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Polydopamine-Coated Graphene as Multifunctional Nanofillers in Polyurethane

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Keywords: Graphene, dopamine, polyurethane, nanocomposite, interface

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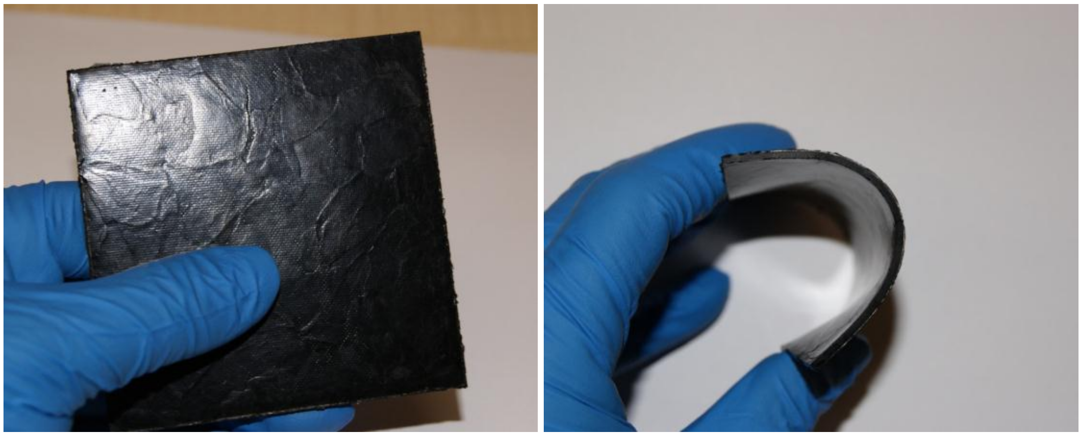

Figure S1. Digital photograph of a PU/D-Graphene nanocomposite film sample containing 0.94 vol.% D-Graphene sheets (100mm×100mm×2mm).

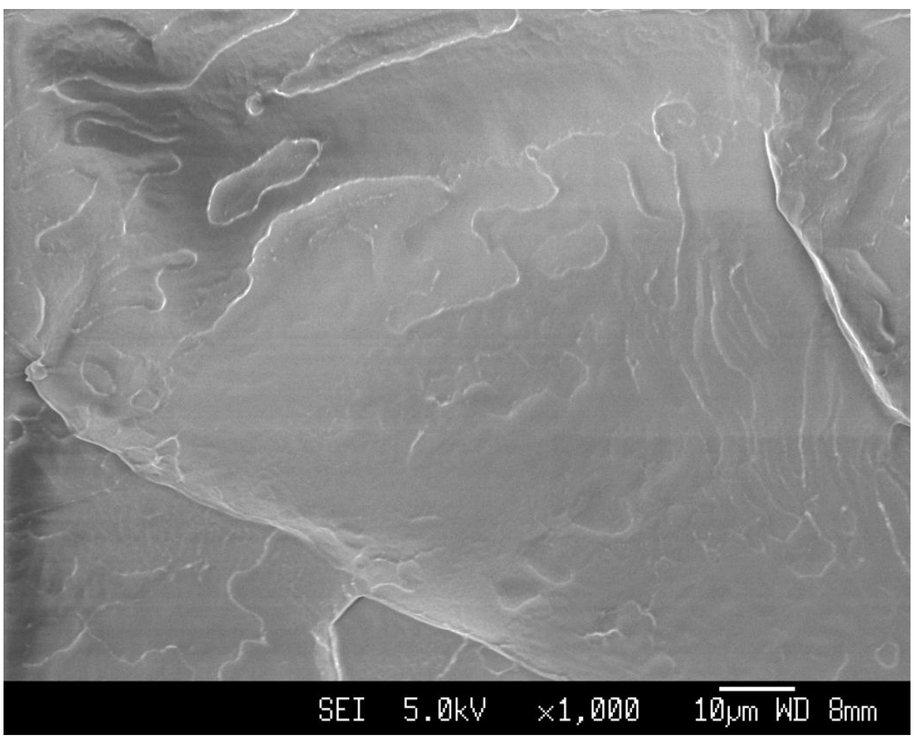

Figure S2. SEM images showing fractured surface of pure PU.

