Study on effect of aeration time on methylene blue removal using titanium dioxide

Aruljothy Malathy¹, Narayanan Selvapalam², Sankararajan Vanitha³ and Chandrasekaran Sivapragasam⁴

¹,²,³,⁴Center for Water Technology, Department of Civil Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Virudhunagar district, TamilNadu, India.
²Department of Chemistry, Kalasalingam Academy of Research and Education, Krishnankoil, Virudhunagar district, TamilNadu, India.

E-mail : s.vanitha@klu.ac.in

Abstract : The aquatic organisms, human beings and other living species are affected due to polluted water excreted from industries. This polluted water contains various chemical substances such as dyes, cyanide etc. One such compound is Methylene blue dye which has an adverse effect on many living organisms. In this study Titanium dioxide (TiO₂) nanoparticles was prepared which completely neutralize the effect of Methylene blue in water. The morphology of titanium dioxide has been studied through Scanning Electron Microscope (SEM). The efficiency of prepared nanoparticles has been tested in the presence of sunlight and aeration. The efficiency of Titanium dioxide was 85% at the end of 15 minutes which prohibit the effect of Methylene blue.

1. INTRODUCTION

It is known that the industrial effluent, particularly those from textile industries needs proper treatment before disposal. Improper disposal of wastewater causes depletion of dissolved oxygen thus creating harmful effect to aquatic organisms. There are varieties of dyes which are used and the color of the dyes should be treated properly and effectively. Hence, the process or material selection for the removal of dye should be such that it does not lead to any environmental or health effects.

Table 1 gives a short summary of some of the works reported in the recent past in the removal of dyes. It is observed that Gold, Silver, Titanium dioxide (TiO₂), Lanthanum oxide (La₂O₃), Copper Sulphide (CuS) etc are used as nanoparticles for the removal of dyes. The usage of dyes and other products leads to effects on environment, such as the pollution of water, mutagenic effects, soil quality degradation etc. [1]. So it should be treated properly without any damage to the environment. Many dyes are used in different types of industries such as textile, paper, printing, leather, cosmetics, food etc [2]. The most common dyes used in industries are methylene blue, crystal violet and congo red. Among the variety of dyes, methylene blue is a heterocyclic aromatic compound, which is toxic and very hazardous and leads to breathing problems, vomiting, hyperhidrosis, and mental disorders [3]. In recent past there are many studies were undergone on removal of Methylene blue. Activated carbon is used as the adsorbent for the removal of methylene blue because of its excellent adsorption efficiency and also its usage becomes less due to its high cost and complexity of regeneration capacity [2]. Fuller’s earth and kaolinite are also used as adsorbents for the removal of methylene blue [4, 5]. Recently more research was carried out for removal of dyes using Nano particles [1, 6, 8-16]. TiO₂
nanoparticles has many properties including being non-toxic, an active photo catalyst, stability over a wide range of pH and is not subjected to photo corrosion and it is easily degrade the organic pollutants[6]. The photo catalytic degradation has the capacity to use energy from the sun to degrade dyes in sunlight conditions; this condition makes degradation relatively low-priced when sunlight is used [7].

In this study an attempt was made to degrade the dyes using TiO₂ Nano particles in the presence of sunlight with aeration with fixed concentration of Methylene blue and TiO₂. No other studies had revealed the usage of aeration for the removal of Methylene blue. To the author’s knowledge, this is the first attempt of removal of Methylene blue using the aeration.

| References | Nanoparticles | Source | Efficiency |
|------------|---------------|--------|------------|
| 11         | Gold          | Sunlight | 50 % degradation achieved in 11 minutes |
| 12         | TiO₂          | 125 W mercury vapor lamp. | 77% |
| 13         | CuS           | Solar, Visible and UV lights. | Highly efficient for treatment of dye pollutants |
| 14         | La₂O₃         | Incandescent lamp (100w) | La₂O₃ with TiO₂ is improved by 30.79% comparing to pure TiO₂ |
| 16         | Silver        | Sunlight | 95% at 72 hours |

2. METHODOLOGY

TiO₂ Nano material is prepared from Titanium Iso Propoxide (TTIP). Figure 1 shows the step by step procedure of experimental study.

2.1. Preparation of Nano material
100 ml of Acetonitrile was dissolved with TTIP. Urea solution is prepared separately, in another beaker. This separate solution is added to the TTIP in the ratio of 10:1. It becomes turbid solution after the addition of urea solution to the TTIP. The solution is evaporated on the hot plate under the magnetic stirring at 300ºC. During evaporation the mixed solution turned into gel. The gel is allowed to make harden and crushed in the mortar. The powder was annealed at 300 ºC, 400 ºC, 500 ºC and 600 ºC for 3 hours
2.2. Experimental setup
Synthetic dye was prepared using Methylene blue. In this study 4 different batch scale setups were made. In every batch scale setup 100 ml was taken. 0.7 g of prepared TiO$_2$ was added to each batch reactor. The aeration time for each reactor 1, 2, 3 & 4 are 0, 9, 12, 15 minutes respectively. Absorbance value is measured for every change in aeration time. The experimental setup is shown in Figure 2.

![Experimental setup of batch scale mode.](image)

3. RESULTS AND DISCUSSIONS

3.1. Characterization of Material by Scanning Electron Microscope
The image has been viewed through SEM. SEM is used to measure the surface morphology of the TiO$_2$ nanoparticles. The interaction of electron with sample emits various signals. The emitted signals can be used to find information about the morphological characteristics and composition. SEM image shows that TiO$_2$ nanoparticles formation was in cluster and spherical in shape and the structure has a large surface area which helps to enhance its photo degrading activity. The prepared Nanomaterial SEM image was shown in Figure 3(a) and Figure 3(b).

![SEM Images for TiO$_2$ Nanomaterial.](image)

3.2. Degradation Study
The degradation effect was studied by using these characterized nanoparticles. From the table 2 and 3 it was observed that the process of decolourization had started after eight minutes simultaneously...
there was no decolourization had happened upto eight minutes. The decolourization of colour has visualized at 9, 12, and 15 minutes respectively. The decolourization of colour has started at 9 minutes which yields 35 percentage removal. At 12 minutes the colour was decolourized to a greater extent and results in 64 percentage removal and the colour of methylene blue has completely decolourized at 15 minutes which yields 85 percentage removal. Figure 4 represents that there was a gradual decrease in the degradation process. The degradation of methylene blue has achieved with the very short duration of 15 minutes with the presence of sunlight and aeration. The short duration which is enough to degrade the dyes with the help of aeration.

![Figure 4. Absorbance values of different aeration time](image)

| Aeration time (minutes) | Absorbance values | Removal (%) |
|-------------------------|-------------------|-------------|
| 0                       | 0.7               | 0           |
| 9                       | 0.45              | 35.71       |
| 12                      | 0.25              | 64.28       |
| 15                      | 0.1               | 85.71       |

**Table 3. Visual observation colour at aeration time**

| Aeration (minutes) | Visual observation colour               |
|--------------------|-----------------------------------------|
| 0                  | No changes in colour                    |
| 9                  | Decolorisation was started               |
| 12                 | Major colour was removed                 |
| 15                 | Colour was completely removed            |

**4. CONCLUSION**

TiO$_2$ Nanoparticles were prepared and characterized using SEM. The experiment result reveals that the Titanium dioxide gives the effective result with the combination of aeration with sunlight. In this
study 85 percentage of methylene blue removal is obtained at 15 minutes. It is suggested to find optimum time for maximum removal of methylene blue.

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