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A Nanoporous Alumina Membrane based Impedance Biosensor for Histamine Detection with Magnetic Nanoparticles Separation and Amplification

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Abstract

Seafood, especially red fish is rich in histidine, which is essential for infants and adults. With fish freshness decline or spoilage, enzyme catalysis or microorganisms cause decarbonylation of histidine to form histamine, which threatens human body by dietary and affects allergic and inflammatory reaction. Current histamine assay needs complex operation, numerous steps, and time-consuming. In this study, a functionalized nanoporous alumina membrane was used to construct a rapid and highly sensitive impedance biosensor with magnetic nanoparticles (MNPs) for target molecule pre-concentration and separation. When the functionalized MNPs accumulated histamine, they were separated by magnetism from samples and added to the anti-histamine antibody modified nanoporous alumina membrane causing blocking effect in the nanopores by immune reaction. Impedance increased as histamine concentrations increased from 1 μM to 40 mM. The limit of detection was as low as several micromolar. The biosensor provides a novel, highly sensitive and specific sensing mechanism and constructs a new technology and method for justifying seafood freshness to prevent toxic reaction in human body. It is a new approach for food quality safety control.

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Keywords: Nanoporous alumina membrane; magnetic nanoparticles; impedance biosensor; histamine

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1. Introduction

Histamine is a heterocyclic organic compound formed by decarbonylation of histidine caused by enzyme catalysis or microorganisms, found in various kinds of food, especially in seafood [1]. It is known to be the causative substance in many food poisoning cases. Current histamine assay needs complex operation, numerous steps, and time-consuming. In this study, a functionalized nanoporous alumina membrane was used to construct a rapid and highly sensitive impedance biosensor with magnetic nanoparticles (MNPs) for target molecule accumulation, separation and signal amplification.

2. Methods

Dimercaptosuccinic acid (DMSA) modified MNPs were activated by N-(3-Dimethylaminopropyl)-N-ethylcarbodiimide (EDC)/N-Hydroxysuccinimide (NHS) for anti-histamine antibody immobilization. When the functionalized MNPs accumulated histamine, they were separated by magnetism from samples and added to the anti-histamine antibody modified nanoporous alumina membrane. It can be measured by impedance analyzer.

3. Results

Impedance increased as histamine concentrations increased from 1 μM to 40 mM (Fig.1a). Fig. 1b showed the relative impedance change percentage of different histamine concentrations. It presented good linearity with impedance increase about 4.4% to 30.6% for histamine concentrations from 1 μM to 40 mM. The limit of detection was as low as several micromolar for histamine detection. It demonstrated the potential for rapid histamine detection for safety confirmation of fish and seafood products

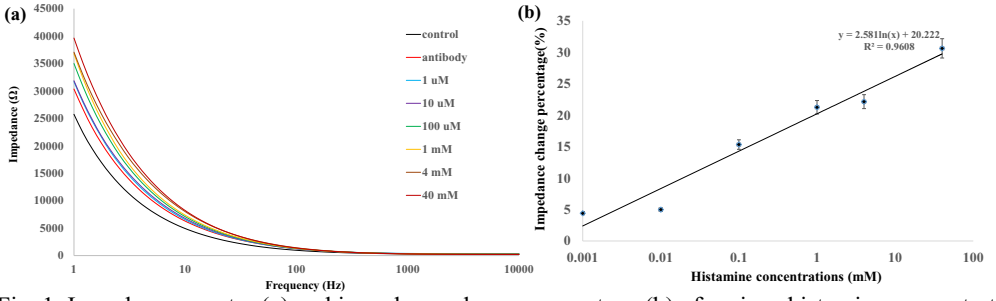

Fig. 1. Impedance spectra (a) and impedance change percentage (b) of various histamine concentrations.

4. Conclusions

The nanoporous alumina membrane based impedance biosensor provides a novel, highly sensitive and specific sensing mechanism and constructs a new technology and method for early justifying seafood freshness to prevent toxic reaction in human body. It is a new approach for food quality safety control.

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