Supporting Information

Electrically Conducting and Mechanically Strong Graphene-Polylactic Acid Composites for 3D Printing

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Table S1. Mechanical and electrical properties of GNP-PLA composite from various researches

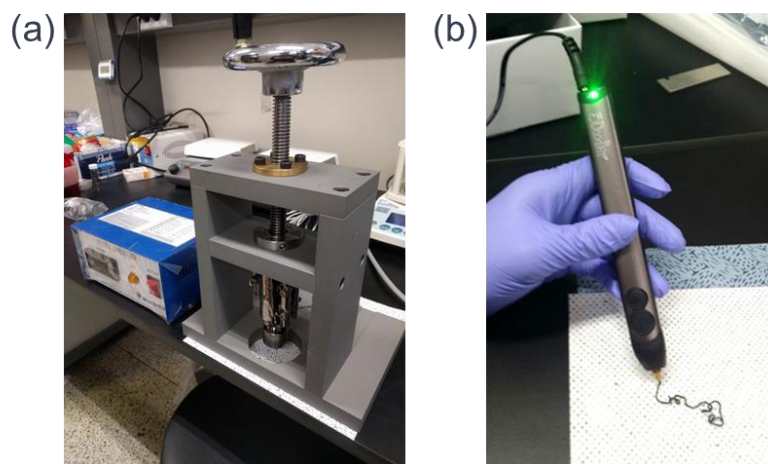| Filler[a]	Elastic modulus[b]	Tensile strength[b]	Elongation at break[b]	Percolation threshold	Electric Conductance	Methods	Ref.
GNP (2wt%)	-8%	44.1%	56.7%	1.49 vol%	1mS/cm (5 wt%)	Liquid exfoliated GNP Solution blending	This work
GNP (0.3wt%)	-50%	26.5%	60.6%	-	-	Commercial GNP Melt blending into PLA/EPO[c]	1
GNP (1wt%)	-	39.6%	-85%	-	-	Sonicating liquid exfoliation Solution blending	2
GNP	-	-	-	4.5 vol%	1S/cm (10 wt%)	Commercial GNP Solution blending	3
rGO	-	-	-	0.4 vol%	1S/cm (2 wt%)	Commercial GNP Solution blending	3
GNP (7wt%)	17.3%	14.1%	-33%	<7 wt%	0.1S/cm (7 wt%)	Commercial GNP Melt blending	4
GNP (7wt%)	50.1%	8.1%	-75.9%	<7 wt%	50uS/cm (7 wt%)	Commercial GNP Melt blending	4
GNP (1wt%)	23.3%	12.9%	-16%	4 wt%	0.1uS/cm (7 wt%)	Rapid thermal expansion of acid treated GNP Melt blending	5
GNP (1wt%)	6.7%	0%	-8%	13 wt%	0.1uS/cm (15wt%)	Commercial GNP Melt blending	5
GNP (10wt%)	34%	29%	-11.5%	-	40mS/cm (10wt%)	Commercial composite	6

