Original Paper

Permeability of Oxygen and Carbon Dioxide in Dried and Water-Swollen Compostable Chitin and Chitosan Self-Standing Membranes

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The permeation behavior of oxygen and carbon dioxide dissolved in water and dried ones was studied by using dried and water-swollen membranes of compostable chitin and chitosan at 25–45 °C for the circular economy. The permeability coefficients of the dissolved oxygen and carbon dioxide of the chitin water-swollen membrane at 25 °C were 47.7 ± 5.4 × 10^{-10} and 328 ± 17 × 10^{-10} cm^3(STP)cm/(cm^2 s cmHg), respectively, which were 73.4 and 77.0 times higher than the dried gas for the dried chitin. The permeability coefficients of the dissolved oxygen and dissolved carbon dioxide of the chitosan water-swollen membrane at 25 °C were 36.4 ± 6.9 × 10^{-10} and 220 ± 15 × 10^{-10} cm^3(STP)cm/(cm^2 s cmHg), respectively, which were 36,400 and 220,000 times higher than the dried chitosan gas permeabilities. Dissolved oxygen and carbon dioxide seemed to permeate the water portion of the water-swollen membranes, especially in the water that did not interact with the polymer chains (*i.e.*, free water). Additionally, the temperature dependence of the permeability coefficient indicated that for carbon dioxide, the chitin and chitosan membranes, which are the glassy polymers at room temperature, exhibited the same permeation behavior as petroleum-derived rubbery polymer membranes in the water-swollen state. For oxygen, however, the permeation behavior did not match that of petroleum-derived glassy and rubbery polymers.

Keywords: Chitin, Chitosan, Polysaccharides, Gas permeability, State of water

1. Introduction

The advent of the circular economy has increased the demand for recyclable or adaptable polymer materials[1,2]. Petroleum-based synthetic polymer membranes are the most common membrane materials. From the viewpoint of resource security, a shift from petroleum as a depletable resource to renewable resources is required.

Plastic materials used in food and beverage packaging should have barrier properties against oxygen, carbon dioxide, water, and water vapor. Packaging materials are used in contact with water. In general, plastics that absorb water are used in a laminate structure sandwiched between plastics that do not absorb water. For packaging applications, an understanding of the degradation of materials in direct contact with water is needed. In other words, the barrier properties of oxygen and carbon dioxide should be explored both when materials are in a dry state and when they contain water.

To date, we have focused on polysaccharides, which are natural polymers that can be composted as materials for water vapor barrier packaging, dehumidifying membranes, and moisture-retaining materials[3-7]. Most polysaccharides are water soluble, but preliminary experiments have shown that chitin and chitosan (Fig. 1) membranes are insoluble in water. In this study, the permeation behavior of oxygen and carbon dioxide in their dried and water-swollen membranes was discussed.

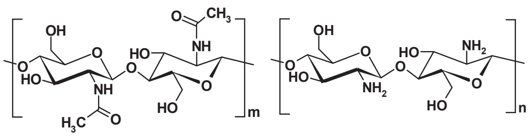

Fig. 1. Chemical structures of chitin and chitosan.

2. Experiment

2.1 Materials and membrane preparation

Powdered chitin (CAS Registry No. 1398-61-4, Lot No. LKG4920) and chitosan (CAS Registry No. 9012-76-4, Lot No. LER1094) were obtained from FUJIFILM Wako Pure Chemical Co., Japan and used as received. Membrane preparation of chitin was

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