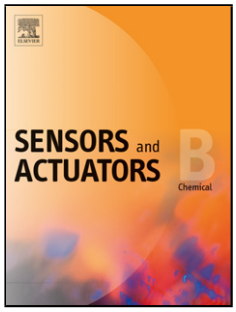

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Author: Fenghong Chu Georgios Tsiminis Nigel A. Spooner Tanya M. Monro

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Explosives detection by fluorescence quenching of conjugated polymers in suspended core optical fibers

Fenghong Chu[1], Georgios Tsiminis[2], Nigel A. Spooner[2,3] and Tanya M. Monro[2]

[1]Shanghai University of Electric Power, Shanghai, 200090, China
[2]Institute for Photonics & Advanced Sensing and School of Chemistry & Physics, The University of Adelaide, Adelaide, South Australia 5005, Australia
[3]Defence Science & Technology Organisation, South Australia 5111, Australia

Abstract: In this work we demonstrate a suspended core microstructured optical fiber-based sensor platform for explosives detection based on the fluorescence quenching of a surface-attached conjugated polymer poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV). These fibers allow for strong evanescent field interactions with the surrounding media because of their small core size, and can sample minute liquid volumes. This is the first demonstration of a fluorescent conjugated polymer sensor capable of measuring liquid explosives samples loaded within an optical fiber. This technique is used to identify 1,4-dinitrobenzene (DNB), a member of the nitroaromatics family of explosives, in acetone for concentrations as low as 6.3 ppm in a total sampling volume of 27 nL and to quantify its concentration using the fluorescence decay lifetime, requiring an analysis time of only a few minutes.

Keywords: Explosives detection; Fluorescence sensor; Optical fiber sensor

1. Introduction

Sensing of nitroaromatic explosives such as trinitrotoluene (TNT), dinitrotoluene (DNT) and picric acid (PA) in groundwater or seawater is of importance for detecting buried unexploded ordnance and for locating underwater mines[1,2]. There are also environmental monitoring applications for characterizing soil and groundwater contaminated by toxic TNT at military bases[3]. Many technologies have been employed for the detection of trace levels nitroaromatics explosives,for example ion mobility spectrometry (IMS)[4], Terahertz spectroscopy[5], Raman spectroscopy [6], molecularly imprinted polymers (MIP) [7] and fluorescence quenching methods[8]. Among these, fluorescence quenching sensing methods are promising for rapid and sensitive detection of explosives[9]. The mechanism of fluorescence quenching is based on photoinduced electron transfer from excited fluorescent molecules to analytes. The electron-deficient nitroaromatics explosives in particular are much stronger quenchers of the fluorescence of electron-rich chromophores than a number of possible quenching molecules, imparting a degree of selectivity to the detection mechanism[10,11]. Utilizing sensory polymer films coated on a planar substrate (e.g., glass plate) has become the common method of choice for fluorescence quenching explosive detection[8,9,12]. However, large sampling volumes are needed as the fluorescent film is immersed in the explosives solution[12] and remote sensing can't be implemented.

Fiber optic sensing systems for explosives detection, in contrast are portable, flexible, low-cost, and capable of accessing hard-to-reach areas over long distances [13].Microstructured optical fibers (MOFs) have the potential to dramatically improve the performance of fiber optic sensors based on fluorescence spectroscopy and have recently attracted considerable interest [14-16], since a significant portion of the guided light can be located in voids within the fiber that can be used to sample the surrounding medium