

1                                    Electronic Supplementary Information (ESI)

2                                    **Graphene Oxide Polymer Brushes based Cross-linked**

3                                    **Nanocomposite Proton Exchange Membrane for Direct Methanol**

4                                    **Fuel Cells**

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1           **Measurement of Water Uptake.** Water uptake measurement of Nafion®117  
2           pristine SPSU membrane, SPSU/GO composite membranes and SPSU/FPGO cross-  
3           linked membranes were carried out as follows. Membranes were firstly dried in a  
4           vacuum oven at 80 °C for 12h, and the weight of dry membranes ( $W_{dry}$ ) was measured.  
5           The dry membranes were fully hydrated in deionized water for 24 h at different  
6           temperatures ranging from 30 to 90 °C, then reweighed ( $W_{wet}$ ) quickly after removing  
7           the surface water by tissue paper. The final water uptake value was the average of the  
8           three measurements with an error within  $\pm 4\%$  using eq 1:

$$9 \quad \text{Water uptake (\%)} = \frac{(W_{wet} - W_{dry})}{W_{dry}} \times 100\% \quad (1)$$

10           **Measurement of Area Swelling.** Area swelling of the membranes was measured  
11           as follows. The pre-measured dry membranes ( $A_{dry}$ , cm<sup>2</sup>) were immersed in deionized  
12           water for 24 h at 30 °C and 70 °C, respectively. Then, the wet area of the membranes  
13           ( $A_{wet}$ , cm<sup>2</sup>) were measured, and the area swelling value was calculated with an error  
14           within  $\pm 1.5\%$  using eq 2:

$$15 \quad \text{Area swelling (\%)} = \frac{(A_{wet} - A_{dry})}{A_{dry}} \times 100\% \quad (2)$$

16           **Measurement of IEC.** *IEC* of the membranes was measured by titration method.  
17           Dry membranes were weight and then soaked into 1 M NaCl for 24h to completely  
18           release all the H<sup>+</sup> and replace them with Na<sup>+</sup>. The amount of protons liberated from  
19           the membranes was titrated using a 0.01 M NaOH solution with phenolphthalein as  
20           PH indicator. The *IEC* value was the average of the three measurements which were  
21           obtained using eq 3:

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$$IEC \text{ (mmol/g)} = \frac{C_{NaOH} \times V_{NaOH}}{W_{dry}} \quad (3)$$

2 Where  $V_{NaOH}$  (mL) is the volume of NaOH solution,  $C_{NaOH}$  (mol/L) is the  
3 concentration of NaOH solution used in titration and  $W_{dry}$  (g) is the weight of dried  
4 membrane samples.. The final  $IEC$  values were the average of the three measurements.

