



GREEN PHOTOCATALYSIS FOR TREATMENT OF DYE POLLUTED WATER

Scientific paper
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ABSTRACT: The increasing contamination of aquatic environments with a wide range of organic pollutants has highlighted the need for the development and implementation of advanced oxidation processes (AOPs). Among these, photocatalysis has attracted considerable attention due to its high degradation efficiency and environmental compatibility, despite certain inherent limitations. Therefore, continuous efforts to enhance both the efficiency and sustainability of photocatalytic systems remain a major focus of current research in water treatment technologies. In this study, synthesized TiO₂ was employed as a photocatalyst for the degradation of methyl violet dye in aqueous solution. The effect of the initial photocatalyst dosage on the degradation efficiency was systematically investigated. The experimental results demonstrated that the optimal photocatalytic performance was achieved using a TiO₂ concentration of 0.20 g/L for an initial dye concentration of 10 mg/L. These findings contribute to a better understanding of photocatalytic processes and provide valuable insights for the development of efficient treatment strategies for textile wastewater.

Keywords: water treatment, photodegradation, TiO₂, organic pollutants.

ZELENA FOTOKATALIZA U PREČIŠĆAVANJU VODA ZAGAĐENIH BOJOM

APSTRAKT: Sve izraženije zagađenje vodenih ekosistema širokim spektrom organskih polutanata ukazalo je na potrebu za razvojem i primenom unapređenih oksidacionih



procesa (AOP). Među njima, fotokataliza zauzima značajno mesto zahvaljujući visokoj efikasnosti razgradnje organskih zagađujućih materija i ekološkoj prihvatljivosti, uprkos određenim ograničenjima. Stoga kontinuirano unapređenje efikasnosti i održivosti fotokatalitičkih sistema predstavlja jedan od ključnih pravaca razvoja savremenih tehnologija za prečišćavanje voda. U ovom radu sintetisani TiO_2 primenjen je kao fotokatalizator za razgradnju metil-ljubičaste boje u vodenom rastvoru. Sistematski je ispitan uticaj početne koncentracije fotokatalizatora na efikasnost procesa razgradnje. Eksperimentalni rezultati pokazali su da je optimalna fotokatalitička efikasnost ostvorena pri koncentraciji TiO_2 od 0,20 g/L i početnoj koncentraciji boje od 10 mg/L. Dobijeni rezultati treba da doprinesu boljem razumevanju fotokatalitičkih procesa i daju značajnu osnovu za razvoj efikasnijih strategija tretmana tekstilnih otpadnih voda.

Ključne reči: tretman vode, fotodegradacija, TiO_2 , organske zagađujuće materije.

1. INTRODUCTION

The persistence, toxicity, and low biodegradability of many synthetic dyes have made the discharge of dye-containing wastewater from the textile and related industries a significant environmental concern. Conventional wastewater treatment methods often fail to achieve complete removal of these contaminants, highlighting the need for the application of advanced oxidation processes (AOPs) as an effective alternative for wastewater treatment [1].

Because it can mineralize a variety of organic contaminants under benign working circumstances, heterogeneous photocatalysis has become one of these technologies' most promising and ecologically acceptable methods [2]. Due to its exceptional photocatalytic activity, low cost, non-toxicity, and good chemical stability, TiO_2 is the most researched photocatalyst [3].

Dyes represent a significant class of pollutants in industrial wastewater, particularly from the textile, paper, and food industries. Their presence in aquatic environments reduces light penetration, disrupts photosynthetic processes, and adversely affects aquatic organisms [4]. In addition to causing aesthetic pollution, many synthetic dyes are highly persistent, poorly biodegradable, and may exhibit toxic, mutagenic, or carcinogenic properties [5]. Therefore, the efficient removal of dyes from wastewater remains a major challenge in environmental protection and water treatment.

