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## Graphene nanosheets solvents

Scientific and technological research in electronics, life sciences, energy and the environment faces challenges in the performance, functionality and sustainability of key materials [1]. Advanced materials play a significant role in overcoming major challenges and achieving breakthrough solutions for technological and practical applications. These materials include carbon-based nanomaterials such as soot, carbon nanotubes (CNT), carbon nanofibres and graphene. These advanced carbon nanomaterials are widely used in various important applications such as energy harvesting and storage, detection, catalysis, transistors and plaster protection [2-11]. Pollution caused by oil, petroleum products and toxic organic solvents poses a major threat to the ecosystem and the marine economy. Porous adsorbents are used to solve leaks in organic oils and solvents. Natural porous adsorbents such as wool, sawdust, consistency and zeolites are traditionally used to clean leaks due to their availability [12-14]. However, these conventional materials have a low oil adsorbing capacity (less than 10× own weight) and characteristic high water adsorption, making it difficult to extract and recycle these adsorbents. Hydrophobic and microporous polymers are formable. Furthermore, these materials can adsorb from 5× to 25× their own weight in both oils and organic solvents, of which up to 80% can be extracted by extrusion [15, 16]. Extended graphite is an important alternative to cheap oil removal. This material has demonstrated a high adsorption efficiency of up to 83× its own weight, and up to 70% of adsorbates can be taken by vacuum filtration [17]. However, solid particles do not show high adsorption of organic solvents, while the powder form is difficult to use and the material can only be recycled several times (only 17% of the capacity remains after five cycles) [18, 19]. The development of new materials that can effectively and reversibly remove organic solvents and oil spill contaminants is crucial for future oil spill treatment and water reclamation required for environmental protection. Three-dimensional (3D) spongy graphene with a high surface area, uniform structure, chemical stability of organic solvents, the ability to maintain structural completeness at high temperatures and highly hydrophobic and oleophilic surfaces are feasible candidates for adsorbents. Graphene sponges have shown significant improvements in the loading capacity of organic oils and liquids, as well as the possibility of reuse, compared to existing adsorbents. We have previously studied the use of spongy graphene as a highly efficient adsorbent for oil and organic toxic for the first time [20]. Graphene adsorbed to 86× own weight. We have also increased the ability to spongy graphene by one size [21] and we developed cheap carbon fibre-based adsorbents made of cotton [22] and recycled paper [23]. In addition, together with graphene, different types of nanomaterial carbon adsorbents were widely for the removal of organic impurities and heavy metal ions [24-28]. This area of field research has shown great development. Figure 1A shows a short timeline of these adsorbents. The adsorption capacity of different 3D graphene and carbon-based materials was compared and the results are shown in Figure 1B. Figure 1:Download figure Figure Download as PowerPoint slide(A) A short timeline in the development of graphene and carbon-based materials as adsorbents. (B) Comparison of adsorption capacity of different adsorbents. The estimated cost of these adsorbents was based on the cost and availability of precursors, the manufacturing process, the heat treatment of materials, the convenience and use of materials and the recyclability of materials. Reproduced with consent: (A), Refs. [20–23, 29, 30]. Copyright: (A) 2012 Wiley, 2013 Wiley, 2013 Royal Society of Chemistry, 2014 Wiley and 2015 American Chemical Society.Citation: Nanotechnology Reviews 5, 1; 10.1515/ntrev-2015-0062See graphene and other carbon-based adsorbents [24-39]. Current adsorbents can be obtained by various procedures, including direct gelling of materials with a high aspect ratio, such as direct gelling of materials with a high aspect ratio (e.g. graphene and CNT) [20, 21, 25, 27, 30], pyrolysis of natural fibres or artificial products (e.g. cotton [22], recycled paper [23], even plants [38, 39]) and chemical vapour deposition (CVD) [34-36]. These techniques are used for the synthesis of hydrophobic and low-density porous structures. However, each method uses different starting materials, temperatures and additives according to the target products. The bottom-up growth of nanomaterials such as graphene and CNT could offer a fundamentally different procedure to achieve macro-scale 3D architecture with well-defined porous sponge structures. However, the top-down procedure makes full use of the existing porous scaffolding. The