

Effect of incorporating cellulose nanocrystals on the mechanical, thermal, morphological and transport properties of dense nanocomposite poly(vinyl alcohol) membranes

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Hydrophilic membrane pervaporation is regarded as an attractive alternative to molecular sieves and azeotropic distillation, the common processes used for ethanol dehydration (1). Three major types of membranes have been studied: i) organic (polymeric), ii) inorganic and iii) hybrid membranes that cover polymeric as well as inorganic ones. During the last decade, considerable efforts have been put in the development of innovative membranes in the quest of better chemical, hydrothermal and mechanical stability and optimized perm-selectivity performances (2). Polymeric membranes remain the most widely used for pervaporation in the industry. These membranes are attractive because of their economical and fabrication advantages. Poly(vinyl alcohol), PVA, is one of the preferred water-soluble polymers as it exhibits high selectivity, tensile strength, elongation and flexibility. PVA is produced from polyvinyl acetate after hydrolysis of acetate groups by saponification. Along with polymerization degree, the hydrolysis ratio enables to modulate the properties of the polymer either before or after processing. Chemical cross-linking and annealing can additionally reduce free-volumes available for transport and therefore increase PVA selectivity. The properties of PVA polymers can be modulated through the incorporation of nanosized particles (3). With the increasing drive towards the valorization of environmentally friendly biopolymers, the use of cellulose nanocrystals (CNC) as nanosized reinforcements in PVA has attracted considerable attention to replace the traditional mineral fillers and take advantage of the large specific surface area and interesting mechanical properties of CNC (4).

This work aimed to study the characteristics of dense nanocomposite membranes based on PVA and CNC (Fig. 1). Membrane casting was performed with CNC loading levels between 3 and 30% w/w. Different techniques were used to study the properties of the membranes: thermogravimetric analysis, differential scanning calorimetry, morphological and mechanical analyses. Moreover, sorption and pervaporation experiments were performed using pure, binary and ternary mixtures of ethanol, methanol and water. Results showed that CNC nanofillers improve the mechanical properties of PVA membranes. Sorption experiments showed an excluded volume effect brought by CNC. The obtained membranes were successfully tested using a pervaporation pilot plant. The permselectivity performances of nanocomposites remained quite interesting even for relatively high amounts of CNC fillers. The improvement in the mechanical properties of nanocomposite membranes could reduce the degree of crosslinking and thus improve the permeability performances compared to the highly crosslinked commercial membranes.

Keywords: *Nanocomposites, Poly-vinyl alcohol, Cellulose nanocrystals, Pervaporation, Ethanol, Methanol, Dehydration.*

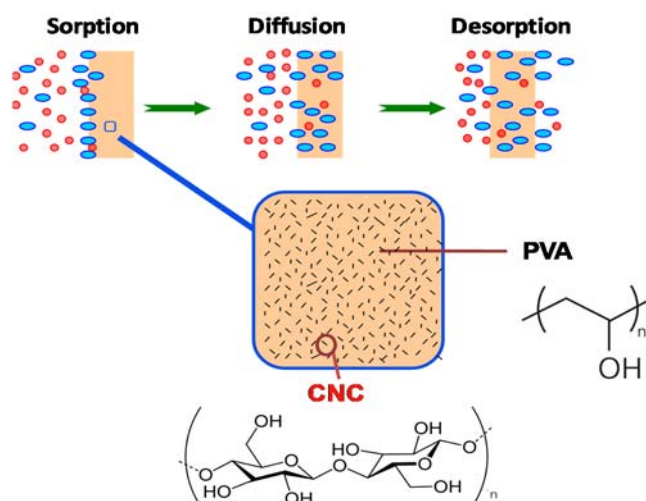


Figure 1. Sorption-diffusion transport mechanism through a nanocomposite PVA-CNC pervaporation membrane.

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