Electrochemical characterization of WO_3 and $WO_3/BiVO_4$ photoelectrodes and their application in the photoelectrochemical degradation of amoxicillin

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The widespread use of antibiotics, pesticides, and other organic pharmaceuticals leads to their accumulation in aquatic environments, including surface and wastewaters. Stringent environmental regulations require new water treatment approaches for various industries and municipal systems. Amoxicillin, a commonly used antibiotic, is considered an emerging contaminant [1] due to its uncertain impact on human health and the environment. Existing wastewater treatment methods often fail to efficiently remove amoxicillin, leading to its persistence in drinking water and natural water bodies. Photoelectrochemical processes offer a promising solution for decomposing organic contaminants in aquatic systems.

Both semiconductor materials examined in this work, WO_3 and $BiVO_4$, exhibit valuable properties for photoelectrochemical applications, including strong chemical stability and long lifespan, low toxicity, cost-effectiveness, and efficient charge carrier separation. Due to the bandgap in the range of 2.6–2.8 eV, WO_3 very efficiently absorbs photons within the UV range. However, its absorption in the visible light region (wavelengths above 400 nm) is limited. $BiVO_4$, on the other hand, has a bandgap of ~2.4 eV and absorbs solar radiation in the visible light region of the spectrum, specifically wavelengths ranging from approximately 400 to 600 nm. Combining these two materials results in a broader range of absorption across the visible light spectrum. According to literature findings, a $WO_3/BiVO_4$ heterojunction enables improved charge transfer and reduced charge recombination compared to the individual materials, thereby enhancing the efficiency of photoelectrochemical processes.

In this study, WO_3 was electrodeposited onto an FTO (fluorine-doped tin oxide) glass substrate from an acidic aqueous solution, following an electrochemical procedure adapted from Yourey and Bartlett [2]. The photo-electrochemical activity of the fabricated electrode was assessed under irradiation from a LED lamp (COB, 50 W, 4400 lm, 6000K). Various electrochemical techniques, including linear sweep voltammetry (LSV), electrochemical impedance spectroscopy (EIS), open circuit potential measurement (OCP), Mott-Schottky analysis, and chronoamperometry (CA), were employed to characterize the electrodes. The electrodes exhibiting the most promising responses were then coated with a $BiVO_4$ layer using a drop-casting approach, characterized using the aforementioned electrochemical methods, and further evaluated for the photoelectrochemical degradation of amoxicillin. In addition to the electrochemical measurements, UV-Vis spectroscopy and X-Ray diffraction analysis were also conducted.

Acknowledgement: This work has been fully supported by Croatian Science Foundation under the project NaSCEnT (IP-2018-01-1982).

References

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