TAILORING FILTRATION MEMBRANES USING PHOTO-INDUCED GRAFT POLYMERIZATION TO MANAGE RISK OF EPA CANDIDATE CONTAMINANTS AND REDUCE FOULING

by

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ABSTRACT

This research investigated permanently modifying membrane surface properties to improve filtration performance, including mitigating organic (natural organic matter and bovine serum albumin) fouling, increasing EPA water candidate contaminants (perchlorate and 2,4-dinitrophenol) rejection.

The UV-assisted graft polymerization was employed to modify membrane surface properties. By grafting hydrophilic vinyl monomers onto poly(ether sulfone) membrane surfaces, the adhesion of organic substances to membrane surfaces was decreased, thus the fouling was mitigated. By grafting charged (either positive or negative) monomers, membrane surface charge increased, therefore the rejection of charged species was enhanced by exploiting the Donnan exclusion mechanism. At the same time, by tailoring membrane pore structure and size distribution during graft polymerization, the retention of trace neutral organic chemicals also increased.

High throughput technique was successfully exploited in this research to screen grafting monomers and modification conditions. This work was the first one using this technique in membrane modification. The promising monomers were further evaluated using the traditional low throughput method with a larger scale. Monomers evaluated included *N*-vinyl pyrolidinone (NVP), 2-hydroxyethyl methacrylate (HEMA), acrylic acid (AA), 2-acrylamidoglycolic acid (AAG); 3-Sulfopropyl methacrylate (SPMA), 2-acrylamido-2-methyl-1-propanesulfonic acid (AMPS), poly (ethylene glycol) (PEG) at molecular weight (MW) of 144, 188, 300, 475 and 1100, 3-(Methacryloylamino) propyl trimethylammonium salt (MAPM), as well as the mixture of SPMA and MAPM.

The NVP, HEMA, AA, AAG, AMPS and SPMA have been evaluated in the previous research using low throughput method. The consistency of the results obtained from this work and previous research is a verification of the success of high throughput method in monomer screening and membrane modification.

PEG results reveal the size of monomers had an effect on their potential to reduce membrane fouling. PEGs with higher MW were more efficient at mitigating fouling. Grafting membranes with positively charged MAPM as well as the mixture of positive

MAPM and negatively charged SPMA also reduced natural organic matter fouling significantly.

Grating of SPMA significantly increased membrane surface negative charge, and improved 2,4-dinitrophenol and perchlorate rejection, even in the mixture of these two solutes. The rejection of 2,4-dinitrophenol was dominated by adsorption at low pHs (3 and 4.3 in this research), and by charge repulsion at high pH (10 at this research).

The effect of membrane roughness and pore size on fouling was investigated using membranes in a large molecular weight cut-off (MWCO) range and both organic and inorganic colloids as foulants. It was found that under the experimental condition, in general, fouling decreased with increasing membrane MWCO; therefore, the effect of pore size and rejection on flux was more important than roughness. Results also demonstrated that larger foulants caused greater flux decline for both organic and inorganic colloids. Membranes exhibiting lower roughness were easier to clean when affinity of foulant with membrane surface was high, and/or when the foulant size was similar to membrane surface roughness value.

The permeate breakthrough behavior of organic chemicals during filtration was modeled using a one-dimensional solute transport model, treating the membrane as a porous medium, coupled with hindered diffusive and convective transport theory to account for the pore wall effect on solute transport. This new modeling approach accurately fitted experimental data, and is a promising approach for predicting