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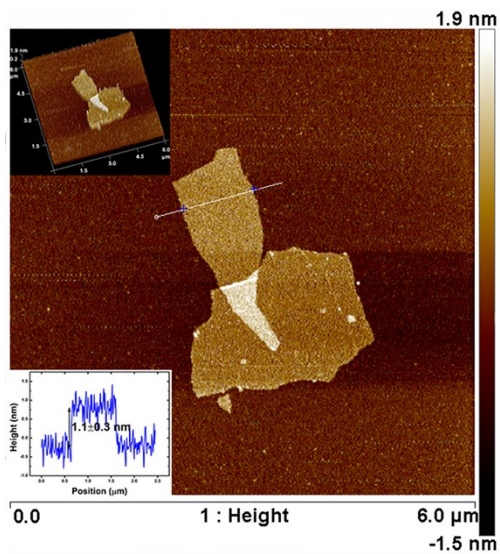
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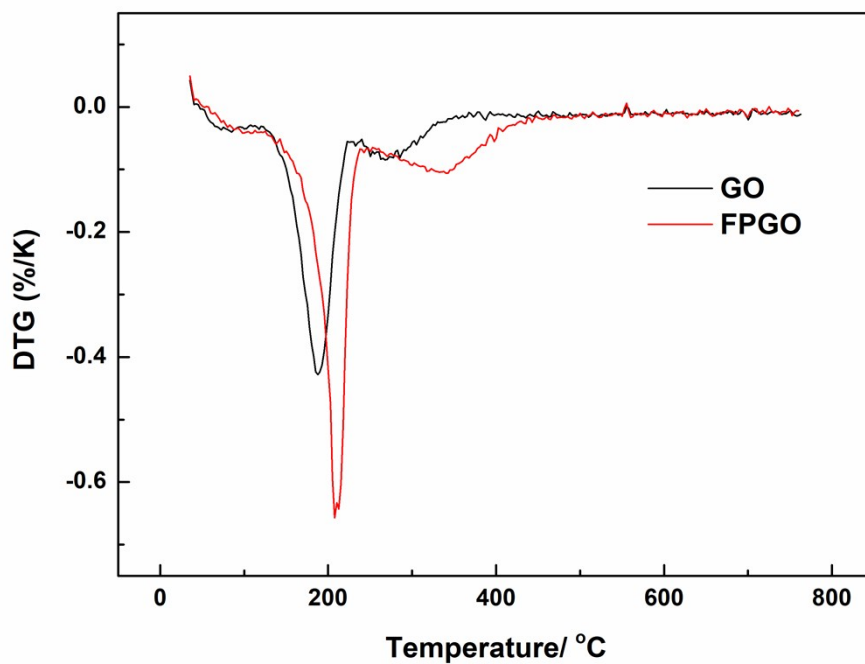
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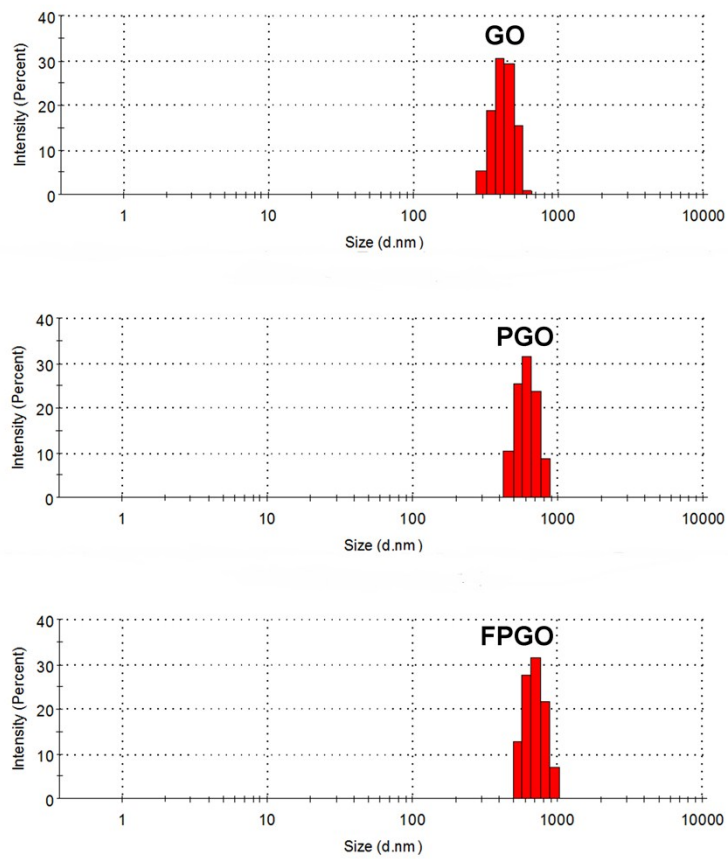
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**Figure S1.** AFM images and height profiles of GO.



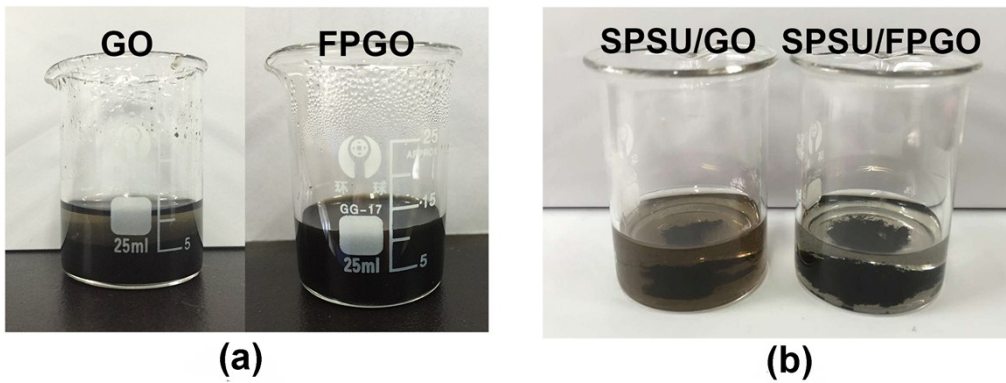
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**Figure S2.** DTG curves of GO and FPGO.



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**Figure S3.** Nanosize and distribution of GO, PGO and FPGO nanosheets by DLS.



