

# Functional Boron Nitride Nanomaterials

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## Abstract

Oil spillage, organic solvents and dyes discharged from e.g. textile, paper, and tannery industries are primary pollutants of water sources.<sup>1</sup> Sorption is an efficient way to clean-up water but common absorbents, including activated carbon, zeolites, and natural fibers, suffer from low separation selectivity and low absorption capacity. A number of advanced materials has been processed and suggested to overcome these principal drawbacks, but they still show poor regeneration and cycling ability.

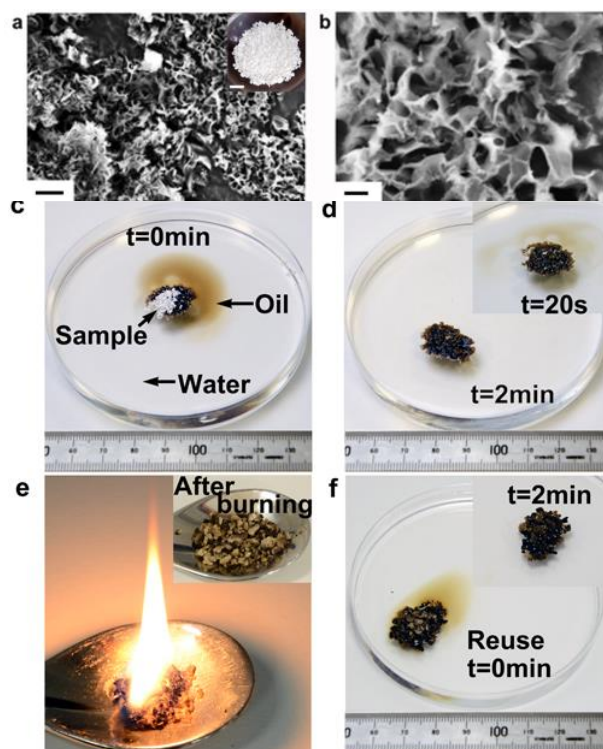
Two-dimensional (2D) boron nitride (BN) nanosheets, also called “non-carbon graphene”, consist of a few layers of alternating boron and nitrogen atoms in a hexagonal arrangement. The polarity of BN bonds and the high surface area of h-BN-related nanostructures provide good adsorption properties of various substances ranging from organic pollutants to hydrogen. Nanostructured h-BN is therefore an ideal candidate as absorbent material. Here we report that porous boron nitride nanosheets with very high specific surface area ( $1427 \text{ m}^2 \text{ g}^{-1}$ ) exhibit excellent sorption performances for a wide range of oils, solvents and dyes (Figure 1).<sup>2-4</sup>

In addition, recently, significant efforts have been focused on the isolation and functionalization of BN nanosheets to achieve better dispersion, which would enable applications in optical devices, biological systems and composites. However, the concentration of the h-BN dispersions was typically below  $2 \text{ mg mL}^{-1}$ , even after long periods of intense ultrasonication. The low concentration may present an especially severe limitation for the aqueous suspensions preferred in many applications. Therefore, the development of a practical high-yield process to achieve highly water-soluble BN nanomaterials remains a challenge. Graphene oxide and graphene, in the form of aerogels and membranes, have been used as efficient adsorbents for the separation of organic pollutants and oils from water, for gas separation, and for molecular and ion selective devices. There is potential for h-BN, which is more oxidation- and intercalation-resistant than  $\text{sp}^2$  carbon, to be used to produce similar structures. However, it is very difficult to achieve aqueous dispersion of h-BN using conventional routes. Here, we present a simple and efficient one-step method for the preparation and functionalization of few-layer BN by solid state ball milling of commercially available h-BN and urea powder (Figure 2).<sup>5</sup> The colloidal solutions of multi-layer h-BN can have unprecedentedly high concentrations, up to  $30 \text{ mg/mL}$ , and are stable for up to several months. They can be used to produce ultralight aerogels with a density of  $1.4 \text{ mg/cm}^3$ , which is  $\sim 1500$  times less than bulk h-BN, and freestanding membranes simply by cryodrying and filtration, respectively. The material shows strong blue light emission under UV excitation, in both dispersed and dry state.

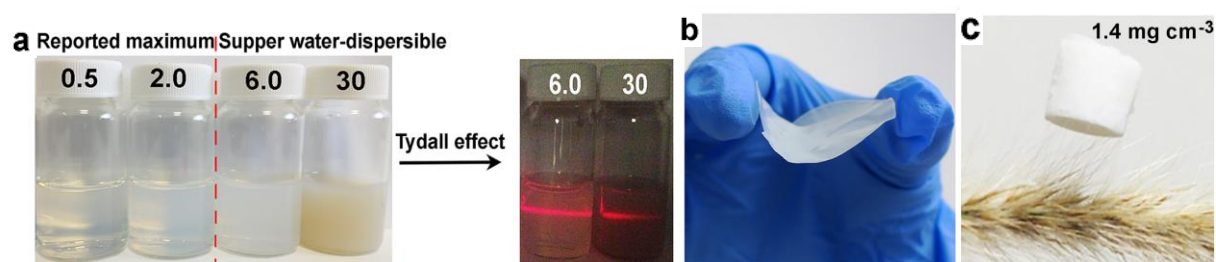
## References

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## Figures



**Figure 1** (a) Low-magnification SEM image of the porous BN nanosheets. Scale bar, 2  $\mu\text{m}$ . The inset shows the typical white powder obtained after synthesis. Scale bar, 1 cm. (b) High-magnification SEM image revealing the porous nanosheet structure. Scale bar, 200 nm. (c) Photograph of the set-up for oil absorption tests with white porous BN nanosheets. (d) Photograph of porous BN nanosheets saturated with oil after 2 min of absorption, inset showing the absorption process after 20 s. (e) photograph of burning oil-saturated porous BN nanosheets in air for cleaning purpose, inset showing the color change after burning. (f) Photograph of the cleaned nanosheets for second oil absorption test, inset showing the absorption result after 2 min.



**Figure 2** (a) Photos of as-prepared colloidal solutions of few-layer BN with concentrations of 0.5, 2.0, 6.0 and 30  $\text{mg mL}^{-1}$ , respectively, and demonstration of the Tyndall effect. (b) Photo of the freestanding BN membrane. (c) Photo of an aerogel with a low density ( $1.4 \text{ mg cm}^{-3}$ ) placed on the spike of a plant.