Research Article

The investigation of basic yellow 28 adsorption by using different carbon material

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Abstract

Accessible water resources on the earth's surface are decreasing day by day. For this reason, the treatment of wastewater released into the environment from different industrial areas is becoming a very important issue. In the present study, the removal of Basic Yellow 28 (BY28), one of the dyes used in the textile industry, from aqueous media using adsorption method was tested. Two different carbon based adsorbents; graphene nanoplatelets (graphene) and activated charcoal (activated carbon) were used as adsorbents. The optimum operating conditions were found as 0.004 g, 10 mL, 10 mg/L BY28, 10 minutes for activated charcoal and 0.05 g, 10 mL, 30 mg/L BY28, 15 minutes for graphene. As a result of the data obtained at optimum operating conditions; it was concluded that activated carbon can perform a more successful treatment than graphene.

Keywords: *Adsorption, Basic Yellow 28, Graphene, Activated carbon*

1. Introduction

Water is an indispensable source of life for living organisms, but the amount of accessible freshwater resources worldwide is decreasing day by day. Furthermore, the global population is expected to reach 9.3 billion by 2050 (World Population Prospects, 2011) and it is predicted that the increasing population may cause a worldwide freshwater crisis. Therefore, the removal of toxic organic pollutants from water that contaminate existing water resources is of paramount importance in this scenario (Imran et al., 2012). As it is understood from many articles published recently, the main sources of organic pollutant dyes that cause water pollution can be listed as textile, paint and food industries (Maria et al., 2019).

Dyes cause colouration of water bodies, posing a serious threat to human life and the ecosystem (Singh et al., 2021; Wang et al., 2021; Mojtaba and Alireza, 2022). In fact, one of the main problems is that coloured organic pollutants penetrate into the water and increase the amount of light radiation, thereby disrupting the balance of photosynthetic activity (Mashkoor et al., 2018). Compliance with strict regulations for the improvement of water quality is aimed at treating coloured wastewater and thus taking important steps towards the protection of life (Ajaz et al., 2018; Franz et al., 2015; Maria et al.,When the literature data on the removal of organic pollutants from water are examined, many different methods varying depending on their physical, chemical, electrical, thermal and biological properties stand out (Imran et al., 2012). However, the cost of water treatment based on adsorption is cheaper compared to others (Gupta et al., 2012). Adsorption is recognised as one of the best wastewater treatment methods due to its universal nature, cheapness and ease of use. Adsorption can also remove soluble and insoluble organic pollutants. The removal capacity of toxic substances by this method can be up to 99.9% (Imran et al., 2012).

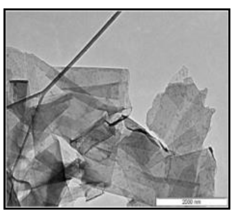

Figure 1: Graphene Nanoplatelets Granules.

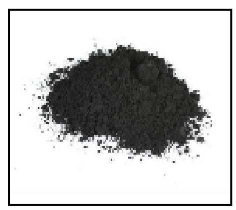

Figure 2: Activated Charcoal Granules.

Nanoporous carbon materials (NPCM) such as activated carbon and its structural model were first proposed in the 1970s (Ramesh et al., 2012; Anastasia et al. 2022). Activated carbon (Regti et al., 2016a; Regti et al., 2017; Regti et al., 2017b; Gupta et al. 1997; Gupta et al. 2013; Saleh and Gupta, 2014) is still the most popular and widely used adsorbent (Abdelmajid et al. 2017).

In this study, the removal of Basic Yellow 28 (Maxilon Golden Yellow GL) (CIBA-GEIGY, 1900s; Julide et al., 2006) dyestuff, which is used in textile industry, from aqueous solution by using adsorption method was carried out. Two different carbon-based materials, graphene nanoplatelets (graphene) and activated charcoal (activated carbon) were used during the adsorption process. Fig. 1 presents the graphene nanoplatelets granules, and Fig. 2 presents the activated charcoal granules (Sabeen et al., 2017). The effects of adsorbent amount, mixing time, initial concentration and the use of two different adsorbents on the adsorption process were investigated. Percentage recovery values were also evaluated (Regti et al., 2017a).

2. Materials and Methods

2.1. Materials and Reagents

Graphene nanoplatelets (graphene) and activated charcoal (activated carbon) used as adsorbents were obtained from Sigma-Aldrich. Basic Yellow 28 (BY28) dye solution was prepared as 100 mg/L stock solution. The working solutions were prepared from this stock using appropriate dilution ratios. The water used during the studies was obtained from Milli-Q (Millipore, USA) purification system.

