Subnano-tuning of amorphous Silicon-based membranes for improved performance: Fabrication, characterization, and application to gas and liquid phase separation

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Abstract

Membrane-based separation is a highly promising and energy-efficient technology. Membranes are generally categorized into either polymeric or inorganic types, based on their material compositions. Over the past decades, inorganic membranes, composed of materials such as zeolite, silica, carbon, and metal-organic frameworks (MOFs), have seen significant advancements in fabrication and application. These membranes can be further classified as either "crystalline" or "amorphous" based on their structures. While zeolites and MOFs are typical examples of crystalline materials, amorphous membranes, represented by silica and carbon, have pores formed by their amorphous network structures. Although these amorphous structures have a broader pore size distribution compared to crystalline membranes, they often exhibit sufficient separation selectivity for practical use [1-3].

This presentation will summarize recent progress in the fabrication of silicon (Si)-based membranes at Hiroshima University, as illustrated in Fig. 1 [1-3]. Si-based amorphous membranes face critical challenges, including (1) separation performance, influenced by pore size control and defect-free thin-film formation, and (2) stability, particularly hydrothermal stability. The presentation will introduce recent fabrication approaches, including organosilica membranes via sol-gel processing, SiC-based membranes for enhanced stability, and metal-coordination aminosilica. Additionally, Plasma-Enhanced Chemical Vapor Deposition (PECVD) for thin-film formation will be discussed.

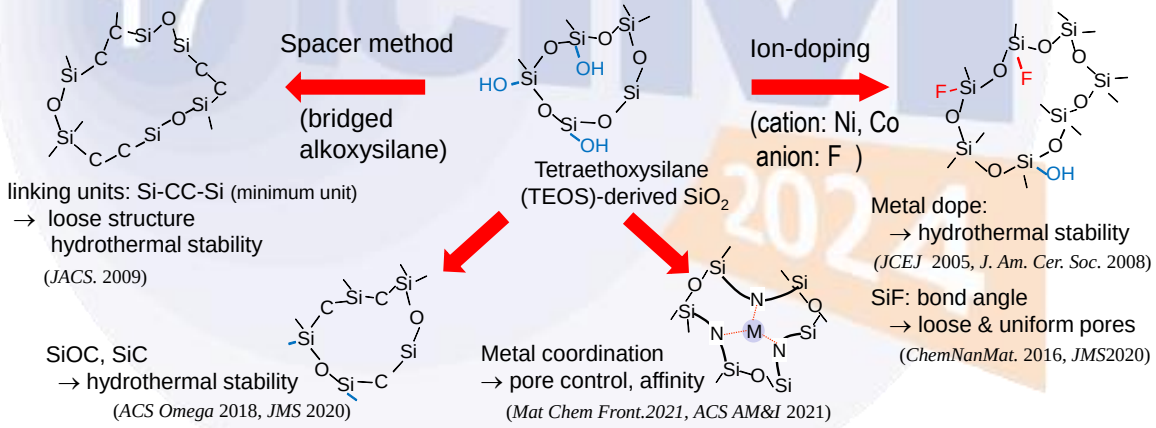

Fig. 1. Silicon-based subnanoporous membranes prepared using difference materials and processes.

For process intensification via membranes, the novel concept of steam recovery from flue gas will be introduced for simultaneous recovery of water and energy. We proposed a new system of steam and latent heat recovery from waste streams using organosilica membranes [4]. Proof-of-concept testing was conducted in a running incinerator plant. The proposed system eliminates the need for a water supply while simultaneously recovering latent heat from the waste stream.

References

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