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Research Article

Utilization of Corn Oil as a Photocatalyst of Carbon Nanodots for Wastewater Cleaning

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Abstract

Water is a basic need of society. Unfortunately, the availability of clean water is very limited due to the large amount of waste in the waters in various regions in Indonesia. Thus, innovation is needed to purify wastewater. This research utilizes corn oil to reduce the pollution of dye waste, which is a problem for the environment. Corn oil is easy to find so it is suitable to be used to purify water waste. The photocatalyst technique using carbon nanodots of sun-assisted corn oil is an economical and easy-to-obtain method. Carbon nanodots from corn oil are made using the Hydrothermal method at a temperature of 2500^{o}C heated for 3 hours. Carbon nanodots from corn oil are used as a photocatalyst in artificial methylene blue waste solutions. The photocatalyst test process is carried out by varying the amount of carbon dots. The result was observed until the artificial wastewater from methylene blue turned clear by varying a lot of carbon from 2 ml, 4 ml, 6 ml, 8 ml, and 10 ml. When the carbon nanodot content is 8 ml, the fastest time needed to clear methylene blue wastewater is 55 minutes. The fewer or more solutions given, the more time to clear up. These results indicate that carbon nanodots from corn oil can be used for photocatalyst purification of methylene blue wastewater.

Keywords: *Corn oil, Carbon nanodots, Photocatalyst*

Pemanfaatan Minyak Jagung Sebagai Fotokatalis *Carbon nanodots* Untuk Penjernihan Air Limbah

Abstrak

Air sebagai kebutuhan dasar masyarakat sangat dibutuhkan. Ketersediaan air bersih sangat kurang, diakibatkan banyaknya limbah pada perairan di berbagai wilayah di Indonesia, sehingga dibutuhkan sebuah inovasi untuk penjernihan limbah air. Penelitian ini memanfaatkan minyak jagung untuk mengurangi pencemaran limbah zat pewarna yang menjadi masalah bagi lingkungan. Minyak jagung mudah ditemukan sehingga cocok digunakan untuk menjernihkan limbah air. Teknik fotokatalis menggunakan carbon nanodots minyak jagung berbantuan sinar matahari merupakan cara yang ekonomis dan mudah didapat. Carbon nanodots dari minyak jagung dibuat dengan metode Hydrothermal pada temperatur 250^{0}C dipanasi selama 3 jam. Carbon nanodots dari minyak jagung digunakan sebagai fotokatalis pada larutan limbah buatan methylene blue. Proses uji fotokatalis *dilakukan dengan memvariasi jumlah kadar Carbon Dots. Hasil ini diamati hingga air limbah buatan Methylene Blue berubah menjadi jernih dengan memvariasi banyak carbon mulai dari 2 ml, 4 ml, 6 ml, 8 ml, 10 ml. Hasil yang didapatkan ketika kadar carbon nanodots sebesar 8 ml, waktu paling cepat yang dibutuhkan untuk menjernihkan air limbah methylene blue yaitu 55 menit. Semakin sedikit maupun semakin banyak larutan yang diberikan waktu untuk menjernihkan semakin lama. Hasil ini menunjukkan bahwa carbon nanodots dari minyak jagung dapat digunakan untuk fotokatalis penjernihan air limbah methylene blue.*

Kata Kunci: *Minyak jagung; Carbon nanodots; Fotokatalis*

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I. INTRODUCTION

Water is one of the human needs, which is an essential basis in the process of human survival. The UNESCO world body has determined the basic human right to water, which is 60 ltr/person/day. Population and industrial growth are increasing. Therefore, currently the need for water is getting higher, and it is estimated that it will continue to increase up to 15% - 35% per capita per year [1]. On the other hand, the availability of clean water tends to decrease due to natural damage and contamination of water sources by organic and inorganic wastes [2].

