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Carbon Quantum Dots In Environmental Remediation

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Abstract

Carbon quantum dots (CQD), is highly stable, biocompatible, and low toxic fluorescence nonomaterial that extensively used in different scientific disciplines such as design and construction of low-cost chemical and biological sensors, cell imaging, clinical diagnosing, and drug loading. Due to their optoelectronic properties, they have recently used in remediation studies as an alternative to or mixed with metal semiconductors. Having used CQD, an economic and green technique in environmental pollution remediation is introduced. Remediation happens through the ability of CQD composites in adsorption of pollutants or using its photo catalytic action. Herein, some recent applications in the environmental pollutant remediation are reviewed.

Introduction

CQDs are a new type of carbon nanomaterial accidentally found in 2004 through purification of single-wall carbon nano tubes [1]. They have attracted much scientific attention since they are stable photoluminescence particles with high chemical stability, low toxicity, and biocompatible as well as having optoelectronic properties. They are produced by different chemical or natural carbon rich precursors in one pot process by different heating methods [1-4]. The CQDs properties have tuned by surface modification through different synthetic protocols and using different chemical reagents [5] for a vast variety of applications since 2004. CQDs have strong and stable luminescence, and have been used in chemical sensors, optoelectronics [6-8] bacterial detection [9], cancer diagnosis [10], cell imaging [11] and drug loading [12].

Exposure of CQDs with photons of energy equal or higher than its band gap leads to the transfer of the electron from the valence band to the conduction band, producing an electron-hole. Both electron and hole on the surface of the CQDs gives it the ability to act as both electron donor and acceptor, and promote oxidation-reduction on the surface of the dots [13]. Doping CQD with dozens of elements like N, P, and S have induced a shift in the photoluminescence wavelength, and suggest its applications as an efficient catalyst. Photo catalytic degradation of organic pollutions and microorganism is extensively reported in the literature using semiconductors [13].The high photo activity of the catalyst has a vital role in the oxidation or reduction of the pollutants. Photo catalytic activity of CQDs improved by incorporating elements such as nitrogen on the surface, and preparation of a composite with other semiconductors such as TiO_2. Pollutant remediation using CQDs is mainly due to the photo catalytic properties. But adsorption of the pollutants on the surface of CQDs composites is another strategy has rarely been used up to now. However, the application of CQDs in the pollutant remediation is briefly discussed and listed. Photocatalytic Degradation of Pollutants is an Title CQDs under photon irradiation generate electron-hole and acts as the visible light photo catalyst in environmental remediation and energy transfer reactions. A few reports on the application of CQDs for adsorption of environmental pollutants are available in the literature. Some recent application of CQDs, doped CQDs, and their composites with other nano particles, in environmental remediation, is reported in (Table 1) and discussed. Photo catalytic conversion of CO_2 to organic acids by nitrogen doped CQD (NCQDs) with visible light irradiation was more efficient than colloidal TiO_2 under UV radiations [5]. Martin et al [13] also synthesized nitrogen doped CQD by hydrothermal irradiation using glycerol as the carbon source and 4,7,10 trioxa-1,13-tridecanediamine for nitrogen doping. They prepared NCQD/TiO_2 nano composite and showed that photo catalytic activity of nano composite for methylene blue and NO remediation is higher than those for TiO_2. Super paramagnetic nitrogen doped CQD /magnetite nano composites (Fe_3O_4@NCQD) [14,15] were used for removal of methyl blue from polluted water samples. They used lemon juice as a green carbon precursor and ethylene amine as the nitrogen source for CQD surface functionalization.

As-prepared Fe_3O_4@NCQD adsorbs 90.84% methyl blue from aqueous solutions in 20 min. Particles were separated from the solution by a magnet, methyl blue has been desorbed by hydrochloric acid, and the recovered particles were used five times without any considerable changes in the removal efficiency. CQD/nitrogen-doped ZnO (CQD/N-ZnO) composite was prepared and used for photo catalytic degradation of three commercial dyes, malachite green, methylene blue and fluoresce in under daylight irradiation. The composite removes all three dyes within 30-45 minutes [16]. CQDs-TiO_2nanosheet (CQDs-TNS) composites were prepared and used in photo catalytic degradation of rhodamine B under visible light irradiation [17].

