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Supplementary information

Enhancing the reinforcing efficiency in CNT nanocomposites via development of pyrene-based active dispersants

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S1 TGA for component determination in composite film

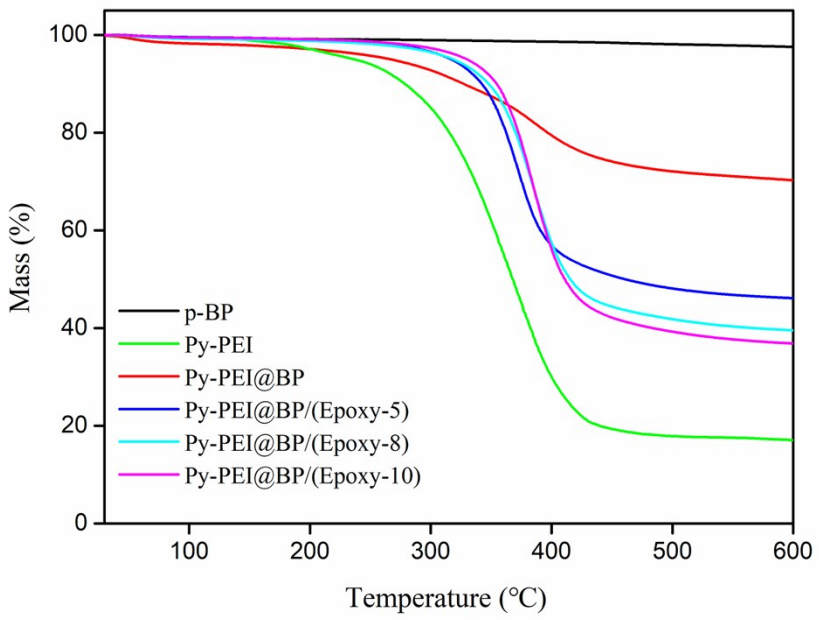

Fig. S1 TGA curve of pristine BP, Py-PEI, Py-PEI@BP, and three Py-PEI@BP /EP composite samples

From TGA plots of individual raw material, noticeable amount of residues are visible in both p-BP and Py-PEI and thus the residual fraction of Py-PEI@BP film was contributed by Py-PEI and CNT. Based on that, the following equation (1) and (2) were derived to estimate the content of Py-PEI and CNT in Py-PEI@BP film. As we know the epoxy matrix was totally decomposed at 600 °C, the residual fraction of composite film was contributed by Py-PEI and CNT; moreover, Py-PEI and CNT amount were considered invariable before and after infiltration in epoxy solution, as both are insoluble in the solution. Therefore, the content of each component in composite film could be calculated by the equation (3), (4), and (5), respectively.

$$W_{Py-PEI}\ in\ Buckypaper = \frac{RF_{CNT} - RF_{Py-PEI@CNT}}{RF_{CNT} - RF_{Py-PEI}} \times 100\%$$

(1)

$$W_{CNT\ in\ Buckypaper} = \frac{RF_{Py-PEI@CNT} - RF_{Py-PEI}}{RF_{CNT} - RF_{Py-PEI}} \times 100\%$$

(2)

$$W_{epoxy\ in\ composite} = \left(\frac{RF_{Py-PEI@CNT} - RF_{Py-PEI@CNT@epoxy}}{RF_{Py-PEI@CNT}}\right) \times 100\%$$

(3)

$$W_{Py-PEI\ in\ composite} = \left(\frac{RF_{Py-PEI@CNT@epoxy}}{RF_{Py-PEI@CNT}} \times \frac{RF_{CNT} - RF_{Py-PEI@CNT}}{RF_{CNT} - RF_{Py-PEI}}\right) \times 100\% \quad (4)$$

$$W_{CNT\ in\ composite} = \left(\frac{RF_{Py-PEI@CNT@epoxy}}{RF_{Py-PEI@CNT}} \times \frac{RF_{Py-PEI@CNT} - RF_{Py-PEI}}{RF_{CNT} - RF_{Py-PEI}}\right) \times 100\% \quad (5)$$

Where:

$W_{Py-PEI in\ buckypaper}$: the wt% of Py-PEI in buckypaper;

$W_{CNT\ in\ Buckypaper}$: the wt% of CNT in buckypaper;

$W_{Py-PEI in\ composite}$: the wt% of Py-PEI in composite;

