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Research paper

Highly selective chromogenic probe for cesium ions prepared from an electrospun film of self-assembled benzenetricarboxyamide nanofibers

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ABSTRACT

Cesium is a common contaminant in industrial, medical, and nuclear wastes, and can cause several health problems. Therefore, the development of chemical probes and absorbents for cesium is important for the medical, biological, and industrial fields. Herein, we report the sensing ability of tri- or dihydroxylphenyl-appended benzenetricarboxyamides (BTAs 1 and 2, respectively) as chromogenic probes for cesium ions. Compounds 1 and 2 form self-assembled nanofibers spontaneously in aqueous solution, which is attributed to the intermolecular hydrogen-bonding interactions of the triamide groups in the BTA core. The color of 1 and 2 in aqueous solution changes from colorless to yellow upon addition of Cs^+, but not any other metal ions. ^1H NMR observation reveals that compound 1 forms a complex with Cs^+ through cation-π interactions. In addition, the nanofiber structures of 1 and 2 adopt spherical morphologies upon addition of Cs^+. To develop a portable cesium sensor, a fiber incorporating 1 (EF-1) is fabricated by the electrospinning method. EF-1 exhibits high affinity and selectivity for Cs^+ over other competing metal ions. Therefore, EF-1 shows promise as a portable sensor for the detection of Cs^+ in aqueous solution.

1. Introduction

Cesium, a common contaminant in industrial, medical, and nuclear wastes, can cause numerous health problems, including cardiovascular disease and gastrointestinal distress [1–3]. There are several well-known methods for detecting cesium in complex environmental and/or biological systems, such as atomic absorption spectroscopy, inductively coupled plasma mass spectroscopy, and the use of solid-state sensors [4–6]. Although these methods are highly sensitive and selective for cesium detection, they are often expensive, involve time-consuming analyses, and result in sample destruction.

A variety of materials including polymers [7,8], semiconductors [9,10], carbon nanomaterials [11], and organic/inorganic composites [12,13] have been utilized as sensing materials to detect specific molecules or ions based on various sensing techniques and principles. The sensitivity of a chemical sensor is strongly affected by the specific surface area of its sensing materials [14,15]. A higher specific surface area leads to higher sensor sensitivity. Therefore, many techniques [16–19] have been adopted to increase the specific surface areas of sensing materials. One such approach is the formation of nanostructures, taking advantage of the large specific surface areas of nanostructured materials.

Electrospinning is an efficient, relatively simple, and low-cost method to produce polymer and composite fibers with diameters ranging from several nanometers to a few micrometers. It involves applying a high voltage to a polymer solution or melt ejected from a micro-syringe pump [20–22]. The ultrafine fibers produced *via* electrospinning can be assembled as three-dimensional structured fibrous membranes with controllable pore structures and high specific surface areas. Thus, fibers prepared by electrospinning show higher sensitivity for specific metal ions compared to bulk solutions. Herein, we describe the Cs^+-sensing abilities of benzenetricarboxyamide (BTA)-based ligands **1** and **2,** and demonstrate an electrospun fiber incorporating **1** (**EF-1**) as a portable Cs^+ detection device.

2. Experimental section

2.1. Reagents and instruments

All reagents were purchased in Sigma-Aldrich. Solvents were purchased in samchun pure chemicals and used without further

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