2.2. The Adsorption of BY28

Adsorption experiments were carried out using batch method. For this purpose, 30 mg/L working solution was prepared at an appropriate ratio from 100 mg/L BY28 stock solution. 10 mL of 30 mg/L BY28 solution was taken into a 50 mL beaker. The adsorbent was added at a certain weight and stirring was carried out on a Julabo SW22 shaking water bath for a certain time. Then the solution was taken into a centrifuge tube and centrifuged at 5000 rpm for 3 minutes. The absorbance values of the sample solution taken from the top of the tube were measured at 438 nm using UV-2600 UV-VIS Spectrophotometer Schimadzu device. In addition, the percentage recovery values of BY28 dyestuff were calculated according to the following Formula 1 (Regti et al., 2017a).

$$\%Removal = [(C_0 - C) / C_0] \times 100 \quad (1)$$

C_0 is the initial concentration of dyestuff, C is the concentration of dyestuff in solution at any time.

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3. Results

3.1. Investigation of the Effect of Adsorbent Amount on BY28 Adsorption Process

In order to investigate the adsorbent effect, 10 mL of 30 mg/L BY28 solution was taken into a 50 mL beaker. Adsorbent was added to the solution in the beaker at a certain weight. The beaker was placed on the shaker and shaken at 150 rpm for 30 min. At the end of the time, it was taken into a centrifuge tube and centrifuged at 5000 rpm for 3 minutes. Then the supernatant was taken with a glass pipette and measured at 438 nm in a spectrophotometer and the concentration of the solution was found.

The specified process was applied by taking weighings ranging from 0.01g to 0.07g for Graphene. The results are shown in Fig. 3. Then the experiments were repeated using Activated Carbon as adsorbent. Activated Carbon weighing values ranged from 0.001 g to 0.007 g. The results are shown in Fig. 4.

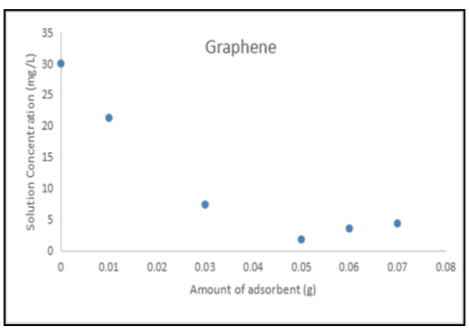

Figure 3. Effect of Adsorbent Amount of Graphene on BY28 Adsorption Process

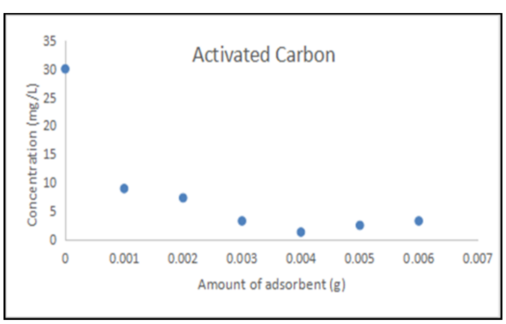

Figure 4. Effect of Adsorbent Amount of Activated Carbon on BY28 Adsorption Process

3.2. Investigation of the Effect of Stirring Time on BY28 Adsorption Process

In order to investigate the effect of stirring time, 10 mL of 30 mg/L BY28 solution was taken into a 50 mL beaker. The optimum weighing amount of 0.05 g adsorbent for graphene was weighed and added to the solution in the beaker. The contents of the beaker were shaken at 50 rpm for periods ranging from 5 minutes to 20 minutes. At the end of the time, it was taken into a centrifuge tube and centrifuged at 5000 rpm for 3 minutes. Then the supernatant was taken with a glass pipette and measured at 438 nm in a spectrophotometer and the solution concentration was found. The results are shown in Fig. 5.

The same process was repeated this time using Activated Carbon. Weighing 0.004 g, which is the optimum weighing amount for Activated Carbon, was added to the solution in the beaker. This time, agitation was carried out for periods ranging from 2 minutes to 20 minutes. The results obtained are shown in Fig. 6.

