Measurement 238 (2024) 115305

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Detection of 17-α-Ethinylestradiol with Bio-Functionalized tapered optical fiber sensor

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ARTICLE INFO

Keywords:
17-α-ethinylestradiol
Estrogen hormone
Environmental pollution
Optical biosensor
Tapered optical fiber
Wavelength shift

ABSTRACT

This paper presents the utilization of tapered optical fiber (TOF) biosensor for the detection of 17-α-ethinylestradiol (EE2), an estrogen hormone. TOF with a waist diameter of 12 μm was fabricated from single mode fiber using heat and pull method. The tapered area was used as the sensing interface between the evanescent waves propagating around the fiber due to its unique geometry and the attached molecules on the tapered surface. EE2 antibodies were used as biorecognition molecules towards the targeted analyte, EE2. When tested with different concentrations of EE2 within the range of 0.1 ng/L – 1 mg/L, the developed sensor attained a detection limit of 1 ng/L with a sensitivity value of 1.088 nm/ngL^{-1} within the operation range of 1 – 10 ng/L. The specificity of the sensor was validated by testing the developed sensor with estrone (E1) and no significant wavelength shift was observed. These findings highlight the potential of our approach for sensitive and selective detection of EE2.

1. Introduction

Environmental pollution is a critical global issue that demands continuous research and innovation to develop effective monitoring techniques. Among various pollutants, endocrine-disrupting compounds (EDCs) have emerged as a significant concern due to their adverse effects on the ecosystem and human health. EDCs have been identified as hazardous components of river and surface water pollution. The ability of EDCs to disrupt the normal function of endocrine systems affects the reproduction systems of living organisms. Therefore, this intervention would modify the hormone's stability and lead to health complications such as infertility, cancer, diabetes, and feminization in aquatic organisms.

Among EDCs, 17-α-ethinylestradiol (EE2) is the most hazardous compound due to the harm it will cause even at low concentrations (ng/L). It has the lowest predicted-no-effect concentration (PNEC) of 0.1 ng/L compared to other EDCs. This synthetic estrogen hormone is derived from the natural estrogen hormone called 17-β-Estradiol (E2). EE2 is commonly used in oral contraceptives and hormone replacement therapies, which eventually finds its way into the environment through wastewater discharge, agricultural runoff, and industrial effluents. Consequently, the contamination of water sources with EE2 has raised an alarm, urging researchers to devise efficient detection methods to safeguard ecological balance and public health.

In response to the pressing need for EE2 detection, researchers have developed various analytical techniques, including spectrometry [8,35], liquid and gas chromatography [4,7,27], immunoassay [29,31,38], and electrochemistry [14,23,37]. Recently, chromatography-based techniques such as high-performance liquid chromatography (HPLC), liquid chromatography (LC), and liquid chromatography-mass spectrometry (LC/MS) methods are widely used to determine EE2 in environmental samples [19,34]. These methods, which have high sensitivity,

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https://doi.org/10.1016/j.measurement.2024.115305
Received 4 April 2024; Received in revised form 4 July 2024; Accepted 11 July 2024
Available online 14 July 2024