Estimation of resistance of starch/polyvinyl alcohol blends to permeation by organic solvents

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ABSTRACT

The chemical resistance of chlorinated hydrocarbons in starch/polyvinyl alcohol (PVA) blends has been investigated using a permeation cell with an in-cell solid phase microextraction (SPME) sampling device. The chlorinated hydrocarbon with a large molecule size or lower polarity was found to be less permeable through the starch/PVA blends. The tensile strength and chemical resistance of chlorinated hydrocarbons decreased with an increase in the starch content of blends. For the starch/PVA blends, the solubility of chlorinated hydrocarbons was inversely proportional to their molecular weight, molar volume and *log* K_{ow}. The diffusion coefficients and solubility of permeants were proportional to the content of starch in the starch/PVA blends. It is plausible that the blends will be inclined to the starch characteristics as the plasticizer (i.e. glycerin) disrupts the rigidity arrangements of the starch and PVA. The present work provides information on the extent of organic compound permeation through starch/PVA blends for the practical application.

Keywords: starch; polyvinyl alcohol (PVA); permeation; diffusion coefficient; solubility.

1. Introduction

Most synthetic polymers are difficult to degrade in a natural environment and may contribute to severe pollution. In the past few years, attempts have been made to solve these problems in the development of biodegradable polymers. Griffin (1974) proposed a method to increase the biodegradability of plastics by blending. Several researchers have focused on the production of starch-based polymers in which starch is blended with biodegradable synthetic polymers such as polyvinyl alcohol (PVA) and polylactide (PLA) (Imam et al., 2005; Park & Im, 2000; Zhao et al., 2006).

PVA is a water soluble polymer with excellent properties, such as low permeability and high water absorption capability. The PVA film has been used in a wide range of industrial and agricultural applications. However, PVA is relatively expensive and has a low biodegradation rate (Mao et al., 2000). Starch is a cheap and fully biodegradable polymer. A small amount of starch (6~30%) is blended with PVA to reduce the cost and enhance the biodegradability of PVA (Jayasekara et al., 2004; Tang & Alavi, 2011).

Starch lacks the physico-mechanical characteristics of traditional plastics such as strength, water resistibility, processability and thermal stability (Tang & Alavi, 2011). In addition, the starch/PVA blends are compounded using a number of plasticizers, e.g. water and glycerol, to increase their flexibility and workability (Chai et al., 2009; Liu et al., 1999). Several studies have been conducted to understand the biodegradability,

69 processability and mechanical properties of starch/PVA blends (Mao et al., 2000;
70 Tudorachi et al., 2000; Zhao et al., 2006). Although PVA exhibits chemical resistance
71 to solvent, oil and grease, it is doubtful that the blending of starch to PVA with the
72 plasticizer, glycerin, may result in a degradation of chemical resistance with faster
73 breakthrough of the chemical as compared to the permeation of PVA material only.
74 Since the packaging and containers for organic chemicals are made of starch/PVC blends,
75 it is critical to assess the resistance of the starch/PVA blends to permeation by these
76 chemicals.
77 In this study, the permeability of chlorinated hydrocarbons through the starch/PVA
78 blends was estimated using a 1-inch permeation cell. The corn starch was grafted with
79 sodium trimetaphosphate (STMP) and then blended with the plasticizer (i.e. glycerin)
80 and PVA. The diffusion coefficients and solubility of chlorinated hydrocarbons in the
81 starch/PVA blends were determined using the diffusion equation of Fick's law. Finally,
82 correlations between the diffusion coefficients or solubilities and several physical and
83 chemical properties of the chlorinated hydrocarbons were investigated. The correlation
84 analysis may provide an understanding in the permeation process of organic compounds
85 in the PVA/starch blends.