Liquid-phase exfoliation of flake graphite by high-shear mixing and fabrication of electrically conductive few-layer graphene films

Sara Lund
Jussi Kauppila, Saara Sirkiä, Jenny Palosaari, Olav Eklund, Rose-Marie Latonen, Jan-Henrik Smått, Jouko Peltonen, Tom Lindfors
Åbo Akademi University, Laboratory of Molecular Science and Engineering, Porthansgatan 3-5, 20500, Turku (Åbo), Finland
sara.h.lund@abo.fi

Graphene in solution-processable form can be converted to printable inks, coatings and composites to be applied for e.g. energy storage, bio-applications and transparent conductive layers [1]. Graphene can be solution-processed by liquid-phase exfoliation (LPE) of graphite. Among the different LPE methods, high-shear exfoliation has shown potential as a scalable and cost effective method for producing defect-free few-layer graphene [2]. However, the LPE methods have some drawbacks such as low concentrations and solvent or surfactant residuals on the surface of the exfoliated sheets, which decrease the applicability of the produced material. Here, we report an optimized process for producing few-layer graphene dispersions with a high concentration and films with high conductivity. We have shear exfoliated graphite in an aqueous surfactant solution and we have studied several aspects of the whole exfoliation process such as surfactant concentration, temperature during exfoliation as well as the effect of the graphite flake size on the concentration and quality of the exfoliated sheets. We show that concentrations as high as 3 mg/ml can be prepared just after 2 h of mixing by regulating the temperature during exfoliation and choosing the right surfactant concentration regime. Additionally, we have dialyzed the graphene dispersions prior to film fabrication to remove extra surfactant from the dispersions. We show that dialysis improves the conductivity of the films as we have reached electrical conductivities as high as 17 000 S/m without any heat treatment.

References

[1] Novoselov K. S., V. I. Fal'ko, L. Colombo *et al*., Nature, 490 (2012) 192-200
[2] Paton K. R., E. Varrla, C. Backes *et al*., Nat Mater. 13 (2014) 624-630

Figures

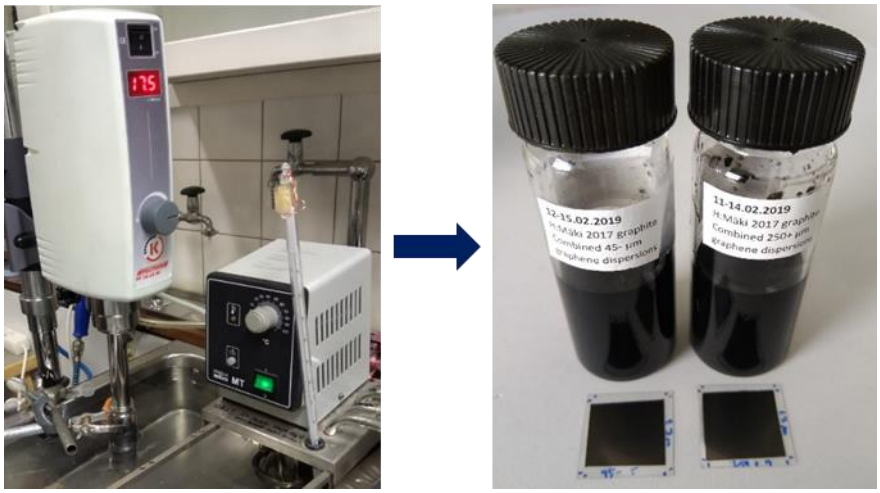

Figure 1: The exfoliation set-up with the high-shear mixer (Polytron PT 10-35 GT) and bath circulator (MGW Lauda MT) and the resulting graphene dispersions and the spray-coated films.