Development of conducting polymer layers on membranes to prevent biofouling and enhance biocide effects

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Aim

The aim of this project is to prevent and reduce biofouling on technical membranes and to remove **biofilms** that have already formed. To achieve this, membranes are coated with **conducting polymers** e.g. **polypyrrole (PPy)**, and the polymer layer is polarised electrochemically (Fig.1). This polarisation inhibits biofouling and enhances the effect of biocides.
Ion-exchanger membranes, **filtration membranes** as well as **reverse osmosis membranes** have been coated with PPy.
The conducting polymer layers can be modified as cation- or anion-exchangers and their porosity can be controlled to avoid any impairment of the membrane by the polymer coating.
This new method of preventing biofouling offers **economic and ecological benefits** compared to conventional methods because it:
•avoids or reduces the use of biocides
•prolongs the operating time of the membranes
•reduces the amount of polluted waste water
•reduces the risk of corrosion damages

This project is worked on in **cooperation with IWW** in Mülheim / Ruhr.

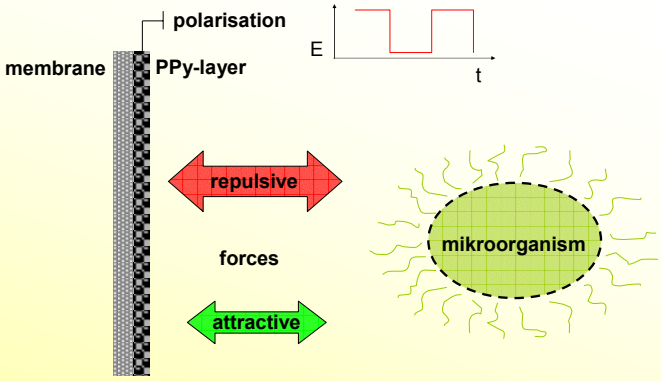

Fig.1: Scheme of preventing biofouling on membranes.

Formation of the polymer coating

A technique for the deposition of conducting polymers on membranes has been developed. The membrane is fixed in a cell. One compartment of the cell is filled with the monomer solution, e.g. pyrrole (py), and the other compartment is filled with an oxidant. The py monomer diffuses through the membrane (Fig.2A) and is polymerised as a PPy coating on the membrane by the oxidant (Fig.2B).

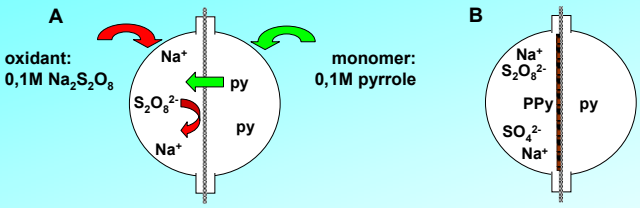

Fig.2: Coating of a membrane with PPy.
A: Filling of the cell, B: Deposition of the PPy layer.

Scanning electron microscopy (SEM) pictures in Fig.3 show PPy layers deposited on a cation-exchanger (PSS) and an microfiltration (PES) membrane.

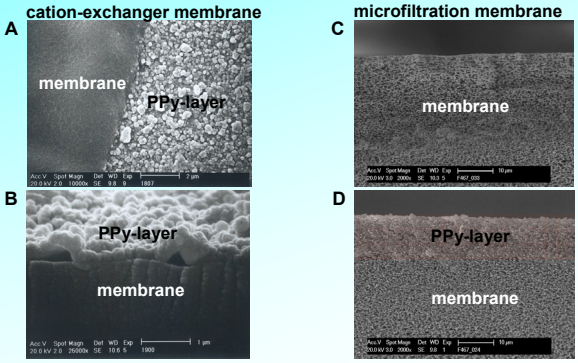

Fig.3: Top view (A) and cross-section (B) of a PPy-coated cation-exchanger membrane of polystyrenesulfonate (PSS).
Cross-section of a microfiltration membrane without (C) and with (D) PPy layer.

Characterisation of the polymer coating

Contact angle measurements show that the PPy coating increases the hydrophilicity of the cation-exchanger membranes (Fig.4 A and B).

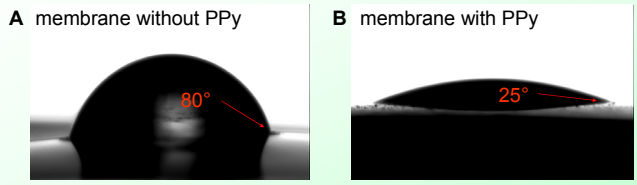

Fig.4: Contact angle of uncoated (A) and coated (B) cation-exchanger membranes of polystyrenesulfonate (PSS).

Cyclic voltammogramms reveal the electrochemical activity of the PPy-coated membranes (Fig.5)
The permselectivity of a PPy-coated anion-exchanger membrane is affected by the counterion which is incorporated into the polymer layer (Fig.6). A PPy coating with Cl^--counterions does not impair the permselectivity of the anion-exchanger membrane, whereas the membrane coated with a PPy layer with PSS-counterions loses its permselectivity .
The influence of the PPy coating on the formation and removal of biofilms is investigated by the IWW.
A patent has been filed (DE 10 2005 049 388 A1).

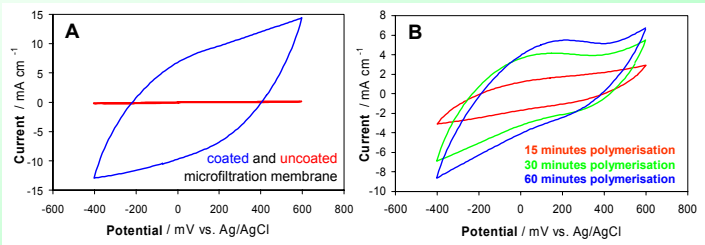

Fig.5: Cyclic voltammograms of a coated and uncoated microfiltration membrane (A). Increasing current with increasing polymerisation time (B).
(0,1M Na_2SO_4, v=10 mV s^{-1})

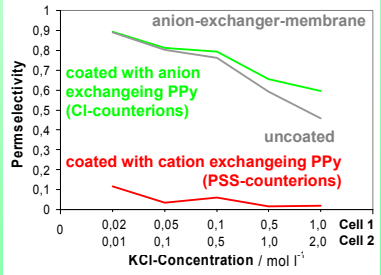

Fig.6:
Permselectivity of an uncoated and a PPy-coated anion-exchanger membrane with Cl^--counterions or PSS-counterions (PSS=Polystyrensulfonate).
Anion-exchanger membrane of poly(2,6-dimethylphenylenoxid) with quaternary ammonium ions.