Microscopic, Optical, and Electrical Characterization of Graphene Films Fabricated from Graphene Dispersions

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Processing graphene into stable dispersions and uniform thin films is essential for its integration into printed electronics, conductive coatings, and flexible optoelectronic applications [1]. This study investigates the dispersions and coating performance of spray-coated graphene films on sapphire substrates using various characterization techniques. Graphene dispersions were prepared from graphene powder synthesized via gas-phase processing in a microwave plasma reactor [2]. The powder was dispersed in different solvents, including ethanol, N-(2-hydroxyethyl)-2-pyrrolidone (HEP), and also water with additives such as carboxymethyl cellulose (CMC) and (di-n-dodecyl) dimethylammonium bromide (DDDA), using probe sonication. The dispersions were spray coated in multiple passes onto the sapphire substrates, and their coating morphology were evaluated using scanning electron microscopy (SEM). Raman spectroscopy and electrical measurements were employed to assess the structural integrity and functional properties of the graphene sheets. Figure 1(a) and Figure 1(b) indicate that films fabricated from graphene sheets dispersed in water with CMC exhibit a more uniform surface morphology compared to those obtained from ethanol dispersions. Raman spectroscopy analysis confirmed the structural integrity of the graphene films, exhibiting an intensity ratio of ~1.5 between the 2D and the G peak (I_{2D}/I_G). Electrical characterization using Hall effect measurements in van der Pauw geometry revealed a high carrier density (~10^{14} cm^{-2}) and moderate mobility (~9 cm^2/Vs). The charge carrier mobility of graphene films fabricated from CMC and DDDA in water is shown in Figure 1(c), highlighting their efficient charge transport properties suitable for flexible electronic applications. These results emphasize the potential of gas-phase synthesized graphene for scalable, dispersion-processed thin-film applications.

References

[1] Tuan Sang Tran et al., Advances in Colloid and Interface Science, Volume 261, 2018.
[2] Adrian Münzer et al., Electrochimica Acta, Volume 272, 2018.

Figures

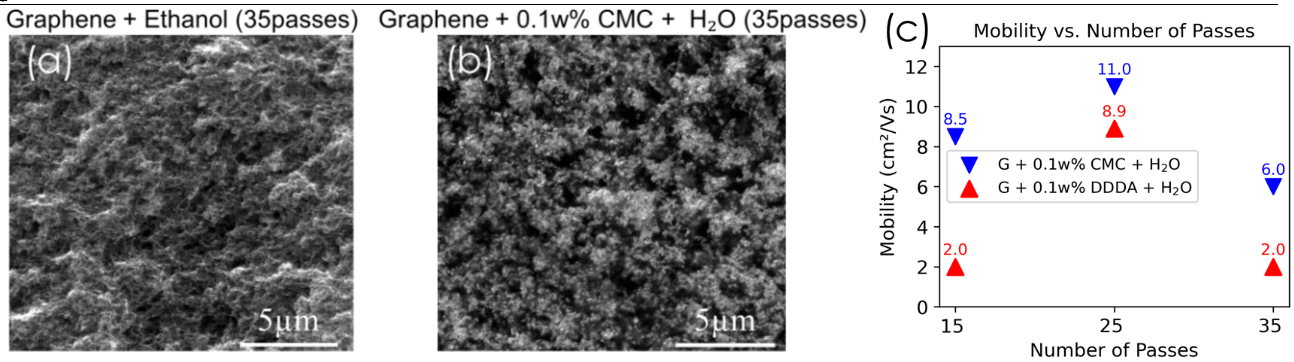

Figure 1: (a) SEM image of graphene sheets dispersed in ethanol after 35 passes of spray coating, (b) SEM image of graphene sheets dispersed in water with CMC after 35 passes of spray coating, and (c) Charge carrier mobility of graphene films fabricated from CMC and DDDA dispersed in water after 15, 25, and 35 passes.