Preparation of a hollow fiber membrane using kaolin ($Al_2Si_2O_5(OH)_4$) as precursor

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Abstract

Introduction

Membrane separation processes, utilized across chemistry, food, and biotechnology industries, feature ceramic membranes as preferred choices due to their robustness in challenging settings, resistance to microbiological degradation, and capacity to endure high pressure conditions [1,2]. The phase inversion method, traditionally employed in polymeric membrane production, has undergone advancements and now integrating a single sintering step to craft asymmetric ceramic membranes [3]. Kaolin ($Al_2Si_2O_5(OH)_4$), is a clay mineral abundant in numerous countries, has emerged as a prominent starting material for the production of ceramic membranes [4] In this study, low cost asymmetric hollow fiber membranes were produced by using kaolin as the starting material.

Material and Methods

The ceramic suspension was prepared according to the procedure described by Hubadillah et al. [4] and the membranes were produced by the phase inversion/sintering technique following the methodology described by Kingsbury and Li [5]. The produced hollow fibers were characterized in terms of their morphology, water permeability and mechanical resistance. Morphological analyses of pristine and AgNP-impregnated kaolin hollow fibers were performed using a scanning electron microscope (SEM, Carl Zeiss, model EVO MA10, Carl Zeiss). The water permeability of the hollow fibers was assessed under varying transmembrane pressures and at room temperature (around 25 °C). Additionally, mechanical strength was evaluated through a three-point bending test utilizing an Instron Model 9600, connected to a 5 kN cell, employing hollow fibers with a length of 3 cm [6]

Results and Discussion

The phase inversion method is employed in ceramic membrane production to achieve asymmetric structures, wherein a spongy layer forms to enhance membrane selectivity and mechanical resilience [5]. Fig. 1 illustrates the cross-section and external surface of the kaolin hollow fiber.

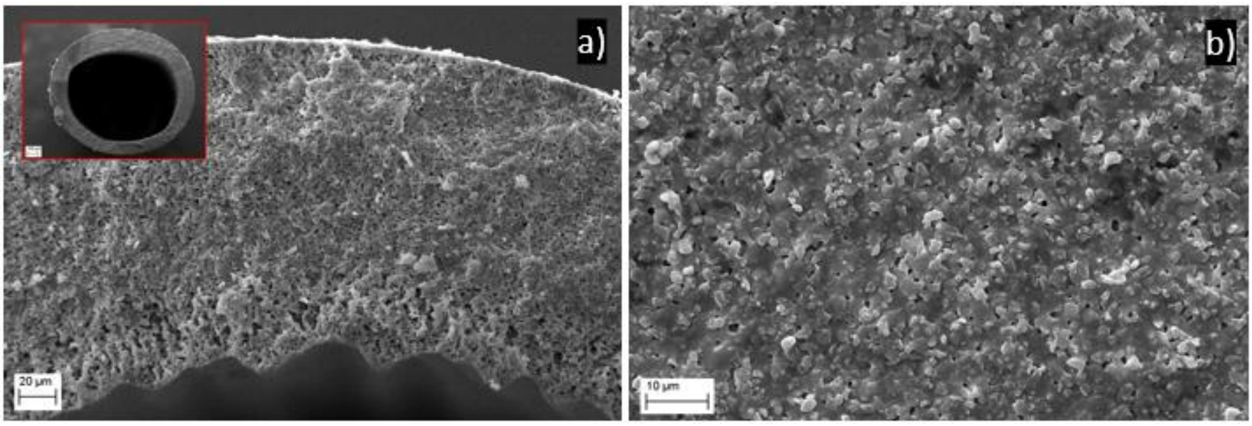

Fig 1. Cross-section (a) and external surface (b) of the kaolin hollow fiber.

The extrusion process facilitated the attainment of the hollow fiber geometry, and the hollow fiber exhibited external and internal diameters of 1.40 mm and 1.07 mm, respectively. As presented in Fig. 1(a) the produced kaolin hollow fiber presented a finger like region at the lumen side. Similar results were reported by Magalhães et al. [6] for kaolin hollow fibers produced at different extrusion conditions.

The water permeability of the kaolin fiber produced was 8.459 ± 0.170 L h^{-1} m^{-2}·kPa^{-1}, as presented in Fig. 1. This result closely resembles the values reported by Sharma et al. (2) for a kaolin-based membrane sintered at 950 °C, which exhibited a water permeability of 12.96 L h^{-1} m^{-2}·kPa^{-1}. Furthermore, the bending strength of the kaolin hollow fiber was measured at 103.58 ± 14.41 MPa, indicating that the kaolin fibers possess adequate mechanical resistance for pressure-driven filtrations.

Conclusions

Ceramic hollow fiber membranes with an asymmetric pore size distribution were fabricated using kaolin as the starting material. The kaolin hollow fiber presented permeability and mechanical resistance characteristics, which suggest the application of this hollow fiber as a support for the impregnation of several nanoparticles or as a membrane itself for filtration processes.

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