Figure S1. (a) Home-built extruder for constructing a GNP-PLA composite filament. The cylinder of the extruder was heated at 120 °C to slightly melt down the composite. The viscous composite was extruded through a nozzle with a diameter of 0.7 mm, followed by air cooling. (b) 3D printing pen used for this work (3Doodler Create+).
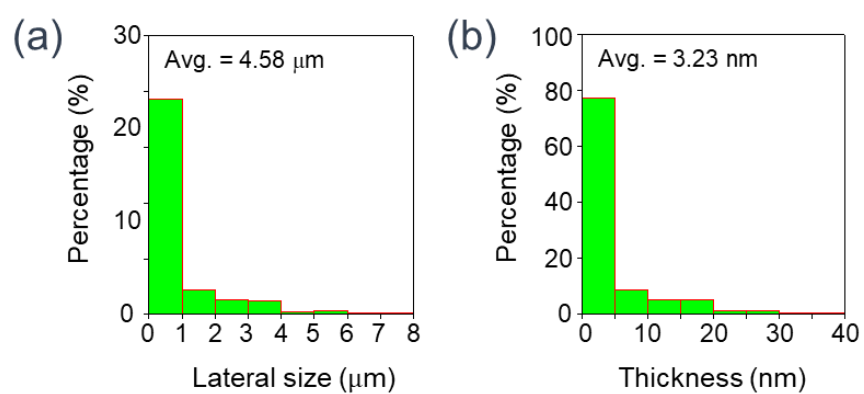
Figure S2. (a) Lateral size and (b) thickness distributions of the GNPs measured by AFM.
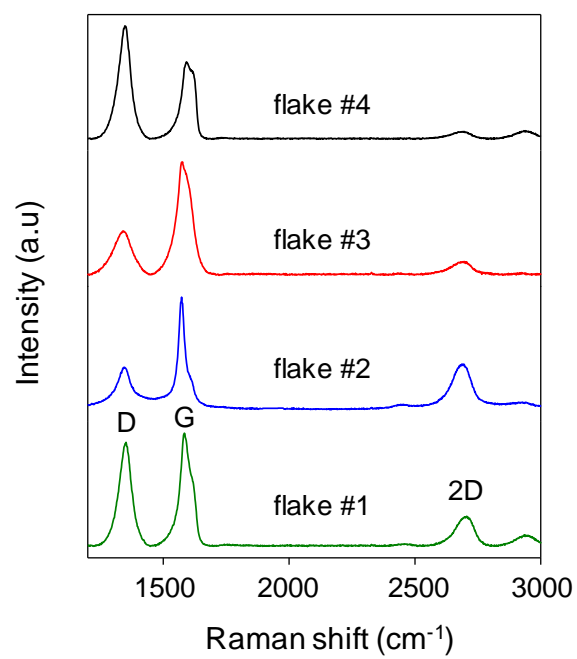
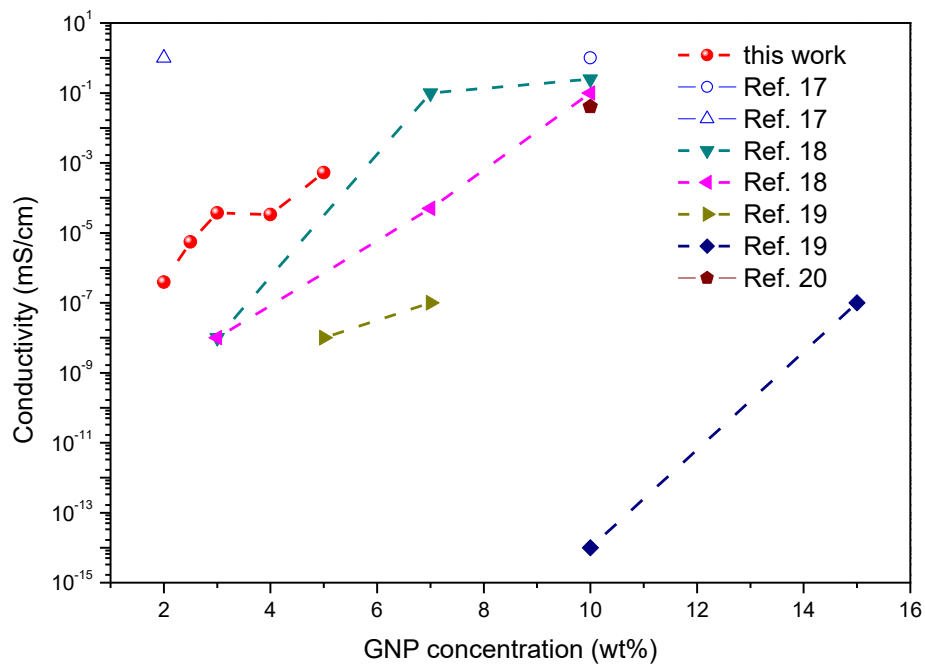**Figure S3.** Raman spectra obtained from different graphene flakes.

Figure S4. Electrical properties of GNP-PLA composite over GNP concentration, from various

researches. Blank symbols are results without mechanical strength data.

(1) Chieng, B. W.; Ibrahim, N. A.; Yunus, W. M.; Hussein, M. Z.; Giita Silverajah, V. S. Graphene nanoplatelets as novel reinforcement filler in poly(lactic acid)/epoxidized palm oil green nanocomposites: mechanical properties. *Int J Mol Sci* **2012,** *13*, 10920-10934.

(2) Li, X.; Xiao, Y.; Bergeret, A.; Longerey, M.; Che, J. Preparation of polylactide/graphene composites from liquid-phase exfoliated graphite sheets. *Polymer Composites* **2014,** *35*, 396-403.

(3) Sabzi, M.; Jiang, L.; Liu, F.; Ghasemi, I.; Atai, M. Graphene nanoplatelets as poly(lactic acid) modifier: linear rheological behavior and electrical conductivity. *Journal of Materials Chemistry A* **2013,** *1*, 8253-8261.

(4) Gao, Y.; Picot, O. T.; Bilotti, E.; Peijs, T. Influence of filler size on the properties of poly(lactic acid) (PLA)/graphene nanoplatelet (GNP) nanocomposites. *European Polymer Journal* **2017,** *86*, 117-131.

(5) Kim, I.-H.; Jeong, Y. G. Polylactide/exfoliated graphite nanocomposites with enhanced thermal stability, mechanical modulus, and electrical conductivity. *Journal of Polymer Science Part B: Polymer Physics* **2010,** *48*, 850-858.

(6) Prashantha, K.; Roger, F. Multifunctional properties of 3D printed poly(lactic acid)/graphene nanocomposites by fused deposition modeling. *Journal of Macromolecular Science, Part A* **2016,** *54*, 24-29.