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Case Report

Highly efficient CuO-doped titania nanotube arrays in photocatalysis-electrocoagulation process for bacterial disinfection

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ABSTRACT

This study investigates the efficacy of the photocatalysis-electrocoagulation hybrid process for bacterial disinfection. The photocatalyst used was titania nanotubes array (TiNTA) doped with CuO using the SILAR (Successive Ionic Layer Adsorption and Reaction) method from the $CuCl_2$ precursor. The synthesized CuO-TiNTA nanocomposite was confirmed with FESEM/EDX, HRTEM, XRD, and UV–Vis DRS. FESEM and HRTEM confirm the formation of TiNTA, while EDX, SAED, and XRD confirm the presence of anatase TiO_2 and CuO. Adding CuO towards TiNTA decreases the band gap energy of TiNTA, which UV–Vis DRS confirms. CuO-TiNTA had better photocatalytic activity when compared to undoped TiNTA, which increased its antibacterial performance due to the dopant's effect on photocatalyst and dopant antibacterial capability. Comparatively, electrocoagulation had better performance than photocatalysis. However, when combined with photocatalysis, the overall hybrid performance was far superior to other processes used in this study.

1. Introduction

A significant amount of organic waste effluent, primarily antibiotics, has recently been released into the environment due to growing activity in several industrial sectors, including hospitals and pharmaceuticals [1–4]. This situation and the new worries about the growth in multidrug-resistant (MDR) bacteria, which have greater resistance and the ability to mutate, lead to increased environmental contamination [5–7]. Such circumstances must be immediately addressed by using effective technology to protect the environment and public safety [4] and stop the escalating risks that these water conditions pose to future generations.

One method that has shown to be very successful in getting rid of bacteria, including MDR, in liquid waste is photocatalysis technology [8–10]. This method is inexpensive and straightforward because it utilizes sunlight for its operation without any need for additional treatment. Through various techniques, oxidative stress is applied to the bacterial cell walls, preventing the bacterial metabolism from transforming and making this strategy of fighting MDR bacteria possible [7]. A common problem in the application of this technology is the excessively high electron-hole recombination rate and the restricted photon energy spectrum that can initiate the process. Both of these issues can be solved to improve the efficiency of the photocatalysis process. It has been common practice to overcome these problems by doping TiO_2 photocatalyst semiconductors with several dopants. Studies on the applications of metal or metal oxide dopants, such as Cu, Ag, and Zn, have been done about their application for removing bacteria [11–13]. Cu is one of the most commonly utilized dopants due to its easy availability, affordable price, stable characteristics, and simple synthesis method. Nevertheless, the current research merely looked at Cu-doped systems in TiO_2 particles, where challenges with post-process separation from the solution remain behind when photocatalysis is used in particle form. The effectiveness of TiO_2 morphological ones, such innovations as Titania Nanotubes Array (TiNTA) film layers for eliminating bacteria in liquid waste, has not been thoroughly tested. TiNTA will simplify the post-photocatalysis steps, ensuring that TiO_2 is easily separated and not combined with the waste solution.

Subsequently, an attempt was made to enhance efficiency by combining the photocatalysis and electrocoagulation processes, which, although using different mechanisms, can both eliminate bacteria. It is

