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A label-free colorimetric sensor for sulfate based on the inhibition of peroxidase-like activity of cysteamine-modified gold nanoparticles

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Abstract: A simple label-free colorimetric sensor for sulfate has been devised based on the analyte-induced shielding of peroxidase-like activity of cysteamine-capped gold nanoparticles (cyst-AuNPs). Aggregation triggered by sulfate through hydrogen bond and electrostatic interaction gave rise to a remarkable decrease of the catalytic activity of AuNPs. By coupling with 3,3',5,5'-tetramethylbenzidine (TMB)-H₂O₂ chromogenic reaction, a novel colorimetric sensor for detection of sulfate was established. Based on the signal amplification effect of the catalytic reaction, a detection limit as low as 0.16 μM was obtained by virtue of UV-vis spectroscopy or 4 μM with the naked-eye observation. The as-proposed sensor exhibited an excellent selectivity over other common anions and metallic ions. In view of these characteristics, such sensing probe features simplicity, cost-effectiveness, and naked-eye screening. These advantages make this sensor a powerful protocol for the quantitative detection of sulfate in water samples with satisfactory results.

Key words: Colorimetric sensor, Sulfate, Gold nanoparticles, Peroxidase-like activity, 3,3',5,5'-tetramethylbenzidine.

1. Introduction

The specific recognition and sensing of anions has been an active field of research owing to their ubiquity and the pivotal roles they play in the ecosystems^{1,2}. Sulfate is widely presented in natural water and wastewater released by a number of industrial processes, such as in the chemical industry, metallurgy, electrolysis, papermaking and so on³. Additionally, magnesium sulfate is always introduced into the mineral water to supply the essential trace element of human body. According to Environmental Protection Agency (EPA) of USA, the maximum tolerated concentration of sulfate in drinking water is 250 ppm⁴. However, the abnormal concentration of sulfate can affect the metabolism of aquatic plants and lead to diseases such as diarrhea, gastroenteritis and so on⁵. Moreover, sulfuric acid has been reported to be the cause of acid rain. The level of sulfate is considered to be an important indicator or tracer of the effects of factory and automobile exhaust gases⁶. Thus, sulfate detection is of great significance for clinical diagnosis as well as water quality and environment monitoring. To date, many strategies, such as spectrophotometry, gravimetric method, ion chromatography and microbial method⁷⁻⁹ have been documented for the quantification of sulfate. Despite of high accuracy, most of these methods suffer from defects of high cost, time-consuming experimental procedure and sophisticated instrument manipulation. Consequently, there is a great need to further develop simple, reliable and low-cost methods for rapid and sensitive determination of sulfate.

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