The aim of this study was to evaluate the photocatalytic performance of synthesized TiO_2 in the degradation of methyl violet from aqueous solution, with particular emphasis on the effect of photocatalyst dosage on the degradation efficiency. By identifying the optimal catalyst loading, this research contributes to a better understanding of the operational parameters governing TiO_2 -based photocatalytic processes. The obtained results provide useful information for the optimization of photocatalytic systems and support the development of efficient and sustainable technologies for the treatment of dye-contaminated textile wastewater.

2. MATERIALS AND METHODS

Synthesis of biobased material was done according to our previous work [6]. Fabricated photocatalyst was tested in order to determine activity under the imitated sunlight irradiation lamp (Osram Vitalux lamp 300 W, Germany).

Photocatalytic probes were performed in temperately controlled quartz reactor (150 ml). Reaction suspension formed from photocatalyst and dye solution was mixed in dark for the first 30 min, and after under radiation. In certain period, aliquots were sampled and monitored on UV spectrometer (Shimadzu 1800, Japan). The photocatalysis process was monitored for 180 min.

3. RESULTS

Figure 1 shows the degradation curves by varying the initial amount of added photocatalyst.

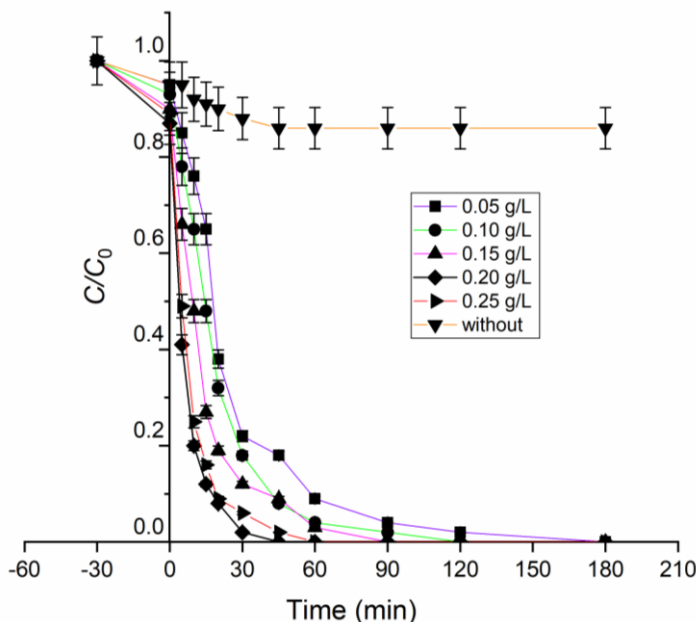


Figure 1: Degradation of MV dye by varyng initial concentration of TiO_2

It was found that at an amount of 0.20 g/l, the degradation percentage was 95%. After 180 min, almost all dye molecules were degraded and observed solution was mostly decolorized. This can be explained by the larger number of active centers for generating electron/hole pairs on the surface of the photocatalyst. Conversely, photolysis does not give prominent results, with degradation rate of only 9%.



4. CONCLUSION

The increasing contamination of aquatic environments by organic pollutants has highlighted the need for the development of efficient and environmentally sustainable advanced oxidation processes (AOPs). Among these, heterogeneous photocatalysis has attracted considerable attention due to its high degradation efficiency, low energy consumption, and potential for complete mineralization of organic contaminants. Continuous improvement of photocatalytic performance and sustainability remains a key research focus in wastewater treatment.

The results of this study demonstrate that synthesized TiO_2 is an effective photocatalyst for the degradation of methyl violet under simulated solar irradiation. Photocatalytic performance was strongly influenced by the catalyst dosage, with the highest degradation efficiency of 95% achieved at a TiO_2 concentration of 0.20 g/L after 180 min of irradiation. The improved performance at the optimal catalyst loading can be attributed to the increased number of active sites available for the generation of electron-hole pairs and the subsequent formation of reactive oxidative species. These findings confirm the potential of TiO_2 -based photocatalysis as an efficient and environmentally friendly approach for the treatment of dye-contaminated wastewater. Furthermore, the obtained results contribute to the optimization of photocatalytic operating conditions and support the development of sustainable technologies for industrial wastewater purification.

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