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Adsorption behavior of cation-exchange resin-mixed polyethersulfone-based fibrous adsorbents with bovine serum albumin

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Abstract

The cation-exchange resin-mixed polyethersulfone (PES)-based fibrous adsorbents were developed to study their adsorption behavior with bovine serum albumin (BSA). A fibrous adsorbent with an open pore surface had much better adsorption behavior with a higher adsorbing rate. The adsorption capacity of the Lewatit CNP80ws resin or SP112ws mixed PES-based fibrous adsorbents with an open pore surface was in the range of 68.2–93.2 mg BSA/g adsorbent for 50% resin loading, which was comparable with the resin static adsorption capacity. Compared to a thick fibrous adsorbent, a fibrous adsorbent with a thin diameter had the higher adsorption capacity with BSA. The results showed that the adsorption for cation-exchange resin-mixed PES-based fibrous adsorbents were controlled by a diffusion process whether in matrix pores of the adsorbent or that of resins.

Keywords: Fibrous adsorbent; Mixed matrix; Adsorber; Adsorption; Bovine serum albumin; poly(ether sulfone)

1. Introduction

Because of microporous membranes as the substrate, membrane adsorbers have several potential advantages [1–5]. A configuration in which the feed solution flows through the membrane provides a very short and wide bed; thus, high velocities and very short residence times are attainable with modest transmembrane pressure drops. Elimination of diffusion resistance usually

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leaves a system controlled by much faster binding kinetics, thereby enabling adsorptive separation of proteins one-tenth the time common for packed columns. Scale-up is very easy; materials and systems allow cleaning in place [6].

Generally the mass transport process for a membrane-based system consists of convection through pores, film diffusion in the pore, and the binding kinetics between solutes and ligands or other affinity sites on the pore inner surface. In comparison with particle-based-packed chromatography, the main difference is the fact that the interaction between a solute (protein) and a matrix (immobilized ligand) does not take place in the dead-ended pores of a particle, but mainly in the through-pores of a membrane. While the mass transport in dead-ended pores necessarily takes place by diffusion, the liquid moves through the pores of a membrane by convective flow. Therefore, the use of membranes reduces the mass transport resistance for the solute to the matrix by eliminating pore diffusion, leaving film diffusion from the core of the liquid to the membrane surface in the interior of a through-pore as the only transport resistance [2].

Several types of configuration for membrane adsorbers have been developed [3,7,8], such as flat-sheet, hollow-fiber, spiral-wound, and polymer rods. However, using the membrane adsorber technique requires a pre-treatment of feed to remove insoluble particles and lipids which otherwise block the membrane. Thus, continuous cross-flow filtration steps have to be performed prior to the membrane adsorber step.

In order to improve the operational performance of membrane adsorbers, the concept of fibrous adsorbers was proposed as a new type of adsorber [9] .This project aimed to develop a fibrous adsorbent with an open pore structure on its surface in order to enhance the mass transport process. Preparation of the resin-mixed polymer-based fibrous adsorbent with an open pore structure on its surface was presented by Zhang et al. [9]. This work mainly focused on adsorption behavior of bovine serum albumin (BSA) with cation-exchange resin-mixed PES-based fibrous adsorbent in different morphological structures.

2. Experimental

2.1. Materials

Polyethersulfone (PES, Ultrason E6020P) with $M_W \approx 50{,}000$ was purchased from BASF. Lewatit CNP80ws (a weak acidic, macroporous, acrylic-based, cation-exchange resin) and Mono-Plus SP112ws (a strong acidic, macroporous, cation-exchange resin) with an average diameter of 10 micron were supplied by Bayer.

Polyethylene glycol 400 (PEG400) (synthesis grade), diethylene glycol monoethyl ether (DEGMEE, synthesis grade), tetra-ethylene glycol(TEEG, synthesis grade) (all supplied by Merck) and n-methyl-2-pyrrolidone (NMP, 99% purity, supplied by Acros Organics) were used without further purification.

BSA (fraction V, Sigma) was used as a model protein in the adsorption experiments. It was used as received. Buffer solutions were freshly prepared. Ultrapure water was prepared using a Millipore purification unit (Milli-Q plus).

2.2. Preparation of resin-mixed PES-based fibrous adsorbents

Different amounts of Lewatit cation-exchange resin were added to same amounts of solution containing 15.8% PES in NMP in order to obtain fibrous adsorbents with different adsorptive properties. PEG400 and water were used as additives in the spinning solution in order to adjust the adsorbent morphology.

For solid fiber preparation, the dope solution was pumped through a two-orifice spinneret, and after a short residence time in an airgap (10–50 mm), immersed into the water bath at room temperature. The inner orifice was used to extrude the dope solution. The outer orifice was