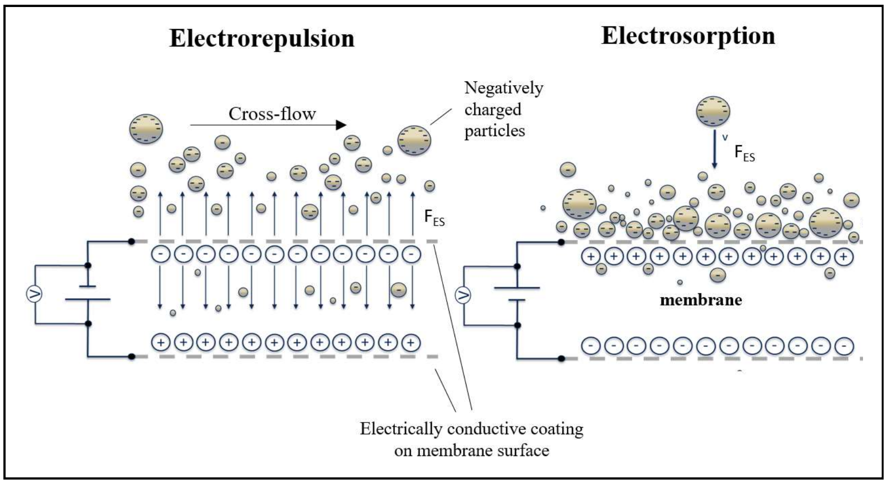
Influence of surface potential of conductive polymer membranes on the fouling- and separation behavior in water treatment (ZETA-Membrane)



Project Duration

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Funding

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Introduction

The usage of membrane filtration in water treatment was rapidly increasing in the last 20 years. Despite of the rising number of applications of commercial membranes, the main drawback in this technology remains the formation of fouling layers. In low-pressure membrane processes (micro- and ultrafiltration), mainly particles, colloids, organic macro-molecules (organic fouling) lead to the formation of blocking layers. A new approach to mitigate fouling and enhance the rejection performance is the application of electrically conductive membranes. By application of an external potential, electrostatic forces are induced that repulse or attract charged organic water constitutes away or towards the membrane surface, respectively.

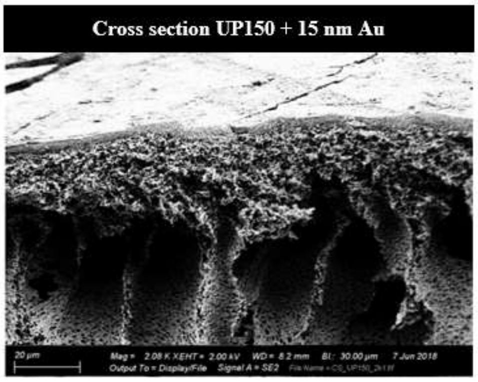
Research Goals

The central goal of this project is the understanding of fundamental mechanisms between potential foulants (particle, natural organics, and bacteria) and electrical conductive ultrafiltration membranes. For this, the Institute for Water Resources and Water Supply (TUHH) and the Helmholtz-Zentrum-Dresden-Rossendorf (HZDR) collaborate to find a suitable deposition technology for ultra-thin and porous metal coatings in order to coat polymer membranes by metals. The experimental setup focusses on the interaction of particles and organic water constituents vs. externally charged membranes. The functionalized membranes were applied at different potentials and fouling as well as rejection behavior were investigated.

Approach

For deposition of thin metal coatings, ion beam enhanced plasma deposition, sputter coating and evaporation is compared (Fig. 1A). By applying an external potential (-1.5 to +1.5 V vs. Ag/AgCl), these modified membranes are examined on their fouling- and separation behavior in different aqueous solutions (Fig. 1B).

