Simultaneous catalyzing and reinforcing effects of imidazole-functionalized graphene in anhydride-cured epoxies†

Wanshuang Liu, Kwang Liang Koh, Jinlin Lu, Liping Yang, Silei Phua, Junhua Kong, Zhong Chen, Xuehong Lu*.

School of Materials Science and Engineering, Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798, Singapore.(Email: asxhlu@ntu.edu.sg)

(Electronic Supplementary Information)

Synthesis of graphene oxide (GO)

2.5 g Graphite and 2.5 g $NaNO_3$ were mixed with 120 ml sulfuric acid (95-97%) in a 500 mL flask. The mixture was stirred for 30 min in an ice bath and then 7.5 g of $KMnO_4$ was slowly added to the suspension under vigorous stirring. The ice bath was removed and the mixture was stirred at 35 $^{\circ}$C for 24 h. Afterwards, 150 ml of deionized (DI) H_2O was slowly added to the pasty mixture still under vigorous stirring. The reaction temperature was observed to rapidly increase to over 90 $^{\circ}$C with effervescence. After 30 min, another 500 ml DI water was added, and then 1.5 mL of 30% aq. H_2O_2. For preliminary purification, the mixture was first washed with 5% of hydrochloric acid (HCl), followed by DI water for five times to remove residual acid and salts. The yellow mixture is centrifuged 30 min at 11,000 rpm. The obtained GO was freeze-dried for 48 h and stored in ambient environment.

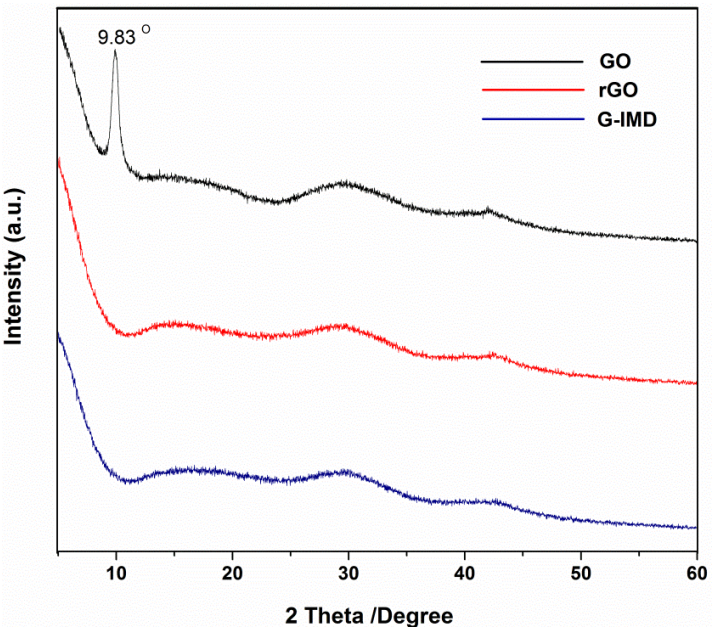

Fig. S1 WAXS of GO, rGO and G-IMD.

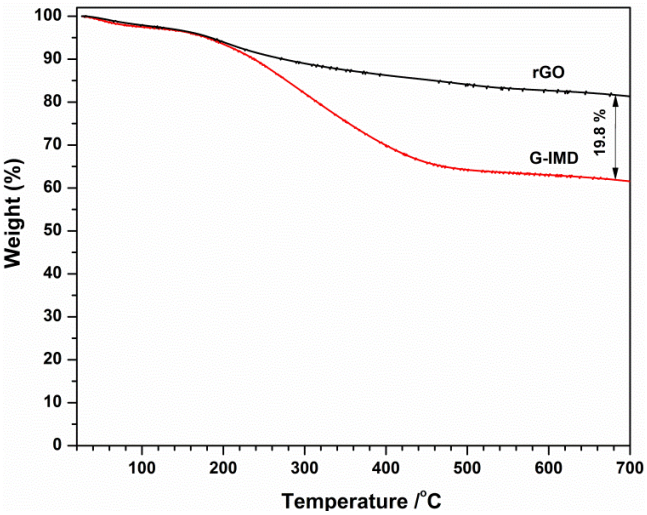

Fig. S2 TGA plots of rGO and G-IMD in a nitrogen atmosphere.