hydrophobic properties of existing scaffolds can be enhanced by heat treatment of carbonization or surface coating of hydrophobic materials. Significant development, wide potential use and numerous differences in spongy graphene and other carbon-based adsorbents demonstrate the benefits, potential uses and disadvantages of these materials. This document aims to review the continuous development and challenges in adsorbent production in a broad perspective. We also emphasized a fundamental understanding of the synthesis and characteristics of graphene and other carbon-based materials. Recent publications have also discussed the future prospects and application areas of high-performance sponges. Graphene, which is one of the advanced carbon nanomaterials, is a two-dimensional (2D) single sheet of carbon atoms arranged in a hexagonal network. Pristine graphene sheets obtained by mechanical exfoliation [40] exhibit exceptional properties such as high surfaces (2630 m<sup>2</sup> g<sup>-1</sup>), high thermal conductivity (5300 W mK<sup>-1</sup>), Young modulus (1 TPa), strong strong and high electron mobility (2.5×10<sup>5</sup> cm<sup>2</sup> V<sup>-1</sup> s<sup>-1</sup>) [41]. However, this type of graphene is not suitable for applications requiring large amounts of graphene. This type of graphene is economically inefficient, especially when used as adsorbents. In this way, several low-cost methods of mass production were developed. Graphene-based adsorbents with ordered 3D networks can usually be obtained through a variety of procedures, including the interaction of self-assembly graphene oxide (GO) during reduction, direct drying solution, CVD, surface coating on scaffolding skeletons and expansion of compact GO films. The following subsections will provide a deeper discussion of these methods. GO is currently the most common and important precursor to the preparation of graphene materials. Graphene can be controlled to form a superhydrophobic material [42]. This material can be produced in a porous sponge-like cylinder in a special drying process in which strong interactions of GO sheets in water play a significant role [43]. Changing hydrophilicity during GO reduction allows you to increase strength and control pore size. What's more, the interactions between GO sheets are strong enough to allow solutions for direct freezing to produce ultralight sponges. In addition, some challenges and process variability also require greater development in order to achieve optimal and consistent results. GO can be prepared by intercalation and oxidation of graphite powder usually by a modified method (44), in which sulphuric acid and potassium permanganate are the key components (45, 46). In this way, functions consisting mainly of epoxy and hydroxyl groups could be created, and these groups are highly hydrophilic and form strong hydrogen bonds with water [47]. In addition, water intercalation may extend the mesh, increasing the distance between graphite planes from 0.335 nm to 0.6 to 1.2 nm (48). Van der Waal bonding forces can be easily overcome after strong mixing or sonication to form thin mono- or multi-layer GO materials [49, 50]. The synthesis process is schematically shown in Figure 2.Figure 2: Download Figure Download as PowerPoint SlideSydycheczna for rough graphene synthesis. 1. Oxidation of graphite to graphite oxide with greater interlayer distance. 2. Exfoliation of graphite oxide in water by sonication to obtain graphene oxide (GO) colloids stabilized by electrostatic retention. 3. Controlled conversion of GO colloids to conduct graphene colloids by deoxidation by reducing hydraine. Reproduced with the consent of ref. [50]. Copyright: 2008 Nature Publishing Group.Citation: Nanotechnology Reviews 5, 1; 10.1515/ntrev-2015-0062 3D graphene tombs can be generated by using water-soluble GO properties to produce high concentration solutions and alkali [51]. GO sheets can be easily dispersed evenly in water due to their hydrophilia and electrostatic repelment effects [52]. Carboxylic acid groups carboxylic acid to go sheets can ionize, resulting in carboxylic ions containing negative charges. Some groups of carboxyls are removed as reactions progress, such as reactions for tens of minutes, thereby reducing the fees for some GO sheets. Additionally, GO journals are snapped to those with fees at no charge to create large journals. The basic GO plane is eventually shifted from a hydrophilic state to a more hydrophobic regime. Hydrogen-water bonding is weakened and van der Waal's attractiveness between aircraft increases, creating several sticky sheets of graphene. The sheets in the solution may begin to self-assemble if not disturbed, as schematically demonstrated by Bi et al. [53] in Figure 3. However, at a sufficiently high concentration, attractive forces between sheets and mutual restriction of mobility may lead to the assembly of reduced graphene materials into a porous hydrogel, formed in the shape of an