

Supplementary Information

Fabrication of Low Cost Functionalized Poly(vinylidene fluoride) Nanohybrid Membrane for Superior Fuel Cell

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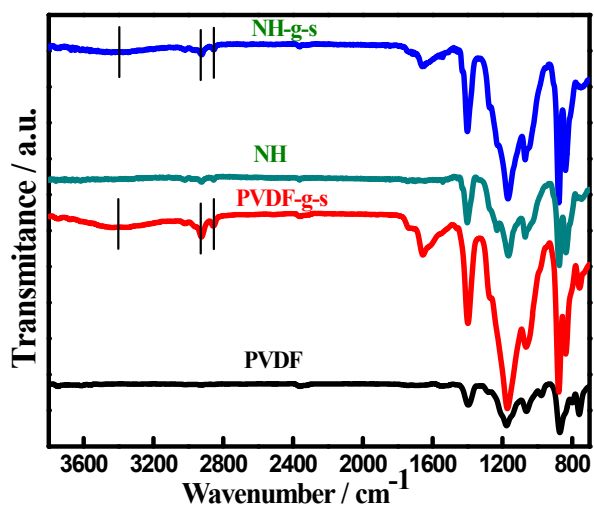


Figure S1: FTIR spectra of before irradiation (PVDF, NH) and after irradiation and grafting (PVDF-g, NH-g) (functionalized membrane) and indicating the stretching vibration frequency through the vertical lines.

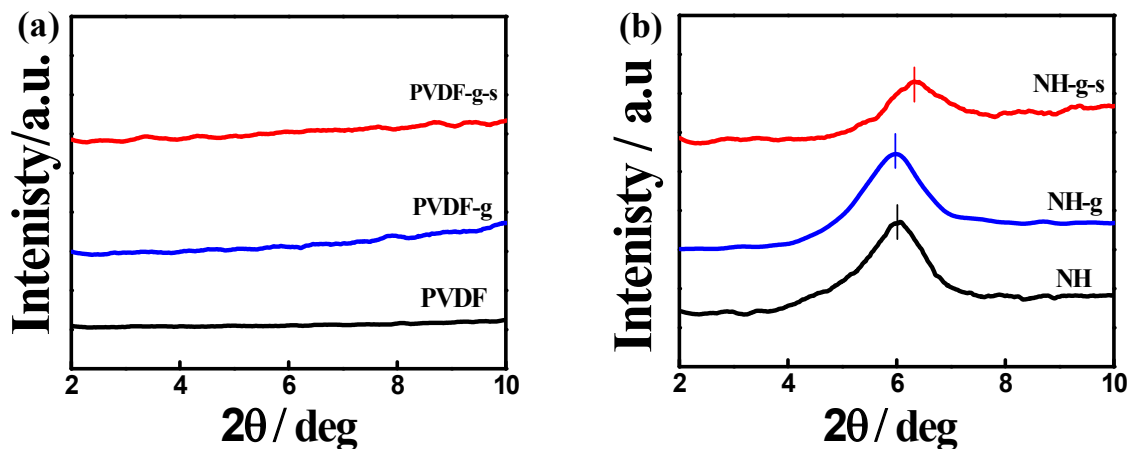


Figure S2: XRD patterns of (a) PVDF, PVDF-g and PVDF-g-s and (b) NH, NH-g, and NH-g-s to understand the nanostructure and marked lines indicate the peak positions of nanoclay dispersed in polymer matrix. The nanostructural investigation of the nanohybrid, before and after sulphonation, has been presented in **Supplementary fig. S2**. Pristine PVDF does not show any nanostructure peak in XRD pattern while in nanohybrids peak at $2\theta = 6.1^\circ$ indicating intercalated structure.

