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Removal of chromium(VI) from aqueous solutions using a polyvinyl-chloride inclusion membrane: Experimental study and modelling

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HIGHLIGHTS

- Sorption of Cr(VI) ions onto PVC/Aliquat 336 PIMs without added plasticizers.
- Kinetic and equilibrium modelling of the sorption process.
- Improved sorption and reuse properties comparing with other sorbents.
- High potential to reduce the price comparing to the plasticized PIMs.
- Very good selectivity towards Cr(VI) from mixtures simulating the real wastewaters.

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ABSTRACT

The present paper reports the use of a polymer inclusion membrane (PIM) prepared without addition of plasticizers as solid sorbent for the removal of Cr(VI) ions from aqueous solution simulating the real industrial effluents. The studied sorbent (PIM) contains 40% organic anion exchanger Aliquat 336 and a polymer matrix of 60% polyvinyl chloride (PVC). The influence of the Aliquat 336 content of the PIM, the contact time, the pH and the initial metal concentration in the aqueous solution on the Cr(VI) sorption process was analysed by using the batch extraction technique. The optimal PIM composition was found to be 40% Aliquat 336/60% PVC (w/w). This sorbent was further used for the kinetic, isotherm, desorption, reusability and selectivity studies. The sorption kinetics was well described by the pseudo-second order model (Ho), and the kinetic experiments confirm that the sorption process of Cr(VI) into the optimal non-plasticized PVC-based PIM is a chemisorption, which occurs through a "relay mechanism". The adsorption isotherm was best fitted by the Sips equation, and the experimentally determined maximum sorption capacity of Cr(VI) into the 40% Aliquat 336/60% PVC PIM was found to be 0.978 mmol/g (50.85 mg/g). The retained metal ions can be desorbed by using 0.5 M $NaNO_3$, this desorption of metal ions occurring concomitantly with the PIM regeneration. The use of this less aggressive eluent permits the reuse of the same PIM for at least five consecutive sorption processes. Moreover, the optimal PIM possesses a high selectivity for Cr(VI) ions from mixtures with other metal ions and anions usually existing in the real industrial effluents.

All these properties indicate that PIM with the composition 40% Aliquat 336/60% PVC has a potential to be used as solid sorbent for Cr(VI) ions. Another advantage is its lower price compared to the plasticized PIMs.

1. Introduction

The continuous increasing pollution with heavy metals is a subject of great concern nowadays. Among these metals, chromium is a highly toxic chemical element for the environment, especially in its chromium(VI) form [1]. Chromium compounds enter in water, air and soil through natural processes and human activities (i.e. steel, chemical, leather and textile manufacturing, electro painting, electroplating, coal combustion and other industrial processes). These applications increase the concentrations of chromium in the environment, especially the very mobile and bioaccumulative Cr(VI) species which has a high degree of toxicity for the living organisms [2]. Therefore, both the reduction of Cr(VI) concentration in the industrial wastewaters below the permissible limit of <1 mg/L before discharging in the environment, as well as its recovery for reuse are important economical task [3].

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