สำนักงานวิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

CHAPTER I
INTRODUCTION

Nowadays, the alternative renewable energy becomes an attractive choice of fuel due to the increasing in price of fuel, a serious shortage of fossil resources and environmental concerns, particularly greenhouse gas emissions. One of the interested renewable energy is biofuels which include of biodiesel, bioethanol, biomethanol, biogas, etc. These fuels are derived from biomass that can be produced from agricultural feedstocks and industrial wastes. The most common renewable biofuel today is bioethanol or otherwise, is also known as "gasohol", which is a mixture of petrol (gasoline) and ethanol (Sun *et al.*, 2008). Gasohol has a number of advantages over conventional petroleum based fuels such as lower price, higher octane number, better antiknocking properties and higher heat of vaporization. Furthermore, its combustion process is complete, resulting in reduced emission of some pollutants. Generally, ethanol used in gasohol is derived from the distillation process that is a simple ethanol-water separation technique used in the petrochemical industry. The separation of ethanol from dilute aqueous solutions by distillation is unattractive since it requires high energy consumption and an auxiliary agent for purification due to the close boiling point of ethanol and water that can form an azeotropic mixture. Other techniques including liquid–liquid extraction, carbon absorption, and air stripping require high operating costs and, have some limitations in some cases, which making these techniques unattractive for industrial applications. Therefore, more efficient ethanol-water separation techniques are preferred in order to reduce the gasohol production cost (Pakkethati *et al.*, 2011).

Pervaporation (PV) is especially attractive separation technique when compared to other conventional techniques for a separation of azeotropic mixture and similar physical of compounds that have chemical properties which cannot be separated by a common distillation processes (Khayet *et al.*, 2008). This technique utilizes the concept of partial vaporization of liquid through a membrane that derived from the two-step of the process. Firstly, liquid permeates through a membrane and then it evaporates into the vapor phase (Pakkethati *et al.*, 2011). Pervaporation technique continues receiving an increase attention due to its higher separation

efficiency and potential savings in capital and energy consumption. Furthermore, polymeric membranes can be used and this technique has great design flexibility to improve the membrane selectivity and permeability.

In this study, polybenzoxazine (PBZ), a newly developed addition cured phenolic system derived from a reaction between various aromatic/aliphatic amines, mono/diphenols, and formaldehyde, was selected as a membrane due to polybenzoxazine provides excellent characteristics such as high heat resistance, flame resistance, good chemical resistance and electrical properties, low absorption of water, low shrinkage upon polymerization, no need of catalyst for polymerization, no by product or volatile generation and excellent molecular design flexibility (Ishida *et al.*, 1996). It has been reported that the brittleness which is a shortcoming of PBZ can be improved by using bisphenol A, formaldehyde and aliphatic diamine as starting materials (Chernykh *et al.*, 2006). However one factor that had to be considered for membrane for separation was the swelling effect which could decrease the membrane selectivity (Pakkethati *et al.*, 2011).

The aims of this research were to prepare a new kind of cardanol-modified polybenzoxazine membrane by using benzoxazine precursor that synthesized from bisphenol–A, formaldehyde, and 1,6–hexanediamine as reactants and 1,4 dioxane as a solvent. Various amounts of cardanol were incorporated into the matrix in order to reduce the swelling effect of polybenzoxazine membrane for ethanol/water separation via pervaporation technique, and also investigated the effect of cardanol content on the permeation flux and separation factor of membranes compared with prestine polybenzoxazine membrane. Moreover, various amounts of NaA zeolite were incorporated into the system in order to increase the permeation flux of the membrane, while separation of the membrane was maintained. The effect of zeolite content on the permeation flux and separation factor of membranes were also investigated.