Removal of heavy metals by ultrafiltration

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1. Summary

Large amounts of polluted water are often obtained from the chemical process industry, which require a mandatory treatment before being disposed of. Heavy metals are employed as homogeneous catalyst in numerous processes, so that recovering and/or recycling of those metals to the reaction unit is essential.

In this study, ultrafiltration is presented as a useful technique to recover heavy metals present in aqueous solutions, without the need of adding further substances. Specifically, recovery of mixtures of iron (II) and iron (III), copper and chromium is presented. Ceramic membranes are mechanically, chemically and thermally more resistant than polymeric ones. Due to the acidic nature of the studied effluents, a 5-kDa commercial ceramic membrane has been selected for this work. The effect of transmembrane pressure and pH are presented. The results show that chemical speciation of metals in aqueous solution is strongly correlated with the retention, which suggests a possible interaction between metallic species and membrane surface.

Keywords: ceramic membrane, ultrafiltration, heavy metal recovery, wastewater treatment

2. Extended Abstract

Ultrafiltration of aqueous solutions containing heavy metals has been studied with a 5-kDa ultrafiltration trichannel tubular ceramic membrane (250 mm of length, 10 mm of external diameter and 94 cm\textsuperscript{2} of filtration area) purchased at TAMI Industries (France). The experimental setup was a home-made filtration module allowing to work at total recycling mode and at room temperature. The tangential velocity was 0.27 m·s\textsuperscript{-1}. Several solutions of Fe(II) and Fe(III) at different Fe(II)/Fe(III) ratios were filtered at different transmembrane pressures. The pH was fixed to 2 by adding hydrochloric acid to the feed solution and the iron sources were iron (III) nitrate nonahydrate and iron (II) sulfate heptahydrate. Iron ions can be partially retained by the selected membrane but, as stated elsewhere (Bernat et al., in press), only iron (III) can be retained by this membrane because of its chemical forms in solution. At the tested concentration (2 mM of total iron) and pH, iron...
(II) does not present hydroxilated species in solution. Thus, only the fraction corresponding to iron (III) has been retained. In order to assure that the mechanism allowing the retention of dissolved metals is the presence of soluble metallic hydroxides, the filtration of copper (II) and chromium (III) has been studied. Copper cannot be retained due to the nonexistence of hydroxilated species at the pH selected. Instead, chromium can be effectively removed as shown in the Figure 1. Figure 1 shows the retention of chromium as function of transmembrane pressure (TMP) and the pH. The filtered solution was 1 mM and prepared from chromium chloride hexahydrate. Chromium (III) diagram demonstrates that, the amount of chromium hydroxilated species increases as the pH does (diagram not shown).

![Figure 1. Chromium retention versus transmembrane pressure. Effect of the pH.](image)

As it can be deducted from the presented results, soluble heavy metals can be effectively removed from aqueous solutions only when charged soluble hydroxides are present in the aqueous media. These results are in agreement with those found by Choo et al. (2002) who stated that cobalt ions can be retained with a nanofiltration membrane by adjusting the pH of the solution.

**References**
