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Rapid Detection of Cocaine Using Aggregation-Induced Emission and Aptamer Combined Fluorescent Probe

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Abstract : In recent years, the diversification and industrialization of drug-related crimes have posed significant threats to public health and safety globally. The widespread and increasingly younger demographics of drug users and the persistence of drug-impaired driving incidents underscore the urgency of this issue. Drug detection, a specialized forensic activity, is pivotal in identifying and analyzing substances involved in drug crimes. It relies on pharmacological and chemical knowledge and employs analytical chemistry and modern detection techniques. However, current drug detection methods are limited by their inability to perform semi-quantitative, real-time field analyses. They require extensive, complex laboratory-based preprocessing, expensive equipment, and specialized personnel and are hindered by long processing times. This study introduces an alternative approach using nucleic acid aptamers and Aggregation-Induced Emission (AIE) technology. Nucleic acid aptamers, selected artificially for their specific binding to target molecules and stable spatial structures, represent a new generation of biosensors following antibodies. Rapid advancements in AIE technology, particularly in tetraphenyl ethene-based luminous, offer simplicity in synthesis and versatility in modifications, making them ideal for fluorescence analysis. This work successfully synthesized, isolated, and purified an AIE molecule and constructed a probe comprising the AIE molecule, nucleic acid aptamers, and exonuclease for cocaine detection. The probe demonstrated significant relative fluorescence intensity changes and selectivity towards cocaine over other drugs. Using 4-Butoxytriethylammonium Bromide Tetraphenylethene (TPE-TTA) as the fluorescent probe, the aptamer as the recognition unit, and Exo I as an auxiliary, the system achieved rapid detection of cocaine within 5 mins in aqueous and urine, with detection limits of 1.0 and 5.0 μmol/L respectively. The probe-maintained stability and interference resistance in urine, enabling quantitative cocaine detection within a certain concentration range. This fluorescent sensor significantly reduces sample preprocessing time, offers a basis for rapid onsite cocaine detection, and promises potential for miniaturized testing setups.

Keywords : drug detection, aggregation-induced emission (AIE), nucleic acid aptamer, exonuclease, cocaine
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