

UV-Grafted Polydimethylsiloxane Membranes for Effective Removal of Tramadol

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Extended Abstract

Pharmaceutical compounds, including drugs and their metabolites, have received a lot of attention in the past few years as new water pollutants. The presence of pharmaceuticals and their metabolites in surface waters at concentrations up to a few $\mu\text{g/L}$ is an emerging environmental problem that raises many concerns about the effects they may have on aquatic organisms and possibly humans through drinking water sources[1]. Membrane separation technology is frequently used for the elimination of pharmaceutical contaminants. The selective removal of the pharmaceutical compound using commercial membranes can be improved by modifying the membrane surface[2]. One of the most commonly found pharmaceutical substances in the water body is tramadol, the top analgesic prescribed in clinics. The presence of tramadol in aqueous media at concentrations well below the doses used for treatment adversely affects the development of aquatic organisms. Thus, exposing fish to low levels of this compound for an extended period can significantly affect the early life stages of fish [3,4]. Acrylic copolymers can be effective modifiers of the membrane surface for the sorption of tramadol. Many acrylic copolymers are polyelectrolytes that can form ions when exposed to an aqueous medium, causing significant volumetric swelling due to the formation of hydrogen bridges or covalent bonds [5]. It is reported that the maximum amount of tramadol that can be absorbed by a polymer composition based on a functional methacrylic acid monomer is 81 mg g^{-1} ($270 \mu\text{mol g}^{-1}$) [6].

In this work, polydimethylsiloxane (PDMS) membranes UV-grafted by polymer composition based on glycidyl methacrylate (GMA), methyl methacrylate (MMA), and 2-(dimethylamino) ethyl methacrylate (DMAEMA) were examined. For separating tramadol from water, two membranes SW 2.10, which consists of GMA:DMAEMA (9: 1) and SW 3.10, which consists of MMA:DMAEMA (9:1), were studied. Water contact angle, XPS, SEM and texture analysis gave a uniform picture of modified membranes. Membranes were tested in pertraction of tramadol from water, permeation mechanism of tramadol was analysed. The study of the contact angle of the modified membranes was carried out to determine the hydrophobicity of the membranes. The membrane grafted with GMA: DMAEMA showed poor hydrophobicity with a water contact angle (WCA) 55° , while the membrane grafted with MMA: DMAEMA showed a higher hydrophobicity WCA is 97° . Within 15 days of continuous separation of the feed solution (500 mg/L) at room temperature (20°C), maximum tramadol, which was recirculated into the receiving solution, was reached by the GMA: DMAEMA grafted membrane. The removal efficiency of tramadol by SW 2.10 membrane was 19.25%; meanwhile, the removal efficiency of SW 3.10 was 7.43%. The interaction between tramadol and the surface of the membrane is possible due to specific binding sites that can strongly interact with the pollutant. Tramadol consists of dimethylaminomethyl functional group and methoxyphenyl group. The glycidyl groups of GMA can interact with the amino groups of tramadol, the quaternary-ammonium groups of DMAEMA can interact with the phenolic group of tramadol. Based on the tramadol permeation mechanism, almost no membrane fouling was detected during periodical operation, which exhibited a relatively stable tramadol separation performance. These findings become particularly significant in the separation of pharmaceutical pollutants and imply that further application of GMA: DMEAMA modified membranes holds promise for successful treatment of such pollutants.

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