Recent Advances in Water Treatment Using Graphene-Based Materials

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Abstract: A variety of processes were reported for efficient removing of heavy metal from wastewater, including but not limited to ion exchange, reverse osmosis, membrane filtration, flotation, coagulation, chemical precipitation, solvent extraction, electrochemical treatments, evaporation, oxidation, adsorption, and biosorption. Among the aforementioned techniques, adsorption/ion exchange has been known as a most important method for removing heavy metal ions and organic pollutants due to great removal performance, simple and easy process, cost-effectiveness and the considerable choice of adsorbent materials.

Nanotechnology and its applications have been developed in most branches of science and technology. Extensive studies have been conducted to remove heavy metal ions from wastewater by preparation and applications of various nanomaterials. Nanomaterials offer advantages in comparison to other materials including an extremely high specific surface area, low-temperature modification, short intraparticle diffusion distance, numerous associated sorption sites, tunable surface chemistry, and pore size. In order to evaluate an adsorbent, two key parameters are: the adsorption capacity and the desorption property. The adsorption parameters including the absorbent loading, pH and temperature, concentration of heavy metal ion, ionic strength, and competition among metal ions are often studied and optimized.

Several reviews have been published on the application of Graphene (G), Graphene Oxide (GO) in water treatment. In this minireview, we attempted to summarize the recent research advances in water treatment and remediation process by graphene-based materials and provide intensive knowledge of the removal of pollutants in batch and flow systems. Finally, future applicability perspectives are offered to encourage more interesting developments in this promising field. This minireview does not include patent literature.

Keywords: Graphene oxide, graphene, hydrogel, reduced graphene oxide, water treatment, water pollution.

1. INTRODUCTION

Water pollution and supplies of clean water have become a major problem worldwide [1]. Currently, the quality of water resources is deteriorating owing to population growth, industrial and agricultural activities, as well as other ecological and environmental phenomena [2–4]. The continuous release of different types of pollutants such as heavy metal ions and organic dyes into the clean water source has caused a growing concern in many countries [5–7].

Up to the present time, a variety of methods have been developed for the efficient removal of heavy metal ions from wastewaters, including but not limited to chemical precipitation, coagulation, reverse osmosis, membrane filtration, solvent extraction, flotation, ion exchange, electrochemical treatments, evaporation, oxidation, adsorption and biosorption [8–13]. The application of above methods have been exhibited some drawbacks; for example, precipitation or coagulation demand a variety of chemicals and include high sludge volumes; electrochemical and filtration methods need electricity equipment and high capital investments [14]. Among the aforementioned techniques, adsorption/ion exchange has been known as the most important method for removing heavy metal ions due to great removal performance, simple and easy process, cost-effectiveness and the considerable choice of adsorbent materials.

In the last two decades, nanotechnology has developed with its applications in almost all branches of science and technology [15, 16]. The nanomaterials have been developed in most fields of science and technology. Nanomaterials are excellent adsorbents and catalysts [17]. The environmental application of nanomaterials has been interested. The nanomaterials exhibited significant improvement in comparison with other materials due to the extremely high specific sur-