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The Fabrication of Modified Titanium Dioxide/Iron/ Diatomite Heterojunction Nanocomposite for Enhanced UV Process -Driven Photodegradation of Industrial Textile

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ABSTRACT

Diatomite (kieselguhr)/Fe₂O₃ /TiO₂ composite as catalyst for heterogeneous photocatalysis of vat green 03 indanthren and characterized in this study. The diatomite/Fe₂O₃ /TiO₂ Called "Diatomite FC" was made through surface modification treatments including Fe(NO₃)₃.9H₂O and NaOH then TiO₂ degussa P25 deposition on raw diatomite. In the Fe(NO₃)₃.9H₂O and NaOH treatments, surface SiO₂ of diatomite and TiO₂ degussa P25 were partially dissolved in the Fe(NO₃)₃.9H₂O and NaOH by means of x-ray fluorescence (XRF), x-ray diffraction (XRD), scanning electron microscopy (SEM), thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) and UV-visible diffuse reflectance spectroscopy (DRS). The surface area of diatomite / Fe₂O₃/TiO₂ is 970 m²/g. Diatomite/Fe₂O₃/TiO₂ " Diatomite FC " was Eg= 1.1 eV by UV-visible DRS technique. The vat green 03 indanthren textile dye degradation has pH dependency, the better result is at pH =10 with colour remove about 92 %. The photodecolourisation rate follows pseudo-first order kinetic with respect to the dye concentration.

Keywords : Diatomite, Fe₂O₃, TiO₂ , photocatalysis, indanthren.

1 Introduction

Diatomite is a type of porous silicate material composed of the skeletal remains of single-cell water plants (algae) with a chemical formula of SiO₂.nH₂O [1], has attracted much attention due to many of its properties, such as high cation exchange capacity, large surface area, porous structure, chemical inertness, low thermal conductivity, low cost, and ready availability [2]. Herein, we report the utilization of the diatomite as a raw material for the fabrication of porous SiO₂ based material [3]. Ferrihydrite-modified diatomite (FHMD) was developed [4] as a low-cost adsorbent. FHMD was produced through surface modification treatments including NaOH treatment and Si-containing ferrihydrite (the least crystalline Fe₂O₃) deposition into raw diatomite [4]. Vat dyes account for about 15% of total consumption of textile dyes [5,6]. Vat dyes cause environmental concerns when released in industrial wastewaters due to their carcinogenic health effects. So this study, methylene blue removal by the photodegradation method using diatomite modified by iron (Diatomite – Fe) photocatalyst has been done. Fe- SiO₂ composite is expected to be an effective and efficient photocatalyst to degraded vat green 03 indanthren dye under UV irradiation.

2 Experimental

Natural diatomite was obtained from Sig deposit located in the westward of Algeria. The chemical composition of raw diatomite RD studied was determined by x-ray fluorescence X (XRF) (Philips PW 1404) and by electronic Micro sounder based on chemical analysis by x-ray fluorescence x (XRF) (Philips PW 1404). Raw diatomite DB is composed of 68.017 % SiO₂ , 19.25 % CaO , 7.575 % Al₂O₃ ; 2.022 % Fe₂O₃ ; 1.241 % MgO ; 1.491 % K₂O ; 0.2 % Na₂O ; 0.14 % TiO₂ and 0.038 % MnO and 0.5 other oxides. 4.07 g Fe(NO₃)₃.9H₂O is taken in 250 ml of distilled water for 15 min with stirring at 300 rpm in room temperature. 0.1 g of TiO₂ degussa P25 and 0.1 g of raw diatomite are added and stirring at 90 °C for 2 h.



This mixture was centrifuged and washed with distilled water then neutralized with 6M NaOH to pH value of 7-8 and dried in oven at 105 °C for 2h to obtain crystalline Fe₂O₃.

3 Results and Discussion

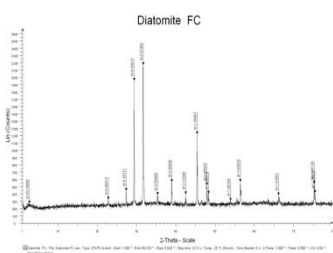


Figure 1: X-ray diffraction patterns of Diatomite FC

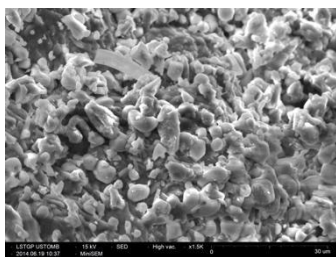


Figure 2: Scanning electron micrograph of diatomite /Fe₂O₃/TiO₂ “diatomite FC”(magnification 1500 X)

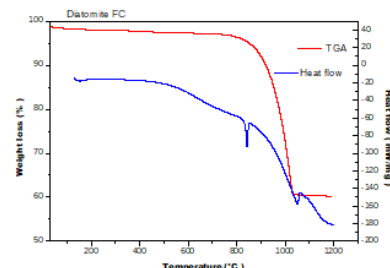


Figure 3: Thermal analysis (TGA-DSC) curves of diatomite/ Fe₂O₃ / TiO₂ “ diatomite FC ”

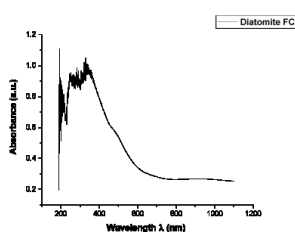


Figure 4: UV-visible diffuse reflectance spectrum for diatomite/ Fe₂O₃ / TiO₂ “ diatomite FC ”

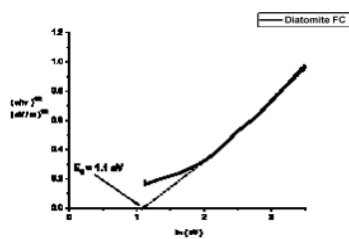


Figure 5: Plot of $(ahv)^{1/2}$ against (hv) from the UV-vis diffuse reflectance for diatomite/ Fe₂O₃ / TiO₂ “ diatomite FC ”.

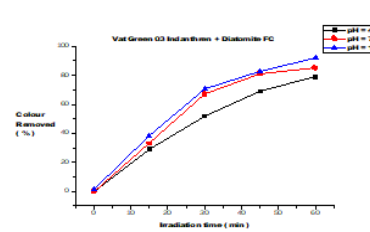


Figure 6: Colour removal of vat green O3 indanthren in different pH's using the diatomite / Fe₂O₃/TiO₂ “ diatomite FC”

4 Conclusions

In this study, it was shown that Algerian diatomite from Sig region could be used as silica rich source for the synthesis of diatomite .In summary , a novel hierarchical structured and disk-shaped Diatomite FC was successfully synthesized and then characterized by XRF, SEM, TGA , DSC , surface charge , point of zero charge “ pHPZC ” and UV-visible DRS analysis.Experimental results showed that iron (III) nitrate nanohydrate Fe(NO₃)₃ .9H₂O , titanium dioxide TiO₂ degussa P25 had important effects on the morphology and structure of the as-synthesized sample as diatomite FC.

5 Acknowledgements

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