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Quantum Dots and Their Application in Water and Wastewater Treatment

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In recent years, the use of nanoparticles has grown tremendously in various fields, including medicine, industry, agriculture, mechanics, and water and wastewater treatment. As a functional nanoparticle, Quantum dots (QDs), have recently been been introduced to the field of water and wastewater treatment [1]. QDs comprising of 200 to 10,000 atoms have demonstrated great versatility due to their small diameter of 2 to 10 nm, and function as a semi-conductor nanocrystal by emitting light after excitation. The QDs characteristics are controlled by changing the molecular structure according to the individual's desirable usage [2]. The size, shape, and structure of QDs control their electrical properties and peak emission frequency [3, 4].

The electrical conductivity of QDs show significant changes by applying external stimuli, such as an electric field or light radiation. QDs are commonly categorized into two groups; metal quantum dots (MQDs); and carbon quantum dots (CQDs). MQDs such as PbS, ZnS, InP, InAs, CdTe, CdSe, and CdS emit light after exciting the electrons in accordance with a certain wavelength of light by an external source. CQDs with a size of less than 10 nm and discrete quasi-spherical shape have been considered as an attractive group of nanoparticles [5, 6].

Graphene QDs, carbon nanodots, and polymer dots are categorized as CQDs and played a valuable and substantial role in aqueous mediums treatment, due to their attractive properties of low toxicity, fluorescence activity, eco-friendliness, low cost, unique optical properties, and chemical stability [7, 8]. The high fluorescence properties of CQDs have made them suitable for various applications, and they have received considerable attention from researchers as fluorescent carbon dots. Various approaches have been developed for the preparation of CQDs, including hydrothermal methods, radiation and ultrasound procedures, electrochemical strategies, and microwave techniques. Hydrothermal techniques are most commonly employed for the synthesis of CQDs, and more progressive techniques have been recently developed for their preparation [9, 10].

CQDs have recently been employed as an efficient adsorbent for removal of organic pollutants such as dyes [11, 12], and inorganic contaminants such as heavy metals, pharmaceutical materials [13], p-nitrophenol [14, 15], pesticides [1, 16], and pathogens [17, 18].

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They have been also used as an active catalyst for photo-catalystic treatment processes of water and wastewater [6, 8].

Although CQDs have been extensively studied by researchers, there are some features and challenges in their utilization and usage in water and wastewater treatment processes which need to be resolved. These include a comprehensive understanding of CQDs performance, cost effectiveness and simple synthesis approaches for preparation of CQDs with green carbon precursors, and regeneration investigations.

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