Table 1: Some recent reports on the pollutant remediation using cqds as well as its composite.

Particle	Pollutant	Matrix	Remediation Method	References
NCQDS	Co_2	-----	Photo catalytic	[5]
NCQD/TiO_2	Methylene blue No	Water	Photo catalytic	[14]
CQDS/TNS	Rhodamine b	Water	Photo catalytic	[17]
Fe_3O_4@NCQDS	Methyl blue	Water	Adsorption	[15]
CQDS/n-ZnO	Malachite green methylene blue fluoresce in	Water	Photo catalytic	[16]
CQDS-TNS	Rhodamine b	Water	Photo catalytic	[17]
CQDS/g-C_3N_4	Solar h_2 evolution with contaminant decomposition	Water	Photo catalytic	[18]
CQDS/Ag/Ag_2O	Methylene blue Rhodamine b	Water	Photo catalytic	[19]
CQDS/g-C_3N_4	Rhodamine b Tc-hcl	Water	Photo catalytic	[20]
Ar+-CDS-Bi_2 WO_6	Tetracycline	Water	Photo catalytic	[21]
Fe(iii)-NCQDS	Hydrogen peroxide	--	Photo catalytic	[22]
La/Cu/Zr/CQDS	Ampicillin Malachite green	Aqueous	Adsorption/photo catalytic	[23]
Bi_2O_3/CQDS	Rhodamine b	Water	Photo catalytic	[24]
CQDS/Bi_2 WO_6	Methyl orange Bisphenol a	Aqueous	Photo catalytic	[25]
Ag-CQDS/g-C_3N_4	Naproxcen	Water	Photo catalytic	[26]
CQDS/$ZnFe_2O_4$	No	Air purification	Photo catalytic	[27]
CQD/MWCNT Fiber	Bacteria	Aqueous solution		[28]

It was reported that photo catalytic activity of CQDs-TNS was higher than CQDs/TiO_2 and pure TNS. Catalytic H_2 production using highly crystalline CQDs on 2D C_3N_4nanosheets was reported [18]. Hydrogen peroxide produced during the reaction promotes bisphenol a removal. Excellent photo catalytic activity was observed for ternary mixture of CQDs/Ag/Ag_2O [19]. The ternary photo catalyst removed methylene blue and Rhodamine B from aqueous solution. Composite of CQDs with g-C_3N_4nanosheet was also reported as an excellent photo catalyst for the degradation of rhodamine B and tetracycline hydrochloride (TC-HCl) under visible light irradiation [20]. Tetracycline mineralization by the composite of Ag+-CDs-Bi_2WO_6 [21] via photo catalytic reactions under visible light is also reported. The Ag+-CDs-Bi_2WO_6 has excellent stability even when recycled and reused for several times. Fe (III)-functionalized carbon dots (Fe(III)-CQDs) was used for remediation of hydrogen peroxide as well as olefin hydrogenation with high selectivity [22]. A green approach applied to the synthesis of La/Cu/Zr/CQDs tri metallic nano composites as both adsorptive and catalytic agent for pollutant remediation [23]. It has been observed that 96% ampicillin antibiotic and 86% of malachite green were degraded in 4 h. The prepared Bi_2O_3/ CQDs photo catalysts [24] showed the best photo catalytic activity in rhodamine B elimination. A new CQDs/ Bi_2WO_6 were applied in the remediation of methyl orange and bisphenol A in aqueous solution [25]. A novel ternary photo catalyst of single atom-dispersed silver and carbon quantum dots co-loaded with ultrathin g-C_3N_4 (Ag-CQDs-gC_3N_4) was synthesized [26]. Environment-Friendly CQDs/ $ZnFe_2O_4$ photo catalyst was synthesized and introduced as a biocompatible catalyst for NO removal in the atmosphere [27]. The catalyst has low cytotoxicity and is a good candidate for air purification. Application of CQDs was extended to the removal of microorganism from aqueous solution. Recently, multiwall carbon nano tube fiber incorporated CQDs (MWCNT-F/CQDs) composite has been proved as highly efficient material for bacterial removal from aqueous solution and inhibition of their activity [28]. In this study, the inhibitory rates for E. coli were 94.21% on the MWCNT filter surfaces coated with 0.2 mg CQDs.

