From lyophobic to lyophilic and back to lyophobic again: Towards Greener Dispersions of Carbon Materials

João Paulo Vita Damasceno[1,2], Mario Caironi[2], Lauro T. Kubota[1]
[1]Institute of Chemistry, University of Campinas (UNICAMP), Campinas (13083-970), Brazil
[2]Center for Nano Science and Technology @PoliMi, Istituto Italiano di Tecnologia, Milano (20134), Italy
joaopvd@unicamp.br

Fundamental concepts of colloidal science will be presented as well as their application to overcome some issues common in carbon-based dispersions, like low colloidal stability of pristine materials in some solvents and low mass concentration of many systems [1]. First, the van der Waals (vdW) interactions between the nanostructures of carbon materials will be discussed, followed by strategies to decrease or opposing these interactions, which are the bases of many dispersion and exfoliation procedures, such as (i) increasing the electrostatic repulsion between dispersed particles, (ii) surface functionalization, or (iii) the use of passivating agents. These concepts were applied to model two carbon-based dispersions, one composed by fullerenol nanoaggregates [2] and other by graphite particles exfoliated in water [3]. In the case of the fullerenol dispersion, fine tuning of colloidal interactions was done by performing controlled surface modification of the fullerene, which decreases the strength of the vdW interactions and increases the lyophilic character in polar solvents. The modified material forms concentrated dispersions that are indefinitely stable, but preserving appreciable electrical conductivity due to the low number of functional groups on the surface [2]. For graphite dispersion, the pristine solid was treated with concentrated ammonium hydroxide, which provides electrons and raises the Fermi level of the carbon material. The treated solid was washed to remove ammonium hydroxide and exfoliated in water, resulting in an aqueous dispersion without surface modification or passivating agents. The raising of the Fermi level produces a negative zeta potential, which in turn generates an electrostatic repulsion between graphite particles. Since exfoliation contributes to break solid particles into smaller ones, the electrostatic interaction can balance the lower vdW attraction of smaller particles and it provides metastability for this lyophobic dispersion without the need of additives or passivating agents [3].

References

[1] J. P. V. Damasceno, L. T. Kubota; Materials Today Chemistry, 21 (2021) 100526.
[2] J. P. V. Damasceno, L. T. Kubota; Carbon Trends, 9 (2022) 100226.
[3] J. P. V. Damasceno, L. T. Kubota; Angewandte Chemie, 61 (2022) e202214995.