A)



B)

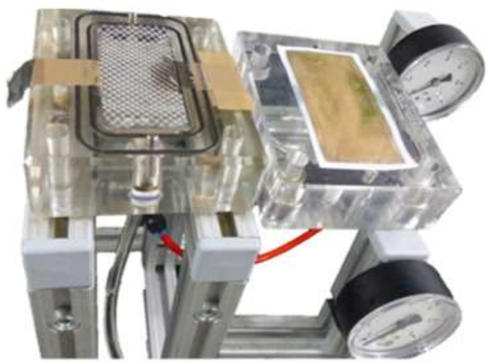
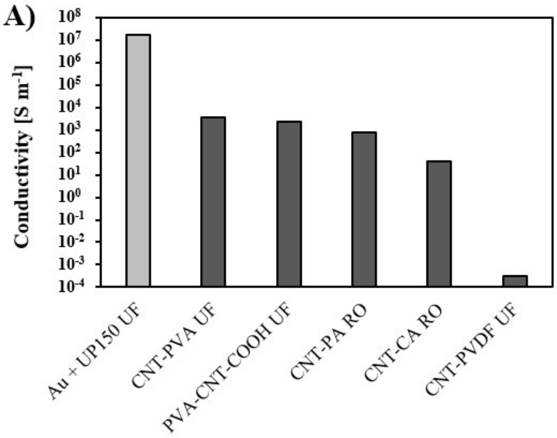


Figure 1: A) SEM foto of gold-coated membrane B) Cross-flow filtration cell with electrically conductive membrane

Recent Results

Sputter coating of 15 nm of gold onto the membrane surface led to high electrical conductivity (Fig. 2). Cross-flow filtration experiments with natural lake water showed that the application negative potential led to fouling mitigation and enhanced of rejection of organic matter, which was attributed to electro-repulsive forces at the membrane interface (Fig. 3). However, also the application of positive potential showed beneficial results for fouling and rejection behaviour due to electro-sorptive effects.

A)



B) Table : Literature data of conductive membranes

Membrane	Conductivity [S/m]
15 nm Au coated UP150	1.77×10^7
CNT-PVA UF (Lannoy et al. 2012)	3.60×10^3
PVA-CNT-COOH UF (Dudchenko et al. 2014)	2.50×10^3
CNT-PA RO (Nolte 2009)	7.86×10^2
CNT-CA RO (Nolte 2009)	4.04×10^1
CNT-PVDF UF (Zhang und Vecitis 2014)	3.20×10^{-4}

Figure 2: A) Electrical conductivity of gold-coated PES-UP150 membrane B) Literature data of conductive membranes

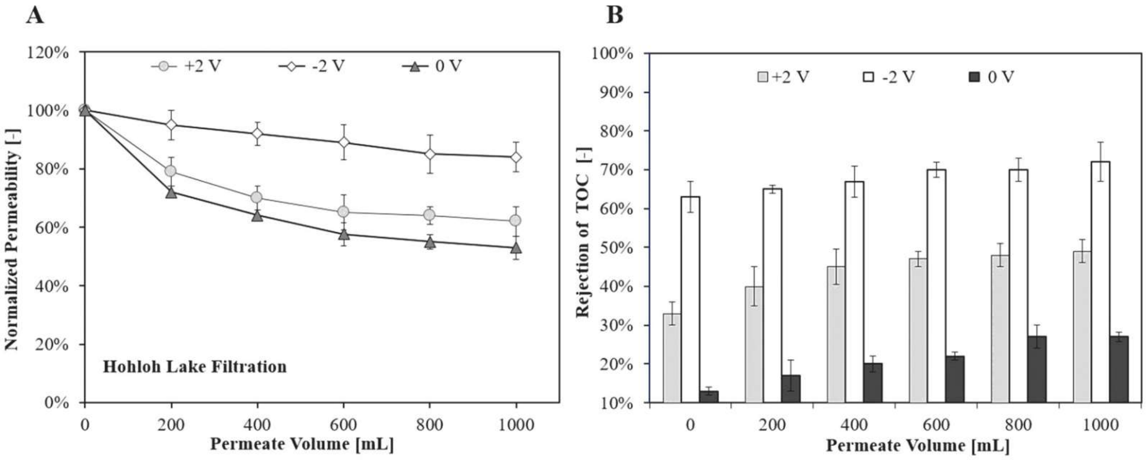


Figure 3: A) Fouling mitigation at different applied potentials B) Rejection enhancement at different applied potentials

Conclusion and Outlook

The present study showed that sputter coating of ultra-thin layers of gold onto a commercial flat sheet membrane led to a UF membrane with high permeability and high electrical conductivity. Fouling mitigation was achieved by the application of negative potential to the membrane surface due to electro-repulsion of concurrently negatively charged natural organic matter. The potential and the mechanisms of electro-sorptive removal of organic matter is part of ongoing research.

Project Partners

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