Ultrahigh permeance metal coated graphene membranes for efficient gas separation applications

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Graphene is considered as the ideal membrane due to its atomic thickness. Indeed, million times higher permeance values compared to the traditional membranes were realized using porous graphene. However, the selectivity values of these membranes were rather low, in the limits of Knudsen selectivity. In order to achieve high selectivity on the graphene membranes, large number of pores below 3 nm are required to operate in the molecular sieving regime without sacrificing the permeance. However, this is extremely challenging and currently existing pore generation techniques result either in high permeance-low selectivity or vice-versa. Herein to overcome this challenge we have developed novel adsorptive membrane approach, in which one of the gases interact with the adsorbent surface and retained while the non-interacting one passes through the membrane. By doing so, we achieved complete separation of helium and hydrogen mixture, which is not possible using conventional approaches. Moreover, using graphene as a membrane support allowed to obtain permeance values in the rage of 10^7 GPU (1GPU = 3.35×10^{-10} mol s^{-1} m^{-2} Pa^{-1}).
In another approach, we developed controlled pore tuning method to create large number of pores below 3 nm. We deposited gold layer in stepwise manner and studied molecular transport properties. Initially, pristine graphene showed Knudsen selectivity, however, upon deposition of few nm of gold layer, the gas transport started to shift to surface diffusion where hydrogen was favored over other gases. Eventually, deposition of more gold led to the molecular sieving and we achieved record high H_2/CO_2 selectivity of 31.3 at H_2 permeance of 2.23×10^5 GPU.

References

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Figures

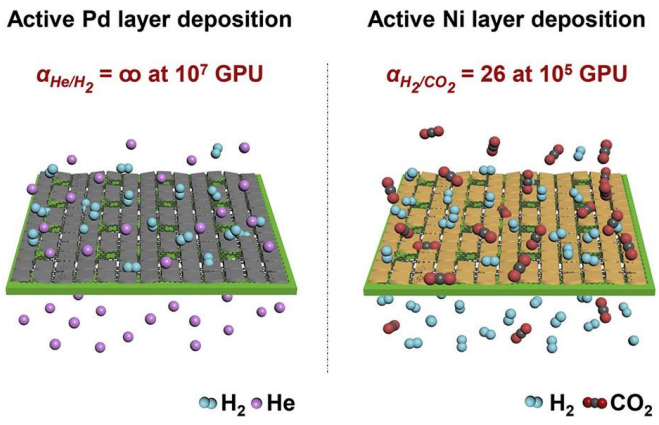

Figure 1: Schematic representation of Pd-coated for He/H_2 (left) and Ni-coated membrane for H_2/CO_2 (right) separation.