approaches to result in a mechanically stable thin composite membrane with superior separation performance. GO-based nanofillers were successfully incorporated in facilitated transport membranes to obtain novel membranes for $CO_2$ separation.

## Material and Methods

GO nanoflakes were synthesised using modified Hummers method. Dry GO was dissolved in deionised water, sonicated and centrifuged multiple times to obtain a stable GO suspension. Additionally, porous GO was also synthesised from this suspension by hydrothermal treatment with hydrogen peroxide solution at high temperature. Poly allylamine (PAA) was obtained by purifying PAA hydrochloride by precipitation in methanol. Polyvinyl alcohol was used as an additive and polysulfone ultrafiltration membrane was used as a support. Cast solutions of varying concentration and filler composition was prepared in deionised water. Thin film flat sheet composite membranes were fabricated through dip coating and bar coating techniques.

## Results and Discussion

The selective layer of the thin composite membranes is composed of PAA-PVA blend containing GO-based nanofillers. Polyvinyl alcohol was chosen as an additive owing to its excellent film forming capability and high compatibility with amine-based polymers by virtue of hydrogen bonding. The synthesized GO had a C/O ratio of 1.79 as determined by X-ray photoelectron spectroscopy (XPS). Defect-free ultrathin selective layers with thicknesses less than 600 nm were successfully coated on porous polymeric supports. No visible pore-penetration of polymeric chains was observed from the SEM results as seen in Figure 1. A similar pristine polymeric membrane fabricated using dip coating method was found to be almost impermeable at dry state due to high crystallinity. Under 100% relative humidity conditions, the permeability of $CO_2$ increased rapidly to 300 Barrer at room temperature with a mixed gas $CO_2/N_2$ separation factor of 68 due to facilitated transport. In the hybrid membranes, the GO nanosheets are found to have very good compatibility with the polymer matrix, giving rise to defect free selective layer. The GO nanosheets are expected to significantly reduce the plasticization (Lee et al. 2017) and enhance permeation properties.

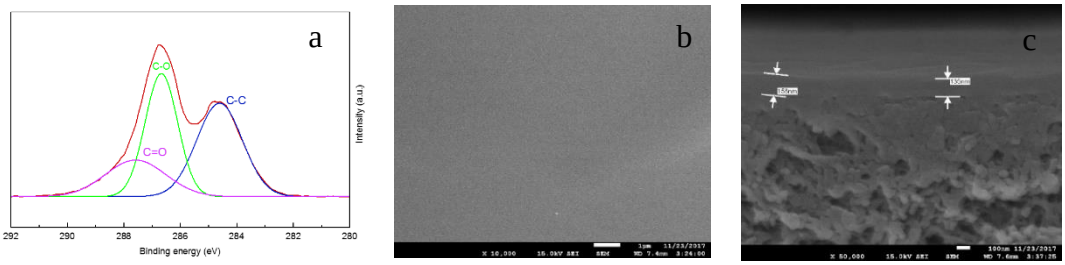



**Figure 1. (a)** Deconvoluted C 1s XPS spectra of synthesised GO; **(b) and (c)** SEM images of surface and cross section of the fabricated hybrid membranes

## Conclusion

Hybrid thin composite membranes with ultrathin selective layer containing PAA and GO-based fillers were successfully fabricated. Good compatibility of GO-based fillers favoured uniform coating with no visible voids or interfacial defects. The permeation studies of the fabricated hybrid membranes are still under investigation. Structural changes and chemical functionalization of GO nanosheets are also made to study the effect of filler modifications on the permeation performance.

## References


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