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INTERACTION OF TITANIUM DIOXIDE AND NICKEL VANADATE ON AZURE B DYE WITH PHOTOCATALYTIC DEGRADATION

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ABSTRACT

Azure B dye was photo catalytically broken down in the presence of a nickel vanadate and tio2 combination. It has been examined how several characteristics, including pH, composite concentration, Azure A concentration, and light potency, affect the rate of decomposition. Superoxide anion radical, an active reducing species, has been suggested as a potential mechanism for the breakdown of Azure B.

KEY WORDS : Photocatalytic processes, tio_2, Nickel vanadate, Azure A, Degradation

INTRODUCTION

Releasing a substantial amount of chemicals into the atmosphere and perhaps causing harm to the biosphere, chemical-based enterprises have made a huge contribution to the growth of human civilization. Dyeing, along with other pollutants, is an important environmental contaminant. As international environmental restrictions get stricter, waste water treatment has attracted the interest of several research initiatives. Only around 1% of the water on earth is suitable for human consumption. Heavy metals, inorganic chemicals, organic compounds—such as pesticides, drugs, insecticides, phenols, fertilizers, detergents, dyes, and some other products—as well as heavy metal ions are put straight into the water supply without any action or even a minimally effective therapeutic treatment.

Many compounds are both very poisonous to humans and severely harmful to other animals. Dyes are commonly used in the dyeing, painting, textile, photography, culinary, cosmetic, and other commercial sectors. Despite being commonly utilized, dyes have cancer-causing and dangerous properties. These harmful compounds have a variety of detrimental effects on the ecosystem that are felt globally. There are several methods for degrading or removing these pollutants, each of which has benefits and drawbacks.

A calcium oxide semiconductor was used by Ameta and Jhalora, (2014) to explore the photocatalytic decomposition of azure B. Researchers have examined the pace of reaction in response to a number of variables, including pH, dye concentration, semiconductor quantity, and light intensity. Multiple control studies showed that semiconductor calcium oxide was crucial in the breakdown of photocatalytic dyes.

The effectiveness of WO3 for photodegradation of Azure B dye was investigated by Vijay *et al*. (2013). Several aspects, such as catalytic amount, concentration of dye, light, potentiality of Hydrogen, and so on, have an effect on degradation. Dye was studied, and the results showed that the process followed pseudo-first order kinetics. Scavenger investigation participants discovered the existence of –OH free radical chemicals.

Yadav *et al*. (2012) employed a variety of techniques to remove and degrade dyes from the wastewater of different companies. Each technique has benefits and drawbacks of its own. The photocatalyst employed for the degradation of azure B was lead sulphide. Numerous factors, including pH, dye concentration, semiconductor quantity, and light intensity, have been examined for their effects on reaction rate. The reaction is controlled by kinetics of pseudo-first order. It was determined that the following circumstances were ideal: azure B dye was studied by Ameta *et al.* (2013). using an advanced oxidation process. They talked about several strategies for removing organic pollutants from industrial effluents. Promising waste water treatment technology has been found in photocatalysis, a part of advanced oxidation technology. Azure B dye was broken down using the photocatalyst Well-Dowson polyoxometalate. Numerous rate-influencing factors have been looked into. Spectrophotometric analysis was used to gauge the rate of degradation. Based on the observed facts, a basic mechanism has been given. Its process is found to follow pseudo-first order kinetics in this system, according to the kinetic study.

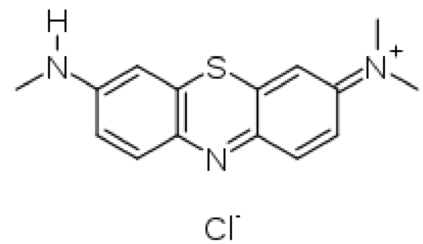
Using Bi_2O_3 and Bi_2S_3, Sharma *et al.* (2013) photocatalytically destroyed azure B dye. Numerous aspects, including pH, dye concentration, semiconductor quantity, light intensity, and others, had an impact that was seen and addressed. The absorbance was measured to identify the photochemical oxidation process. Experimental research was used to find the ideal reaction conditions. Pseudo-first order kinetics controls dye photochemical oxidation. The breakdown products and a potential mechanism for dye photochemical oxidation were outlined.

Under visible irradiation, Zhao *et al.* (2008) noticed an increase in the photocatalytic degeneration of pollutants on Al (III) changed TiO_2.

