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Food polymer pullulan-κ-carrageenan composite membrane performed smart function both on mass transfer and molecular size recognition

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ABSTRACT

Biopolymer pullulan (P) can be cross-linked easily by glutaraldehyde, and additive κ-carrageenan (κC) completes an attractive combination for increasing tensile strength sufficiently for practical use. In this study, the κ-carrageenan mass fraction (F_C) was defined as $F_C \equiv (\kappa C[g]/(P[g] + \kappa C[g]))$ and was set at 0.33, 0.50, 0.66, and 0.83. Composite membranes were successfully prepared in our experiment F_C ranges by the casting method. The maximum stress and strain, water content, mass-transfer characteristics, and pure water permeability were demonstrated to be a function of the added cross-linker glutaraldehyde. Increasing the mass fraction of κ-carrageenan enhanced the maximum stress and the maximum strain at break, suggesting that pullulan imparts flexibility and the κ-carrageenan imparts stiffness to the composite membranes. The mass-transfer characteristics were analysed based on changes in the effective diffusion coefficient in the composite membranes. Some water-soluble marker components were employed to estimate the size of the mass-transfer channel in the composite membranes. The reference molecular size was from 60 to 826Da, indicating Urea, Methyl Orange, Indigo Carmine, Bordeaux S, and Brilliant Blue. The effective diffusion coefficient was dramatically changed by a factor of 26,000 for F_C 0.66, even though the molecular weight of the reference only changed by a factor of 14. The F_C value significantly controls not only the mechanical strength but also the molecular size recognition of the membrane. A large dependence on the molecular size was achieved by specific polymer frame-works using the excellent combination of pullulan and κ-carrageenan.

Keywords: Pullulan; κ-Carrageenan; Mechanical strength; Effective diffusion coefficient; Composite membrane; Water permeability

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