Water has properties as a good solvent so that it can easily dissolve organic materials left over from disposal (waste). Organic materials that dissolve in water will decompose [3]. This event causes water to become polluted [4]. This pollution causes oxygen levels in the water to drop drastically, which causes the death of the water biota [5]. Some of the characteristics that indicate that the water is polluted can be seen qualitatively from its color, viscosity, and odor. The very high level of water consumption demands humans' efforts to meet the water needs. One of the efforts is to purify polluted water [6].

Water purification is currently being done through oxidation processing with chlorine, filtration methods using porous composites from clay, activated carbon, and clay silver/zeolite composites, as well as flocculation, reverse osmosis, and ultrafiltration methods [7]. There are several disadvantages of this water purification technique. For example, the filtration method using porous composites from clay in its manufacture requires a very high combustion temperature of T= 900 ^{o}C – 1200 ^{o}C and can only be used to filter large pollutants because of its permeability value at order ~10-17 m^2 to ~10-15 m^2 [8]. Yet, water purification techniques using flocculation, reverse osmosis, and ultrafiltration are techniques that are relatively expensive.

Oil as a water purifier, and vegetable oil as a type of cooking oil is divided into two groups [9]. First, oils used in the non-food industry (non-edible oils) such as eucalyptus oil, castor oil, and so on. Second, vegetable oils that can be used in the food industry (edible oils) known as cooking oil.

Cooking oil is the final result (refined oils) from a process of refining vegetable oils of edible group and consists of various types of triglyceride compounds [10]. Cooking oil serves as a medium for conducting heat, adds a savory taste, adds calories in food, and adds nutritional value. Oils that are classified as edible oils are corn oil, canola oil, and so on [11]. Corn oil is rich in calories, approximately 250 calories per ounce. Corn oil is a stable cooking oil that resistant to rancidity due to the presence of oil-soluble tocopherols.

One of the water purification techniques currently being studied by researchers in the photocatalytic technique uses a semiconductor material as a catalyst [12]. Several advantages of the photocatalytic technique compared to other methods are (1) strong oxidizing properties; (2) it does not form new toxic compounds; (3) the chemical bond is stable to light; (4) insoluble in water; (5) degrade water-dissolved pollutants; and (6) relatively low cost and simple process [13].

The photocatalytic process mechanism occurs when photons from sunlight strike the photocatalyst material causing the excited electrons from the valence band to the conduction band to form electron pairs and holes [14]. The resulting electrons and holes will react with water (H_2O) and oxygen (O_2) and produce free radicals to decompose organic pollutants. One of the semiconductor materials widely used in the photocatalyst process is the titanium dioxide (TiO_2) [15]. TiO_2 has excellent performance as a catalyst in the photocatalyst process for organic pollutants [16]. Photocatalyst materials can be effective as catalysts in the photocatalyst process if direct sunlight or UV light is obtained [17]. TiO_2 has a density that is much greater than the density of water, which is 4.32 g/cm^3, so TiO_2 requires modification by immobilizing TiO_2 particles in a low-density and transparent polymer [18]. This modification is made so TiO_2 particles can float on the surface of the water and receive direct sunlight [19]. The immobilization process of TiO_2 particles is one of the most complex problems because very good conditions and adhesives are needed so that the filtrate and catalyst are not mixed [20]. Another disadvantage of TiO_2 is that it includes inorganic materials that are not environmental friendly and can become pollutants in the water purification process.

C-Dots can be used in various applications such as photocatalysts, energy conversion, bioimaging, biological labeling, sensors, and optoelectronics [21]. The difference in density between cooking oil and water is an important basis for utilizing C-dots from corn oil as a photocatalyst for water purification [22]. The difference in density will cause oil and water not to mix easily so that it is easy to separate after the photocatalyst process ends [23]. C-Dots is a new material in the class of carbon nanomaterials which is currently of interest to many researchers because it has the potential in a very wide field of application such as bioimaging, sensors, ink, drug delivery, optoelectronics, and photocatalysts [24]. C-Dots can be produced simply from organic materials such as soybeans, oranges, ginger, and garlic through a hydrothermal process [25]. C-Dots can also be synthesized from waste cooking oil [26]. The abundance of carbon chain bonds in used cooking oil makes it the basis for making C-dots [27]. Used cooking oil with a density lower than water, which is 0.93 g/cm^3, can easily float on the surface of the water and receive direct sunlight [28]. The difference in density between used cooking oil and water is an important basis for utilizing C-dots from used cooking oil as water purifying photocatalyst. Again, the difference in density causes oil and water not to mix easily so that it is easy to separate after the photocatalyst process ends. The C-dots performance of used cooking oil was observed to be more effective as a photocatalyst material in the methylene blue solution purification process than the photocatalyst process without being coated with C-dots. This can be seen from a very sharp decrease in the degradation of the absorption intensity [29].

