Efficient Liquid-Phase Exfoliation of Pristine Graphene for Ink Formulation: Ultrasonication vs High Shear Mixing

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The growing demand for printed electronics has increased the necessity for functional inks. The properties of graphene, such as high conductivity, high surface area, acceptable adhesion based on 2D morphology, along with its abundant natural sourcing, position it as an excellent choice for ink formulation. This facilitates the utilization of pristine graphene in a wide array of applications and devices, including transparent conductive films, sensors, and various electronic components on a wide range of substrates. Nevertheless, challenges persist, particularly in achieving high yields in the production processes of graphene and in ensuring stable, high-concentration graphene dispersions. One of the most effective methods for graphene exfoliation to obtain a reasonable amount of graphene at the end of the process is Liquid Phase Exfoliation (LPE) [1]. Given its remarkable scalability, the entire LPE process takes place in a liquid medium, providing an added advantage for subsequent processes such as solution-based procedures, including printing and coating methods [2].
In this study, we conducted a comprehensive comparative analysis to elucidate the distinct effects of Ultrasonication (US) and High Shear Mixing (HSM) on the efficiency of graphene exfoliation [3,4]. The results indicate that US surpasses HSM in terms of yield. However, we delved deeper to investigate potential synergies arising from combining these two methods due to differences in their exfoliation mechanisms. The findings revealed two particularly promising strategies. Firstly, employing HSM followed by US treatment proved remarkably effective, resulting in a substantial increase in yield (approximately 30%). Secondly, the alternating use of US and HSM, especially with the final step using US treatment, consistently demonstrated significantly enhanced yields compared to using either US or HSM in isolation. This work also underscored the crucial role of dispersion mixing in influencing aggregation. This phenomenon appears to diminish yield in processes where HSM predominantly operates in the final stages of exfoliation. Understanding these distinctions between US and HSM, along with the synergies harnessed by their strategic integration, represents a significant advancement in optimizing graphene production for a wide range of applications.

References

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