Conclusion

To sum up, CQDs are introduced recently as the visible light photo catalyst for environmental remediation. The catalytic activity of CQDs increases by metals doping or making composites with the other semiconductor. Adsorption ability

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of CQDs for environmental pollutants are not well investigated. Another outstanding action of CQDs is in bacterial growth inhibition and removal from aqueous solution. Overall, CQDs is a green and biocompatible material for treatment and purification of water and atmosphere.

References

1. W You fu, H Aiguo (2014) Carbon quantum dots: synthesis, properties and applications. Journal of Material Chemistry C 2: 6921-6939.
2. J Wang, Q Li, J Zhou, Y Wang, L Yu, et al. (2017) Synthesis, characterization and cells and tissues imaging of carbon quantum dots. Optical Materials 72: 15-19.
3. P Roy, PC Chen, AP Periasamy, YN Chen, HT Chang (2015) Photo luminescent carbon nanodots: synthesis, physicochemical properties and analytical applications. Materials Today 18(8): 447-458.
4. Z Ramezani, M Qorbanpour, N Rahbar (2018) Green synthesis of carbon quantum dots using quince fruit (Cydonia oblonga) powder as carbon precursor. Application in cell imaging and As3+ determination, Colloids and Surfaces A: Physicochemical and Engineering Aspects 549: 58-66.
5. KA Fernando, S Sahu, Y Liu, WK Lewis, EA Guliants, et al. (2015) Carbon Quantum Dots and Applications in Photo catalytic Energy Conversion. ACS Applied Materials & Interfaces 7(16): 8363-8376.
6. M Zhao, Q Zhao, B Li, H Xue, H Pang, et al. (2017) Recent progress in layered double hydroxide based materials for electrochemical capacitors. Design, synthesis and performance, Nanoscale 9: 15206-15225.
7. M Wu, J Zhan, B Geng, P He, K Wu, et al. (2017) Scalable synthesis of organic-soluble carbon quantum dots: Superior optical properties in solvents, solids, and LEDs. Nanoscale 9: 13195-13202.
8. Y Wang, J Zheng, J Wang, Y Yang, X Liu (2017) Rapid microwave-assisted synthesis of highly luminescent nitrogen-doped carbon dots for white light-emitting diodes. Optical Materials 73: 319-329.
9. H Safardoust Hojaghan, M Salavati Niasari, O Amiri, M Hassanpour (2017) Preparation of highly luminescent nitrogen doped graphene quantum dots and their application as a probe for detection of Staphylococcus aureus and E. coli. Journal of Molecular Liquids 241: 1114-1119.
10. K Bhise, S Sau, H Alsaab, SK Kashaw, RK Tekade, et al. (2017) Nano medicine for cancer diagnosis and therapy: Advancement, success and structure-activity relationship. Therapeutic Delivery 8: 1003-1018.
11. L Wu, X Li, Y Ling, C Huang, N Jia, (2017) Morpholine Derivative-Functionalized Carbon Dots-Based Fluorescent Probe for Highly Selective Lysosomal Imaging in Living Cells. ACS Applied Materials and Interfaces 9(34): 28222-28232.
12. S Rai, BK Singh, P Bhartiya, A Singh, H Kumar, et al. (2017) Lignin derived reduced fluorescence carbon dots with theranostic approaches: Nano-drug-carrier and bio imaging. Journal of Luminescence 190: 492-503.
13. K Mondal, A Gupta (2018) Recent Advances in Carbon-Semiconductor Nano composites for Water Remediation. In S Bhattacharya, AB Gupta, A Gupta, A Pandey (Eds.), Water Remediation, Springer Singapore, pp. 45-74.
14. NCT Martins, J Ângelo, AV Girão, T Trindade, L Andrade (2016) N-doped carbon quantum dots/TiO2 composite with improved photo catalytic activity. Applied Catalysis B: Environmental 193: 67-74.