$W_{epoxy in\ composite}$: the wt% of epoxy matrix in composite;

$W_{CNT\ in\ composite}$: the wt% of CNT in composite;

RF_{CNT}: The residual fraction of p-BP film after heating to 600 ℃;

RF_{Py-PEI}: The residual fraction of Py-PEI after heating to 600 °C;

$RF_{Py-PEI@CNT}$: The residual fraction of Py-PEI@BP film after heating to 600 °C;

$RF_{Py-PEI@CNT@epoxy}$: The residual fraction of composite film after heating to 600 °C;

S2 SEM images of the composite films

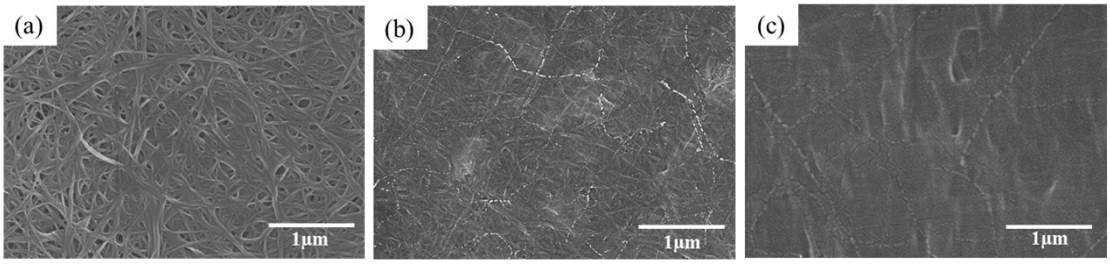

Fig. S2. SEM images of the surface morphology: the composite films infiltrated with EP concentration of (a) 5 wt%, (b) 8 wt% and (c) 10 wt%.

After infiltration with 5 wt% EP, there were still some pores on the film surface, and CNTs bundles were clearly visible, indicating insufficient resin to bind the CNTs; with the EP amount increasing to 8 wt%, the pores on the film surface disappeared and CNTs were almost invisible, indicating sufficient resin to bind the CNTs; further increasing to 10 wt%, the film surface was covered by a thick layer of resin, and CNTs bundles were completely invisible.

S3 DSC analysis of the cross-link reaction

Fig. S3 showed the DSC curve of Py-PEI/epoxy and curing agent/epoxy, 10°C/min heating rate. The curing process is 100°C/1h+140°C/4h。DSC curve demonstrated 100°C is pre-curing stage, curing agent (DDM+2E4MZ) and epoxy reacted to increase the molecular link. When temperature was raised to 140°C, both Py-PEI and curing agent reacted with epoxy, forming final cross-link structure including epoxy, curing agent and Py-PEI.

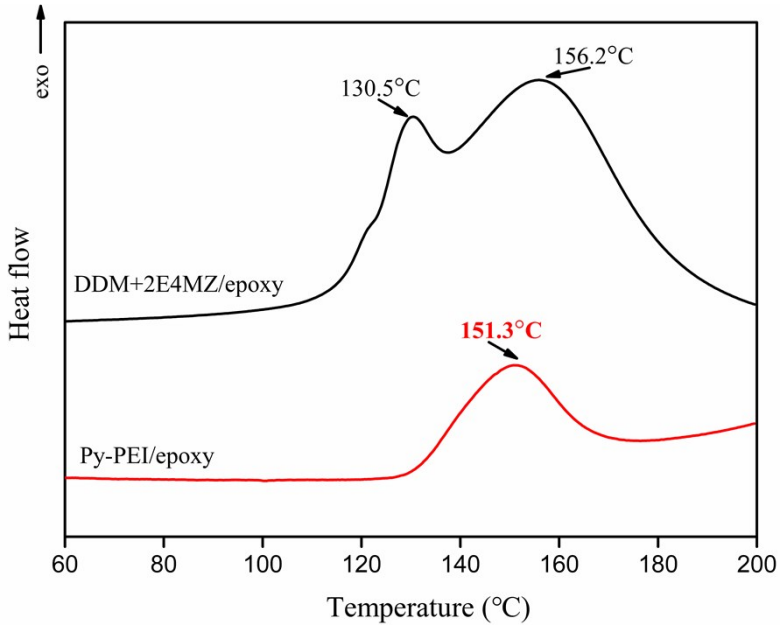

Fig. S3. The DSC curves of curing agent/epoxy and Py-PEI/epoxy