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Research Article

Photocatalytic Efficiency of TiO_2-Biomass Loaded Mixture for Wastewater Treatment

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The objective of this study was to assess the efficiency of a novel TiO_2/modified sago bark (TiO_2/MSB) mixture for the degradation of sago wastewater effluent by employing response surface methodology (RSM) using chemical oxygen demand (COD) removal as the target parameter. The highest COD removal of 64.92% was obtained using TiO_2/MSB mixture sample prepared by combining 0.2 g/L TiO_2 and 1 w/w% MSB. Given that the highest removal was produced using this mixture sample, further optimisation of sago wastewater treatment was conducted by varying the independent variables, namely, dosage and contact time. Under this optimum condition, 0.10 g of 0.2 g/L TiO_2/1% MSB had successfully reduced 52.83% COD in 120 min. Surface morphology, functional groups, and elemental analysis supported observations of the ability of TiO_2/MSB mixture to remove COD. Additionally, aeration had further improved COD removal by 11%. The regression value ($R^2 > 0.99$) of the model indicated a high degree of correlation between the evaluated parameters. These results proved the feasibility of TiO_2 photocatalysis as an appealing alternative protocol for sago wastewater treatment and solid waste from the industry can be utilised for wastewater degradation.

1. Introduction

Solid or liquid wastes derived from a series of postprocessing steps in the agricultural industry could impose significant environmental impacts if not properly treated or managed. Agro-based industries contribute significantly to the economic growth and development of countries around the globe. Nevertheless, from the environmental point of view, this industry also inevitably tends to increase the accumulation of wastes, which demand considerable attention. The Advanced Oxidation Processes (AOPs) are nonbiological methods that could become the most suitable alternative to degrade organic compounds present in agricultural effluents.

AOPs, which are chemical oxidation processes, have been highly effective in the oxidation of wastewater containing toxic and organic materials [1]. AOPs involve in situ generation of reactive oxygen species (ROS), such as hydroxyl radicals (HO•), O_3, H_2O_2, and superoxide anion radical ($O_2^{\bullet -}$). These ROS act as strong oxidants to oxidise organic compounds into biodegradable forms and simpler end-products, such as CO_2 and H_2O [2, 3]. Among the various AOPs, titanium dioxide (TiO_2) photocatalysis has been known for its potential to effectively treat wastewater. TiO_2 appears to be one of the most widely used photocatalysts because it is biologically and chemically inert, cheap, photostable, and noncorrosive [4]. Nonetheless, the application of TiO_2 in large-scale wastewater treatments is restricted by its limitations. TiO_2 has two major constraints that limit its photocatalytic activity: (i) the large bandgap (3.2 eV for anatase phase) limits its absorption to the UV region, in which only 3 to 5% of the solar spectrum can be utilised for its activation, and (ii) the fast recombination of photogenerated electron-hole pairs occurs during TiO_2 photocatalysis [5]. In addition, nanosized TiO_2 is in the form of slurry (suspension) during treatment, which makes recovery and recycling particularly difficult. Hence, to increase the photocatalytic activity of TiO_2, several methods have been proposed, such as doping with nonmetals and transition metals [6, 7], noble metal or metal ion incorporation [5, 8], fabrication of TiO_2 mixture with other materials [9], surface sensitisation [10], and the inclusion of inert support [11].

TiO_2 was combined with modified sago bark (MSB) to prepare a novel mixture material (TiO_2/MSB), which was then further assessed for the degradation of sago effluent