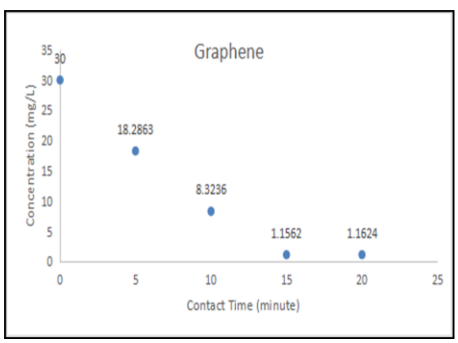

Figure 5. Effect of Stirring Time on BY28 Adsorption Process of Graphene

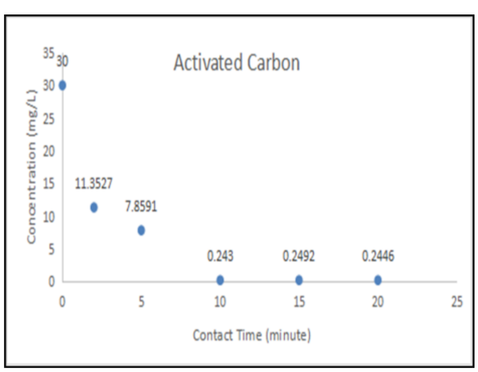

Figure 6. Effect of Stirring Time on BY28 Adsorption

3.2. Investigation of the Effect of Initial Concentration on BY28 Adsorption Process

In order to examine the effect of BY28 initial concentration of the solution on the adsorption capacity, BY28 initial concentrations were prepared in the range of 5 mg/L - 40 mg/L in the studies using graphene. 10 mL each portion was taken into 50 mL beakers. 0.05 g Graphene was weighed and added. It was shaken at 150 rpm for 15 minutes, which is the optimum working time. At the end of the time, it was taken into a centrifuge tube and centrifuged at 5000 rpm for 3 minutes. Then the supernatant was taken with a glass pipette and measured at 438 nm in a spectrophotometer and the solution concentration was found. The values found by calculating the % recovery values according to the Formula 1 are shown in Fig. 7.

The same process was repeated this time using Activated Carbon. In the studies using Activated Carbon, BY28 initial concentrations were prepared in the range of 5 mg/L - 30 mg/L. 10 mL each portion was taken into 50 mL beakers. 0.004 g Activated Carbon was weighed and added. It was shaken at 150 rpm for 10 minutes, which is the optimum working time. At the end of the time, it was taken into a centrifuge tube and centrifuged at 5000 rpm for 3 minutes. Then the supernatant was taken with a glass pipette and measured at 438 nm in a spectrophotometer and the solution concentration was found. The values found by calculating the % recovery values according to the Formula 1 are shown in Fig. 8.

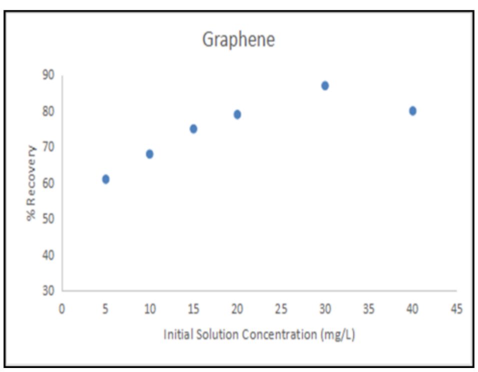

Figure 7. Effect of Initial Concentration on BY28 Adsorption Process of Graphene

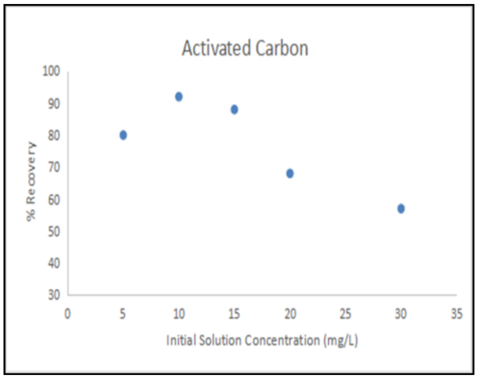

Figure 8. Effect of Initial Concentration on BY28 Adsorption Process of Activated Carbon

The optimum operating conditions created using the data obtained are given in Table 1.

Table 1 Optimum Parameters

The name of parameters		Graphene	Activated carbon
Amount of adsorbent	(g)	0.050	0.004
Shaking time	(min.)	15	10
Initial concentration	(mg/L)	30	10
Recovery	(%)	90,33	94,35

4. Discussion and Conclusion

Experimental studies were carried out to remove BY28, one of the most frequently used dyestuffs in the textile industry, from aqueous solutions. During these experiments, two different carbon-based materials, graphene and activated carbon, were used as adsorbents.

As shown in Table 1, when the results obtained were analysed, the optimum operating conditions for the adsorption process using activated carbon were found to be; 0.004 g activated carbon, 10 mg/L BY28 and the optimum operating time was found to be 10 minutes. Other operating conditions were 25 °C, 10 mL BY28 working solution, 150 rpm as the operating speed of the water bath and 5000 rpm as the centrifuge speed. On the other hand, the optimum operating conditions for the adsorption process using graphene are; 0.05 g graphene, 30 mg/L BY28, the optimum operating time of the experiment can be expressed as 15 minutes. In addition, the experiments were repeated by keeping the other operating conditions constant. When the percentage recovery data were examined, 90.33% recovery was achieved when graphene was used when the optimum conditions were provided for both adsorbents, while 94.35% BY28 recovery was successfully achieved in experimental studies with activated carbon. These data are in accordance with the literature and it is seen that activated carbon can successfully recover a larger percentage of BY28 than graphene in a shorter time and using much less adsorbent material.

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