Water is a basic need of society. Unfortunately, the availability of clean water is significantly decreased due to the large amount of waste in the waters in various regions in Indonesia. Thus, innovation is required in order to purify wastewater. In general, the discussion about photocatalysts stops at the results showing that the photocatalyst material can degrade pollutants faster. In connection with this, there are no parameters that indicate the quality of water resulting from the photocatalyst process [30]. Therefore, this study will analyze water quality standards resulting from the C-dots photocatalyst process from used cooking oil against the methylene blue test solution. The results of this research are expected to have the potential to be used as a reference in the study of environmental conservation efforts and as an answer to dealing with the problem of liquid waste.

II. METHOD

Materials and Instruments

Carbon nanodots (C-dots) are the basic material for this photocatalyst effect. As a base for the C-dots, corn oil is very easy to find and is commonly used for cooking. The photocatalyst process here is to purify methylene blue artificial wastewater utilizing the help of C-dots made from corn oil. The research process was carried out at the Physics Laboratory of FMIPA Universitas Negeri Yogyakarta.

The first photocatalyst made from corn oil C-dots was done by breaking the carbon oil first. To do this, corn oil is put into the hydrothermal (oven) for 3 hours at 2500 ^oC. Then, mix 2 ml of methylene blue with 200 ml of distilled water. The artificial waste is poured into five cups containing 40 ml each. After the oil is heated, C-dots are formed and then mixed with artificial waste from methylene blue. After that, the photocatalyst effect is carried out on the artificial waste. The photocatalytic effect is accomplished by pouring oil into an artificial waste solution. Wait until the oil is completely on the water, then dry in the sun at the same time.

Method and Procedure

This research was conducted experimentally, where the results of the study were analyzed by referring to related references. The C-dots content mixed in the methylene blue solution was varied for this research, by 2 ml, 4 ml, 6 ml, 8 ml, and 10 ml. The research stages are described in Figure 1.

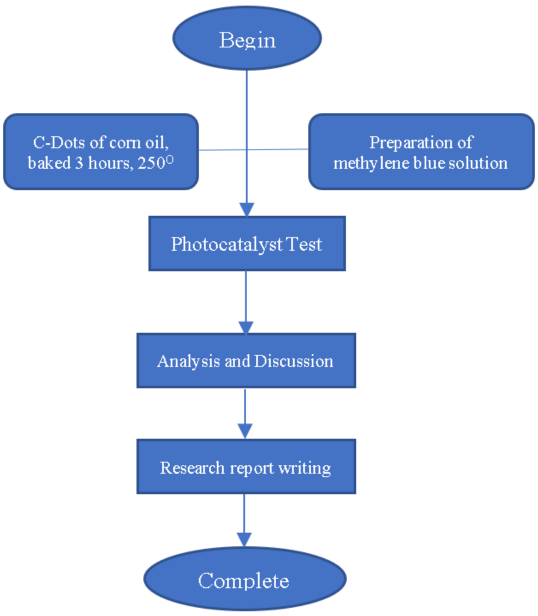


Figure 1. Research flow chart

III. RESULTS AND DISCUSSION

This study aims to clear up waste using a photocatalyst process using carbon nanodots in corn oil. The making of carbon nanodots from 40 ml of corn oil by heating them in an oven at a temperature of 2500 ^{o}C for 3 hours can be seen in Figure 2.

