PERFORMANCE OF PHOTOCATALYST BASED CARBON NANODOTS FROM WASTE FRYING OIL IN WATER PURIFICATION

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Abstract. Carbon Nanodots (C-Dots) from waste frying oil could be used as a photocatalyst in water purification with solar light irradiation. Performance of C-Dots as a photocatalyst was tested in the process of water purification with a given synthetic sewage methylene blue. The tested was also conducted by comparing the performance C-Dots made from frying oil, waste fryng oil as a photocatalyst and solution of methylene blue without photocatalyst C-Dots. Performance of C-Dots from waste frying oil were estimated by the results of absorbance spectrum. The results of measurement absorbance spectrum from the process of water purification with photocatalyst C-Dots showed that the highest intensity at a wavelength 664 nm of methylene blue decreased. The test results showed that the performance of photocatalyst C- Dots from waste frying oil was better in water purification. This estimated that number of particles C-dots is more in waste frying oil because have experieced repeated the heating process so that the higher particles concentration make the photocatalyst process more effective. The observation of the performance C-Dots from waste frying oil as a photocatalyst in the water purification processes become important invention for solving the problems of waste and water purification.

Keywords: Carbon Nanodots, Photocatalyst, Waste, Water, frying oil.

INTRODUCTION

The growth of population and industrial are rapidly in many urban cities causing decreased levels of water quality due to pollution. Water is a basic necessities for every human being to diverse their activities. The level of water consumption is very high demanding of efforts made by humans to fulfill these necessities. A wide range of attempts were made to water purification such as filtration process using porous clay composites [1,2]. Porous clay composite which is used as a filtration medium had permeability on the order of $\sim 10^{-17}$ m^2 up to $\sim 10^{-15}$ m^2 and could be used as water purification. However, these materials was obtained by the combustion process at high temperatures T = $900_{o}C$-$1200_{o}C$ [3]. Meanwhile, the composite porous with the combustion process at a lower temperature T = $650_{o}C$-$750_{o}C$ could be obtained from waste glass. The porous composite made from waste glass was quite effectively as a medium in the filtration process of river water and water with synthetic pollutants from the type of methylene blue [4]. Although it could be used as a filtration medium in water purification, the porous composite had small permeability so ineffective if it used on the large scale.

The other mechanism for water purification could be done by photocatalytic process using a semiconductor material such as titanium dioxide (TiO_2). Performance of TiO_2 as a catalyst is excellent in the photocatalytic processes for organic pollutants in water [5,6]. The photocatalytic process occurs when the photons from the solar light irradiation or UV light crash into semiconductor material that produces electron and hole pairs. Electron were excited from the valence band to the conduction band. Electron and hole were produced will react with water (H_2O) and oxygen (O_2) which produce free radicals for decomposing organic pollutants. TiO_2 can be effective as a catalyst in the photocatalytic process when obtaining solar irradiation or UV light directly. A high density of TiO_2 about of 4.32 g/cm_{3}, TiO_2 require a modifications with the method of immobilization of TiO_2 particles on a polymer with a low density and transparent [7,8]. This modification be done so that TiO_2 particles can float above the water surface and receive solar irradiation or UV light directly. Although the semiconductor material of TiO_2 could be a catalyst for photocatalytic process, immobilization TiO_2 particles became one of the complex problems because is required conditions and excellent adhesive so that the filtrate and catalyst are not mixed. TiO_2 particles are inorganic materials that are not environmentally friendly and can become pollutant in the water purification process.

Photocatalytic properties of organic materials are owned by carbon nanodots (C-Dots). C-Dots is a new carbon material which is now become an attraction for many researchers because it has wide potential in various fields of application such as bioimaging, sensors, ink, drug delivery, optoelectronic and photocatalyst [9]. C-Dots can be produced simply from organic materials such as paper, food waste, water melon, flowers and vegetables through a hydrothermal process [10-14]. In addition, C-Dots are found and could be obtained from waste frying oil [15,16]. Because it has abundant hydrocarbon chains and can be easily damaged caused by heating, frying oil or waste frying oil is very easily synthesized become C-Dots. C-Dot have a low density about of 0.93 g/cm_{3} and lower than water, C-Dots from waste frying oil can float on the water so that it can receive solar irradiation are directly. In the present work, we report on the use of C-Dots from waste frying oil as photocatalyst for water purification under solar light irradiation. This work have important benefits as a solution to the environmental problems of water purification and the utilization of waste frying oil.

METHODS

C-dots were synthesized from waste frying oil through a hydrothermal process at a temperature of T=300oC for 2 h. C-Dots as a photocatalyst was tested on a solution with pollutants synthetic methylene blue at a concentration of 100 ppm. The test solution of methylene blue that used an amount of 250 ml and 10 ml C-Dots. A water purification process of methylene blue solution conducted for 5 h, 10 h, 15 h, 20 h, 25 h and 30 h under solar irradiation light were directly. Scheme of performance test of C-Dots from waste frying oil as a photocatalyst is shown in Fig. 1.

