Optimization of nanostructred smart biosensors incorporated in a fouling resistant ultrafiltration membrane used for water treatment

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Membrane replacement is the largest operating cost in water separation applications. Irreversible fouling and permeate flux decline occur due to macromolecular adsorption of organic matter (e.g., bacteria) on the membrane surface, which cannot be removed by backflushing or backpulsing. The presence of microorganisms in feed water can further exacerbate fouling due to the accumulation of microorganisms onto the membrane surface and on the feed spacer between the envelopes, or biofouling. Accurate prediction of membrane performance requires early detection of bacteria in membrane-based water treatment systems. A novel temperature-activated cellulose acetate ultrafiltration membrane in a cross flow configuration has been developed. A stimuli-responsive polymer brush (hydroxypropyl cellulose) was attached to the membrane surface and coupled with antibodies to detect potential biofouling species, mycobacteria. It is hypothesized that by continuously triggering the phase transition via stimulus response, the non-equilibrium movement of the polymer brush would offer better protection of the membrane surface than at equilibrium, thereby reducing fouling. In addition, it is anticipated that the movement of the polymer brush will improve the performance of the sensor in the presence of foulants (organics). The smart biosensor recovery was measured following temperature activation (above $50^{\circ}C$) of the polymer brushes. Recovery was significantly decreased from 15% to 8%. Ongoing experiments involve alternative methods of polymer brush activation including using a low intensity ultrasound probe ($\approx 1 \text{ W/cm}^2$) to increase biosensor recovery efficiencies. A combination of the fouling resistant layer and early detection method could increase the potential for membrane use in a wider range of water separation applications.