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**Figure S4.** (a) GO and FPGO dispersion images in DMAc by ultrasonication, (b) Solubility test of SPSU/GO-2 composite membrane and SPSU/FPGO-2.2 cross-linked membrane.

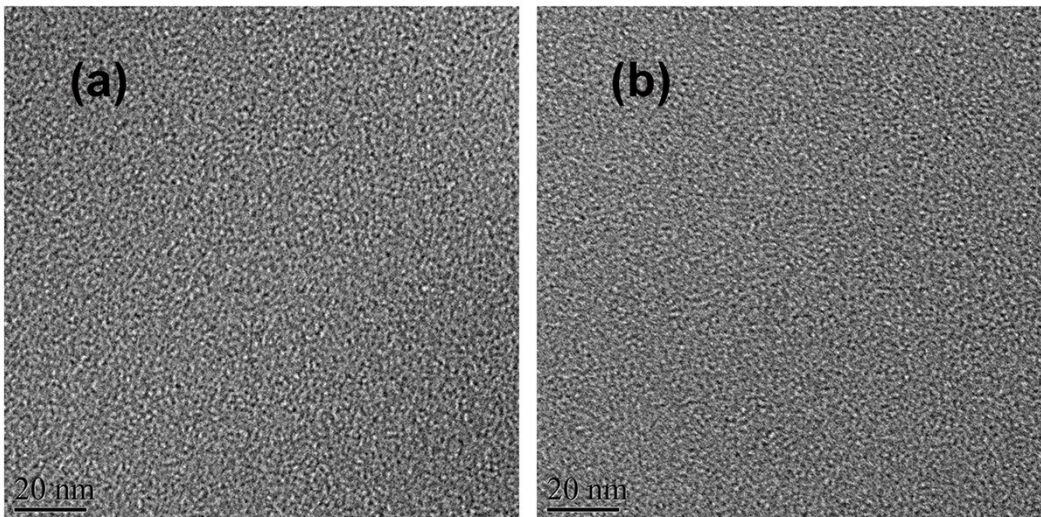


Fig. S5. TEM images of SPSU/GO-1 and SPSU/FPGO-1 membranes.

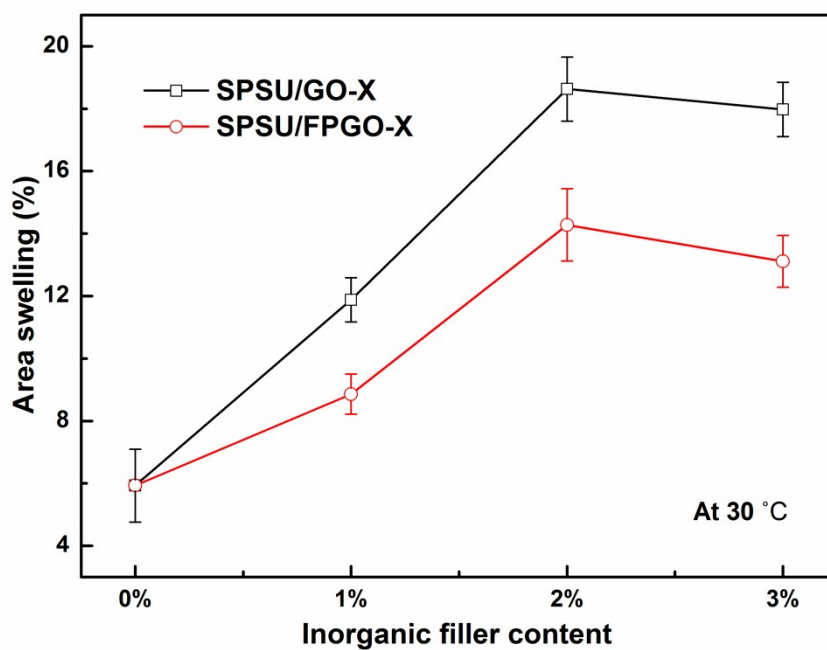
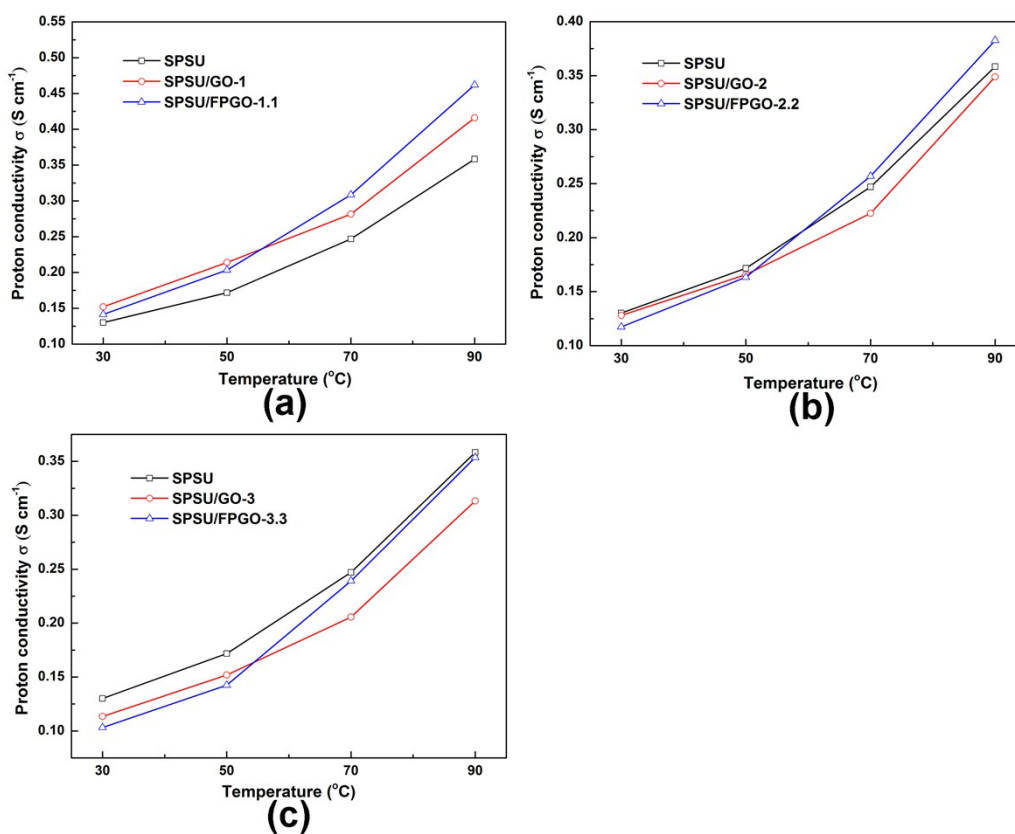


