Photodegradation of synthetic dyes with Ag decorated WO3 structures under UV and visible light and its antibacterial activity

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1 Introduction

Industrial operations have played a significant role in the production of dyes with a main focus on the manufacturing and textile sectors. Millions of tons of dyes are produced each year mainly because of the growth in the global economy to be used in paper, plastic, and textiles among others. These textile effluents contain many azoic, anthraquinonic, and heteropolyaromatic dyes [1].

The main source of aquatic pollution is through the release of dyes from industries into water bodies. Textile dyes are released into the environment without being treated first because people are unaware of it and keep doing so regularly. The continuous discharge of textile dyes into the atmosphere causes a decrease in water quality through eutrophication and turbidity, which causes long-term effects such as the accumulation of carcinogenic products. In addition, textile dyes are persistent and produce by-products that can also be carcinogenic or mutagenic [2].

Synthetic dyes are not biodegradable and have serious implications for the environment and health. They build up on rivers and lakes causing ecological problems [3]. Methylene blue is among the most toxic synthetic dyes. It causes harm to aquatic life and human health by causing respiratory problems, skin irritations, blindness, etc [4]It is therefore important to remove these dyes from wastewaters.

The elimination of synthetic dyes using conventional wastewater treatment methods like physical filtration, chemical precipitation, or biological degradation is often not enough, and new methods like photocatalysis hold promising potential for dye degradation [5]. For example, photocatalytic materials such as Ag-decorated WO show great advantages since they can break down these colors under UV and visible light thus enabling environmentally friendly efficient treatment of waste waters [6-7]. The primary goal of this study is to synthesize and characterize Ag decorated WO for photodegradation of methylene blue (MB) intending to provide an alternative way out against water-born dye pollution.

2 Background

A month ago, I joined research initiated by Professor Timur Atabayev and his team to deal with a major environmental problem of water pollution caused by artificial dyes. Since then, I have been involved in this ongoing project under Dr. Yerkanat Kanafin's supervision, which has enabled me to gain insights from his extensive experience. As this work is still unfinished, this research paper will only include materials and information that are present today.

The current challenge arises from the continuous dumping of untreated textile coloring agents into water bodies which presents a significant ecological and health risk. There are dangerous dyes such as methylene blue that are highly poisonous and make breathing difficult, cause skin irritations and other complications both for aquatic life and humans. Traditional technologies for wastewater treatment cannot effectively treat these persistent pollutants.

This study aims to find new techniques through the synthesis and characterization of Ag-decorated WO3 , a photocatalyst material that can break down these carcinogenic substances under UV or visible light rays. The novel approach is aimed at establishing an efficient method of removing dye-contaminated water from industries through more eco-friendly ways hence minimizing water-borne dye pollution.

Keywords: Ag/WO, methylene blue, photocatalysis, antibacterial activity, UV light, visible light, nanoparticles, synthesis, characterization, NaBH, AgNO.

3 Materials and Methods

Tungsten (VI) oxide (WO_3, 99.5%), silver nitrate ($AgNO_3$, 99.0%), methylene blue dye (MB $\geq$95.0%), sodium borohydride ($NaBH_4$, 99.0%), isopropanol (99.5%), potassium iodide (99.0%), and p-benzoquinone (98.0%) were purchased from Merck KGaA (Darmstadt, Germany) and used as received.

50 mg of WO powder was mixed with 50 mL of pure water and was subjected to ultrasonic treatment for thirty minutes in order to achieve a uniform dispersion. The suspension of WO was stirred continuously for one hour while adding an aqueous solution of silver nitrate (AgNO) to it. During stirring, the sodium borohydride (NaBH) was added dropwise, and this mixture was further stirred for two hours so that complete reduction of Ag ions into Ag nanoparticles would take place. Then, this mixture was centrifuged to gather Ag-decorated WO particles which were washed repeatedly using deionized water and then dried in an oven at 60°C over several hours.

Photocatalyst (2 mg) was dispersed in 6 mL of methylene blue solution (1×10 M) and stirred for 30 minutes in the dark to achieve adsorption - desorption equilibrium. Samples were illuminated using an LCS-100 solar simulator (100 W, AM 1.5G filter, Newport-Spectra Physics GmbH, Darmstadt, Germany) for a specified duration. Dye concentrations were measured using a UV-Vis spectrophotometer (Thermo Fisher Scientific Inc., Waltham, MA, USA).

Scavenging solutions with a concentration of 2 mmol were prepared first, i.e.,

potassium iodide (KI) as hole capturer, isopropanol (IPA) as ˙OH capturer, and p-benzoquinone (BQ) as ˙O2 capturer. Scavenging agents were added to dye solutions containing the photocatalyst before illumination. Post-illumination, solutions were filtered, and dye concentrations were determined with a UV-Vis spectrophotometer.

A scanning electron microscope (SEM, Auriga Crossbeam 540, Carl Zeiss, Oberkochen, Germany) equipped with energy-dispersive X-ray spectroscopy (EDX, Aztec, Oxford Instruments, Abingdon, UK) was used for morphological and elemental analyses. The morphology of prepared samples was also observed using a transmission electron microscope (TEM, JEM2010F, JEOL Ltd., Tokyo, Japan).

4 Future Plans

In the future we will continue to investigate the photocatalytic activity of Ag-decorated WO. In order to completely assess the performance of this photocatalyst under different light sources, further experiments will be conducted on the degradation of methylene blue (MB) and rhodamine B (RhB) under UV, visible, and solar light.

Moreover, X-ray diffraction (XRD) analysis will be carried out to reveal information about the crystalline structure and phase composition of Ag-decorated WO. This characterization is essential for understanding the material's structural properties and its relationship with photocatalytic activity.

Also, we plan to assess antimicrobial properties for 1% Ag-WO. Hence it may be necessary to determine if it can act against many different microorganism species so that they can determine its potential application in areas such as antimicrobial treatments and environmental sanitation.

5 References

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