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A highly selective and reversible turn-off fluorescent chemosensor for Cu^{2+} based on electrospun nanofibrous membrane modified with pyrenecarboxaldehyde

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Abstract

A fluorescent nanofibrous membrane (NFM) was successfully fabricated by functionalizing electrospun ethylene-vinyl alcohol copolymer (EVOH) NFM with 4-aminobenzoic acid (PABA) and 1-pyrenecarboxaldehyde (Py-CHO) for fast and selective determination of Cu^{2+} in aqueous solution. The effective grafting of PABA and Py-CHO on the surface of EVOH NFM was confirmed by FTIR and XPS spectra. Benefiting from the integrated merits of electrospun EVOH NFM, PABA and Py-CHO, the as-appeared EVOH-PABA-Py NFM exhibited high sensitivity and selectivity towards Cu^{2+} detection. The quenching efficiency was 91.7% when the concentration of Cu^{2+} reached 5×10^{-3} M, while the detectable fluorescence response of the NFM was still observed when the concentration of Cu^{2+} was 1×10^{-9} M. The fluorescence quenching caused by Cu^{2+} was hardly affected by other commonly co-existent metal ions. More importantly, the fluorescent NFM exhibited fast response and high reversibility towards Cu^{2+} detection. The "off-on" fluorescence switching process via alternating addition of Cu^{2+} and Na_2EDTA occurred in three minutes, and the quenching efficiency of the NFM kept relatively stable values within 10 cycles. This work may provide a new insight into the development of rapid, portable, stable and reusable fluorescent sensor based on electrospun nanofibers that can satisfy the requirements of practical metal ions detection.

Keywords: electrospun nanofibers; 1-pyrenecarboxaldehyde; fluorescent sensor; Cu^{2+} sensing; reversibility

1. Introduction

Contamination of water by heavy metal ions has become an increasing concern to the environment and health[1]. Many diseases were caused by heavy metal accumulation in human body, which arose from ingesting contaminated water. Therefore, water intake had the most direct effect on people's health[2]. For this reason, safe limits or maximum contaminant levels have been defined for drinking water by several organizations, including World Health Organization (WHO) and Environmental Protection Agency (EPA). Cd^{2+}, Pb^{2+}, Cu^{2+}, Zn^{2+} and Ni^{2+}, which were harmful to human body, should not exceed 1~50 μg L^{-1}[3]. In view of this, low trace detection of heavy metal ions in water has become a critical issue. Various detection methods have been developed, including atomic absorption spectrometry[4], atomic emission spectrometry[5], X-ray fluorescence spectrometry[6] and inductively coupled plasma mass spectrometry[7]. However, due to the complex sample pretreatment and large-scale test equipment, these methods could not meet the market demand for rapid detection. Hence, it is necessary to develop a