CHAPTER I

INTRODUCTION

1.1 Background

Alcohols are widely used in pharmaceutical and chemical industries. Moreover, it is considered a leading applicant as the fuel of choice for vehicle applications. Such as methanol is used as an olefins feedstock, as a clean fuel for electric-power generation, or as a fuel for either diesel powered vehicles or fuel-cell operated vehicles that can convert methanol into hydrogen power. Methanol is a chemical used to produce formaldehyde, acetic acid, and a variety of other chemical intermediates. A significant amount of methanol is also used to make MTBE (methyl *tert* butyl ether), an additive used in gasoline.

Alcohols are manufactured from natural feedstocks by fermentation, from synthesis gas, and as a by-product of the Fisher-Tropcsh synthesis [1]. The use of alcohol as fuel is limited by a high water content in alcohol products. Also, the alcohol products are purified. Conventionally, the most common methods for separation and concentration of alcohol from an alcohol aqueous solution have been distillation and adsorption.

Distillation is a separation process based upon differences in boiling points, obtained by repeated vaporization and condensation steps. The distillation equipment for separating the water from the methanol aqueous solution can be generalized into the following: single-, two-, and three-column distillation depends on the specifications of product grade [2]. For two column distillation, the first column is the extraction column which requires 40-50 trays with reboiler duty of 0.5-0.7 pounds of steam per pound of methanol product, and the second column is the refining column which requires 60-70 trays with reboiler duty of 1.2-2.0 pounds of steam per pound of methanol product. The conventional distillation method requires a substantial amount of heat and a large distillation system when present the small amount of water.

In the process of dehydrating by adsorption on solid particulate desiccants such as zeolite, anhydrous calcium sulfate, activated aluminum and silica gel is discussed by Othmer [3]. This process separates a relatively small amount of water from a hot gas mixtures mostly containing methanol. Selective adsorption of the water present is accomplished, using some part the sensible heat of the gas stream for generating mechanical and/or electrical energy and for heating of the adsorbed water so that no energy from outside the system is added or required for operating this dehydration. Although, the capital costs of adsorption are usually low (assuming existing beds are inplace), operating costs including adsorbent replacement, high energy of regeneration, adsorbent disposal, and hazardous gaseous effluents are significant deterrents in separation process.

The energy consumption is often a critical process parameter for a large-scale separation. The cost of energy supply is usually a major contributor to the process cost. From the above reasons, both methods require a large energy consumption and hence the operating cost will increase, leading to an increase of the cost of purified product. Therefore, alternative methods which give low energy consumption are needed.

Recent, studies have also been made of other separation and concentration methods including the methods of concentration by membrane technology such as reverse osmosis (RO) [4] and pervaporation (PV) [5].

Reverse osmosis process requires low direct energy consumption because of the absence of phase transformations. The driving force of this process is the pressure difference across the membrane. The pressure difference of 10 –100 atm are typically used in RO. The osmotic pressure of alcohol solution is high value, so the higher upstream pressure and the lower downstream pressure must be used.

One of the advantages of PV over RO is that PV transport is not limited by osmotic pressure because the driving force for mass transfer in PV through the membrane is provided by the chemical potential gradient across the membrane. The permeate side of the membrane is kept at vacuum pressure, and consequently the upstream pressure is not critical. Moreover, PV is attractive for several reasons such as a low energy operation compared to distillation, since only a fraction of the feed (the permeate) is vaporized. PV equipment is compact, easily automated, and easy to operate. Startup and shutdown are relatively simple. PV is flexible; the same equipment can perform different separations and can handle changes in feed composition. Construction can be rapid and relatively inexpensive equipment; only a small vacuum pump is needed to create a driving force. PV membrane device is modular in construction. There is no significant economy of scale, so it can be used in either large or small processing capacity.

The keys to successful pervaporation systems are the suitable membrane materials and operating conditions on the performance of the process, expressed in terms of flux and selectivity. The development of high flux and selectivity of membrane especially for removal of organic components from aqueous solution is necessary. This work is interesting because the resulting product is expected to have high concentration of methanol, and the cost of energy through the pervaporation system is low.

1.2 Objectives

The objectives of the this research are i) to study the influence of operating parameters on the pervaporation performance of a methanol-water mixture using the poly(tetrafluoroethylene)/polypropylene (PTFE/PP) membrane, and ii) to determine the suitable operating conditions for maximum pervaporation performance for separation of methanol from the methanol-water mixture.

1.3 Scope of the investigation

The PTFE/PP membrane is selected for this study since PTFE is an excellent polymer membrane material which is preferentially permeable to methanol and exhibits high hydrophobicity. In addition, PTFE is highly stable at high temperature and resistant to most acids, alkalis, and solvents [6,7]. The influence of operating parameters, such as feed concentration, downstream pressure, feed temperature, and feed flow rate, on the pervaporation performance will be studied. Then, the optimum conditions which give high concentration of methanol in the permeate will be discussed.