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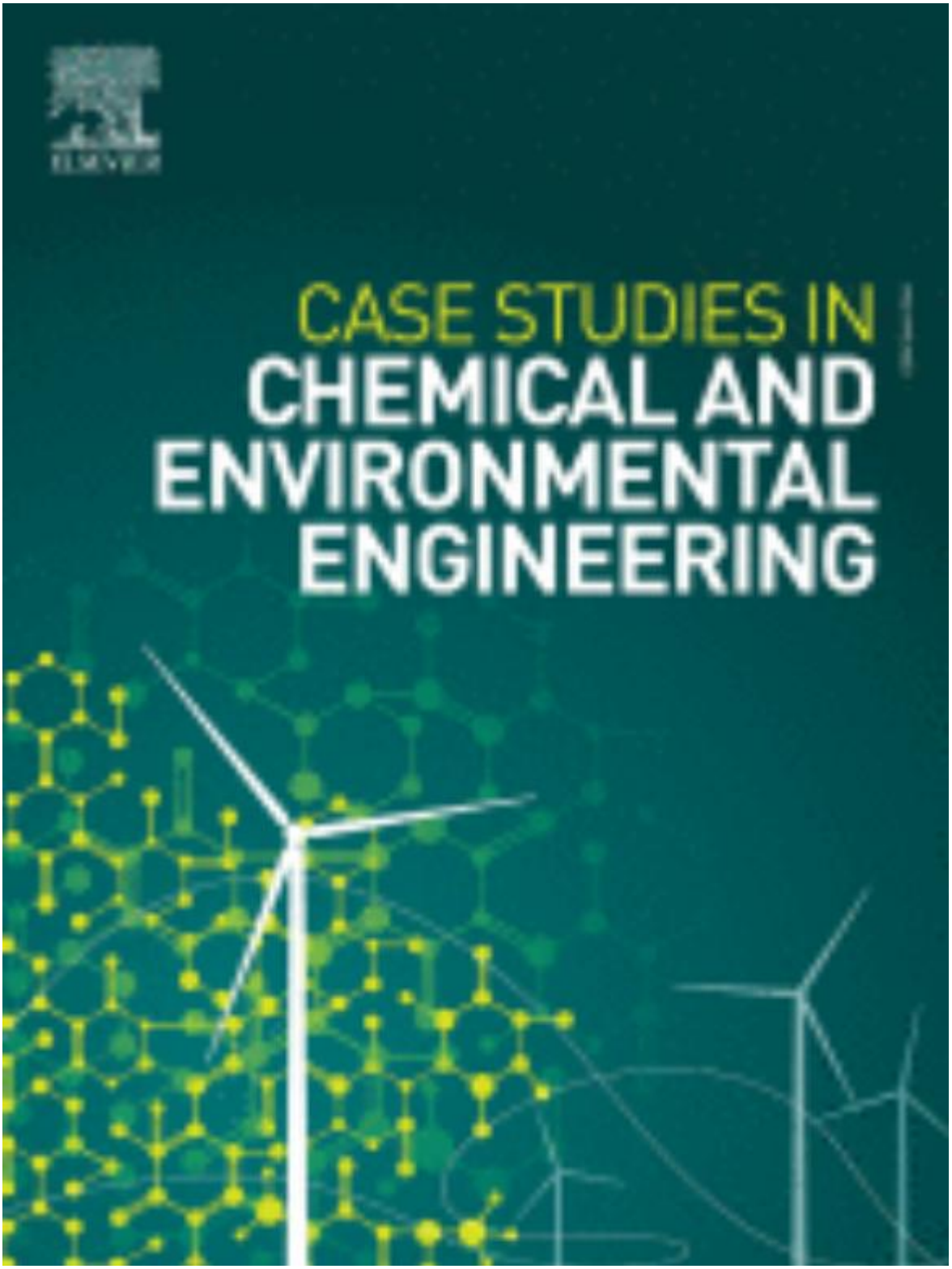

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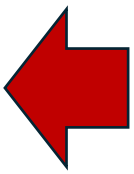

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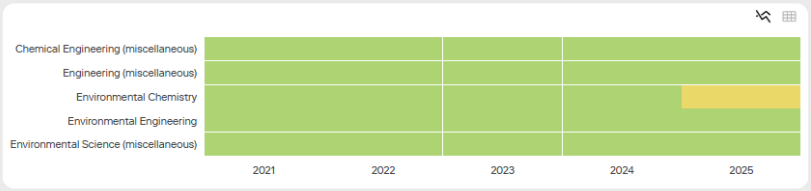

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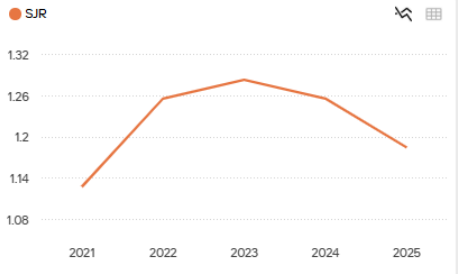

