Significantly enhanced water flux in forward osmosis desalination with polymer-graphene composite hydrogels as a draw agent

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Supplementary Information

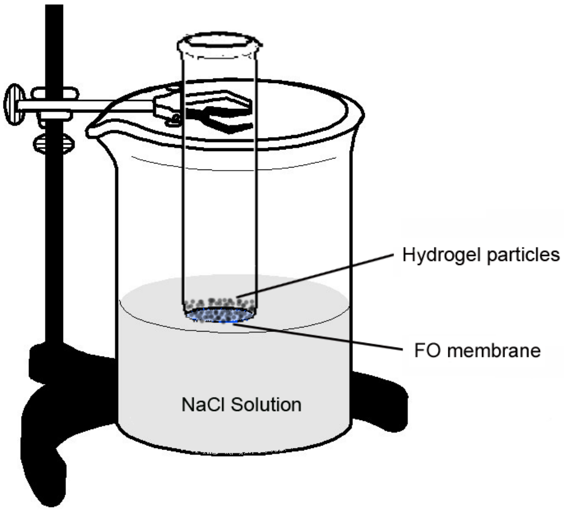

Fig S1. Schematic diagram of a FO setup used in this study.

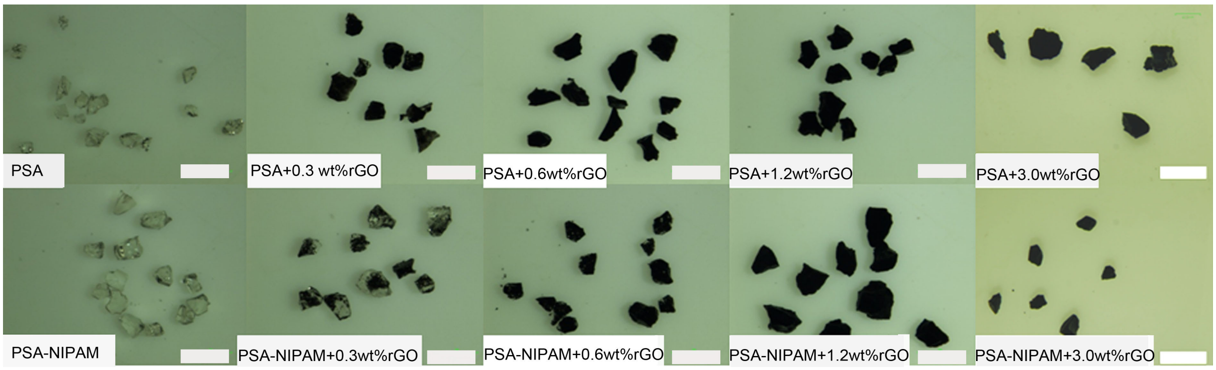

Fig. S2. Optical microscopy images of dried PSA and PSA-NIPAM particles with different amounts of rGO (0%-3 wt%) (scale bar =1 mm).

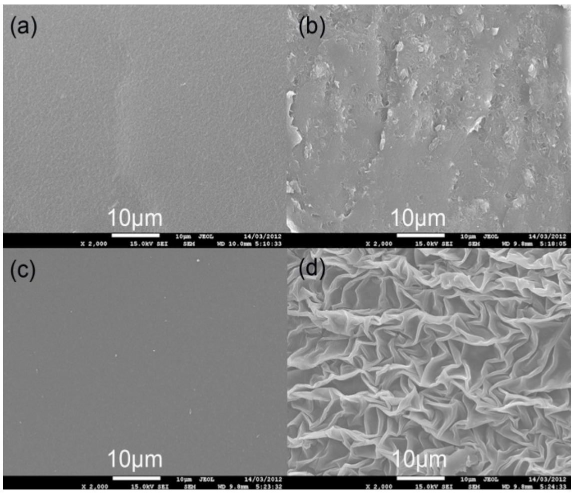

Fig. S3. SEM images of (a) PSA, (b)PSA with 1.2 wt% rGO, (c) PSA-NIPAM and (d) PSA-NIPAM with 1.2 wt% rGO at low magnifications.

