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Magnetic carbon-based photosensitizers for the removal of antibiotics from water

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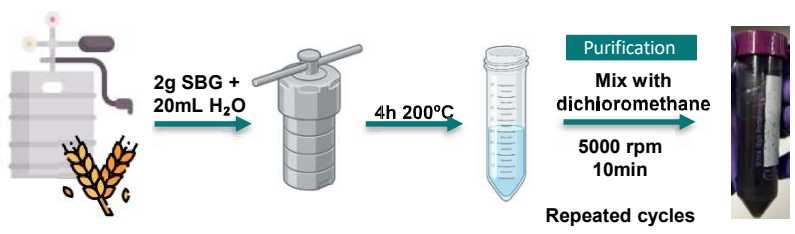
INTRODUCTION

The combined challenges of water scarcity and increasing pharmaceutical contamination, specifically antibiotics, pose significant risks to ecosystems, as well as to human and animal health. Advanced oxidation processes, particularly photocatalysis powered by natural sunlight, provide an environmentally friendly method for removing antibiotics from water. Carbon Quantum Dots (CQDs) are promising photocatalysts, and their efficiency improves when paired with semiconductor materials, such as titanium dioxide (TiO_2). Producing CQDs from biomass waste like spent brewery grains (SBG), also supports circular economy goals by converting waste into useful materials. By integrating the photocatalysts with magnetic components, the resulting materials become magnetically recoverable, enabling easy separation from treated water and efficient reuse after antibiotic degradation.

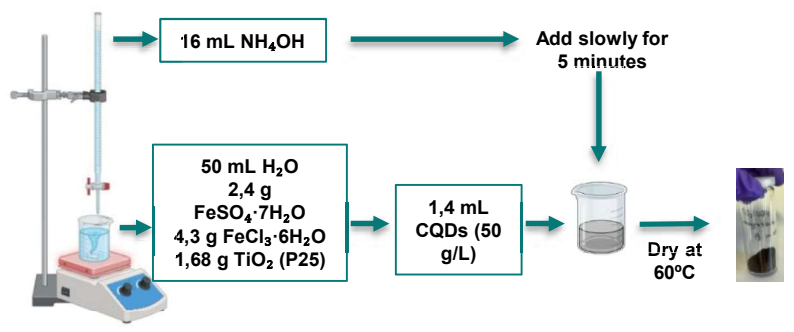
This work aims to synthesize magnetic TiO_2/CQDs (Mag-TiO_2/CQDs) photocatalyst using SBG as a sustainable carbon source and to evaluate their efficiency in the photocatalytic degradation of sulfamethoxazole (SMX) and trimethoprim (TMP) in water.

METHODOLOGY

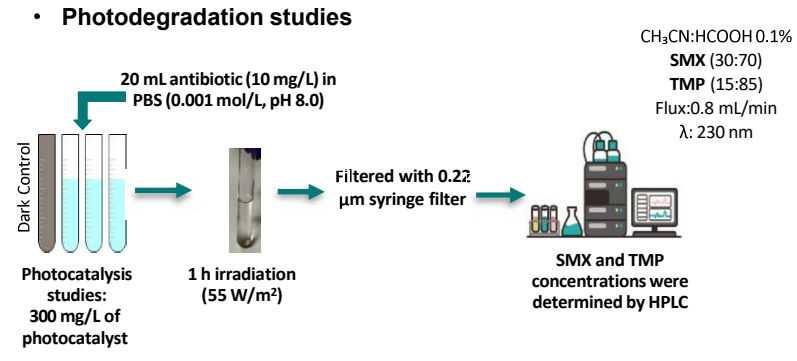
- **CQDs synthesis**



- **In situ co-precipitation: magnetic TiO_2/CQDs synthesis**

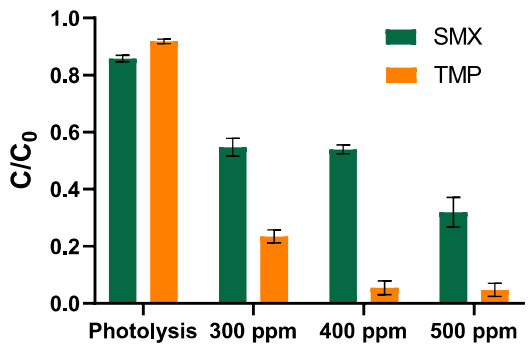


- **Photodegradation studies**



RESULTS & DISCUSSION

Catalyst loading optimization



Optimal catalyst loading at 300 ppm, providing good SMX/TMP removal while minimizing material costs compared to higher dose

Fig 1. Results for the application of different concentrations of Mag-TiO_2/CQD for the removal of a mix of 10 mg/L of SMX and TMP in PBS (pH = 8) after 1 hour of irradiation.