The water purification results of methylene blue solution was observed by measuring the absorption spectra with the UV-Vis-NIR Ocean Optics type USB 4000. Whereas the C-Dots performance from waste frying oil in the water purification process of methylene blue solution were analyzed from degradation intensity of the absorption spectra from methylene blue solution. Degradation intensity of this absorption spectra representing the decreasing concentration of methylene blue in the water. In addition, the performance of C-Dots from waste frying oil in the water purification process be compared to the photocatalyst C-Dots from frying oil.

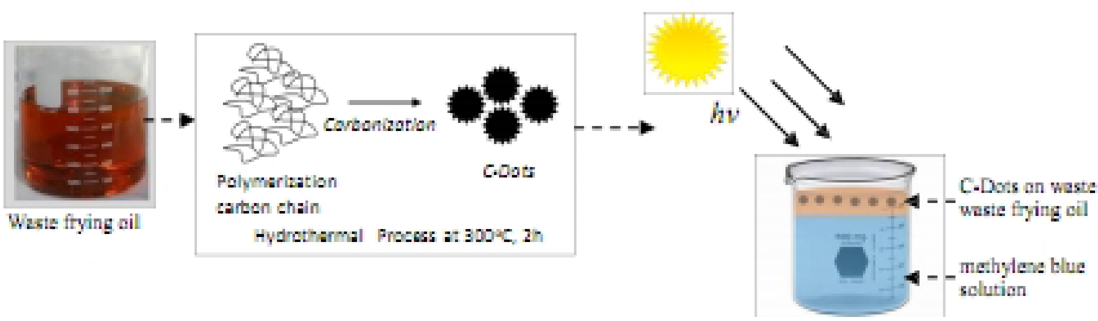

FIGURE 1. Illustration of The Water Purification Test With C-Dots.

RESULT AND DISCUSSIONS

The performance of C-Dots from waste frying oil as a photocatalyst were observed from the degradation of absorption spectra of methylene blue solution, as shown in Fig. 2. Degradation intensity of the absorption spectra represent presence of decreasing in the concentration of methylene blue in the water [1], [7-8]. The performance of C-Dots from waste frying oil in the water purification was measured from the time needed until there was no absorption spectra of methylene blue in the water. At Fig. 2, a solution of Methylene Blue (MB) has absorption spectra which are very wide and high. The peak with highest intensity of absorption observed at wavenumber ~ 664 nm. This absorption spectra are characteristic of the methylene blue solution.

These results also indicate there are

electronic transitions π □ π * in the visible light region with the energy absorption from the light at a wavelength of UV. The properties of methylene blue which is able to absorb energy at UV wavelengths area which causing methylene blue without photocatalyst C-Dots can experience the photocatalytic process. The results of absorption spectra measurements showed the presence of degradation intensity during photocatalytic process as shown in Fig. 2 (a). The intensity of absorption from methylene blue more decrease with the length time of photocatalytic process with solar light irradiation were directly.

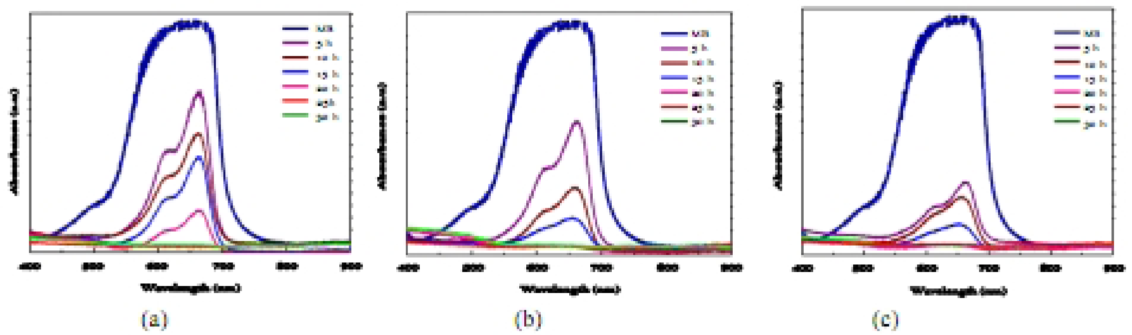

FIGURE 2. Absorption Spectra of The Water Purification Results: (a). Without C-Dots, (b). C-Dots from Frying Oil, and (c). C-Dots from Waste Frying Oil.

Degradation intensity of absorption from the water purification process using the photocatalyst C-Dots from frying oil and waste frying oil are shown in Fig. 2 (a) and Fig. 2 (b). Absorption spectra from methylene blue were observed in the photocatalytic process for 5 h, 10 h and 15 h. However, the process of photocatalyst more than 15 h already showed that there was no absorption spectra of methylene blue. The different conditions on the photocatalytic process for 20 h without photocatalyst C-Dots where the absorption spectra of methylene blue was still observed. With the time of water purification process which much faster, C-Dots have good performance as a photocatalyst in a solution of methylene blue. C-Dots from frying oil and waste frying oil have same good performance as a photocatalyst. The test results of photocatalyst performance show that the degradation methylene blue solution reached immaculate condition with the time process of photocatalytic which is same, ie during 20 h. However, the degradation intensity of the absorption from methylene blue solution decreased more sharply when the photocatalytic process using the photocatalyst C-Dots from waste frying oil, as shown in Fig. 2 (c).