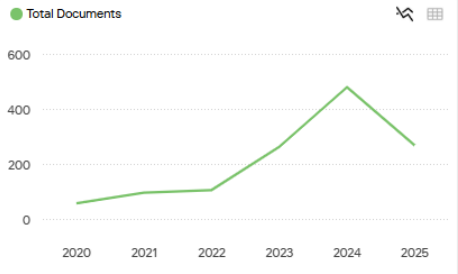

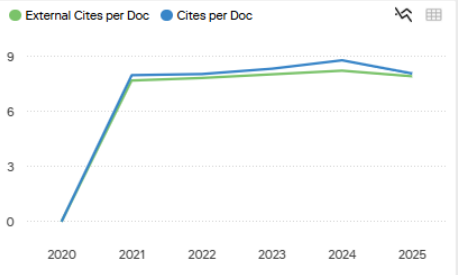

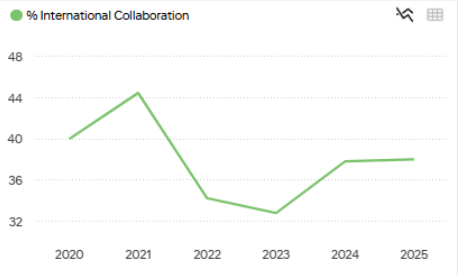

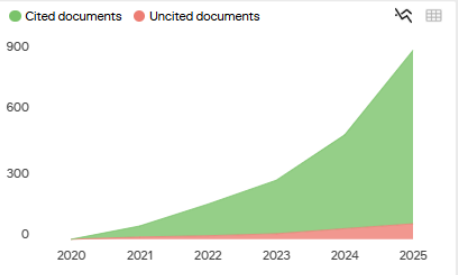

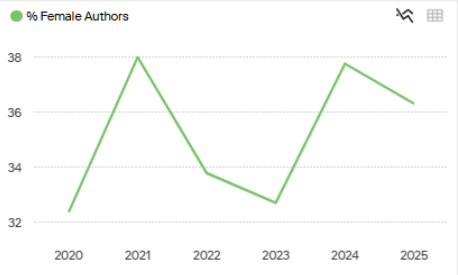

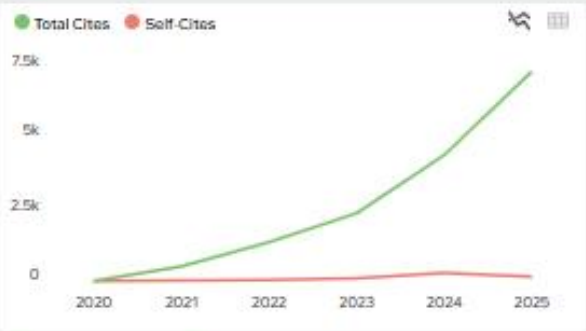
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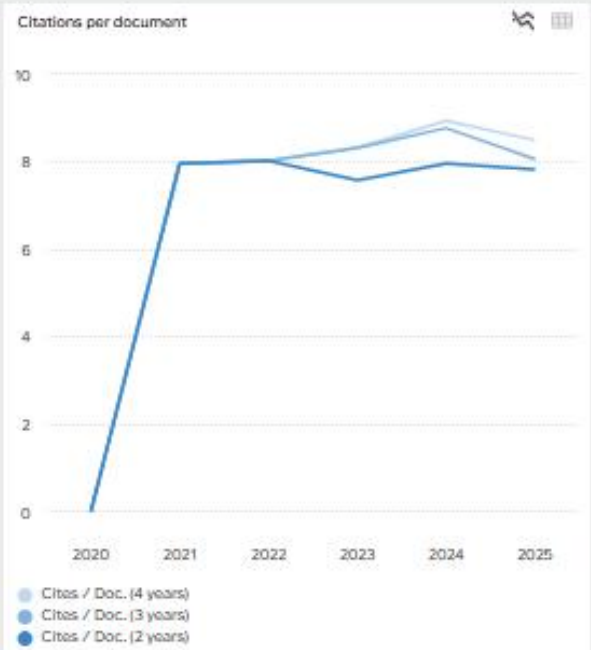
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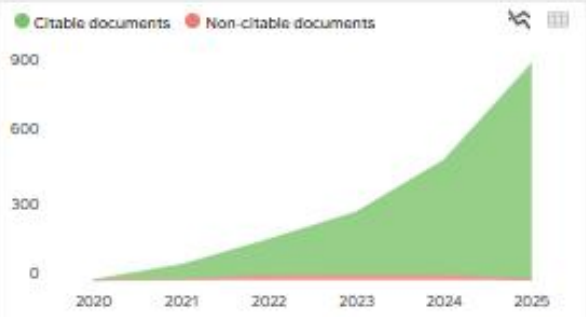
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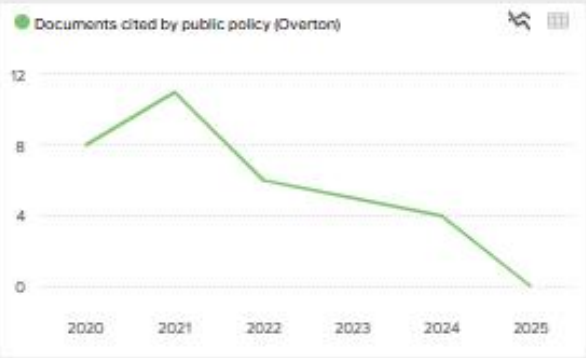
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Abstract

This study investigates the efficacy of the photocatalysis-electrocoagulation hybrid process for bacterial disinfection. The photocatalyst used was titania nanotubes array (TiNTA) doped with CuO using the SILAR (Successive Ionic Layer Adsorption and Reaction) method from the $CuCl_2$ precursor. The synthesized CuO-TiNTA nanocomposite was confirmed with FESEM/EDX, HRTEM, XRD, and UV–Vis DRS. FESEM and HRTEM confirm the formation of TiNTA, while EDX, SAED, and XRD confirm the presence of anatase TiO_2 and CuO. Adding CuO towards TiNTA decreases the band gap energy of TiNTA, which UV–Vis DRS confirms. CuO-TiNTA had better photocatalytic activity when compared to undoped TiNTA, which increased its antibacterial performance due to the dopant's effect on photocatalyst and dopant antibacterial capability. Comparatively, electrocoagulation had better performance than photocatalysis. However, when combined with photocatalysis, the overall hybrid performance was far superior to other processes used in this study. © 2024 The Authors