Ionic and non-ionic surfactants for the production of highly concentrated aqueous dispersions of pristine graphene

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Graphene dispersions are usually prepared through conversion of graphite to graphite oxide, subsequent exfoliation of the latter in aqueous or organic medium to yield graphene oxide sheets, and finally chemical reduction of the exfoliated dispersion [1-3]. Such procedure boasts the merit of affording single-layer sheets in very large quantities and has proved suitable toward some specific applications [4]. Still, the resulting graphenes bear a substantial amount of structural defects and residual oxygen inherited from the oxidation step [5]. This constitutes a serious drawback, as many of the unique properties of graphene are severely degraded by the presence of disorder. With a view to attaining dispersions of defect-free graphene, some recent research has concentrated on the liquid-phase exfoliation of more pristine forms of graphite, rather than graphite oxide [6, 7]. In particular, aqueous dispersions of relatively defect-free graphene stabilized by some ionic surfactants have been demonstrated [6]. However, the reported concentrations were typically on the order of 0.01 mg mL^{-1}, which are too low for many practical uses. Likewise, the availability of aqueous dispersions of high-quality graphene with surfactants of different types (e.g., non-ionic) could facilitate its use in a wider range of applications. To the best of our knowledge, these issues have not yet been addressed.

In this communication, we present the preparation of aqueous dispersions of high-quality graphene in a wide range of surfactants [8]. We compare the performance of non-ionic and ionic surfactants toward the ultrasound-assisted dispersion/exfoliation of pristine graphite in water. We find the former to be generally superior to the latter as regards the amount of exfoliated material that can be stably suspended. Concentrations of high-quality, single- and few-layer graphene as high as ~1 mg mL^{-1} can be attained with some specific surfactants (Figure 1). The potential utility of these highly concentrated dispersions is demonstrated by processing them into different materials, such as free-standing paper-like films and hydrogels (Figure 2).

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Figures

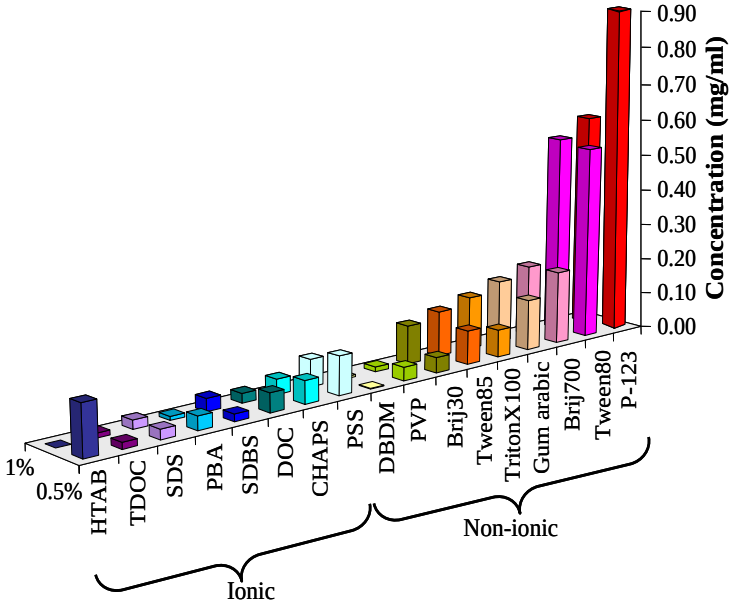

Figure 1. *Graphene concentration in aqueous dispersions achieved by using different surfactants, as estimated from UV–vis absorption measurements. Two surfactant concentrations are shown: 0.5% and 1.0% wt./vol.*

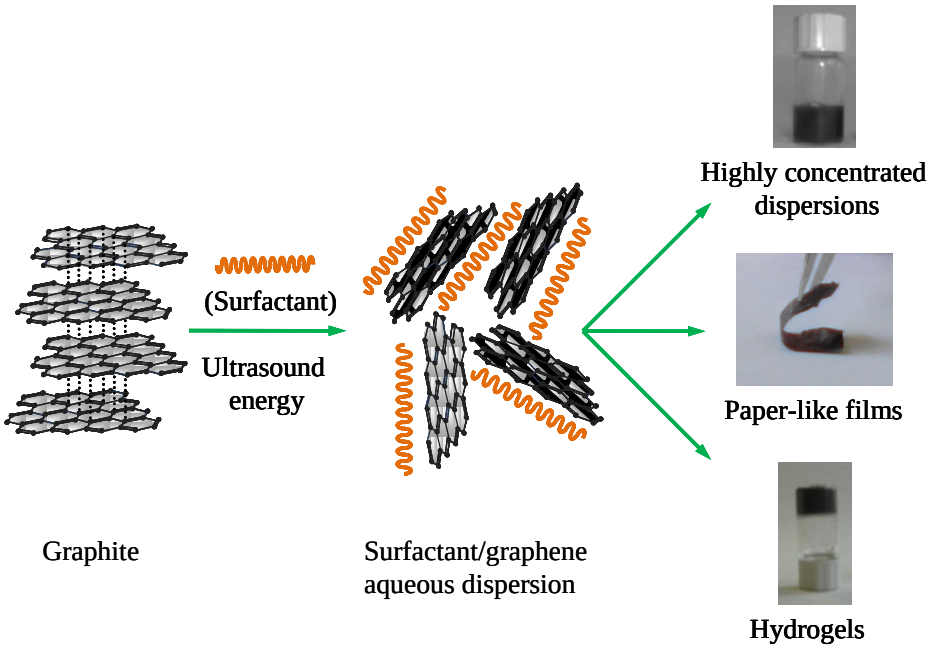

Figure 2. *Scheme for the production of aqueous dispersions of pristine grapheme, paper-like films and hydrogels.*