NITROGEN- AND SULFUR-CO-DOPED GRAPHENE OXIDE AS AN EFFICIENT METAL-FREE CATALYST FOR PERSULFATE ACTIVATION IN VANCOMYCIN DEGRADATION

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Vancomycin plays a vital role in the treatment of severe bacterial infections, particularly those caused by drug-resistant pathogens. Nevertheless, its release into water systems through improper disposal can pose significant environmental and public health risks. Addressing these issues requires implementing advanced water treatment technologies alongside responsible antibiotic stewardship strategies. In this study, a sustainable approach was employed to synthesize nitrogen- and sulfur-doped graphene oxide (NSGO), which was used as a persulfate activator for the degradation of vancomycin. The results showed that VAN was reduced to below the detection limit (ADD) within 5 minutes at near-neutral pH and room temperature (NSGO: 50 mg/L, VAN: 10 mg/L, volume: 50 mL), demonstrating superior performance compared to graphene oxide.

Keywords: Vancomycin, Graphene oxide, Persulfate, Activator, Room temperature

INTRODUCTION

Vancomycin is an essential antibiotic widely used to treat bacterial infections, particularly those resistant to conventional drugs. However, its extensive use has led to its accumulation in aquatic environments, raising concerns for both environmental and human health. The presence of antibiotics such as vancomycin in water bodies can promote the development of antibiotic-resistant bacteria in aquatic systems, which may ultimately impact humans through contaminated water and food sources [1]. In recent years, advanced oxidation processes (AOPs) have gained significant attention as highly efficient methods for the degradation of organic contaminants. In particular, sulfate radical-based advanced oxidation processes have demonstrated strong potential for wastewater treatment because of their high oxidation capability, broad applicability toward various pollutants, and adaptability under different operating conditions [1]. Notably, graphene oxide (GO) has attracted increasing interest due to its distinctive physicochemical properties and its effectiveness in activating persulfate for the

degradation of Vancomycin in aqueous systems [2]. Most GO production methods rely on hazardous reagents. The widely used Hummer's method [2], for example, involves concentrated sulfuric acid, permanganate, and hydrogen peroxide, among other strong oxidizing agents. In contrast, electrochemical synthesis offers a safer and more environmentally sustainable route for GO fabrication [2].

METHODOLOGY

NSGO is synthesized via a one-pot in situ electrochemical exfoliation process. The synthesis is carried out by applying a constant voltage of 10 V for 4 hours, during which the graphite foil undergoes electrochemical exfoliation to form a graphene oxide suspension. Following the reaction, the black powder is collected by filtration, thoroughly washed with deionized water to remove residual impurities, and subsequently dried at 55°C for 24 hours.

RESULT

The chemical structure of the NSGO activator was validated using a range of analytical techniques. The EDX spectrum confirmed the presence of nitrogen, sulfur, oxygen, and carbon in the NSGO sample, indicating successful in situ heteroatom doping within the material Fig. 1.

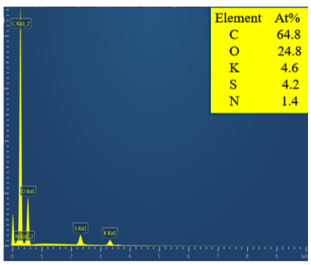


Figure 1: EDX image of NSGO.

The concentration decreases sharply from its initial value and reaches nearly zero within 5 minutes, indicating highly efficient degradation. The concentration then remains undetectable throughout the 60 minutes, confirming the excellent catalytic performance and stability of the NSGO activator under the experimental conditions Fig. 2.

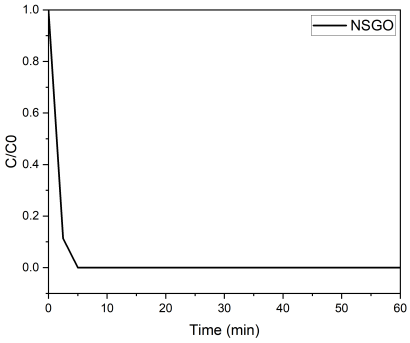


Figure 2: Vancomycin removal efficiency.

CONCLUSIONS

This study investigates the removal of Vancomycin from water using a greener NSGO catalyst. NSGO was synthesized via a one-pot electrochemical method and characterized using SEM, Raman, and EDX. It effectively activated persulfate, achieving rapid degradation of vancomycin to below detection limits within 5 minutes under neutral pH and using NSGO (50 mg/L) and the concentration of sodium persulfate (1 mmol/L). The results demonstrate high efficiency and improved performance over undoped graphene oxide.

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