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Vacuum-Assisted Tailoring of Pore Structures of Phenolic Resin Derived Carbon Membranes

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Abstract

This work shows the preparation and separation performance assessment of carbon membranes derived from phenolic resin by a vacuum-assisted method and carbonisation in an inert atmosphere. The vacuum time played an important role in tailoring the structure of the membranes. For instance, pore volumes and surface areas increased from 0.81 and 834 to 2.2 cm^3 g^{-1} and 1910 m^2 g^{-1}, respectively, as the vacuum time exposure increased from 0 to 1200 s. The significant structural changes correlated very well with water permeation, as fluxes increased by 91% as the vacuum time increased from 0 to 1200s, reaching up to 169 kg m^{-2} h^{-1} at 5 bar. Molecular weight cut-off tests showed no rejection for the smaller glucose and sucrose molecules, though this increased to ~ 80% and full rejection for 36kD and 400kD polyvinyl pyrrolidine. Interestingly, FTIR spectra showed that the peaks of C-H stretching vibration (2800-3200 cm^{-1}) and C-O stretching (1030 cm^{-1}) became more pronounced as a function of increasing vacuum time, strongly suggesting that the use of vacuum further assisted in the polycondensation of phenolic oligomers. Based on these outcomes, a cluster to cluster model is proposed, whereby vacuum application promoted crosslinking reactions of the phenolic resin, creating microporous regions within the clusters, and mesoporous regions between the clusters.