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Simple paper-based colorimetric and fluorescent glucose sensor using N-doped carbon dots and metal oxide hybrid structures

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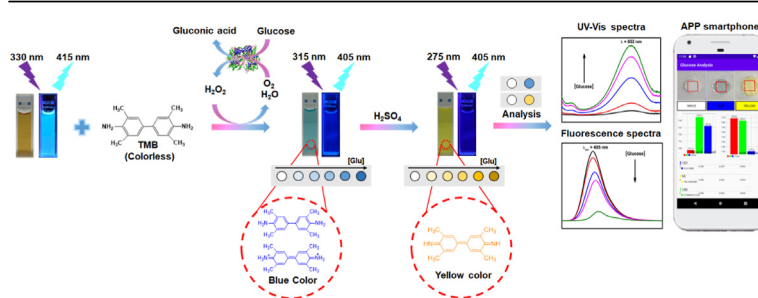
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HIGHLIGHTS

- Metal oxide hybrid with N-doped carbon dots (MFNCDs) as a peroxidase-like catalyst was fabricated by a hydrothermal method.
- A colorimetric and fluorescent sensor for H₂O₂ and glucose was developed.
- The MFNCDs exhibited excellent selectivity towards glucose.
- MFNCDs showed low cytotoxicity and excellent biocompatibility.

GRAPHICAL ABSTRACT



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ABSTRACT

A new strategy for the fluorescent and colorimetric sensing of hydrogen peroxide (H₂O₂) and glucose based on the metal oxide – carbon-dot hybrid structure was investigated. The sensing system is related to the catalytic oxidation reaction of glucose-by-glucose oxidase (GOx) to H₂O₂. In this study, a metal oxide hybrid with nitrogen-doped carbon dots (MFNCDs) that showed intrinsic peroxidase-like activity was synthesized and used as a catalyst instead of GOx to oxidize 3,3',5,5'-tetramethylbenzidine (TMB) to blue-emitting oxidized TMB (oxTMB) in the presence of hydrogen peroxide (H₂O₂). The fluorescence of MFNCDs/TMB at 405 nm was quenched in the presence of H₂O₂ through the inner filter effect (IFE) and electron transfer within MFNCDs, oxTMB, and glucose system. Therefore, the fluorescence and absorbance intensity can be applied to the quantitative determination of the concentration of H₂O₂ and glucose with a wide linear range. The detection limit for H₂O₂ and glucose based on the colorimetric method were as low as 84 nM and 0.41 μM, respectively. In contrast, the detection limit for H₂O₂ and glucose based on the fluorescent method were as low as 97 nM and 0.85 μM, respectively. Furthermore, the colorimetric readout on the paper device based on the changing color of the solution could also be integrated with a smartphone platform to conduct the on-site analysis of glucose without the use of the spectrometer. In addition, this dual sensor can be applied to detect glucose in real serum with highly accurate results, making it a good candidate for biosensor applications.

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1. Introduction

Diabetes mellitus is one of a group of metabolic disorders

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