

# Screening of solvents for 2D materials exfoliation

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The selection of appropriate solvents for the exfoliation of 2D materials from their bulk form mostly rests on semi-empirical correlations with surface energy terms [1],[2]. Herein, we present a method based on nanoindentation for the rapid screening and selection of solvents for the exfoliation of graphene and other 2D materials through measuring the first recorded pop-in on loading. The analysis of the load-displacement curves of nanoindentation on highly oriented polycrystalline graphite (HOPG) immersed in solvents show that the minimum average first pop-in depends on solvent composition. Figure 1a shows that with the solvent NMP (a standard exfoliation solvent) the mean stress for first pop-in is  $4.58 \pm 0.81$  mN. Further investigation using solvent mixtures of isopropyl alcohol/water and ethanol/water at different ratios mix with water showed a minimum in the pop-in load occurring at or close to the solvent composition that showed the most effective exfoliation following ultrasonic bath sonication (figure 1-b). A similar correlation is seen between nanoindentation of MoS<sub>2</sub> in IPA/water mixture with the optimum composition at 40% IPA (figure 1-c).

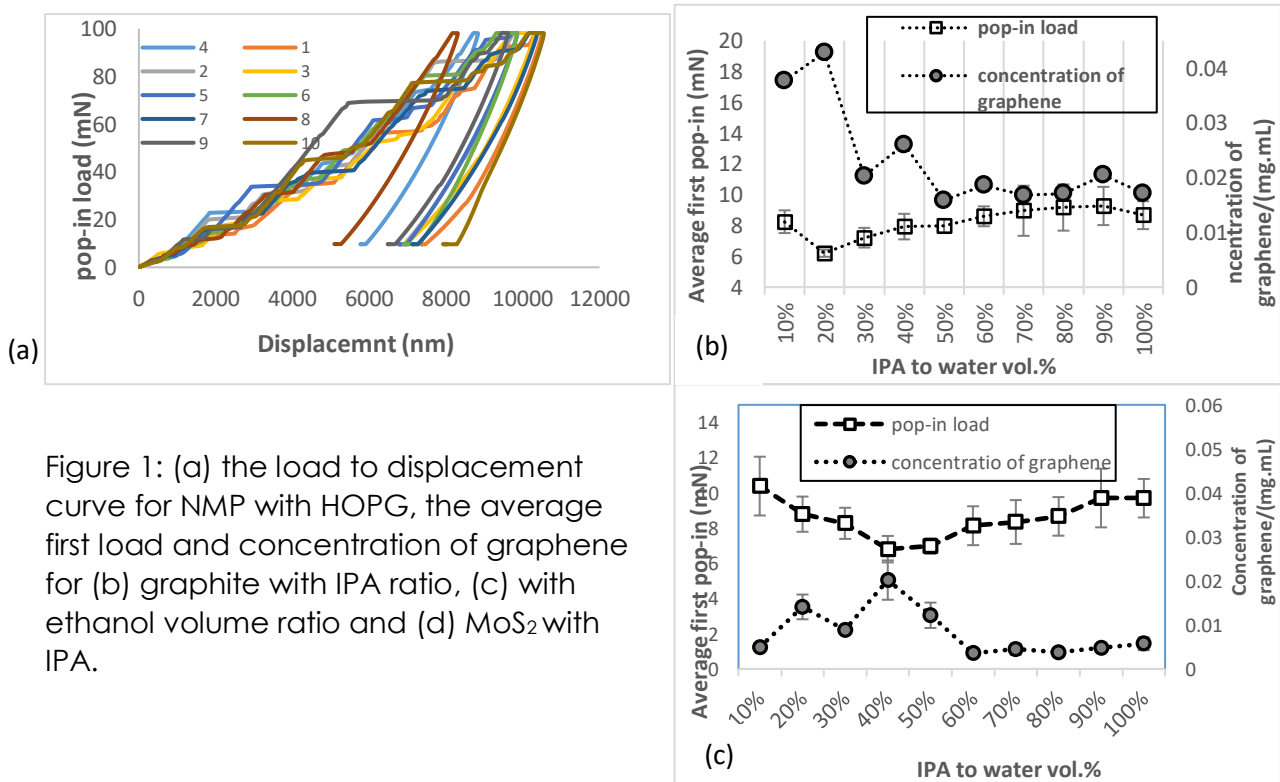


Figure 1: (a) the load to displacement curve for NMP with HOPG, the average first load and concentration of graphene for (b) graphite with IPA ratio, (c) with ethanol volume ratio and (d) MoS<sub>2</sub> with IPA.

- [1] J. N. Coleman, "Liquid-Phase Exfoliation of Nanotubes and Graphene," *Adv. Funct. Mater.*, vol. 19, no. 23, pp. 3680–3695, Dec. 2009.
- [2] J. Shen et al., "Liquid Phase Exfoliation of Two-Dimensional Materials by Directly Probing and Matching Surface Tension Components," *Nano Lett.*, vol. 15, no. 8, pp.