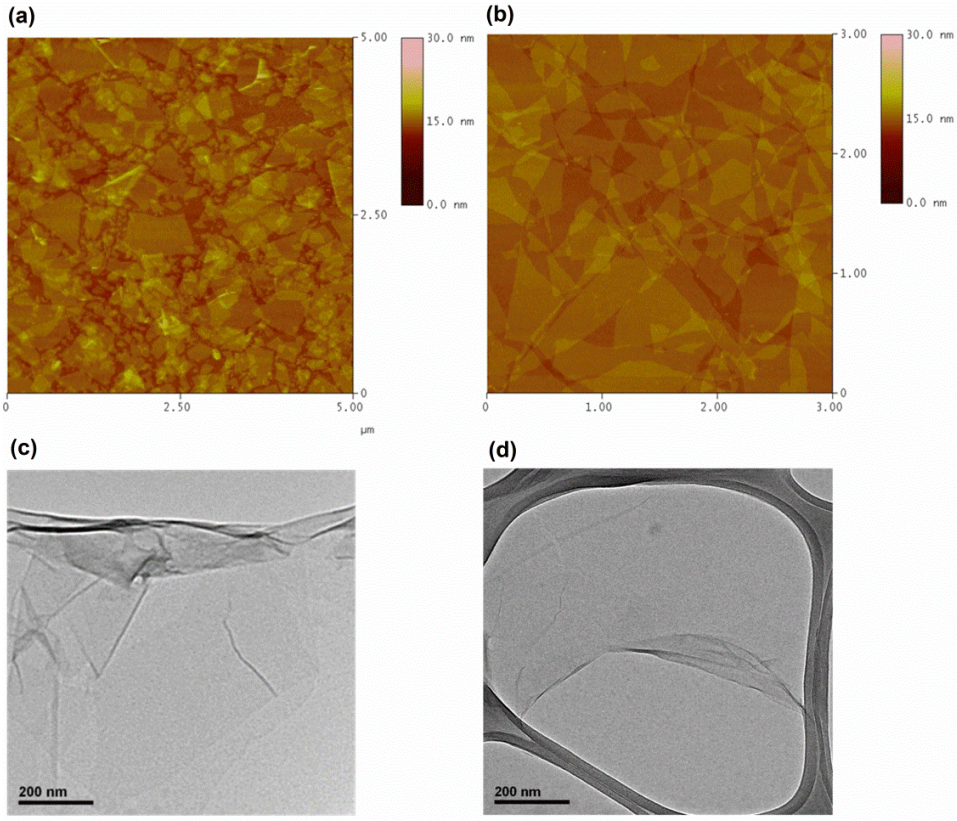

Fig. S3 AFM (a and b) and TEM (c and d) images of G-IMD

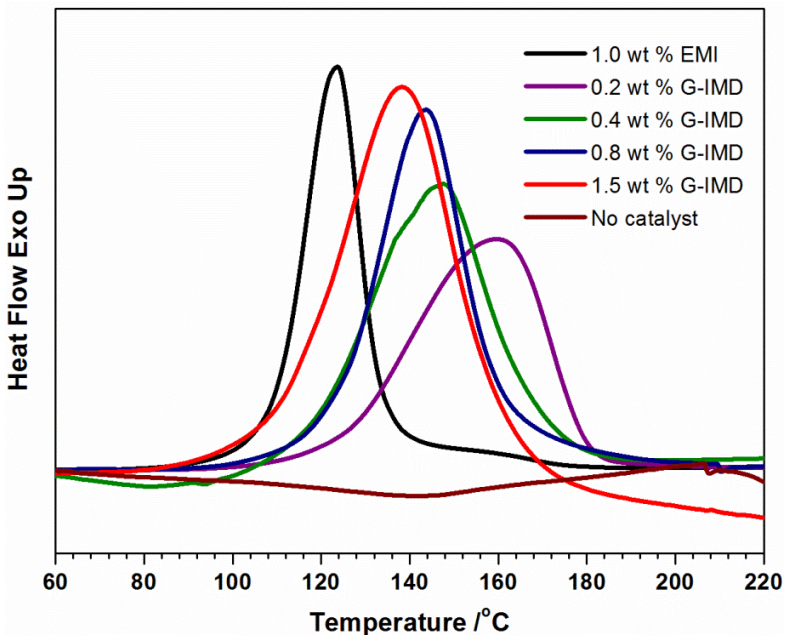

Fig. S4 DSC plots of curing reaction catalysed by EMI and G-IMD with different filler loading.