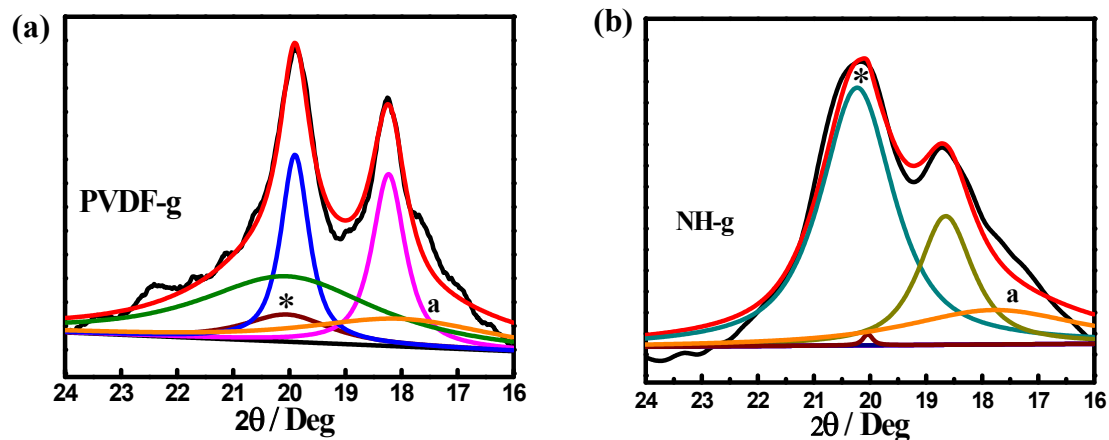


Figure S3: Deconvolution of (a) PVDF graft with P3-HT; (b) NH graft with P3-HT. The (a) peak indicate the area of the amorphous phase of PVDF-g and NH-g system and the (*) peak indicate the area of the piezoelectric β -phase of PVDF-g and NH-g specimens. The β -phase fractions after grafting were 8 and 59% in PVDF-g and NH-g, respectively. This is to mention that PVDF does not possess any β -phase before irradiation while $\sim 25\%$ polar β -phase is observed in NH.

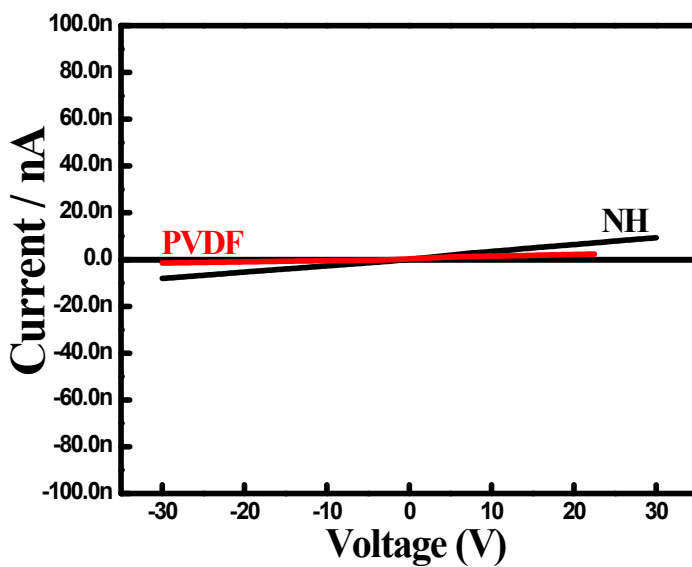


Figure S4: Current-voltage (I-V) characteristics of PVDF and NH showing their insulating behavior. The Current- voltage (I-V) characteristics shows that the pristine PVDF membrane show insulating range current (~ 2 nA at 20V bias) as there are no functional group present in the backbone of pure polymer. Furthermore, when nanodimensional nanoclay is mixed in polymer matrix, enhance current is observed from the membrane. But after the grafting and functionalization the current increases upto $\sim 1\mu\text{A}$ as explained in the manuscript. Moreover, the

increase in current in nanohybrid membrane is due to grafting of the conducting monomer inside the conducting nanochannel followed by their sulphonation which is responsible to enhance the current in semiconducting range.