Colors are extensively used in a variety of sectors, including yarn, plastic, and textiles, according to Nihalani *et al.* (2013). These harm the environment when they are absorbed and some of them are released into it. The removal of these pollutants by photocatalytic degradation has been attempted using a new semiconductor dubbed $BaO_3TiO.SrO_3TiO$. By altering among other variables, the perfect conditions were discovered. The pseudo-first order rate rule that the process followed was validated by kinetic parameters. Due to the creation of innocuous degradation products as NO_2, CO_2, H_2O, etc., this process is crucial. Scavenger assistance was used to confirm the presence of the free radical •OH

Wang *et al.* (2018) and Wan *et al.* (2017) state that it is effective in reducing adulteration caused by antibiotics, fumes, pigments, and poisonous ores.

At neutral pH conditions, Cheng *et al.* (2004) found striking photo-aided dye pollution degradation over Fe (III)-loaded resin. According to Rao *et al.* (1997), crystal violet was bleached photo catalytically in an aqueous solution of zinc oxide.



STRUCTURE OF AZURE B

0.0306 g of Azure B were dissolved in 100 ml of doubly distilled water, a solution measuring 1.0×10^{-3} M was created. It acted as a standard remedy. This stock solution was further diluted. It was determined what wavelength, 650 nm, a spectrophotometer set to measure absorbance at, the Azure B solution. Solution had been divided equally among the beakers.

After the beakers were stored for three to four hours, the absorbance of the solution was measured using a spectrophotometer. It was found that the fourth beaker's solution had a lower starting absorbance value than the ones from the previous three. This discovery makes it clear that light and semiconductor nickel vanadate combination should both be there for the reaction to take place. As a result, this process is photocatalytic by nature.

A reduction in Azure B liquid sensitivity was noticed with increased treatment times. The photocatalytic degradation of Azure B was found to be governed by pseudo- first-order kinetics, as seen by the linearity of the plot of 1+ log A versus time.

Equation of rate constant

$$k = 2.303 \times \text{slope} \quad \ldots (1)$$

Effect of pH

The potentiality of the Hydrogen of the solution is most influencing the breakdown of Azure B. The impact of pH on the rate of breakdown of Azure B was Analyzed in the pH of 5.0 to 10.0. Light intensity = 70.0 $mwcm^{-2}$Nickel vanadate and titanium dioxide composite 0.10 g.

Impact of Dye Concentration

The impect of dye was researched using varying quantities of Azure B. It was found that the rate of dye degradation by photo catalysis increased as the concentration of Azure B was raised up to $1.80 \times 10^{-}$

Table 1. A Typical Run

pH = 9.0 Azure B = 1.80× 10^{-5} M

Nickel Vanadate and tiO_2 composite= 0.10 Light intensity = 70.0 mWcm-2

Time (min)	Absorbance A	1+log OD
0.0	0.632	0.8007
10.0	0.582	0.7649
20.0	0.541	0.7331
30.0	0.504	0.7024
40.0	0.472	0.6739
50.0	0.442	0.6454
60.0	0.411	0.6138
70.0	0.382	0.5820
80.0	0.349	0.5428
90.0	0.324	0.5105
100.0	0.301	0.4785