Kinetic studies

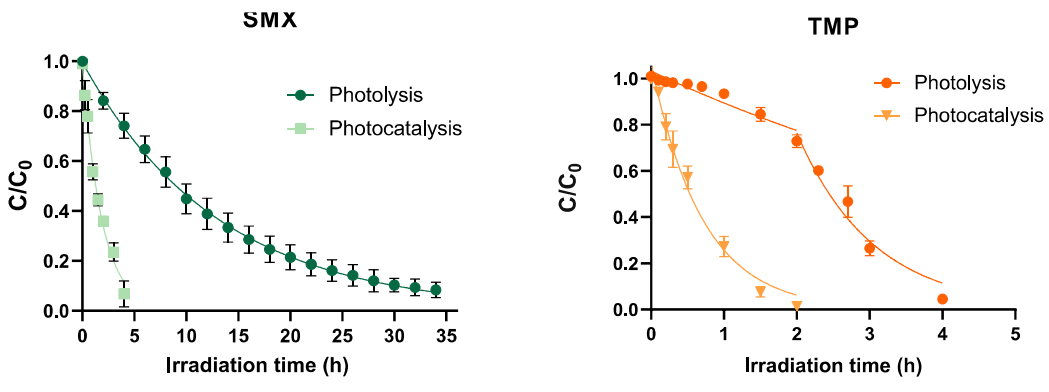


Fig 2. Kinetics of photolysis and photocatalysis with Mag-TiO_2/CQDs (300mg/L) of TMP and SMX, in PBS (pH=8).

Mag-TiO_2/CQDs

- **Increase of 9 times in SMX removal**
- **Increase of 5 times in TMP removal**

Effects of pH in photocatalysis

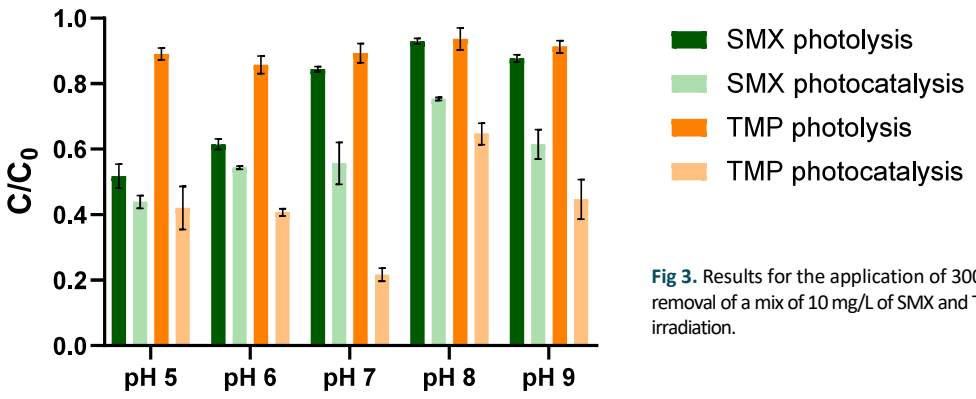


Fig 3. Results for the application of 300 mg/L of Mag-TiO_2/CQD for the removal of a mix of 10 mg/L of SMX and TMP in PBS (pH 5-9) after 1 hour of irradiation.

Mag-TiO_2/CQDs efficiently degrades SMX/TMP at every tested pH, demonstrating good operational versatility for real WWTP conditions (pH 6-9 range)

CONCLUSIONS

- **Mag-TiO_2/CQDs photocatalysts derived from SBG shows much higher degradation than photolysis for removing TMP and SMX from water, achieving approximately 5-fold and 9-fold increases in removal efficiency respectively;**
- **The results demonstrate the versatility and the promising potential of the photocatalyst for wastewater treatment, in line with economy principles.**

Acknoledgements

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