Abstract

Green bimetallic iron (Fe)/palladium (Pd) and iron (Fe)/Nickel (Ni) nanoparticles were synthesized employing extract from Moringa leaf as a capping and reducing agent and used as additives for the polyether sulfone (PES) membrane modification. Synthesis of both nanoparticles using plant sources makes this approach eco-friendly and sustainable. Such hybrid nanoparticles could be employed to treat other harmful synthetic dyes to control water pollution. In this study, hybrid Fe/Pd and Fe/Ni nanoparticles were applied to investigate their catalytic synergistic effect for removing Congo Red (CR), and Naphthol Blue Black (NBB) dyes. The produced nanocomposite membrane was proposed as a potential removal technique for dyes. The CR and NBB dyes were employed as representatives for dye contamination.

The addition of Fe/Pd and Fe/Ni nanoparticles were optimized concerning their weight loading in the PES solution. Modified membranes and green synthesized bimetallic (Fe/Pd and Fe/Ni) nanoparticles were characterized by Field Emission Scanning Electron Microscope (FE-SEM), Energy Dispersive Spectrum (EDS), Fourier Transform Infrared (FTIR), Atomic Force Microscope (AFM), Contact angle (CA), Particle size distribution, and Zeta Potential & Mobility.

The optimum Fe/Pd loading was found to be 0.5 g (membrane denoted as M 0.5) resulting in the highest fluxes of 80 and 84 L/m^2.h with 100 mg/L solute concentration of NBB and CR, respectively, as compared to 51 and 52 L/m^2.h of the respective fluxes with pristine PES membrane (denoted as M 0.0). The rejection has also improved from 86% to 98.4% for NBB and 88.5% to 97.4% for CR when M 0.0 was replaced with M 0.5. The structural and

chemical characteristics of the synthesized membrane as well as their dyes' removal efficiency were (13.6% NBB and 9.5% CR) improved.

Also the optimum Fe/Ni NPs loading was found to be 0.7g (membrane denoted as M-0.7) resulting in the highest fluxes of 84 and 86 $L/m^2.h$ with 100 mg/L solute concentration of NBB and CR, respectively, as opposed to 58 and 54 $L/m^2.h$ of the respective fluxes of the two dyes with pristine PES membrane (denoted as M-0.0). In this work, it was proposed that the Fe/Ni nanoparticles added to the membranes will act as a hydrophilic modification of the PES membrane and be an excellent self-cleaning material, which in turn will significantly extend the membrane lifetime. The rejection has also improved from 81% to 93.2% for NBB and 83% to 93% for CR when M-0.0 was replaced with M-0.7. The structural and chemical characteristics of the synthesized membrane as well as their dyes' removal efficiency were (12% NBB and 9.4% CR) improved.

The integration of Fe/Pd NPs and Fe/Ni NPs have also improved the membrane's antifouling characteristics as the increase in membrane surface smoothness and hydrophilicity stand behind the development of reversible fouling. The functional groups introduced by the Moringa leaf extract are believed to have a promising role in polymeric membranes modification for improving dye separation. The functional groups provided by Moringa leaf extract have been shown to play an important role in improving dye rejection while the increase in membrane surface smoothness and hydrophilicity led to the development of reversible fouling.