Removal of Tartrazine Dye Using Kyllinga Brevifolia Extract And Silver Nanoparticles As Catalysts

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Abstract. The objective of this study was to determine the effectiveness of kyllinga brevifolia (KB) with silver nanoparticles (AgNPs) as catalysts in the removal of tartrazine dye. The experiment was carried out in batch mode. Different parameter such as temperature, initial concentration, contact time and pH were studied. It was found that the equilibrium was achieved in 20 min and the optimum pH was 2. The removal of dye highest at 80 °C, which is 64%. From an initial concentration of 60 ppm and onwards, the removal efficiency of dye was the most (62.34%) when compared to other initial concentrations. The use of a AgNPs as catalyst increases the removal efficiency 20.68% more effective than without a catalyst. Significant of this study is to show the effect of AgNPs as catalyst in tartrazine dye removal from wastewater.

1. Introduction

Clean water is an incredibly precious commodity. It is not only limited to a commodity, it is a basic human right. With the improvement of certain industries, the amount of clean water is reducing. Acids, bases, toxic organic and inorganic dissolved solids and colours are examples of the contaminants in wastewater. Among the contaminants, colours are considered the most unwanted. These colours are mainly due to dyes. The properties that consumers desire for in dyes – brightness, efficiency and stability (meaning the dye will not fade easily) – are the very qualities that make dye so hard to remove from wastewater.

One of the most common dyes in wastewater used today is tartrazine. Effluents that contain dye are wastewaters with huge problems because it affects aesthetic value and decreases light penetration for photosynthesis [1]. A public health risk formed by pollution is an outcome of industrialisation of the textile industry and use of a large collection of chemical treatments and dyes. In fact, textile dyeing and treatment is the cause of 17-20% of industrial freshwater pollution. During the manufacturing of textile products, it is estimated that 10-15% of total dye byproducts are discharged into the environment worldwide per year [2-4].

During manufacturing, the dyeing and completing processes are the major parts where pollution is discharged. The harmful effluents formed are not always biodegradable. Moreover, the dyestuffs repeatedly pose serious environmental and health risks to the population around them. Tartrazine is used as the dye to be removed in this study. Tartrazine was chosen because tartrazine is being more
used in the industry due to its low cost. This harmful additive may cause asthma attacks, urticaria, thyroid tumors, hyperactivity and chromosomal damage [5-6].

There are several current and typical methods can be used to remove of pollutants from the wastewater which by adsorption [7], oxidation [8-9], reduction [10-11], coagulation [12], electrochemical treatment [13], membrane [14] and ion exchange [15]. Heterogeneous catalysts have been used widely in industry especially in water treatment because it easy to recover and more separable than homogenous catalysts. Several catalysts based on metal and metal oxide such as Cr, TiO2, SnO2, ZrO2, ZnO, CeO2 including AgNPs were reported [8,16-23].

*Kyllinga brevifolia* with the help of silver nanoparticles (AgNPs) were used as the substance to remove the dye. One of the reasons it was selected is because its use is safe for the environment due to it is biodegradability. This plant is also found easily in the environment. In some areas, it is found in excess. Therefore, the cost of obtaining this plant is considerably cheap.

2. Methodology
A stock solution of 100 ppm of tartrazine (SIGMA) was prepared then diluted to obtain concentrations ranging from 20-100 ppm. KB weed was collected from Pulau Pinang, Malaysia. The preparation of 100% concentration of KB extract was conducted using our previous method [3,24]. For brief preparation of 100% KB extract, 5.0 g of KB powder was soaked in 100 mL of deionized water at 70 °C. For preparation of silver nitrate and silver nanoparticles were prepared using our previous method [10,25]. In this method, 1 mL of 100% KB extract was added to 9 mL, 2 mM of AgNO3 for 90 mins at room temperature. In order to identify the optimum reaction time on removal of tartrazine by KB with AgNPs, the different reaction time from 2 to 120 mins, concentration of tartrazine dye from 20 to 200 ppm, effect of pH (2 – 12) and temperature (4-80 °C) were examined.

