# Vapor-deposited molecular modification of PDMS nanomembranes for efficient $CO_2$ capture

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Climate change, driven by increasing levels of greenhouse gases (predominantly $CO_2$), necessitates effective $CO_2$ capture methods. Membrane-based separation has emerged as a promising solution for industrial applications and wide societal deployment for ubiquitous direct air capture (DAC) [1]. Polydimethylsiloxane (PDMS) nanomembranes stand out due to their excellent mechanical stability, chemical resistance, and high $CO_2$ permeance [2], which allows their application for membrane-based DAC (m-DAC). However, their moderate selectivity for $CO_2$ with respect to other components of air (($CO_2/N_2$) ~ 10 and ($CO_2/O_2$) ~ 5) requires enhancement to meet practical separation needs [1]. The improvement is conventionally achieved by adding a selective layer of another polymer, but this usually leads to significant reductions in permeance.

This study aims to improve the selectivity of PDMS nanomembranes by introducing an additional, surface modification layer via physical vapor deposition (PVD) of small molecule compounds that can interact specifically with $CO_2$. Such surface modification is believed to enhance selectivity without significantly impacting the membrane's $CO_2$ permeance. Among the available PVD methods, thermal evaporation offers the advantage of producing ultra-thin, uniform coatings in a relatively simple experimental setup. This approach was used in this study to deposit 18-Crown-6 ether (and other small molecules) on the PDMS. As a result, both $CO_2/N_2$ and $CO_2/O_2$ selectivity were transiently improved in CE/PDMS, while permeance was not impacted. The stabilization of the CE layer on PDMS however remains as a current issue.

The expected outcome of this work is an optimized membrane with improved selectivity and minimal trade-offs with gas permeance, potentially advancing the energy efficiency of $CO_2$ separation technologies, specifically m-DAC.

References:

1. S. Fujikawa, R. Selyanchyn and T. Kunitake, *Polymer Journal* (2021) **53**, 111-119.

2. S. Fujikawa, M. Ariyoshi, R. Selyanchyn and T. Kunitake, *Chemistry Letters* (2019) **48**, 1351-1354.