Figure S6. Area swelling of SPSU, SPSU/GO and SPSU/FPGO membranes at 30 °C.



**Figure S7.** Temperature-dependent proton conductivity of (a), (b) and (c) SPSU/GO and SPSU/FPGO membranes with the same inorganic contents,

**Table S1.** IEC, water uptake, area swelling and proton conductivity of the membranes.

| Membrane      | IEC<br>(mmol·g <sup>-1</sup> ) | WU (%) |      |      |       | Area swelling<br>(%) |       | $\sigma$ (S cm <sup>-1</sup> ) |       |       |       |
|---------------|--------------------------------|--------|------|------|-------|----------------------|-------|--------------------------------|-------|-------|-------|
|               |                                | 30°C   | 50°C | 70°C | 90°C  | 30°C                 | 70°C  | 30°C                           | 50°C  | 70°C  | 90°C  |
| SPSU          | 1.44                           | 36.2   | 46.5 | 65.7 | 127.3 | 5.93                 | 20.18 | 0.130                          | 0.172 | 0.247 | 0.358 |
| SPSU/GO-1     | 1.40                           | 50.7   | 55.5 | 73.2 | 116.3 | 11.88                | 23.19 | 0.152                          | 0.214 | 0.281 | 0.416 |
| SPSU/GO-2     | 1.41                           | 49.9   | 52.9 | 70.5 | 114.4 | 18.63                | 23.31 | 0.128                          | 0.166 | 0.223 | 0.349 |
| SPSU/GO-3     | 1.23                           | 49.4   | 50.9 | 67.6 | 113.5 | 17.98                | 23.90 | 0.113                          | 0.152 | 0.206 | 0.313 |
| SPSU/FPGO-1.1 | 1.23                           | 42.9   | 47.2 | 61.6 | 104.0 | 8.86                 | 15.09 | 0.142                          | 0.203 | 0.309 | 0.462 |
| SPSU/FPGO-2.2 | 1.26                           | 42.1   | 43.6 | 65.1 | 104.1 | 14.28                | 19.72 | 0.117                          | 0.163 | 0.257 | 0.383 |
| SPSU/FPGO-3.3 | 1.21                           | 40.4   | 43.5 | 59.1 | 94.4  | 13.11                | 21.59 | 0.103                          | 0.142 | 0.239 | 0.354 |