Rate Constant=1.12×10^{-4} Sec^{-1}

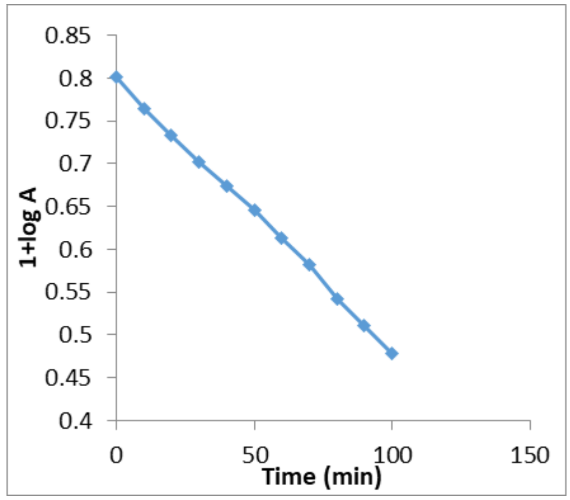


Fig. 1. A Typical Run

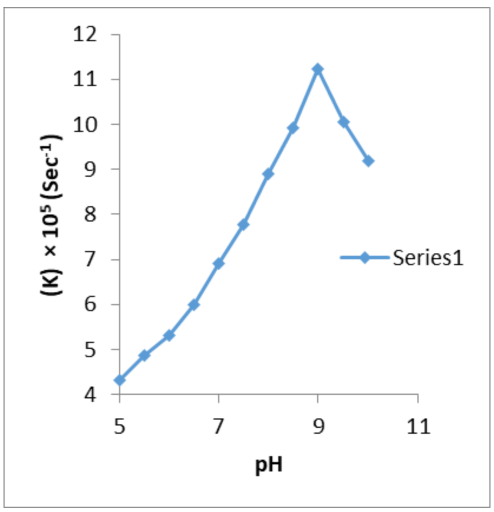


Fig. 2. Effect of pH

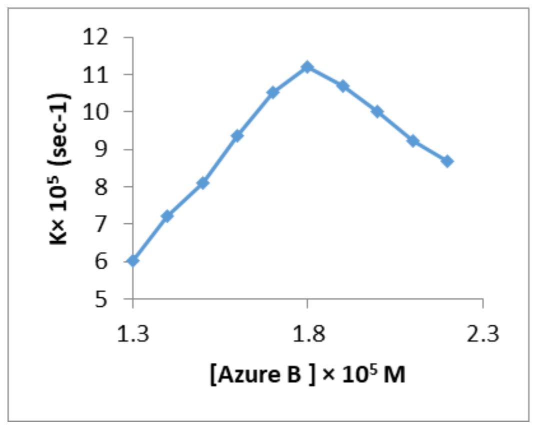


Fig. 3. Effect of Dye Concentration

^{5} M. It could be because more dye molecules were accessible for excitation and energy transfer as dye concentration rose, leading to an increase in the rate of dye breakdown. In order to prevent dye from serving as an internal filter and preventing the necessary light intensity from reaching the surface of the semiconductor placed at the bottom of the reaction vessel, a drop in rate was seen when dye concentration was increased over 1.80 × 10^{-5} M.

Effect of Semiconductor Amount

Different photo catalyst concentrations were utilized since it's possible that the amount of semiconductor will also affect how quickly dye degrades. It's discovered that the rate of re action goes up as the nickel vanadate and titanium dioxode composite does. The quickest rate of degradation was achieved at a photocatalyst concentration of 0.10 g. above 0.10 g, the rate constant was almost constant. This may be due to the fact that when semiconductor was utilized, its exposed surface area grew as well. However, the semiconductor layer only gets thicker and the surface area is not exposed when the amount of semiconductor is more than this limiting number (0.10 g).This was confirmed using reaction containers of various sizes. The saturation threshold increases upward for bigger vessels whereas smaller vessels show the opposite tendency.

Effect of Light Intensity

Increasing the number of photons per unit area of semiconductor powder per unit as per time. As the

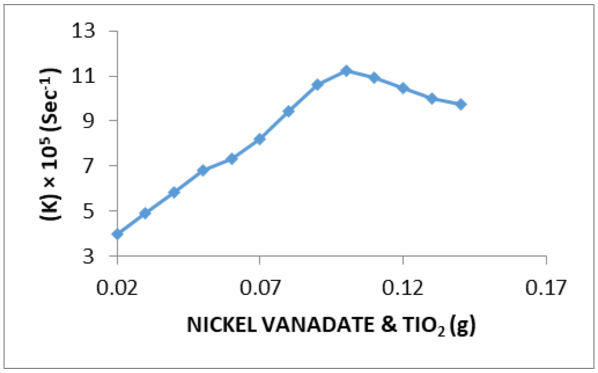


Fig. 4. Effect of Ammount of Nickel Vanadate and Tio_2 (G)

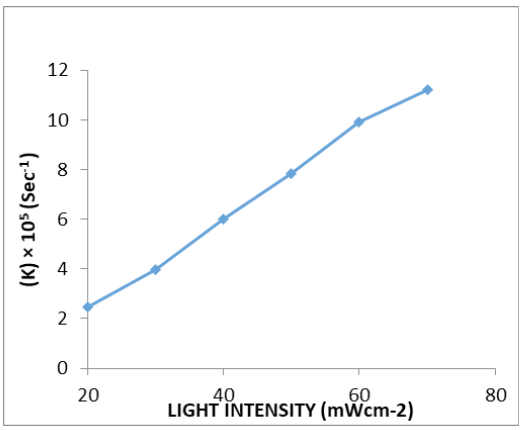


Fig. 5. Effect of Light Intensity

intensity was increased above 70.0 $mWcm^{-2}$, the rate did, however, start to somewhat decrease. This could happen as a result of different impacts.

