Supplementary Information

Preparation of Graphene Oxide Nano-composite ion-exchange membranes for desalination application

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Preparation of anion exchange membrane (AEM)

The interpolymer anion-exchange membranes (AEM) used in the investigations is prepared by the procedure reported earlier [1, 2]. The membrane is based on an interpolymer of polyethylene and styrene-divinyl benzene copolymer with quaternary ammonium as a functional group. The membranes were conditioned by treatment with 0.1 M HC1 and 0.1 M NaOH successively and then thoroughly washed with distilled water before use.

Chemical and structural characterization:

The Fourier-transform infrared (FTIR) spectra of GO, SGO and dried membranes is recorded using KBr pellet method with a spectrum GX series 49387 spectrometer in the frequency range 4000-400 cm^{-1}. X-Ray Diffraction (XRD) of GO, SGO and SGO-1 membrane is recorded on Philips X'Pert MPD System using CuK$_{\alpha}$ radiation with 0.15406 nm within scattering angle range 1 to 80°. Surface characterization of SGO and composite membrane cross section are recorded by scanning electron microscopy (SEM) using LEO microscope after gold sputter coating. Transmission electron microscopy (TEM) images of GO and SGO are obtained on JEOL,JEM

2100 microscope with an accelerating voltage of 200 keV. Atomic Force microscopy (AFM) is used to estimate the surface roughness in semi contact mode on NTEGRA AURA (NTMDT).

Thermo-mechanical stabilities

Investigation of thermal degradation and stability of GO and membranes were done on thermogravimetric analyser (TGA) under N_2 atmosphere on Mettler Toledo TGA/SDTA851e with stare software, with a heating rate of 10 °C/min from 50 to 600°C. The glass transition behavior of composite membranes was assessed through Differential Scanning calorimetry (DSC) using Mettler Toledo DSC822e thermal analyzer with stare software under temperature range 0 to 200°C. Dynamic mechanical stabilities of the membranes was carried out on Mettler Toledo dynamic mechanical analyzer (DMA) 861c instrument with stare software under nitrogen environment with a heating rate of 5°C/min from 30 to 450°C with 1 Hz frequency.

Physiochemical Characterization

Water retention capabilities of the membranes were calculated by immersing the membranes in distilled water for 24 h at room temperature. Membranes were weighted immediately after wiping the water drops from membrane surfaces. Weight of dry membranes was also measured after drying for 2 h at 70°C.

$$\emptyset_w = \frac{W_{Wet} - W_{dry}}{W_{wet}} \times 100\%$$

Dimensional change was evaluated by taking the volume difference between wet and dry membranes using the following equation:

$$\emptyset = \frac{V_{Wet} - V_{dry}}{V_{wet}} \times 100$$

Ion exchange capacity (IEC) [2] of the membranes were evaluated by equilibrating in acid-base. Membranes were washed and immersed in 0.1M NaCl (50 ml) for 24h at room temperature to exchange sodium ion with proton in the membranes. After that 10 cm^3 sample solution was titrated against 0.01M NaOH using the following equation:

$$IEC(mequiv\ g^{-1}_{dry\ membrane}) = \frac{C_{Na^+} V_{sol}}{W_{dry}}$$

where C_{Na^+} is the concentration of Na^+ in the extraction solution, V_{sol} is the volume of titrated or consumed NaOH and W_{dry} is the dried membrane weight.

Methanol permeability:

Resistance to methanol crossover of the membranes was evaluated by the measurement of the methanol permeability with a two compartment cell. The membrane was placed between the two compartments and then clamped tightly. After that, 100 mL of a methanol solution and 100 mL of deionised water were circulated in first and second compartment of the cell, respectively. The concentration of methanol in second compartment was measured as a function of the diffusion time with a refractometer. The methanol permeability (P_M) was obtained by the equation;

$$P_M = \frac{1}{A}\frac{C_{II(t)}}{C_{I(t)}t} V_{II}\, l$$

where A is the effective membrane area, l the membrane thickness, $C_{II(t)}$ the methanol concentration in second compartment at time t, $C_{I(t)}$ the change in the methanol concentration in first compartment at time t, and V_{II} the volume of second compartment. For the suitability of membrane for fuel cell, we calculate the selectivity of the membrane by following equation;

$$S_P = \frac{\sigma}{P_M} \qquad (6)$$

where P_M is the methanol permeability (cm^2/s), and σ is the membrane conductivity ($S.cm^{-1}$).

