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Electronic Supplementary Information

Quasi-solid DSSC based on gel-state electrolyte of PAN incorporated with 2-D graphene

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The amount of light absorbed for the excitation of dye that can generate photoinduced electrons injected into TiO2 layer has closed relation to the total solar power conversion efficiency. The transmittance UV-vis spectra of the gel composite (Fig. 4, upper row of inset) are given Fig. S1 inclusive of the dye absorption range, i.e. beyond 350nm. It is clearly from Fig. S1 that at >0.2wt% addition of graphene, the film transmittance drops significantly. As the amount of graphene added exceeds 0.2 wt%, the efficiency started to lower and the current density also decreased as expected. Excessive amount of graphene disguise its conducting role in the PAN-Gr PGEs, resulting in poor photovoltaic performance of the device due to the higher optical absorbance. These factors, in addition to the poorer ion mobility, devastatingly reduce the amount of photon absorbed by dye and hence decrease the amount of photoinduced electrons that can be possibly transported into TiO2 matrix for photocurrent generation. This explains the decline in cell efficiency for the PAN PGE at higher loading of graphene and demonstrates optimized graphene needs to be compromised with the photon absorbance as well.

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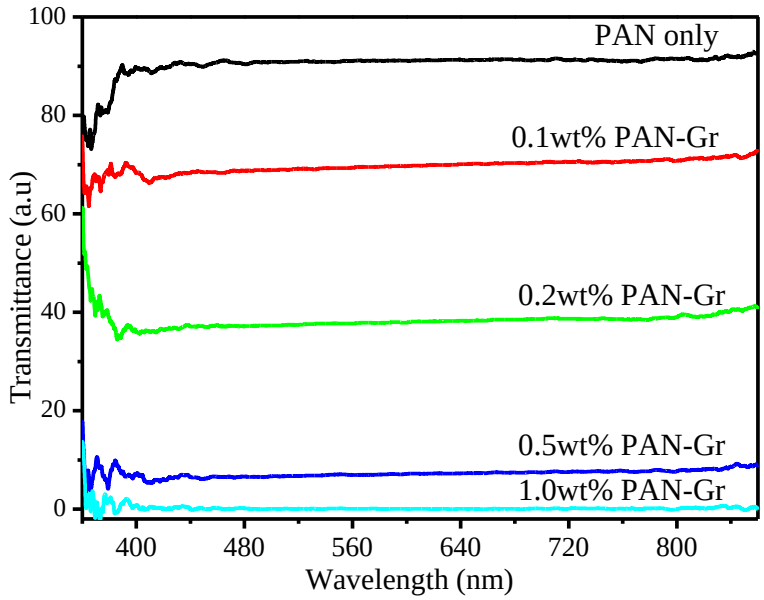

Fig. S1 Film transmittance of the PAN and its composite films incorporated with loading amount of graphene

The two gel-state DSSCs (PAN and 0.2wt% PAN-Gr PGE) were subjected to EIS under different bias voltage. Values of chemical capacitance (C_μ) and charge transfer resistance (R_{ct}) were yielded by for fitting the spectra obtained with equivalent circuit. Fig. S3a shows the C_μ as a function of bias voltage, which indicates the distribution of electron state density in the TiO_2 electrode[1]. The C_μ of 0.2wt% PAN-Gr is higher than that of PAN one, indicating that the energy gap between TiO_2 conduction-band edge is lower [2]. This leads to higher J_{sc} and lower V_{oc} of the DSSC assembled with PAN-Gr PGE. The underlying reason leading to such band movement remains to be fully assessed. Fig.S3b on the other hands, shows the R_{ct} as a function of bias voltage for both cells studied. The R_{ct} in PAN PGE DSSC is higher than that in 0.2wt% PAN-Gr one at each bias voltage, hence higher conduction band edge of the TiO_2 as well as FF in the PAN-only system. The results are in good agreement with the EIS spectra as depicted in Fig. 9.