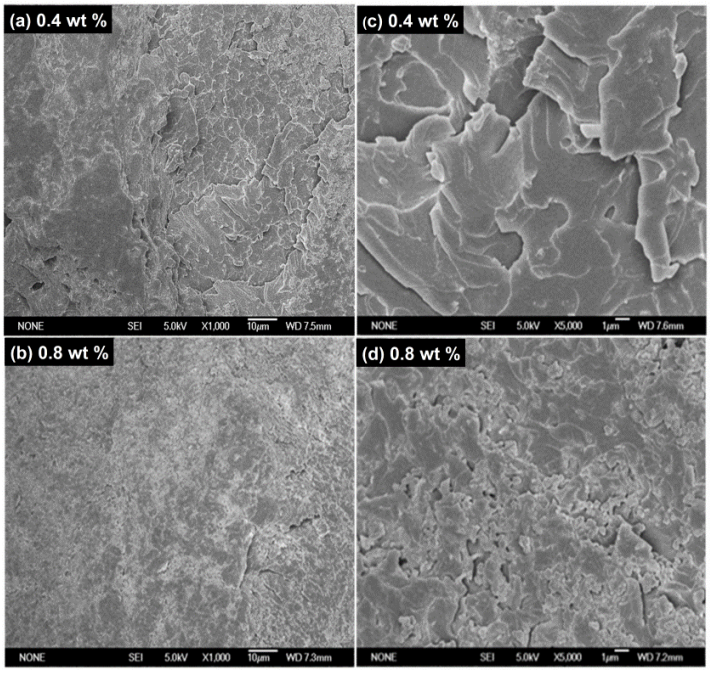

Fig. S5 SEM images from fracture surface of epoxy/G-IMD composites after tensile testing: under ×1000 magnification (a-b); under ×5000 magnification (c-d).

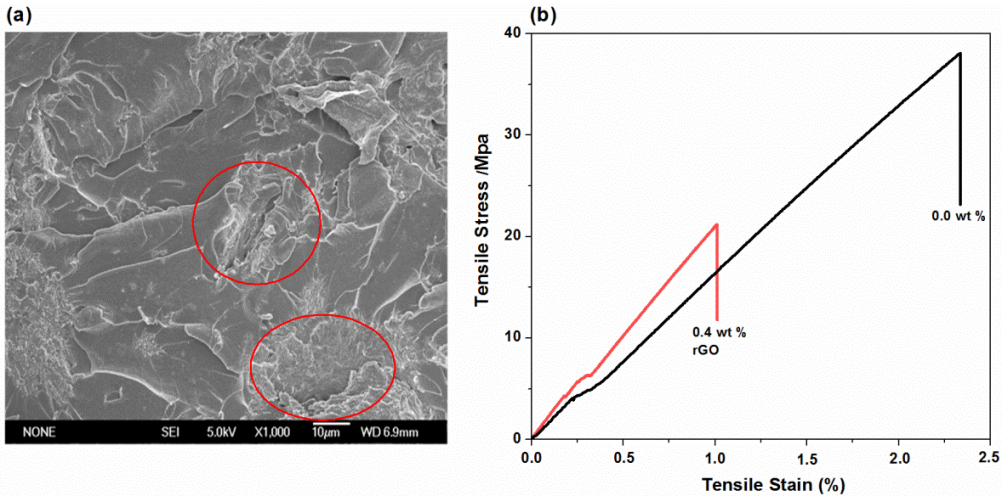

Fig. S6 SEM image from fracture surface of epoxy/rGO composites with 0.4 wt% filler loading after tensile testing: under ×1000 magnification (a); Representative stress-strain curves of neat epoxy and epoxy/rGO composites (b).

Table S1 Elemental analysis for G-IMD

Element Name	Nitrogen	Hydrogen	Carbon	Difference
Atomic Content (wt %)	10.92	4.08	48.48	36.52

Table S2 DSC data of the curing reaction with different accelerator content

Catalyst content	$T_{initial}$ /°C	T_{peak} /°C	T_{end} /°C
Pristine Epoxy[a]	110	123	132
0.2 wt % G-IMD	125	159	179
0.4 wt % G-IMD	116	147	169
0.8 wt % G-IMD	122	143	160
1.5 wt % G-IMD	108	138	156
No catalyst	---	---	---

[a] Using 1 wt % EMI as cure accelerator