

Continuous water softening process for industrial applications based on an electrochemically switchable ion exchanger

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Introduction

Conventional methods for water softening are using special resins containing ionic functional groups, e.g. sulfonate groups in cation exchangers. After loading this special resins with cations (and anions), this materials have to be regenerated (removal of bonded cations and anions) under usage of chemicals like concentrated aqueous solutions of acids or salts. This disadvantage motivated us to develop of new concepts for water softening techniques without the demand of chemicals for the regeneration process.

Aims and Concept

The aim of this project was the development of an innovative water softening technique based on an electrochemically switchable ion exchanger composite of polypyrrole and polystyrenesulfonate (Fig. 1). This new type of ion exchangers should be improved to overcome some problems and disadvantages concerning the desired technical application. Amongst other things the adherence and the thickness of the electroactive polypyrrole layer on the graphite felts had to be increased in order to reach the technical requirements for such a type of ion-exchanger. In former studies the principle of electrochemically switchable polypyrrole ion exchanger was already proved [1-3].

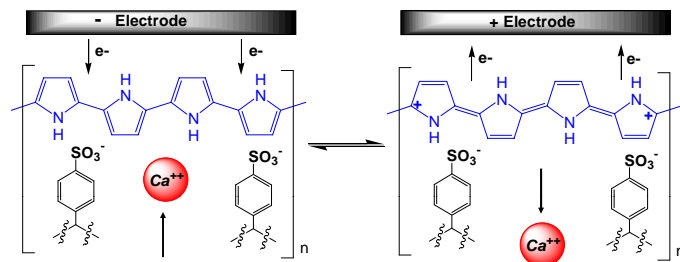


Fig. 1 : Concept of removing ions (e.g. calcium and magnesium ions) from aqueous solutions by reversible binding them inside an electrochemically polarised Polypyrrole – PSS layer.

The activation of the carbon electrode materials by different pretreatments turned out to improve the electrochemical activity (Fig. 2).

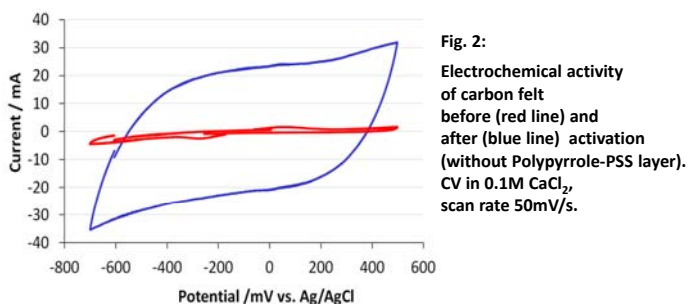


Fig. 2: Electrochemical activity of carbon felt before (red line) and after (blue line) activation (without Polypyrrole-PSS layer). CV in 0.1M CaCl₂, scan rate 50mV/s.

References:

- [1] C. Weidlich, K.-M. Mangold, K. Jüttner, *Electrochimica Acta*, 50 (2005), 5247-5254
- [2] C. Weidlich, K.-M. Mangold, K. Jüttner, *Electrochimica Acta* 47 (2001) 741-745
- [3] DE 199 42 347, DE 102 18 193

Results

A testing method for electroactivity is cyclic voltammetry (CV), which was performed in 0.1 M CaCl₂ using carbon felt samples (2 x 1 x 0.5 cm³). The magnitude of the current density here is an indicator for the amount of ions, bonded and released by changing the polarisation of this electrode materials. Some examples from this measurements are shown in Fig. 3. The results indicate, that the covering with a PPy/PSS layer leads to the required significant increase of ion exchange capacity.

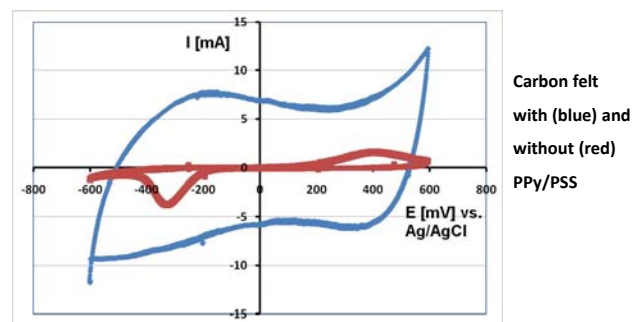


Fig. 3 : CV measurements of carbon felt electrodes with and without PPy/PSS layers (scan rate 10 mV/s).

Water Softening Module

A prototype of a water softening module was built by the DFI-workshop. The module consists of to half cells separated by an ion exchanger membrane. Each half cell contains an carbon felt, which is located between the membrane and the graphite plates which are used as current collectors. Fig. 4 shows the water softening module and a scheme of the used components.

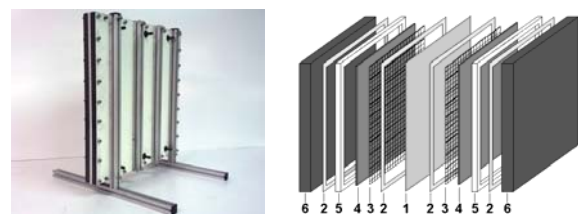


Fig. 4: Assembled module (50x50x4.5 cm) (left) ; Used components (right): 1 = anion exchange membrane, 2 = silicon seal, 3 = supporting tissue, 4 = carbon felt (44x44x0.25cm), 5 = Teflon frame, 6 = graphite plate

To test the performance of the module different experiments were carried out. In the batch mode one half cell is circulated by drinking water supplied by a storage vessel, while drinking water from the water tap flows through the other half cell. First experiments showed that after 12 minutes cathodic polarization the calcium ion concentration was reduced by more than 80%. After inversion of potential (anodic polarization) more than 80% of the initial calcium concentration was retrieved.

Conclusion and Outlook

Stability tests with the prototype, which are still in progress, will show, if this concept of electrochemically switchable ion exchangers will meet the requirements of technical applications (e.g. water softening units for technical purposes).