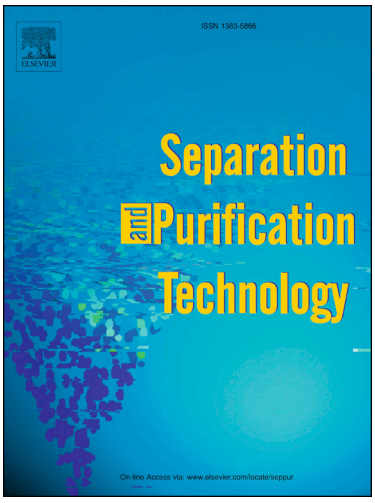

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Martyna Grzegorzek, Katarzyna Majewska-Nowak

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The use of micellar-enhanced ultrafiltration (MEUF) for fluoride removal from aqueous solutions

Martyna Grzegorzek[1,*], Katarzyna Majewska-Nowak[2]

[1,2] Wroclaw University of Science and Technology, Department of Environmental Engineering, WybrzeżeWyspiańskiego 27, 50-370 Wroclaw, Poland

[*]Corresponding author e-mail: martyna.grzegorzek@pwr.edu.pl
[2]e-mail: katarzyna.majewska-nowak@pwr.edu.pl

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ABSTRACT

Fluorine is a common chemical element. Due to the harmful influence on human health, the World Health Organization determined the permissible level of fluoride in drinking water to be 1.5 mg F^-/L. Fluorine can be removed from water solutions by various methods (i.e. ion-exchange, precipitation, adsorption and membrane techniques). One membrane technique that can be effective in fluoride removal is micellar enhanced ultrafiltration (MEUF). This method involves the ability of surfactants to create micelles, which are retained by classic ultrafiltration membranes. In the presented paper, the suitability of the MEUF process for fluoride removal was verified. Polyethersulfone and regenerated cellulose ultrafiltration membranes, as well as two cationic surfactants (cetylpyridinium chloride - CPC, octadecylamine acetate - ODA),were used in the batch experiments. The fluoride content in the model solutions amounted to 10 and 100 mg F^-/L, whereas surfactant concentration varied in the range of 1-3 CMC. The MEUF tests were performed under a pressure of 0.2 MPa with and without a salt (NaCl) dosage to the treated solutions. The results obtained showed that for a low fluoride content (10 mg F^-/L) and a high CMC value (3CMC), the polyethersulfone membrane allowed F^- ions below the permissible level for drinking water to be removed. The presence of NaCl in the model solutions resulted in a significant worsening of fluoride removal efficiency.

1. INTRODUCTION

Fluorine is a common chemical element present in the natural environment. Due to the harmful impact on human health, the World Health Organisation (WHO) determined the permissible limit of fluorine in drinking water as 1.5 mg F^-/L [1–3]. A low content of fluoride has a beneficial influence on a human's organism. An excess of fluoride may lead to fluorosis, brain damage or dental caries [1–4].The problem of elevated fluoride concentration in water is present all over the world [5–6]. In Tanzania, the fluoride content can exceed 330 mg F^-/L, whereas a concentration of 180 mg F^-/L is possible in the groundwater resources of Kenya [5]. This problem was also discovered in Pakistan, USA, Canada, China and Thailand [6]. There is a need to find new ways of overcoming the problem of water contamination by fluorine. Various methods can be used for fluoride removal such as: ion-exchange, adsorption, precipitation and membrane processes (i.e. electrodialysis, membrane distillation, nanofiltration and reverse osmosis) [2,7].

One possible way to solve the problem of elevated fluoride concentration may be micellar enhanced ultrafiltration (MEUF). The first tests with MEUF were made by Dunn et al. [8] in the mid-80s. This method is usually used for organic compounds, inorganic substances or the removal of metal ions from water. It is especially suitable for the removal of ionic and hydrophobic components. The MEUF process is based on conventional ultrafiltration (UF) and surfactants, which have a hydrophobic tail and hydrophilic head. Micelles lead to surface tension reduction and can contain even 150 molecules. Surfactants can be divided into three types: cationic, anionic and non-ionic. When surfactant concentration is greater than the critical micelle concentration (CMC), micelles are created. Contaminants are attached to the external surface of the micelle by electrostatic interactions or are