containment vessel (54). Further reduction of graphene materials as the C/O ratio of the net increases leads to stronger van der Waal forces as well as to a more rigid and denser self-assembled rGO hydrogel [55]. In addition, the reduction can also be carried out by adding combining agents or more environmentally friendly reducing agents. The reduction process can be additionally supplemented by high temperature high-temperature cleaning. After installation, the structure is dried to prepare sponges. Two techniques are usually adopted, namely freeze drying and drying at a critical point, to avoid the screening process during ambient drying. Both techniques reduce the stress of the pore structure by replacing the liquid with gas to form sponges, thus avoiding refilling and leading to a high surface area of the macro-scale sponge. Freeze drying usually reduces capillary stress by overcoming the triple water point limit. This phenomenon lowers the water temperature and then converts it directly from solid to gaseous phase through low pressure. Figure 3:Download the Download Drawing drawing as a PowerPoint(A) hydrothermal reduction process slide. Porous hydrogel is formed with the shape of an encapsulated vessel. B) Agglomeration with the addition of different amounts of ammonia. Graphene hydrogels with varying surface morphology were synthesized based on the amount of ammonia. The agglomeration of a relatively loose graphene hydrogel is demonstrated by black arrows. Most GO sheets without fees for the first time attracted small GO sheets with negative fees and became large sheets. Large GO sheets eventually lost their fees and agglomerations easily due to the removal of carboxyl groups. The agglomeration of a relatively compact graphene hydrogel is indicated by green arrows. Carboxyl groups ionize in COO<sup>-</sup>, which reduced the partial agglomeration of the initial small GO sheets. Go sheets became hydrophobic and COO groups were gradually removed, resulting in a compact uniform go sheets. Reproduced with the consent of ref. [53]. [53]. 2012 Wiley.Citation: Nanotechnology Reviews 5, 1; 10.1515/ntrev-2015-0062Personal solubility and hydrophilic edges of the created GO facilitate its good dispersion at high concentrations. An uneasy solution which exhibits sufficiently strong binding interactions may be directly freeze-dried to form go sponges, controlling its concentration between 1 and 15 mg ml<sup>-1</sup> (55, 56). Figure 4A schematically illustrates the formation of a graphene sponge during rapid freezing of the solution. This process caused the internal expansion and macroscale cracking of the freeze-dried solution, and the pore size was controlled by a change in freezing point [57]. This phenomenon caused a block of graphene sponge (Figure 4B). Figure 4C-G shows scanning micrographs of porous electrons of the structures of four graphene sponges made at different freezing temperatures of -170°C, -40°C, -20°C and -10°C. Figure 4H shows a qualitative diagram of the relationship between nuptiation and the growth of crystals as a function of freezing temperature during ice clotting. Nucleation dominates the process at low temperatures, as opposed to the preferred crystal growth at high temperatures. The size of the ice crystals is not drawn in proportion to the size of the graphene sponge. Ice crystals are artificially demonstrated in the background, based on facts scanning electron microstructures of microstructures. Improving the quality and strength of the GO network is important in the production of repeatable, scalable sponges. GO sponges have been reduced to rGO sponges to change the hydrophilic GO to the desired hydrophobic properties of graphene to meet adsorbents requirements. However, using a chemical reduction of the solution with a reducing agent such as sodium borohydride, hydrazine, ascorbic acid and HI is difficult [47, 48, 58-61] because the reintroduction of GO sponges into high humidity and moisture can cause the sponge to collapse rapidly. Instead, GO sponges can be reduced at relatively high temperatures (600-1000°C) in a dry environment with an inert gas atmosphere or at lower temperatures with strong reducing fumes, such as hydreaea fumes, forming a rGO sponge [62-64]. The speed of the temperature ramp in this heat reduction process should not be too high. Otherwise, the sponge would suffer a thermal shock by rapidly releasing the gas and interfering with the integrity of the sponge structure [56]. Figure 4:Download the Drawing Download drawing as a PowerPoint(A) Slide Production of Improved Spongy Graphene. The components are not intentionally pulled into the scale. (B) Macroscopic image of improved spongy graphene. (C-F) Scanning micrographs of porous electrons of the structures of four graphene sponges made at different freezing temperatures -170°C, -40°C, -20°C and -10°C. Scale bar: 500 μm. (G) High-magnification electron micrographs



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