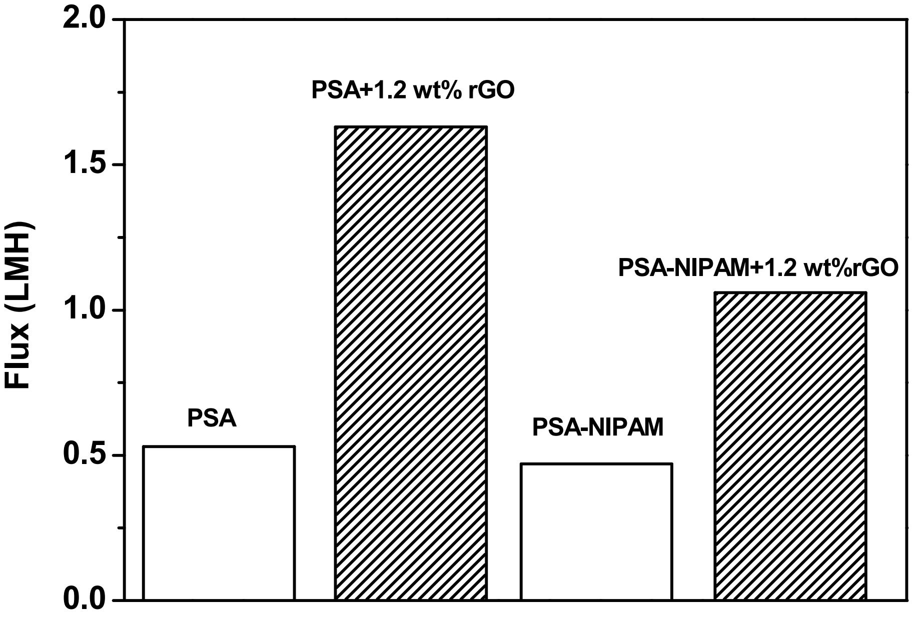

Fig. S4. Water fluxes in the 1 h FO process by using different hydrogels as draw agents, and 8000 ppm NaCl as the feed solution.

When the NaCl concentration of feed solution is increased to 8000 ppm, the water fluxes decrease to 0.53 LMH and 0.47 LMH for PSA and PSA-NIPAM, respectively. When 1.2 wt% rGO is incorporated, a water flux of 1.63 LMH is achieved for PSA-rGO composite hydrogel and 1.06 LMH for PSA-NIPAM-rGO composite hydrogel, which are still 3 times and 2.2 times of water flux obtained from pure PSA and PSA-NIPAM, respectively.

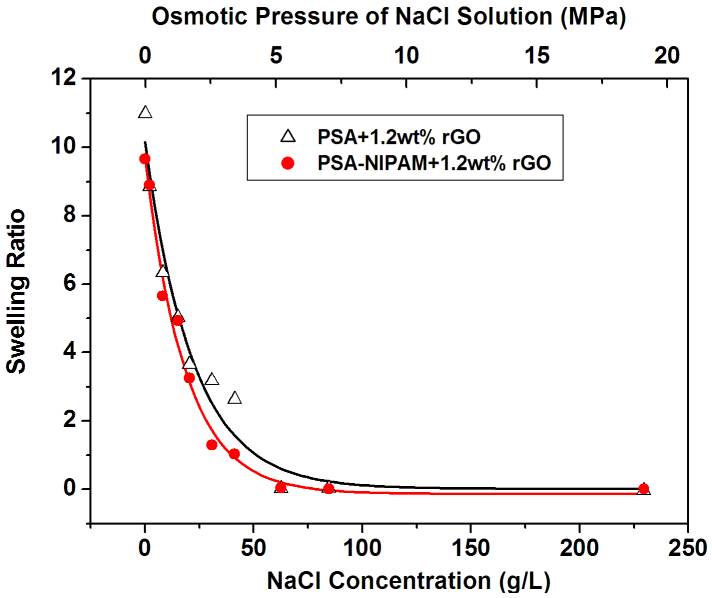

Fig. S5. The swelling ratios for composite hydrogels at different concentrations (osmotic pressures) of NaCl solution. The FO setup shown in Fig.S1 was used. 0.2 g of dried hydrogel was placed on the active side of FO membrane with an effective area of 1.77 cm^2, while a different concentration of NaCl solution was used as the feed solution on the other side of FO membrane. The hydrogel was allowed to absorb water for 24 h at room temperature to reach equilibrium. The swelling ratio was caculated by taking the ratio of the mass of the water absorbed by the hydrogels, and the mass of the dry hydrogels.

Table S1. The water fluxes for different draw agents in the FO process.

