CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

Increasing growth in biotechnology industries such as pharmaceutical and food industries requires reliable and efficient methods to purify the commercial-scale quantities of proteins (Przybycien et al., 2004). Various type of separation can be used to capture the desirable protein of interest. The most common technique is by using packed bed chromatography. In packed bed chromatography, resin bead with specific functionality based on different charged group, hydrophobicity or affinity, was packed in cylindrical column. The chromatography media inside the column will interact specifically with the protein during the feed flow through the column. However, the conventional packed bed chromatography shows several weakness such as high pressure drop, limited diffusional of solute to the binding site and low flow rate capability (Ghosh, 2002; Klein, 2000; Zeng and Ruckenstein, 1999).

Membrane chromatography can be used to overcome the limitation of the conventional packed bed chromatography. Membrane chromatography consists of an adsorptive membrane that carried similar chromatography functionality as the resin bead. The pressure drop across the membrane chromatography is very low since it only used very thin membrane as the chromatography media. Due to this pressure drop, it is possible to operate the membrane chromatography system using high flowrate. The binding of the protein in membrane chromatography is through the convective flow which is very fast and can prevent the protein from denaturation (Borneman et al., 2010; Zhong et al., 2011; Guo and Ruckenstein, 2003).

Membrane chromatography is functioned similar to the normal chromatography resin bead which is depend on the type of functionality attach to the membrane. The production of chromatographic membranes involve a chemical modification of the microfiltration membrane with specific type of functional groups to produce different types of chromatography interactions inside the membrane (Saufi and Fee, 2009). Different types of interaction are also possible for membrane chromatography such as anion exchange, cation exchange, hydrophobic interaction and affinity interaction. Three steps are usually involved in the preparation of adsorptive membranes chromatography: (1) preparation of the base membrane, (2) chemical activation of the base membrane and (3) coupling of ligands to the activated membrane (Zeng and Ruckenstein, 1999).

Common method to activate the polymer base material was through grafting technique, which introducing various type of functional group on the membrane surface. Grafting was a promising method to modify polymers by attaching the specific monomer onto the polymer chain by covalent bond. Several type of grafing technique has been discovered such as UV grafting, chemical grafting, photochemical grafting, plasma radiation induced grafting and enzymatic grafting. UV grafting is one of the common methods used for modification of ultrafiltration (UF) membrane for fouling control. UV grafting is simple, useful and versatile in improving the surface properties of the polymers (Deng et al., 2009). The membrane was exposed to the UV light at certain wavelength and intensity in specified time of radiation. The monomer is then grown continuously on the radical groups generated during the UV grafting process.

Commercial polyethersulfone (PES) UF membrane was grafted by Taniguchi and Belfort (2004) at 300 nm wavelength with various types of monomer such as N-2-vinyl pyrolidinone (NVP), 2-hydroxyethyl methacrylate (HEMA), acrylic acid (AA), 2-acrylamidoglycolic acid (AAG), 3-sulfopropyl methacrylate (SPM) and 2-acrylamido-2-methyl-1-propanesulfonic acid (AMPS) in order to produce membrane that has low protein fouling. Abuhabib et al. (2012) combined two monomers, which are acrylic acid and ethylenediamine dihydrochloride during grafting to improve the fouling resistance of PES nanofiltration (NF) membrane for brackish water desalination. Mansourpanah and Momeni Habili (2013) studied the effect of UV-irradiation time and AA

concentration on the performance and morphology of modified polyamide thin film composite (TFC) membranes.

Another approach for monomer grafting is through chemical grafting via redox reaction. The concept is quite similar to UV photo-grafting which produced free radical on the membrane surface for monomer attachment, but it is assists by redox initiator pair. Different redox initial pairs were used during grafting such as potassium persulfate ($K_2S_2O_8$)– potassium thiosulfate ($K_2S_2O_3$) (Van der Bruggen, 2009), $K_2S_2O_8$– sodium sulfite (Na_2SO_3) (Wang et al., 2007), $K_2S_2O_8$–$Na_2S_2O_5$ (Belfer et al., 1998a) and potassium methabisulfite ($K_2S_2O_5$)–$Na_2S_2O_8$ (Bernstein et al., 2010).

Much of the membrane modification in the previous works, mainly aim for producing fouling resistant membrane by introducing new functionality of the membrane. This new functional group can also be a charged group similar to the charge group required for the binding in the chromatography process. Therefore, in the current study, membrane with negatively charged functional group was produced for binding to the protein through ionic interaction for preparing membrane chromatography. In the first part of the study, polyamide membrane was grafted with acrylic acid monomer using two modification approaches which are chemical grafting using redox initiator and UV photo-grafting. The effects of modification parameters on the protein binding capacity were studied such as initiator concentration, monomer concentrations and time of reaction. The best conditions obtained from the first part of study were used for optimization using Response Surface Methodology (RSM) for the membrane chromatography prepared from UV photo grafting modification.