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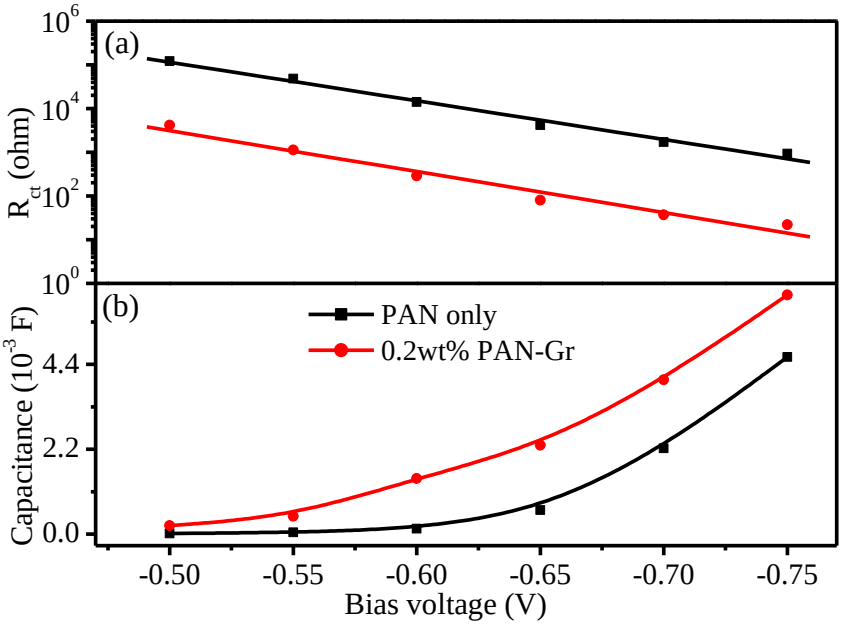

Fig. S2 (a) Chemical capacitance, and (b) charge recombination resistance as a function of bias voltage for the PGE DSSCs using PAN and 0.2wt% PAN-Gr.

Both the liquid and 0.2wt% PAN-Gr PGE DSSCs were subjected to a stability test at room temperature. After 10-days of test, the PGE DSSC can retain 97% of its initial efficiency, as shown in Fig. S3. However, the efficiency decreases to less than 70% of its initial value in the liquid cell. Detailed analyses on the I-V characteristic measurement indicate that the efficiency decrease of the liquid cell is mainly due to the drastic drop in the J_{sc} caused by the leakage of the volatile solvent. The higher stability of the PGE DSSC shows that the polymer-gel can inhibit the evaporation of solvent. Optimizing a PGE DSSC based on both energy conversion efficiency and stability is definitely an issue acquiring of further study in future.

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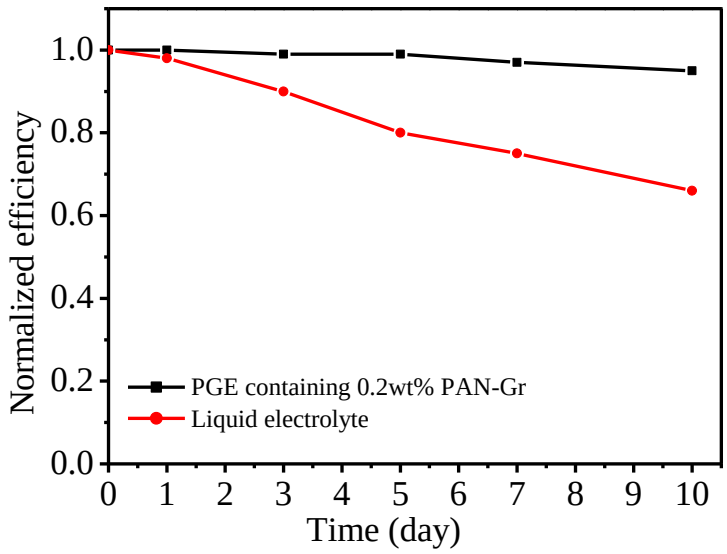

Fig. S3 Normalized efficiency at room temperature for the DSSCs using liquid electrolyte and 0.2wt% PAN-Gr PGE. The liquid electrolyte comprises of 0.1M LiI, 0.05M I_2, 0.6M 1,2-dimethyl-3-n-propylimidazolium iodide, and 0.5M 4-tert-butylpyridine in acetonitrile.

References

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2. C.L. Chen, H. Teng and Y.-L. Lee, *Advanced Materials*, 2011, **23**, 4199-4204.