SELF-HEALING PROPERTIES OF MICROCAPSULE-EMBEDDED AND HYDROGEL-COMPOSITE WATER FILTRATION MEMBRANES

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We herein report our successful attempts to fabricate self-healing water treatment membranes that restore their water flux and particle rejection properties autonomously. Water filtration membranes routinely suffer from damages that compromise their filtration ability. Locating and replacing faulty membranes is the cause of significant downtime and increased maintenance cost in full-scale operations. We take two approaches to make self-healing membranes that overcome this issue. In the first approach, we embed microcapsules with a polyurethane shell and an isophorone diisocyanate core within a conventional polyethersulfone membrane. When the membrane structure is physically damaged, the microcapsules release a reactive isocyanate healing agent that reacts with the surrounding water to form a polyurea matrix that plugs the damage. A dual surfactant system and polydopamine allow for control of the size of these microcapsules and avoid capsule buckling. In these membranes, self-healing was found to recover the water flux and particle rejection of the membranes to 103% and 90% of the original membranes' performance, respectively. In the second approach, a hydrogel pore-filled membrane is fabricated by using poly(2-acrylamido-2-methyl-1-propanesulfonic acid) (PAMPSA) as the pore-filling hydrogel and polyethersulfone microfiltration membranes as the support layer. When these membranes are damaged, the differential swelling ability between free and constrained hydrogels leads to expansion of the hydrogel near the damage area, effectively sealing the damage. We suspect that molecular-interdiffusion of the hydrogel chains may play a role in fully mending the damage. After being damaged, the flux and rejection of these membranes was restored to 115% and 98% of the original membrane's performance, respectively. The results of this study show that microcapsule embedded membranes and hydrogel pore-filled membranes are a promising approach to fabricate versatile, next-generation membranes that can self-heal.