3. Results and Discussion

3.1 Effect of pH
Determination of the optimum pH for the removal of tartrazine dye is very important as the pH affects the degree of ionization of tartrazine, surface charge of KB, speciation of tartrazine dye and interaction with AgNPs as catalyst. The effect of pH on tartrazine removal was investigated by using a pH range of 2-12. Figure 1 shows the removal of tartrazine dye was found to decrease gradually with increasing the pH. The efficiency of the AgNPs as catalyst for degrading tartrazine dye decreased as well in acidic medium. The graph shows the removal of tartrazine highest at a pH of 2 and lowest at pH 12. At lower pH, the bioactive compounds in KB are protonated and interacted with tartrazine dye as azo dye.

![Figure 1. Effect of pH on removal of tartrazine dye.](image-url)
the positively charged particles at high pHs. Therefore, a selectivity process will occur between the 
OH⁻ ions and the negatively charged dye ions. This will decrease the adsorption of dye removal.

3.2 Effect of temperature
It is known that temperature can influence the reaction of the KB and AgNPs as catalyst during the 
tartrazine dye removal. Figure 2 shows that removal of tartrazine increases 29.8% from with 21°C to 
60°C. The amount of tartrazine removed is lowest at 4°C. Its highest removal is at 80°C. The process 
being faster in higher temperatures can be due to increase of movement of the dye particles. It could 
also be due to a higher number of active sites for the adsorption with increasing temperature [24].

![Figure 2. Effect of temperature on removal of tartrazine dye.](image)

3.3 Effect of contact time
Figure 3 shows that the first 15 min indicates that removal of tartrazine is very rapid. After the 20th 
min, removal process slows down. This is because in the beginning stages, there are many readily 
active sites on the KB. This instantaneous reaction is known as bulk diffusion [26]. The dye molecules 
then undergo a slower uptake before it reaches equilibrium. When equilibrium is reached, the dye 
molecules react in very small amounts or none at all.

![Figure 3. Effect of reaction time on removal of tartrazine dye.](image)

3.4 Effect of concentration
In order to investigate the effect of initial dye concentration, tartrazine dye concentration was varied 
from 20 to 100 ppm while keeping the KB and AgNPs concentration at constant. Figure 4 shows that
the removal efficiency of tartrazine increased from 7.8% to 56.4% with increasing initial concentration. The most drastic change in percent removal is from 20 ppm to 60 ppm, which is 49.96%. The concentration of KB is not changed in this experiment, hence the removal of dye depends mainly on the initial dye concentration. The interaction between adsorbent and dye is intensified due to a higher number of dye molecules per volume [28]. Thus, the amount of molecules that collide per time increases. Consequently, an increase in initial dye concentration will cause an increase in dye adsorption.

![Graph](image1.png)

**Figure 4.** Effect of initial tartrazine dye concentration.

### 3.5 Effectiveness of catalyst

Figure 5 shows the difference between using a catalyst and without catalyst in the experiment. The removal efficiency is higher when the AgNPs was used as catalyst. After two hours of contact time, the percentage removed of dye removed by the controlled experiment is lower than using KB with AgNPs as catalyst. At 20 min, the amount of tartrazine removed in the experiment with catalyst is 62.45% whereas in the controlled experiment, the only 51.75% of the dye is removed. The use of a catalyst produced a removal of dye 20.68% more effective than without using a catalyst. The effectiveness of the catalyst is due to the Ag⁺ ions that serve as a carrier ion to the negatively charged dye ions. This in turn, speeds up the whole process. But, this results showed that KB alone without AgNPs as catalyst also showed a significant performance in tartrazine removal from wastewater.

![Graph](image2.png)

**Figure 5.** Comparative removal of tartrazine dye using KB with and without AgNPs as catalyst
4. Conclusion
The present study demonstrated that KB which abundantly available in Malaysia, is used for the removal of tartrazine dye from wastewater. AgNPs act as catalyst and the removal performance only up to 20.68%. Different parameters conditions were studied for the removal of tartrazine dye. It was found that the optimum pH is in an acidic medium (pH 2). The temperature that yields the quickest reaction is at 80 °C. The contact time shows a rapid adsorption for the first 15 minutes and remains almost constant after that. For the effect of concentration, the highest percentage of removal is highest at 80 oC. The results revealed that KB alone without AgNPs as catalyst also showed a significant performance in tartrazine removal from wastewater. Hence, the study on the effect of AgNPs dosage to enhance the tartrazine dye removal are important in the future.

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