15. A Tadesse, D Rama Devi, M Hagos, G Battu, K Basavaiah (2018) Synthesis of nitrogen doped carbon quantum dots/magnetite nano composites for efficient removal of methyl blue dye pollutant from contaminated water. RSC Advances 8: 8528-8536.
16. S Muthulingam, IH Lee, P Uthirakumar (2015) Highly efficient degradation of dyes by carbon quantum dots/N-doped zinc oxide (CQD/N-ZnO) photo catalyst and its compatibility on three different commercial dyes under daylight. J Colloid Interface Sci 455: 101-109.
17. X Yu, J Liu, Y Yu, S Zuo, B Li (2014) Preparation and visible light photo catalytic activity of carbon quantum dots/TiO_2 nano sheet composites. Carbon 68: 718-724.
18. G Zhang, Q Ji, Z Wu, G Wang, H Liu, et al. (2018) Facile Spot-Heating Synthesis of Carbon Dots/Carbon Nitride for Solar Hydrogen Evolution Synchronously with Contaminant Decomposition. Advanced Functional Materials 28(14).
19. J Chen, H Che, K Huang, C Liu, W Shi (2016) Fabrication of a ternary plasmonic photo catalyst CQDs/Ag/Ag2O to harness charge flow for photo catalytic elimination of pollutants. Applied Catalysis B: Environmental 192: 134-144.
20. Y Hong, Y Meng, G Zhang, B Yin, Y Zhao, et al. (2016) Facile fabrication of stable metal-free CQDs/g-C3N4 hetero junctions with efficiently enhanced visible-light photo catalytic activity. Separation and Purification Technology 171: 229-237.
21. Z Li, L Zhu, W Wu, S Wang, L Qiang (2016) Highly efficient photo catalysis toward tetracycline under simulated solar-light by Ag+-CDs-Bi2WO6: Synergistic effects of silver ions and carbon dots. Applied Catalysis B: Environmental 192: 277-285.
22. AB Bourlinos, AK Rathi, MB Gawande, K Hola, A Goswami, et al. (2017) Fe(III)-functionalized carbon dots-Highly efficient photoluminescence redox catalyst for hydrogenations of olefins and decomposition of hydrogen peroxide. Applied Materials Today 7: 179-184.
23. G Sharma, S Bhogal, M Naushad, Inamuddin, A Kumar, et al. (2017) Microwave assisted fabrication of La/Cu/Zr/carbon dots tri metallic nano composites with their adsorption vs. photo catalytic efficiency for remediation of persistent organic pollutants. Journal of Photochemistry and Photobiology A: Chemistry 347: 235-243.
24. Q Que, Y Xing, Z He, Y Yang, X Yin, et al. (2017) Bi2O3/Carbon quantum dots hetero structured photo catalysts with enhanced photo catalytic activity. Materials Letters 209: 220-223.
25. J Wang, L Tang, G Zeng, Y Deng, H Dong, et al. (2018) 0D/2D interface engineering of carbon quantum dots modified Bi2WO6 ultrathin nano sheets with enhanced photo activity for full spectrum light utilization and mechanism insight. Applied Catalysis B: Environmental 222: 115-123.
26. F Wang, Y Wang, Y Feng, Y Zeng, Z Xie, Q, et al. (2018) Novel ternary photo catalyst of single atom-dispersed silver and carbon quantum dots co-loaded with ultrathin g-C3N4 for broad spectrum photo catalytic degradation of naproxen. Applied Catalysis B: Environmental 221: 510-520.
27. Y Huang, Y Liang, Y Rao, D Zhu, JJ Cao, et al. (2017) Environment-Friendly Carbon Quantum Dots/ZnFe2O4 Photo catalysts: Characterization, Biocompatibility, and Mechanisms for NO Removal. Environmental Science & Technology 51(5): 2924-2933.
28. X Dong, M AL Awak, P Wang, YP Sun, (2018) Carbon dot incorporated multi-walled carbon nano tube coated filters for bacterial removal and inactivation. RSC Advances 8(15): 8292-8301.

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