Responsive Microgels for Fouling Removal

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Stimuli-responsive surfaces have been shown to be effective in cleaning membrane fouling by shaking off the foulants from the membrane surface following a response to appropriate stimuli. In this study, temperature and ionic-strength responsive microgels are used for fouling removal. Microgels are added into the feed solution such that they deposit on the membrane surface together with the foulants during filtration and for cleaning, microgels in swollen form are collapsed by applying a temperature or ionic strength change.

PES (polyethersulfone) membranes were used in filtrations using poly(N-isopropylacrylamide), p(NIPAm), poly(sulfobetainemethacrylate), p(SBMA), and poly(N-isopropylacrylamide-co-sulfobetainemethacrylate) or p(NIPAm-co-SBMA) microgels. First, pure water permeances were measured and then, 1 g/L humic acid in 2 mM $CaCl_2$ solution was filtered in dead end mode at 2 bar and room temperature with or without microgel addition. When P(SBMA) microgels were used 0.5 M NaCl was added to the feed to have the microgels in swollen form. Finally, PWP values were measured after a cleaning step done via temperature or ionic strength change with simultaneous stirring. Hydrodynamic radii of microgels measured by Dynamic Light Scattering and filtration/cleaning conditions are given in Table 1.

Table 1. Hydrodynamic radii and filtration and cleaning procedures for the microgels

Microgel	Swollen radius (nm)	Collapsed radius (nm)	Filtration condition	Cleaning condition
p(NIPAm)	565	190	20°C	35°C
p(SBMA)	337	143	0.5 M NaCl, 20°C	pure water, 20°C
p(NIPAm-co-SBMA)	375	180	20°C	35°C

Figure 1 shows normalized filtration and pure water fluxes and pictures after cleaning for p(NIPAM-co-SBMA) microgels in humic acid filtrations. Filtrations were performed consecutively with the same membrane for each case. Addition of p(NIPAM-co-SBMA) microgel enabled more efficient cleaning compared to microgel-free case. Flux recovery after physical cleaning was higher than 90% for each cycle of p(NIPAM-co-SBMA) added filtrations while the recovery started from 84% and decreased to 57% at the end of HA filtrations without microgels. Membrane photographs of both cases after first cleaning further illustrate the effect of microgel addition on fouling removal.

