

Chapter 11

Study on the Use of Biomass Polymer Sheets in Water/ Alcohol Pervaporation as a Sustainable Source of Alcohol Energy

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ABSTRACT

This chapter presents an overview of the study of cellulose sheets used as a bio-membrane in water/alcohol pervaporation for a variety of purposes in order to offer an environmentally sustainable, renewable, low-energy use and economical alternative. Particular interest is the utilization of readily available biological materials such as cellulose and chitosan to create biomass polymer membranes for the environmentally responsible and sustainable process of reclaiming alcohol from alcohol/water mixtures through the use of cellulose in the pervaporation process. This process is a promising and innovative alternative to the more energy intensive, environmentally destructive methods and materials currently used.

INTRODUCTION

Growing public health and environmental awareness accompany an increasing number of stricter environmental regulations on waste discharge, water purification, air pollution contaminants and the over utilization of natural resources. The ability to use abundant, sustainable and renewable resources in processes and materials related to bio membranes is highly attractive. In particular, the separation of alcohol from an alcohol/water mixture can have important implications in the ability to secure the energy that the reclaimed alcohol can provide, and that may have been lost without this technology. The fuel source provided by the separated alcohol in this ecologically friendly manner can then be utilized in a range of ways, including the automotive, industrial and mechanical fields. Attention has been focused on uses of

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biopolymers from renewable resources as alternatives to synthetic polymers (Amar, Mohanty, Depan, Tomer & Singh, 2007). Biopolymers produced in nature by living organisms and plants (e.g., microorganisms, plants, crustaceans) have the characteristics of often being biodegradable and non-toxic, being part of the natural bio-cycle and eventually degrading and being reabsorbed into the natural environment. Biopolymers have repeated sequences that vary broadly in chemical composition including a variety of repeating functional groups of such carboxyl, hydroxyl and amino group. This makes them reactive and subject to cross-linking. Therefore, biopolymers having a high molecular weight and containing repeated sequences may have a greater opportunity for chemical interaction with other compounds. Depending on their functional groups, biopolymers can bind metals, organic contaminants, or soil particles and form interpenetrating cross-linking networks with other polymers (Chandra & Rustgi, 1998).

In general, compared to conventional plastics derived from mineral oil, biopolymers have a more diverse chemistry and side chain architecture, giving the material scientist unique possibilities to tailor the properties of the final package (Kumar, Srivastava, Galaev & Mattiasson, 2009). All of these biopolymers are by nature hydrophilic and somewhat crystalline, factors that can cause difficulties, especially in relation to the packaging of moist products. The excess of disulphide cross-linking and thermal degradation of these polymers are also two main problems in their processing and performance. On the other hand, these polymers produce materials with excellent gas barriers (Meyers, 2008). Three interesting materials applicable to this function are whey, gluten and chitosan. The development of their application in food packaging has increased due to the large surpluses of the raw materials which are found in large amounts in the processing of cellulose for paper. Over the last few years, interest in the naturally available class of polymers known as polysaccharides has been increasing rapidly and biopolymers are replacing synthetic polymers in numerous applications (Krochta & Mulder, 1997).

MATERIALS FOR BIOPOLYMER MEMBRANES

Cellulose

Cellulose is the most abundant and major biopolymer on the earth. It is a renewable biopolymer with a long and well-established technological base (Klemm, Fink, & Bohn, 2005). It can be a primary chemical resource of the future as it is renewable, biodegradable, biocompatible and derivatizable. Cellulose is a complex carbohydrate consisting of a chain of linked glucose molecules (Figure 1), a polysaccharide consisting of a linear chain of several hundred to ten thousand β (1 \rightarrow 4) linked D-glucose units held together with hydrogen bonds to form the microfibrils that contribute to the strength of cellulose. The configuration of the hydrogen bonds also allows cellulose to be more soluble in both water and aqueous alkaline solutions (Schurz, 1999).

In the past century, cellulose has been produced and used in applications including films and injection-molded products. The development of biomaterial-based cellulose membranes is one of the most exciting fields in relation to many potential applications such as bio-separation, tissue engineering, and food processing. Cellulose membrane and its derivatives have been widely utilized for membranes separation technologies such as dialysis and ultrafiltration and have proved to be important because of the chemical stability, biological compatibility, and high tenacity in the dried state.

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