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Influence of ultrafiltration membrane characteristics on adsorptive fouling with dextrans

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Abstract

This paper presents a detailed investigation of fouling mechanisms for ultrafiltration membranes with polysaccharides obtained by studying membrane–solute (static adsorption) and membrane–solute–solute interactions (ultrafiltration (UF)). Two polyethersulfone (PES) membranes and one stabilized cellulose (cellulosic) membrane with a nominal cut-off of 10 kg/mol and dextrans with average molar mass (*M*) of 4, 10 and 15 kg/mol were used. The membranes before and after static adsorption of dextran were characterized by captive bubble contact angle and tangential streaming potential measurements as well as ultrafiltration sieving curves for polyethylene glycols. Significant water flux reductions (4–15%), which also correlated with dextran molar mass, and changes of the other membrane characteristics occurred after static dextran adsorption for the PES membranes. An empirical model to describe the correlation between the relative water flux reduction and the concentration of solute had also been proposed. In contrast, no significant changes could be detected for the cellulosic membrane. Significant membrane–solute interactions had also been confirmed in the ultrafiltration experiments with dextrans where irreversible fouling had been observed for the PES but not for the cellulosic membranes. The results provide fundamental information for a better understanding of fouling by polysaccharides. In particular, it had been confirmed that hydrophilic and neutral dextrans can significantly foul PES membranes via adsorption to the surface of the membrane polymer. On this basis, methods for control of this fouling can be properly developed.

Keywords: Ultrafiltration; Fouling; Polysaccharides; Dextran; Surface characterization

1. Introduction

In the last decade, ultrafiltration (UF) has been successfully developed from a useful laboratory tool to an industrial process. The application areas of UF include the production of pure water, fractionation or concentration steps in the food, pharmaceutical and biotechnological industries, and the treatment of waste water [1–3]. Nevertheless, in the use of UF processes, the decline of flux over time due to the concentration polarization and membrane fouling is the major limitation. This limitation prevents a more widespread commercial applicability of UF. Many studies have been conducted to elucidate the fouling mechanisms [3–11]. Membrane fouling is affected by three major factors namely the membrane material properties, the feed characteristics and the operating parameters. The concentration polarization can facilitate irreversible membrane fouling by altering interactions among solvent, solute and membrane. In particular, membrane surface chemistry, membrane–solute interactions and solute–solute interactions are the key to understanding the fouling phenomena. Membrane–solute interactions will determine fouling through adsorption of solute on the membrane surface. This interaction had been proposed as the important parameter in a fouling study by Mathiasson [4] using bovine serum albumin as a model solute. Furthermore, this interaction will enhance or modify the particle deposition and the pore blocking processes whereas the solute–solute interactions will facilitate fouling by solute aggregation in solution and/or on the surface preadsorbed with solutes [12].

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