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Fluorescent Nanofilms for Nitroaromatic Explosives Detection-Promises and Challenges

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Editorial

Fast and sensitive detection of nitro-aromatic explosives is of vital importance for finding hidden explosives in airport luggage or mails, screening of personnel, and detection of buried landmines [1-3]. A crucial example is the detection of trace amount of 2,4,6-trinitrotoluene (TNT), which is a typical nitro-aromatic explosives [4-8]. Various TNT detection methods are currently available, such as, the fluorescence quenching method, micromechanical sensors based on micro cantilever, the electrochemical method, ion mobility s pectroscopy (IMS), the surface-enhanced Raman spectroscopy (SERS) and semiconductor based gas sensors [7,9-23]. Among t he above-mentioned methods used for TNT detection, the fluorescence quenching method is considered to be the most effective tool for sensing nitro-aromatic explosives in recent years owing to its high sensitivity, convenience, easy visualization, and short response t ime for detection [24].

Much attention has been paid to the development of novel fluorescence materials for explosives detection [2,7,15,25]. Metal organic frameworks (MOFs), fluorescent conjugated polymer, and fluorescent fibers are three typical detecting materials based on fluorescence quenching method [2,11,26-28]. For MOFs, detectable changes in luminescence along with tailorable porosity and a high surface area make MOFs excellent candidates for detecting TNT [2]. Fluorescent conjugated polymers have an advantage over small fluorescent molecules in excition migration along the polymer chains, which could amplify signal like "molecular wire" [26-28]. This advantage leads to the rapid development of fluorescent conjugated polymers in explosives sensing. From 1995-2007, Swagers' group continuously demonstrated the amplification possibility with molecular wires for chemical sensors [29-34]. Based on their work, commercialized product (Fido NXT) which can detect TNT at part per quadrillion (ppq) levels has been applied in war zones of Afghanistan and Iraq [35]. In China, based on fluorescent conjugated polymers, Cheng and co-workers also explored trace explosives detector (SIM series) which could detect explosives, such as nitro-aromatic explosives and plastic explosives at part per trillion (ppt) levels in 2007 [36]. Although significant advances have been achieved, the sensing performance of fluorescent conjugated polymers depends highly on the film thickness due to the slow diffusion of analyte vapors in the non-porous rigid conjugated polymer films [30,37]. And the synthesis process of conjugated polymers is complex [38].

In this regard, electrospinning technology which is a simple and cost-effective approach to prepare nanofibrous films has been developed very rapidly in recent years [37]. Guangtao Li pioneered electrospun fibrous membranes for TNT detection, and the quenching efficiency was comparable to that of conjugated polymer-based TNT sensors [11]. Feng Liu fabricated a novel electrospun fluorescence film in which porous structure and amine modification were introduced to improve the sensitivity for detection of nitro-aromatic explosives [39]. Yu Lei synthesized a novel electrospun fluorescent nanofibrous membrane with a function like "molecular wires", leading to ultrasensitive and fast response to 2, 4-dinitrotoluene (DNT) [37].

Electrospinning is a promising method to prepare nanofibrous films, and there are several attractive aspects of this technique over others. First, the highly inherent porosity and the large surface-to-volume ratio of nanofibers. On one hand, the diffusion of explosives vapor could be greatly promoted and both of the sensitivity and the response time could be improved. On the other hand, more explosive molecules could be adsorbed on the surface of nanofibers and the quenching efficiency could be further improved [25]. Second, the simple, cost-effective and environment-friendly approach for fabricating nanofibrous films. Compared to most of the multi-step synthesis processes of fluorescent conjugated polymers, which severely restrict their practical applications, the synthesis of nanofibrous films is a one-step process and it meets practical production [38]. Third, the flexible sensor, which is reusable and light weight could be expected for smart sensing applications [40].

However, the application of nanofibrous films in practical detection of explosives confronts with some challenges. First, how to achieve the goal of specific detection towards TNT using nanofibrous films? The molecular imprinting technique (MIT) is a method to prepare polymers with recognition sites having a predetermined selectivity for given molecules [41]. It would be a promising method if MIT could be applied into nanofibrous films without damaging the films. Second, how to realize the detection of explosives in liquid solvent since the morphology of nanofibrous films is prone to change or destroy. It is suggested to select a suitable polymer which has good mechanical properties. Furthermore, how to obtain more effective and sensitive fluorescence quenching? Last but not least, the response time, which is also a vital factor to evaluate the sensing performance and for practical application.

In conclusion, the design and synthesis of flexible, porous fluorescent nanofibrous films, which can specifically, rapidly and sensitively detect nitro-aromatic explosives is a promising but challenging work.

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