Perspective

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Aggregation-Induced Emission Characteristics in Carbon Dots for Detection of Nitroaromatic Explosives

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ABSTRACT

Abbreviations: TNT: Trinitrotoluene; DNT: Dinitrotoluene; PA: Picric Acid; IMS: Ion-Mobility Spectroscopy; ACQ: Aggregation-Caused Quenching; AIE: Aggregation-Induced Emission; CDs: Carbon Quantum Dots

Prospective

Detection of nitroaromatic explosives such as Trinitrotoluene (TNT), Dinitrotoluene (DNT) and Picric Acid (PA) is of great concern for homeland security, battlefield protection, industrial and environmental safety control [1,2]. These nitroaromatic explosives are primary constituents of many unexploded land mines worldwide [3]. Among them, TNT is a widely used explosive and found to be poisonous, carcinogenic and can adversely affect male fertility [4-6]. Soil and ground water of war zone can contain toxic levels of these NACs as well as their degradation products. Thus, these nitroaromatic explosives are found to be environmental contaminants and toxic to living organisms. On the other hand, the explosive power of nitroaromatic compound PA is higher than that of TNT and found to be highly reactive as it complexes with metals to generate shock sensitive explosive metal salts [7]. The use of PA in the manufacture of rocket fuel, fireworks, and matches releases a large quantity of it into the environment [8,9]. In view of this, detection of explosives is very important in combating terrorism, maintaining national security and providing environmental safety. Various methods are available for the detection of these nitroaromatics, such as GC-MS, Ion-Mobility Spectroscopy (IMS) and surface enhanced Raman spectroscopy and various other spectroscopic techniques [10]. However, these methods cannot be used in the field due to their high cost, lack of selectivity and sensitivity.

In this context, fluorescence signaling is one of the first choices due to its high detection sensitivity and selectivity [11]. However, emission of various fluorescent probes is often quenched at high concentrations or in an aggregate state, which is known as Aggregation-Caused Quenching (ACQ). In contrast to ACQ, there are some molecules that behave differently as they are non-luminescent in the solution state but become strongly emissive when aggregated and these molecules are termed as ‘‘Aggregation-Induced Emission’’ (AIE) active materials [12]. Fluorescent Carbon Quantum Dots (CDs) are found to be environment friendly, easy synthesis, easy to modify by doping, which, make them an excellent candidate for application in optoelectronics, sensors, solar cells, bioimaging and so on [13]. These properties provide CDs an edge over other fluorescent materials [14-16]. Recently, AIE property in CDs has provided a new extent to their optical properties. CDs having AIE characteristic was first reported by Gao et al. in 2013 [17] where adenosine-5-triphosphate brings the aggregation of CDs. Since then, AIE in CDs becomes the scientist's first choice due to their sensitivity to pH change, large Stokes shift, photostability and biocompatibility, which can be fruitful for various applications [18]. From various experiments, it was observed that aggregation in CDs lead to structural rigidity, which relaxes the non-radiative path, hence, improving the fluorescence intensity. Aggregation-Induced Emission (AIE) phenomenon in Carbon Quantum Dots (CDs) has been found to improve the optical properties and cracked a new research area for the potential application of materials. The AIE in CDs has been utilised for various applications same as of AIE macromolecules. However, no research so far has been done using AIE in CDs for the detection of nitroaromatic explosives. In view of this, we believe that AIE coupled with CDs may aid a new pathway for the detection of nitroaromatic explosives.

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