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Copper ions removal from liquid phase by polyethersulfone (PES) membranes functionalized by introduction of carbonaceous materials

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HIGHLIGHTS

- ▶ Char and activated carbon was introduced into PES membrane structure.
- ▶ Functionalized membranes characterized by differential surface functional groups.
- ▶ Membranes show higher efficiency in removing of heavy metal ions from the liquid phase.
- ▶ After modification the anti-fouling properties of the membrane have changed.

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ABSTRACT

The method of synthesis of polymeric membranes based on polyethersulfone (PES) and modified by addition of carbonaceous materials (char or activated carbon) is presented and their potential application for removal of copper ions from liquid phase are examined. The addition of carbon brings about changes in the content of the surface oxygen group but has no significant effect on the chemical character of the groups, and acidic groups dominate. After filtration of a copper solution the total content of surface oxides considerably increases but the acidic groups remain dominant. Modification of PES membrane by addition of carbonaceous materials was found to strongly increase the membrane effectiveness in copper ions removal. The membrane with addition of char is the most effective at low copper concentrations, while the membrane with addition of activated carbon is the best at high concentrations of copper ions.

1. Introduction

Over the last 40 years, membranes have developed from a research topic to a mature industrial separation technology. This increase in the use of membrane technology is driven by spectacular advances in membrane development, wider acceptance of the technology in preference to conventional separation processes, increased environmental awareness and, most importantly, strict environmental regulations and legislation. Various membrane processes are currently applied in the chemical (including petrochemicals), pharmaceutical, food and beverage industries [1–3]. Particularly strong development and growth of membrane technology can be observed in the purification of wastewater and the production of drinking water [4–6].

Water contamination of heavy metals has become a grave environmental issue [7]. Heavy metals are discharged from a variety of sources in daily life and can be readily oxidized into ions when dissolved in water. Among the heavy metals, cadmium (Cd), lead (Pb), mercury (Hg), nickel (Ni), copper (Cu), and zinc (Zn) are the most hazardous. To date, three major strategies are used to approach the problem of metal ion removal from water: chemical precipitation, reverse osmosis processes, and adsorbents, such as activated carbon or ion exchangers [7–10]. Although these methods are effective in removing metal ions, they are expensive to operate, non-reusable, or they cause membrane fouling or secondary contamination.

Polysulfone and its derivates mainly polyethersulfone (PES) are suitable membrane materials because of their good film-forming properties and high thermal, chemical, and biological resistance. For the past four decades, PES membrane has been widely used in advanced separation technology such as microfiltration (MF) and ultrafiltration (UF) [11,12]. Various methods have been proposed to improve the properties of polyethersulfone membrane, including preparation of copolymers with desired functionality, blending with hydrophilic polymers, surface coating, or introduction of hydrophilic groups into the polymer backbone [13]. Recently, carbon membranes have been increasingly often applied in waste purification plants, especially for adsorption of low-molecular organic compounds as well as for enzymatic reactors

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