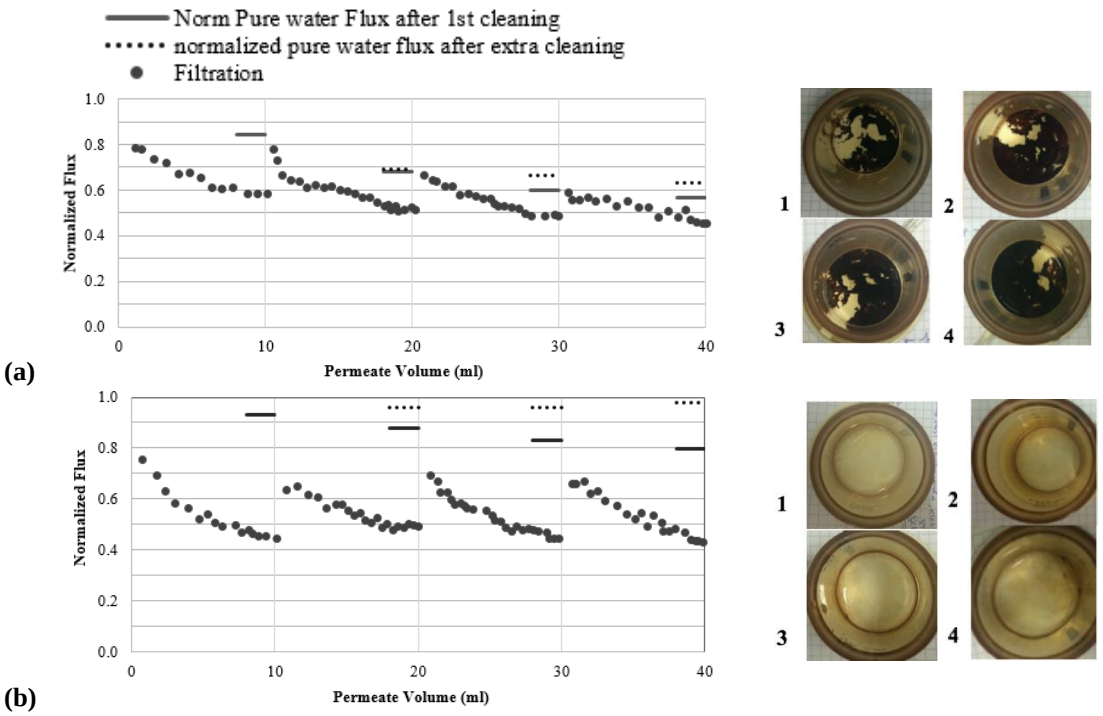


Figure 1. Filtration of 1 g/L Humic acid - 2 mM $CaCl_2$ solution (a) without and (b) with P(NIPAM-co-SBMA) microgels (0.01 g/L)

In the case of p(SBMA) microgels, humic acid cleaning was partly irreversible in the first filtration, with flux recovery of 70% with and 53% without microgels, respectively. In subsequent filtrations 98% and 93% flux recovery (compared to the flux before each filtration) was obtained in the presence of microgels while these values were 83% and 92% in their absence (Figure 2). On the other hand, humic acid fouling alone was also more reversible in the presence of 0.5 M NaCl during filtration.

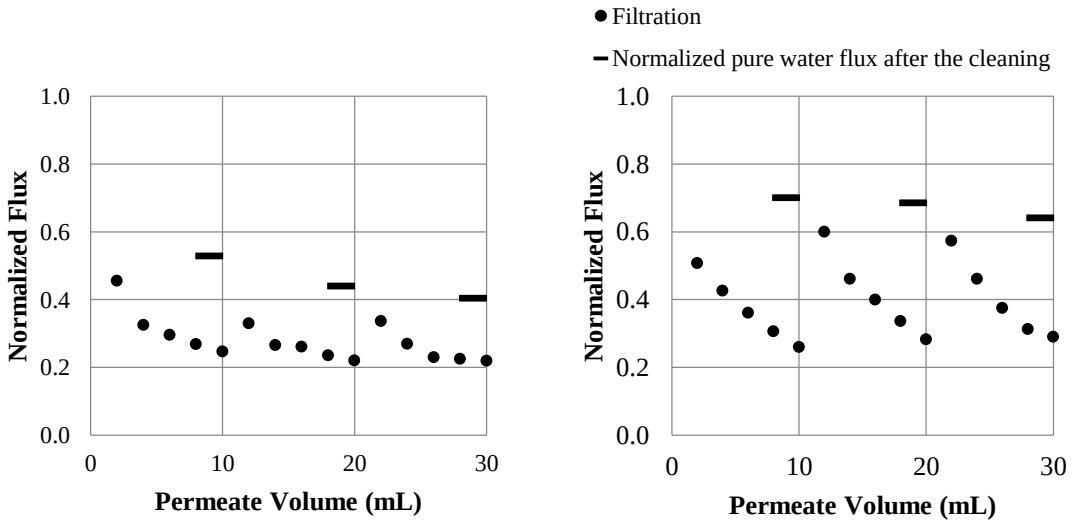


Figure 2. (a) Filtration of 1 g/L Humic acid - 2 mM $CaCl_2$ solution (a) without and (b) with P(SBMA) microgels (0.1 g/L with 0.5 M NaCl during filtration)

Use of p(NIPAM) microgels did not improve fouling reversibility, which was attributed to the strong interactions of p(NIPAM) with the membrane and the foulants, which aggravated the fouling in presence of the microgel.