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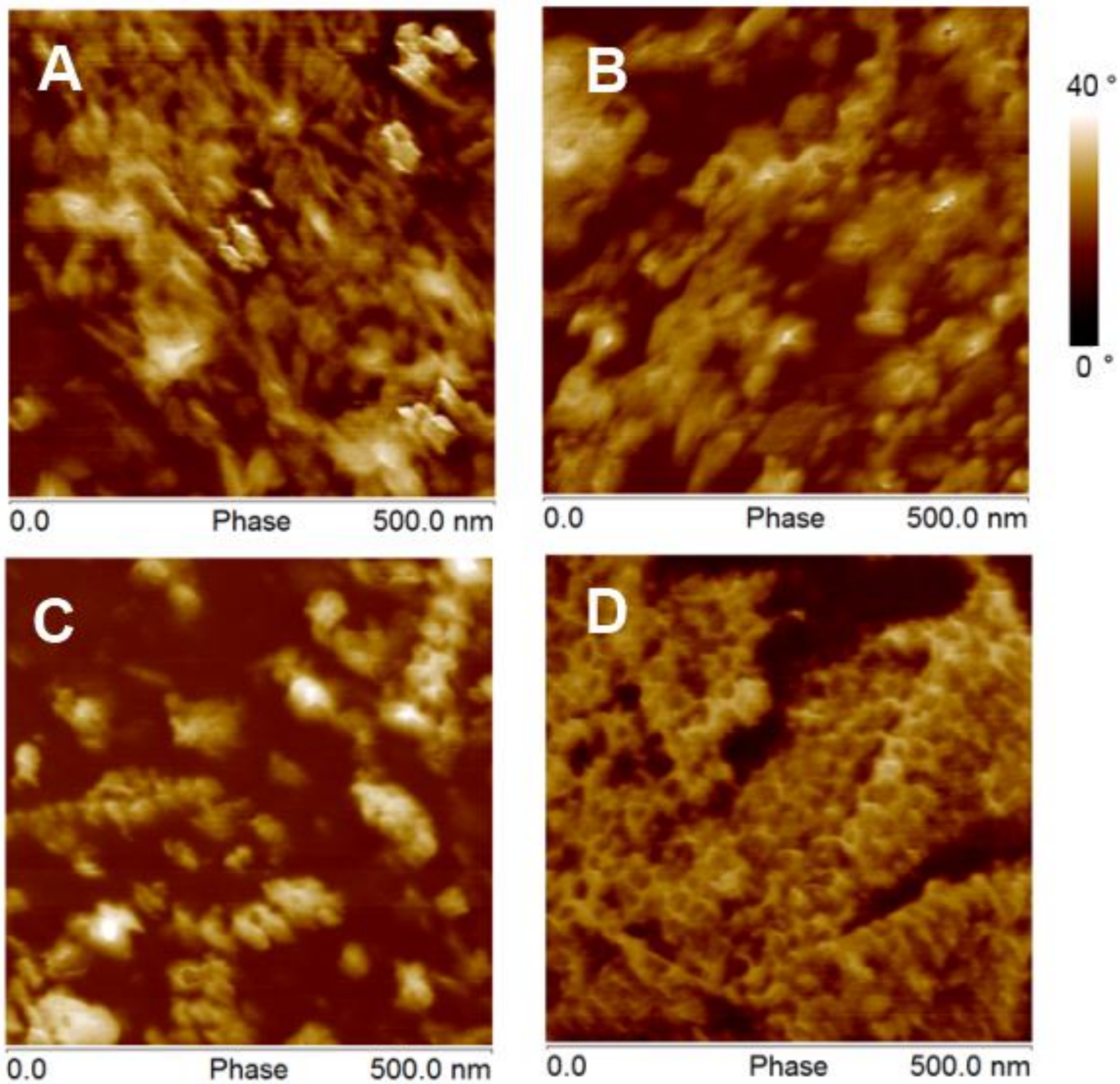

Figure S3. Tapping mode AFM phase images of (A) pure PU film, (B) PU/D-Graphene nanocomposite film with 0.24 vol. % D-Graphene and (C) PU/D-Graphene nanocomposite film with 0.47 vol. % D-graphene and (D) PU/D-Graphene nanocomposite film with 2.75 vol. % D-graphene. The hard-segment and soft-segment domains are represented by brighter and darker areas, respectively.

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The Halpin–Tsai model used for predicting the theoretical moduli values of filler-reinforced nanocomposites with unidirectional or randomly distributed fillers

The mechanical reinforcement of filler-reinforced polymer composites depends on the size, shape and orientation of the fillers and the load transfer efficiency between the filler and polymer.[1] To have a better comprehension of the effects of interfacial interactions and filler orientation on elastic moduli of the PU/D-Graphene nanocomposites, the Halpin–Tsai model used for predicting the moduli of filler-reinforced nanocomposites with unidirectional or randomly distributed fillers was adopted to estimate the moduli of the nanocomposites.[1]

For randomly oriented and 2D aligned graphene sheets in the polymer matrix, the nanocomposite modulus E_R or E_A are given by equation (1) and (2), respectively,

$$E_R/E_m=3/8*(1+\eta_L\zeta V_G)/(1-\eta_L V_G)+5/8*(1+2\eta_T V_G)/(1-\eta_T V_G) \quad (1)$$

$$E_A/E_m=(1+\eta_L\zeta V_G)/(1-\eta_L V_G) \quad (2)$$

in which η_L and η_T are described by the following equations, respectively,

$$\eta_L=(E_G/E_m-1)/(E_G/E_m+\zeta)$$

$$\eta_T=(E_G/E_m-1)/(E_G/E_m+2)$$

where E_R, E_A, E_G, E_m represent the Young's modulus of the nanocomposite with randomly distributed D-Graphene, the Young's modulus of the nanocomposite with 2D aligned D-Graphene parallel to the surface of the sample film, the Young's modulus of the D-Graphene, and the Young's modulus of polymer matrix, respectively. ζ is the aspect ratio of D-Graphene, and V_G is the volume fraction of graphene in the nanocomposites. The Young's modulus of the chemically reduced graphene sheet was previously measured as around 250 GPa,[2] the Young's modulus of pure PU was 9.10 MPa based on our experimental data. The density of the PU matrix

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is 1.1 g cm^3, and the density of graphene is 2.2 g cm^3.[3] The average size and thickness of D-graphene sheet are about 1.0 μm and 1.25 nm, respectively, as determined by AFM analysis in ref.[4] Young's modulus of the PU nanocomposites with different graphene dispersion and orientations are calculated by substituting these parameters into the equations.

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