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Controlled nanoconfinement of two-dimensional polyimide network in alumina membranes using a step-by-step growing approach

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The design of membrane materials with a controlled nanostructure and properties is key in developing stable, resilient, and efficient separation layers for applications under demanding conditions. This can be achieved using crystalline covalent organic frameworks that can be precisely customized to exhibit low densities and highly ordered channels of ~ 1–5 nm with well-defined porosities.

Nevertheless, current organic-based materials are not always compatible with industrial streams, particularly mixtures of water and organic solvents due to degradation or dissolution of the material itself in the presence of apolar solvent. Combining a chemically inert porous ceramic support functionalized with two-dimensional crystalline polyimides (PI) networks can overcome this instability issue [1]. Polyimide-based materials are among the most resilient polymeric membrane-based materials used nowadays. Particularly interesting are the recent polyimide-based nanomaterials composed of a two-dimensional triazine-based network with defined pore diameter (1- 2 nm), and high surface area [2]. The possibility of simultaneous pore confinement and covalent attachment of triazine-based covalent organic frameworks (COFs) into porous ceramic membranes is desirable but still unexplored. Besides, conventional methods to prepare such triazine-based materials involve pressurized vessels or toxic solvents, limiting the upscaling possibilities [1], [2].

In this work, a new synthesis method was used to prepare a triazine-based two-dimensional polyimide layer. The preparation of this membrane first requires the step-by-step preorganization of a molecular network directly in a porous ceramic membrane, followed by an imidization reaction in the solid state (Fig. 1). Relevant methods have been explored to demonstrate the nanoconfinement of the polyimide network on/in alumina ceramic supports. In this presentation, the physicochemical characteristics and membrane performance in various solvent mixtures will be described and discussed.

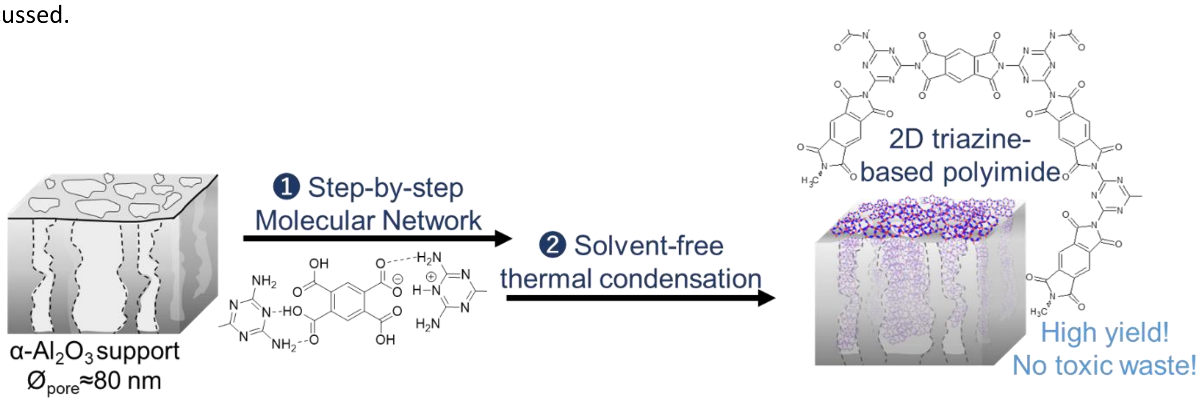

Fig. 1. Schematic illustration of the solvent-free approach to preparing nanoconfined two-dimensional triazine-based network directly in ceramic membranes.

[1] N. Kyriakou, L. Winnubst, M. Drobek, S. de Beer, A. Nijmeijer, and M.-A. Pizzoccaro-Zilamy, 'Controlled Nanoconfinement of Polyimide Networks in Mesoporous γ-Alumina Membranes for the Molecular Separation of Organic Dyes', *ACS Appl Nano Mater*, 2021, doi: 10.1021/acsanm.1c03322.

[2] H. Duan, P. Lyu, J. Liu, Y. Zhao, and Y. Xu, ‘Semiconducting Crystalline Two-Dimensional Polyimide Nanosheets with Superior Sodium Storage Properties’, *ACS Nano*, 2019, doi: 10.1021/acsnano.8b09416.