Draw agent	**Water flux (LMH)**		
	DDI	2000 ppm	
PSA+1.2 wt% rGO	8.2	3.1	This work
PSA-NIPAM+1.2 wt% rGO	6.8	1.7	This work
Magnetic nanoparticles	1.8	NA	Ref. 13
1.5 M NH_4HCO_3	16.55	NA	Ref. 6
PSA+Carbon particles	NA	1.32	Ref. 11
PSA-NIPAM+Carbon particles	NA	0.77	Ref. 11

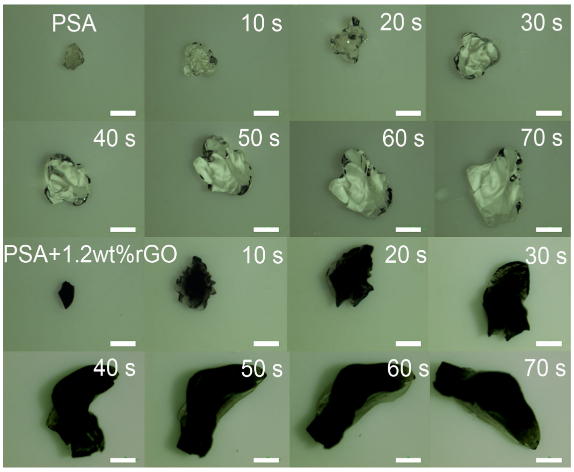

Fig. S6. The swelling process of PSA and PSA+1.2 wt% rGO in first 70 s (scale bar =1 mm).

Table S2. The projected area of individual hydrogel particles during the swelling process shown in Figs. S6, S8.

	Projected Area (mm^2)			
Time(s)	PSA	PSA+1.2wt% rGO	PSA-NIPAM	PSA-NIPAM+ 1.2 wt%rGO
0	0.564	0.443	0.191	0.308
10	1.251	2.119	1.277	2.810
20	1.447	3.135	2.020	5.636
30	2.126	4.364	2.729	7.110
40	2.760	5.742	3.211	8.383
50	3.488	6.334	3.254	8.838
60	4.067	6.931	3.417	8.995
70	4.698	7.001	3.682	9.200

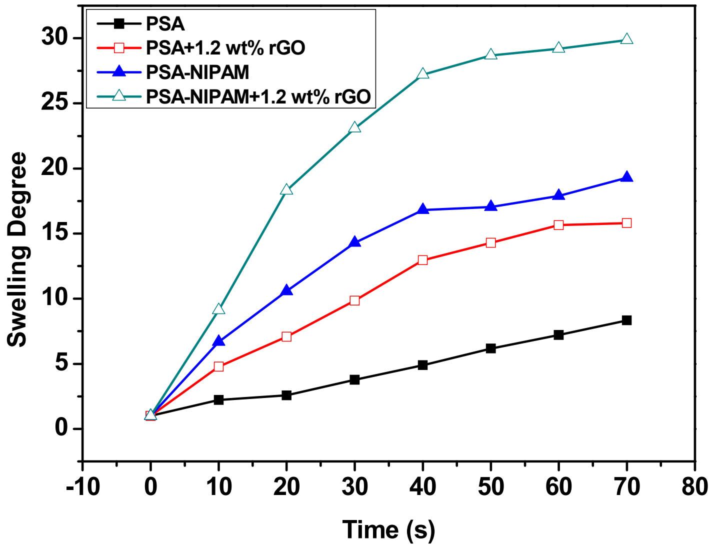

Fig. S7. The swelling degree of hydrogel during the swelling process.

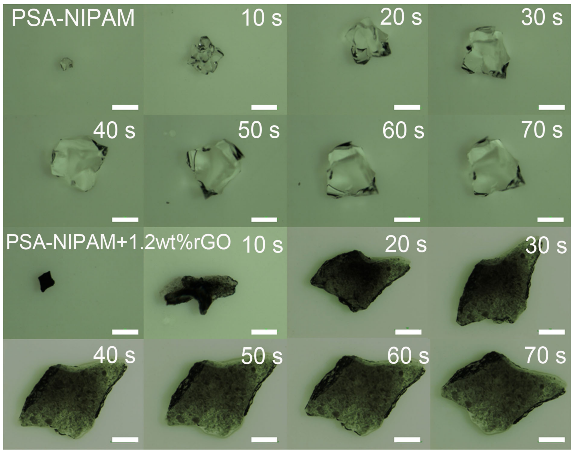

Fig.S8. The swelling process of PSA-NIPAM and PSA-NIPAM+1.2 wt% rGO in first 70 s (scale bar =1 mm).