OE8) Nanoporous multilayer graphene membranes for efficient water treatments

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1. Introduction

Separation has become one of the critical technologies to solve the problems that mankind faced including resource depletion and environmental issues. Comparing to other separation approaches, membrane separation is energy effective, continuous and can be integrated in small volume facilities, reducing the total cost of operation. In the past several decades, polymeric and inorganic membranes have been utilized for the separation and purification and even commercialized in industry, but a trade-off between permeability and selectivity has hindered the wide adoption of membrane in practical applications, requiring high operation cost. Because subnanometer scale interlayer spacing of low-dimensional materials such as graphene, graphene oxide, MXene can determines the high selectivity and because these materials can be fabricated into the nanometer thick film, high performance membrane can be realized with high selectivity and permeability.

2. Materials and Methods

As in the case of currently available polymer membranes, the formation of nanometer pores on bulk-scale graphene is essential to realizing the mass production of high-performance graphene membranes. However, all previous graphene membranes have relied on the use of small quantity graphene with meso- or nanopore structures by using e-beam, ion beam exposure and thermal treatment with metal nano particles. Therefore, all previous graphenes are critically limited to the commercialization of the graphene membrane via cost-effective solution process. In this talk, the history of graphene membrane and basic separation mechanism will be briefly introduced, especially for separation of ions and dye molecules by multi layered graphene film. And our novel chemical method to fabricate the nano-porous graphene in bulk scale will be presented, showing the high selectivity to dye molecules with dramatically enhanced permeance.

3. Results and Discussion

Bulk scale graphenes containing narrow and dense pores are realized via potassium hydroxide activation of pre-oxidized graphite (size: *ca*. 3 nm, density: *ca*. $10^{15} m^{-2}$). A film (20 nmthickness) comprised of this nanoporous graphene displays much enhanced water flux (*ca*. 37 $L \cdot m^{-2} h^{-1} bar^{-1}$) than that of conventional graphene oxide membrane (~6 times), as maintaining the seiving performances of GO laminates with *ca*. 20% rejection for NaCl and up to 99% rejection for various dyes around 1 nm diameter size. This advantageous property is a result of the fact that in addition to the effect of the interlayer stacking of graphene sheets, nanopores in the graphene generated by using the new method serve as additional channels through which water molecules can diffuse. We believe that the new approach will play a key role in preparing and designing the graphene membrane with high flux.