The process of water purification of methylene solution blue requires an oxygen (O_2). Oxygen has a role to unravel the molecular of methylene blue become water (H_2O), CO_2 and slightly acid, as shown in the following chemical reaction:

$C_{16}H_{18}SCl + 11/2\ O_2$ □ $16CO_2 + 6H_2O + 3HNO_3 + H_2SO_4 + HCl$ (1) The photocatalyst C-Dots can accelerate the process of water purification of methylene blue solution because C-

Dots in the photocatalytic process can produce a hydroxyl free radicals OH* which are very reactive to degraded methylene in the water. Photocatalytic process occurs when the surface of the C-Dots which received UV light from solar light irradiation can produce electron e_{-} and hole h_{+} that do not experience the process of recombination. Electron e_{-} and hole h_{+} pairs will react with O_2 and H_2O from the environment. Hole h_{+} has oxidative potential are high and will react with H_2O to form a hydroxyl free radicals OH*. Whereas in other processes, a hydroxyl free radicals OH* were produced from the reaction e_{-} with O_2. Electron e_{-} has reduction potential which is very reactive. Electron e_{-} will react with oxygen to form superoxide radicals O_{-*} and form a hydrogen peroxide H_2O_2 which is a

strong oxidizing materials [17]. The series of reactions that form a hydroxyl free radicals OH* in the water purification process of methylene blue solution, as shown in Equation 2.

$$h^{+} + H_2O \rightarrow H^{+} + OH^{*}$$
$$e^{-} + O_2 \rightarrow O_2^{-*}$$
$$O_2^{-*} + e^{-} + 2H^{+} \rightarrow H_2O_2$$
$$e^{-} + H_2O_2 \rightarrow OH^{-} + OH^{*}$$

Based on the reaction of photocatalytic process in the Equation 2, the number of e_{-} and h_{+} were produced by photocatalyst C-Dots very affects to the performance of C-Dots in the water purification process. By analyzing the absorption intensity in the highest peak at wavenumber about of ~664 nm, the performance of C-Dots as a photocatalyst can be estimated, as shown in Fig. 3. Degradation intensity of the absorption from methylene blue solution appear differently in the some process of water purification without photocatalyst C-Dots, using phtotocatalyst C-Dots from frying oil and waste frying oil. Degradation intensity of this absorption is proportional with the decreasing of methylene blue concentration in the water [7,8]. The performance of C-Dots from waste frying oil was observed more effectively as a photocatalyst in the water purification process of methylene blue solution. This was observed from the degradation intensity of absorption were very sharp during the process of water purification.

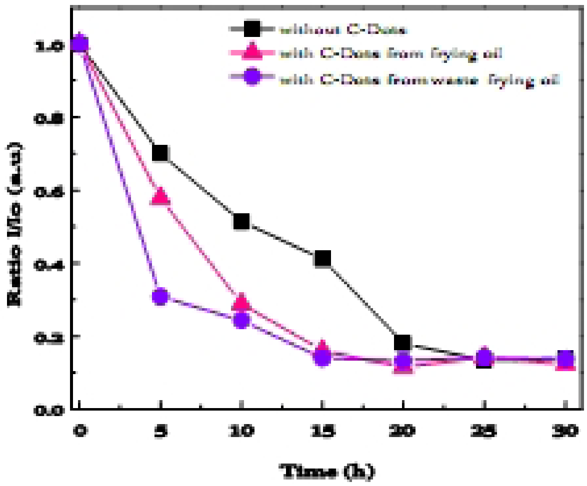

FIGURE 3. Degradation Intensity of the Methylene Blue Absorption.

C-Dots from waste frying oil has a good performance as a photocatalyst due to the concentration of particles C-Dots are high on methylene blue solution. Continuous of the heating process on waste frying oil caused the fabrication of C-Dots that pass through polymerization and carbonization process more easily formed and were resulted the number of C-Dots particles with a higher concentration. In the photocatalytic process, the solar light irradiation crash into the surface of the C-Dots from waste frying oil, that produce hydroxyl free radicals OH* with a higher concentration so that the process of water purification can run faster.

CONCLUSIONS

C-Dots from waste frying oil can be used as a photocatalyst in the water purification process of the methylene blue solution. In the process of water purification, C-Dots from waste frying oil have a better performance if compared to the process without photocatalyst and photocatalyst C-Dots from frying oil. The photocatalyst C-Dots from waste frying oil have degradation intensity of the absorption of methylene blue solution decreased sharply so that the water purification process can run faster.

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