Mechanism

Findings from this study, the following underlying mechanisms for the photocatalytic degradation of the dye Azure B is proposed:

$^1AB_0 \xrightarrow{hv} {}^1AB_1$ …(2)

$^1AB_1 \xrightarrow{ISC} {}^3AB_1$ …(3)

$SC \xrightarrow{hv} e^-(CB) + h^+(VB)$ …(4)

$e^- + O_2 \rightarrow O_2^{\cdot-}$ …(5)

$O_2^{\cdot-} + {}^3AB_1 \rightarrow$ Leuco AB …(6)

Leuco AB $\rightarrow$ Products …(7)

The azure B dye (AB) creates its initial singlet state of excitation after absorbing photons of the proper wavelength. The dye then enters the triplet state as a result of intersystem crossover (ISC). To move an electron from the valence band to the conduction band, the semiconducting nickel vanadate and titanium dioxode composite also uses radiant radiation. O2-, or superoxide anion radical will be created when this electron is abstracted by an oxygen molecule (dissolved oxygen). It will be changed the Azure B dye into its leuco form, and it may eventually decompose into byproducts.

Description of the Composite Edx Evaluation

When a sample is bombarded by an electron for X-rays that are released from the sample. Table presents the findings, and Figure displays the findings.

Element [wt.%]	Series [wt.%]	C norm. [wt.%]	C Atom. [wt.%]
Vanadium	K-series	60.47	52.21
Titanium	K-series	30.80	28.30
Oxygen	K-series	6.43	17.67
Aluminium	K-series	0.10	0.16
Nickel	K-series	2.20	1.65

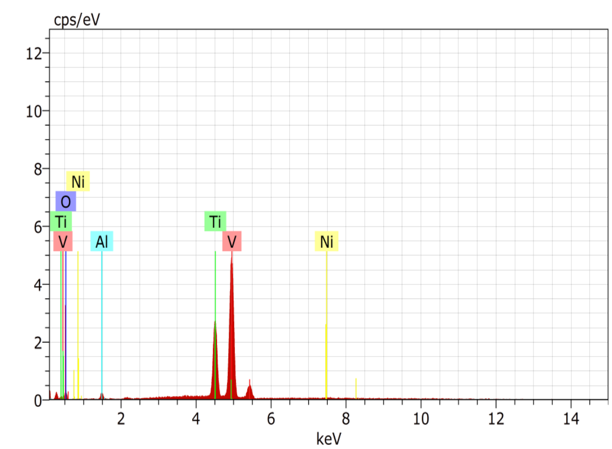


Fig. 6. EDS of Nickle vanadate and Titanium Dioxide

XRD Analysis

For the purpose of detecting unknown minerals and materials, it is a quick and effective procedure. Constructive interference between monochromatic X-rays and a crystalline sample is the foundation of X-ray diffraction. The sample is exposed to these X-rays after they have been produced by a cathode ray tube, filtered to create monochromatic radiation, concentrated by collimation, and directed towards it.

Application

The treatment of contaminants from industrial effluent, including those from the papermaking, pigment, and health industries, among others, is especially generates higher to this study.

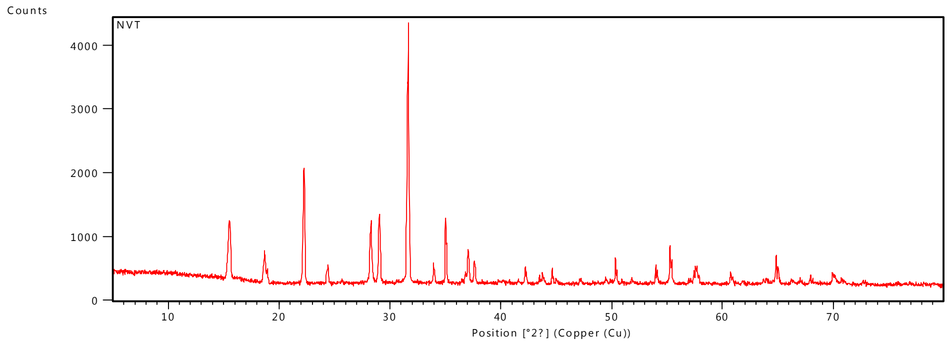


Fig. 7. XRD of Nickle vanadate and Titanium Dioxide.

CONCLUSION

Using a titanium dioxide and nickel vanadate photocatalyst combination, the Azure B dye was degraded. The data showed that the photocatalytic degradation efficiency of AzureB dye was affected by pH, dye solution, semiconductors, and light intensity. It is possible to investigate how various pollutants degrade in relation to how the photo catalyst is used.

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