Original Paper

Permeability, Diffusivity, and Solubility of Dried Gases in Alginic Acid, Sodium Alginate, and Ammonium Alginate Self-Standing Membranes

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Biomass plastics are attracting research attention owing to the growing environmental problems caused by plastic products. In this study, we investigated the effects of counter cations on the gas-permeation properties of hydrogen, oxygen, nitrogen, carbon dioxide, and methane in the membrane state of alginic acid (Alg) and sodium alginate (Na-Alg), in which the hydrogen atom of the carboxy group of Alg from seaweed is replaced with sodium, as well as ammonium alginate (NH_4-Alg), in which it is replaced with ammonium ions. These polysaccharide membranes exhibited permeation behavior based on a solution-diffusion mechanism similar to that of common polymeric membranes. Using Alg as the standard, the counter cations in the Na-Alg and NH_4-Alg membranes affected the aggregation structure of the polymer chains and contributed to the construction of a densely packed membrane structure. These polysaccharide membranes can be used as gas-barrier layers for earth-friendly industrial applications such as packaging.

Keywords: Alginic acid, Alginates, Polysaccharides, Gas permeability, Solution-diffusion mechanism

1. Introduction

Plastics, which are used in wide-ranging fields including packaging materials, are chemically synthesized from fossil fuel. On the basis of the production volume of fossil fuels in 2020, the number of years fossil fuel can be extracted is estimated to be 53.5 years, so securing stable fossil-fuel resources and searching for alternative resources have become urgent issues[1]. One solution to this problem is to utilize biomass plastic by using biomass resources, which are non-depletable resources, as raw materials. The use of biomass resources as raw materials is expected to eliminate resource depletion. It can also uppress the increase of CO_2 in the atmosphere through the carbon cycle via biomass resources, on the basis of carbon neutrality. However, most of the biomass resources currently used are produced on land, such as corn, which is difficult to procure because of land-area issues.

This work focused on alginic acid (Alg) and alginates in seaweeds, which can be produced at sea. In the case of *Undaria pinnatifida*, commonly known as wakame in Japan, the content of alginates in seaweeds reportedly reaches more than 50% by dry weight[2]. As part of our studies on food supplements, food additives, and packaging materials, our research group has been investigating natural polysaccharides, such as hyaluronic acid, sodium hyaluronate, starch, chitin, chitosan, Alg, sodium alginate (Na-Alg), calcium Alg, (Ca-Alg), ammonium alginate (NH_4-

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