1. P.K. Narayanan, S.K. Adhikary, W.P. Harkare and K.P. Govindan, Indian Patent No. 160880, August, 1987.
2. P.K. Narayanan, W.P. Harkare, S.K. Adhikary, N.J. Dave, D.K. Chouhan and K.P. Govindan, Performance of an electrodialysis desalination plant in rural area, Desalination, 54 (1985)145-150.

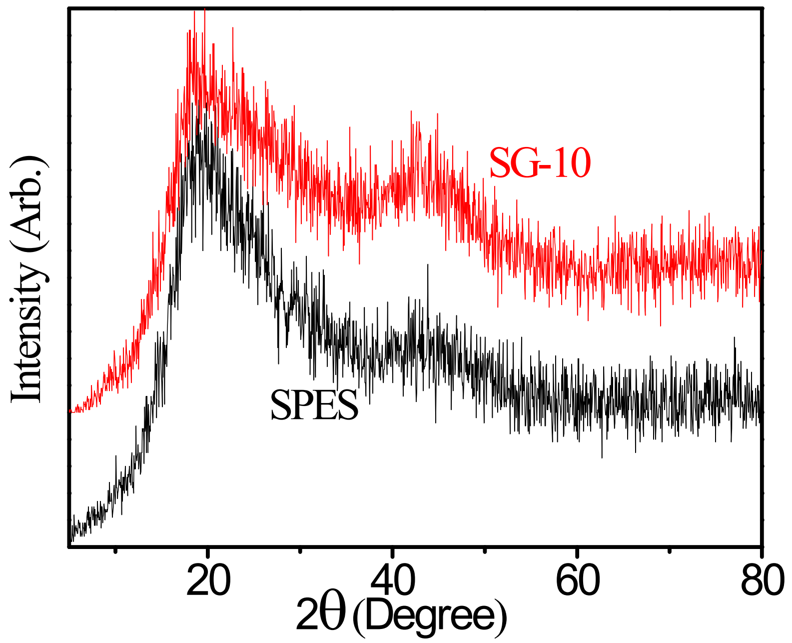

Fig. S-1: XRD patterns for SPES and SG-10 membranes

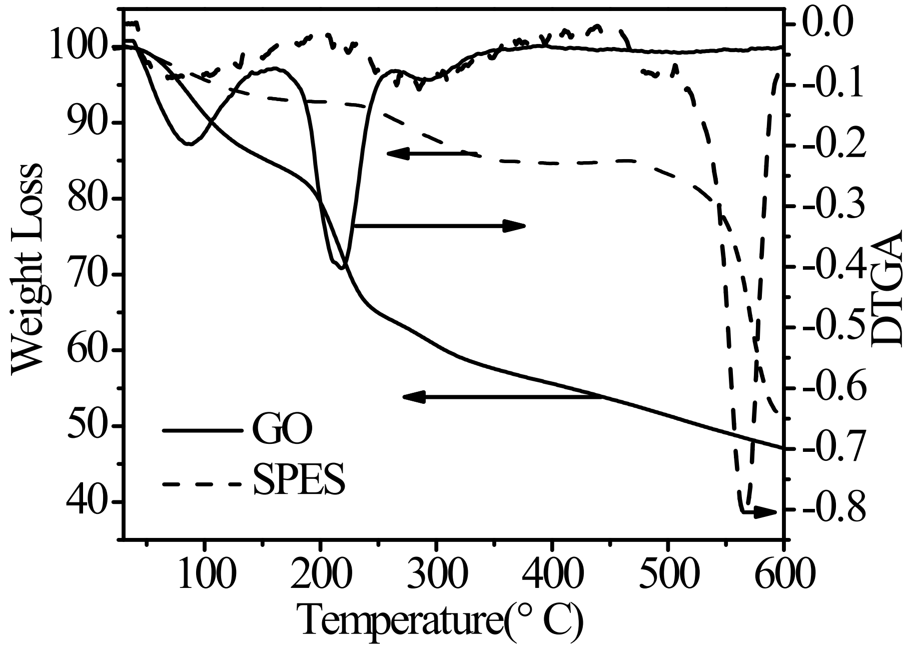

Fig. S-2: TGA and DTGA patterns for Graphene Oxide and SPES membrane

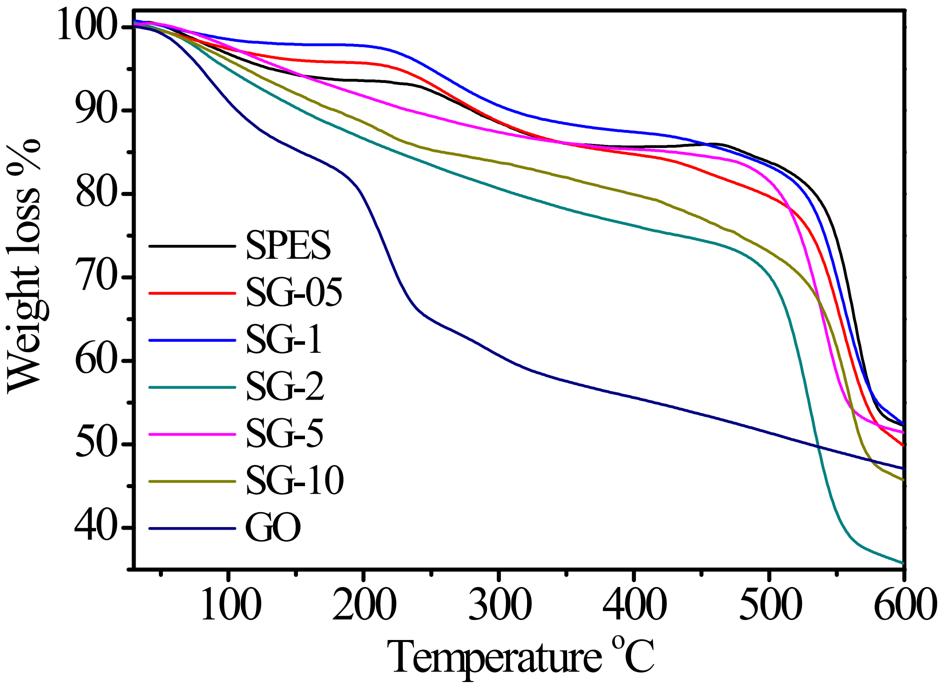