Figure 2. Heating oil

The long heating process will increase the saturation of fatty acids in the oil. Saturated fatty acids have more carbon bonds than unsaturated fatty acids, so the number of broken carbon chains and C-dots particles is also increasing. The abundant content of carbon chain bonds in oil is the basis for making C-dots. The carbon chain bonds abundant in oil are easily broken due to the heating process and undergo the rearrangement of carbon chains to form particles. The oil sample after being in the oven can be seen in Figure 3.

Figure 3. Corn oil C-dots

After that, the photocatalyst process is carried out using sunlight by looking at the effect of the carbon nanodots solution on the purification of methylene blue artificial wastewater. This study used five samples of artificial wastewater with a ratio of 1:50 ml of methylene blue and distilled water, by varying the number of carbon nanodots, namely 2 ml, 4 ml, 6 ml, 8 ml, and 10 ml. The methylene blue liquid waste purification experiment can be seen in Figure 4.

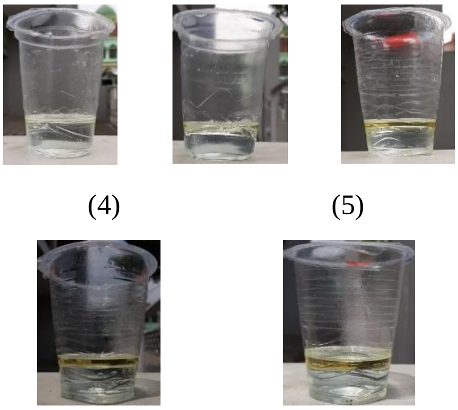
Figure 4. Methylene blue and carbon nanodots waste

After that, the experiments on methylene blue waste purification using carbon nanodots assisted by sunlight in the photocatalyst process was conducted by making a sample of 5 methylene blue waste with various carbon nanodots. The results are as follow: for methylene blue waste and 2 ml carbon nanodots, the time it takes to purify water is 120 minutes; methylene blue waste and 4 ml carbon nanodots waste takes 85 minutes to purify water; methylene blue waste and 6 ml carbon nanodots takes 75 minutes to purify water; methylene blue waste and 8 ml carbon nanodots takes 55 minutes to purify water; methylene blue waste and 10 ml carbon nanodots takes 60 minutes to purify the water. This stage can be seen in Figure 5 and Table 1.

Table 1. Lots of carbon nanodots and time are needed to clean up methylene blue waste

Carbon nanodots (ml)	Time (minutes)
2	120
4	85
6	75
8	55
10	60

(1) (2) (3)



(4) (5)

Figure 5. (1) carbon nanodots 2 ml; (2) carbon nanodots 4 ml; (3) carbon nanodots 6 ml; (4) carbon nanodots 8 ml; (5) carbon nanodots 10 ml.

The results of this study indicate that corn oil-based C-dots can clear up cloudy water based on the experimental results, and different results are obtained due to different doses of carbon dots. The research was conducted by varying the content of carbon nanodots mixed in the methylene blue waste solution. There were five variations, 2 ml, 4 ml, 6 ml, 8 ml, and 10 ml. The artificial wastewater used is methylene blue. The methylene blue test solution that has gone through the photocatalyst process has experienced color degradation from deep blue to colorless (clear). This shows that the C-dots photocatalyst material from corn oil is effective in degrading methylene blue particles. This will produce different photocatalytic purification times in wastewater. Table 1 displays the depiction of the results of the photocatalyst process, including the relationship between carbon nanodot levels and time. Of the five samples tested, the 8 ml of carbon nanodots required the shortest time to clear methylene blue artificial waste, namely 55 minutes, and 2 ml of carbon nanodots required the longest time, which was 120 minutes.

IV. CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that the analysis of water quality standards from the photocatalyst process using C-dots material from corn oil in terms of waste purification is effective in degrading methylene blue particles. The methylene blue test solution that has gone through the photocatalyst process has experienced color degradation from deep blue until the solution is colorless (clear). These results have met the water quality standards physically, namely, the colorless (clear) solution.

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