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Rhodamine derivatives-loaded electrospun membranes for Hg^{2+} sensing membranes

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Abstract

It is well known that mercury (Hg) can cause serious human health problems as well as it can easily enter the food chain and accumulate in human body. This research aim is to find a practically alternative way to monitor the Hg ion which can be simply used and handle such as a naked-eye Hg ion strip tester. The sensing membranes were fabricated by electeospining process containing rhodamine derivatives based on hydrophobic polymer as the main media. The parameters of electrospinning process such as organic solvent types and polymer concentration were investigated. Moreover, sensitivity and interference for Hg^{2+} sensing membrane were investigated.

Key words: Electrospun membrane, Fibers, naked eye strip test, Hg detection, electrospinning.

Introduction

The Hg^{2+} and its derivatives are considered to be one of the most common and toxic pollutants. Their residues can be accumulated in the air, water, soil, marine, mines, industrial, plants, and animals including human beings which are parts of food chain [1]. Thus, rapid and efficient monitoring the presence of Hg^{2+} at low concentration in environmental and biological samples is very crucial and highly desirable.

Among fluorescent sensors for toxic element detection, rhodamine derivatives have been promising to be used as Hg^{2+} sensors. This is because it exhibits excellent photophysical properties including absorption and emission in visible wavelength light, high sensitivity and high selectivity. Rhodamine-based sensor could be worked effectively as "OFF – ON" Hg^{2+} fluorescent chemosensors. When selective ring of spirolactam in rhodamine molecules opened by binding with Hg^{2+} a color of rhodamine-based sensor changed and it was able to be observed by naked-eye [2]. Thus, this research focused on Hg^{2+} sensors based on rhodamine derivatives

In this research, the sensor molecules were loaded on both inorganic and polymeric substrates as the polymeric electrospun membrane sensors for Hg^{2+}.

Experimental

Polymer resin with a solubility parameter (δ) of 22.68 ($MPa^{1/2}$) about 10-20 wt.% was dissolved in binary solvent mixtures of acetic acid, acetone, chloroform, dichloromethane, dimethylformamide, ethanol, ethyl acetate, tetrahydrofuran and toluene. Mixture of solubility parameter ($\delta_{mixture}$) calculated as shown in follow:

$$\delta_{mixture} = \frac{X_1 V_1 \delta_1 + X_2 V_2 \delta_2}{X_1 V_1 + X_2 V_2} \qquad (1)$$

Where, X_1 and X_2 are mole fraction of solvent 1 and 2, respectively.
V_1 and V_2 are molar volume of solvent 1 and 2, respectively.
δ_1 and δ_2 are solubility parameter of solvent 1 and 2, respectively.
After that, the composition of mixture of solubility parameter ($\delta_{mixture}$)

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In theory of polymer dissolving to get a high surface area with a narrow distribution of fiber diameter, the different solubility parameter ($\Delta\delta$) between binary solvent mixtures and polymer were less than 0.5. Thus, the best composition of binary solvent mixtures should similar to polymer.

After that, the 0.1 %wt of rhodamine derivatives was added to the polymer solution (optimal binary solvent mixtures). Then, nanofiber membranes were prepared by electrospinning technique as in Fig. 1. The membrane were kept at room temperature with 30 %RH before testing.

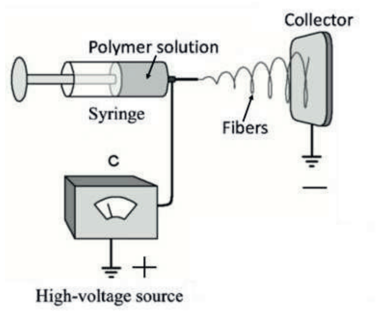

Fig. 1. Schematic diagram of electrospinning apparatus.

Results and Discussions

The optimal binary solvent mixtures which provided a high surface area with a narrow distribution of fiber diameter of membranes was ethanol/THF at 60/40 %v/v. The optimal of polymer concentration was 10 wt.%.

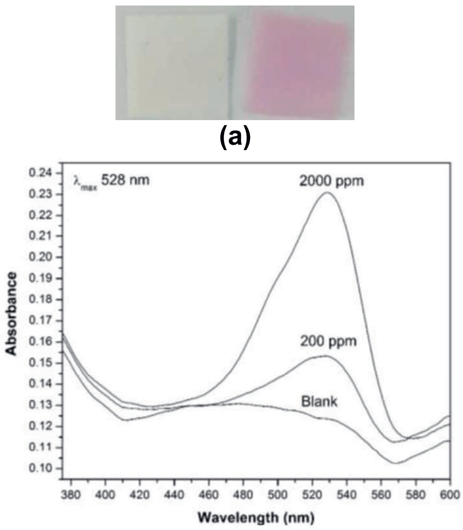

Fig. 2. (a) The color changes of 10 wt.% Polymer in EtOH/THF (60:40 %v/v) with 0.1 %wt rhodamine derivative membrane before (left) and after (right) adding Hg^{2+} ion concentration of 200 ppm. (b) The DRS UV–Vis absorption spectra of membrane with different Hg^{2+} ions concentrations.

Then, membranes were treated with different Hg^{2+} ions concentrations (200 and 2000 ppm). The metal ion binding property of rhodamine derivative was confirmed by UV–Vis spectroscopy. It indicated that new absorption maxima (λ_{max}) appeared at 528 nm, approximately, as seen Fig. 2 (a-b). These spectral changes could also be observed by the naked-eye. The color of this membrane changed from colorless to pink–orange.

Conclusions

Based on results, the rhodamine derivatives-loaded electrospun membranes exhibited a potential to use as naked-eye for Hg^{2+} sensing as a strip test.

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