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Novel membranes for treatment of water: Graphene oxide membranes cross-linked with metal cations

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Declining of water resources and rapid expansion of the consumption of water worldwide have led to the search of novel water treatment technologies that can provide a safe water supply to the mankind. Graphene oxide (GO), which is an oxidative exfoliation product of graphite, is an ideal candidate to be used as a new material for this purpose. However, GO sheets gradually disintegrate in water because of electrostatic repulsions between ionized oxygen containing functional groups. This research work explores the ways in which impart physical properties needed for GO sheets to overcome their inherent dispensability in water environment and to enhance the necessary stability by cation cross-linking. GO membranes cross-linked with unit amount of Al^{3+}, Zn^{2+} and K^{+} shows greater stability in water compared to the unmodified GO membranes. Energy Dispersive X-ray Absorption (EDXA) analysis proves the incorporation of metal ions into the GO membrane. Accordingly GO membrane cross-linked with Al^{3+}, $Zn^{2+}$and K^{+} (1000 mg mL^{-1}, 300 µL) has caused a surface composition of 0.14%, 0.14% and 0.13% respectively by weight of particular metal cation. Scanning Electron Microscopy (SEM) images confirm the cation cross linking since cross-linked GO membranes have a wrinkled surface morphology compared to unmodified GO membranes. According to FTIR-ATR spectrums of GO membrane cross-linked with Al^{3+}, $Zn^{2+}$and K^{+} (1000 mg mL^{-1}, 300 µL, 2000 µL, 3200 µL) intensity of carbonyl and epoxy peaks have been decreased and peak positions have been shifted to lower wave numbers with the increase of cation concentration compared to unmodified membrane since the amount of freely available functional groups decrease as the cross-linker concentration increase. Following cross-linking with Al^{3+}, $Zn^{2+}$and K^{+} (1000 mg mL^{-1}, 300 µL) elastic modulus of GO membranes has been increased by 191%, 173% and 147% respectively. Hence tensile testing analysis confirms the cation cross-linking in the in-plane direction. Also tensile testing analysis represents the presence of a linear relationship between charge density of the cross-linker and enhancement of mechanical strength as the charge density of the cross-linker increased the enhancement in the mechanical strength has been increased. According to X ray diffraction (XRD) analysis, there is no significant change in the interlayer spacing of GO membranes with and without metal ion cross-linking. This may suggest that metal ion intercalation via the stacking direction has not been taken place or it is non-homogeneous. Studies are underway in order to further investigate the relationship between charge density of the cross-linker and the enhancement in mechanical strength and the aqueous stability caused due to cation cross-linking of GO membranes.

Keywords: Graphene oxide, Aqueous stability, Cross-linked GO, Mechanical strength, Charge density