Fig. S-3: TGA thermo grams for different SPES/GO composite membranes

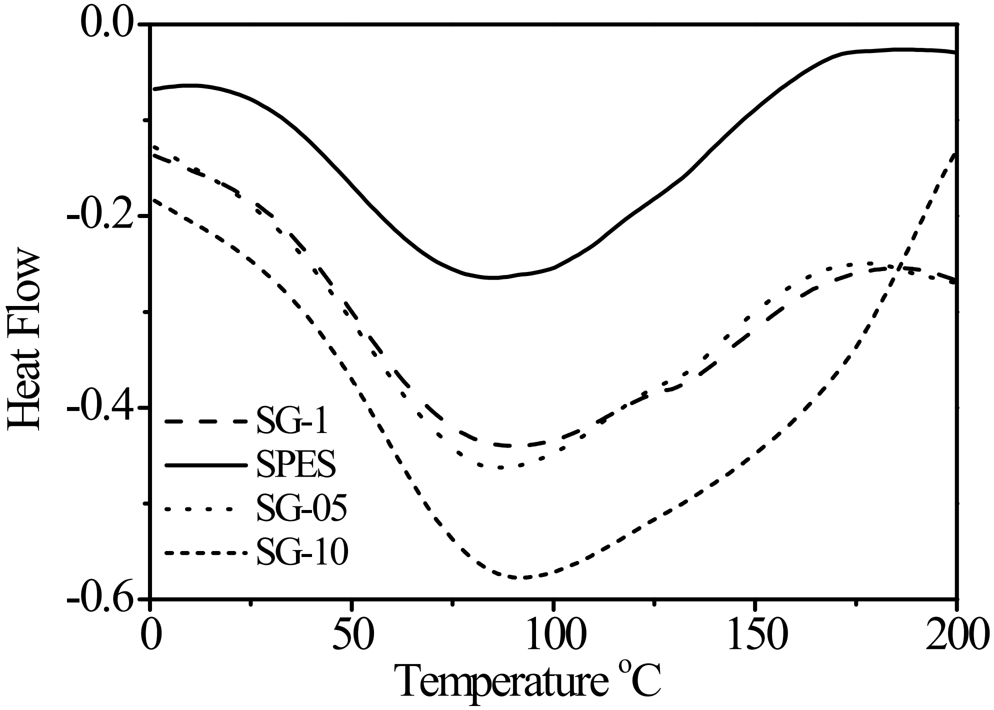

Fig. S-4: DSC patterns for different SPES/GO composite membranes

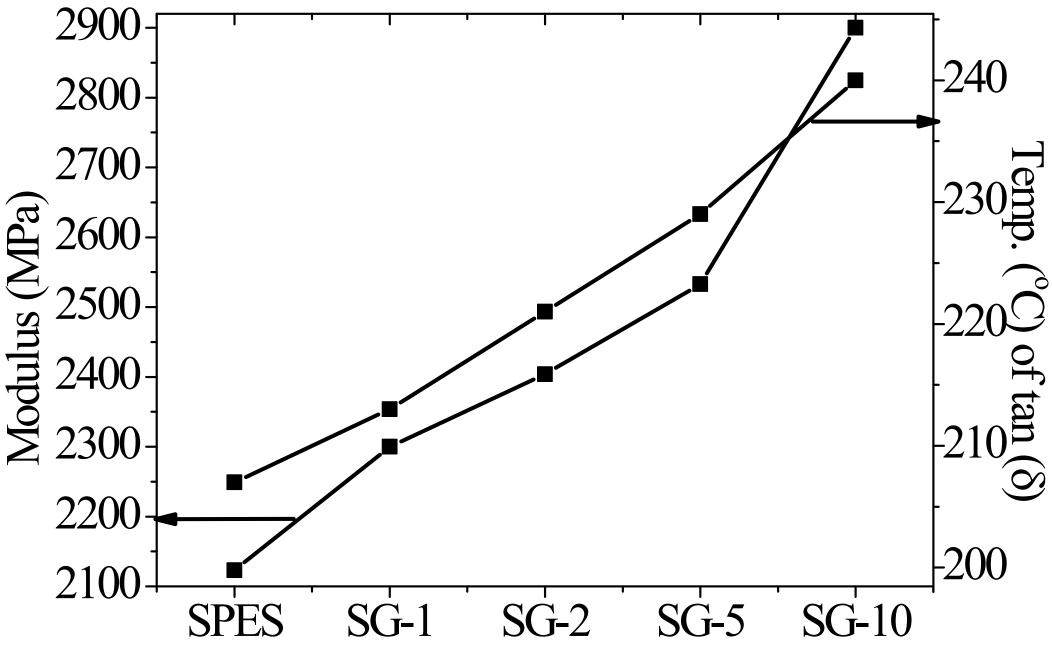

Fig. S-5: Storage modulus and Temp. of tan (δ) for different SPES/GO composite membranes