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A Design Study of Cajaput Oil Industry Based on Carbon Nanodots

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ABSTRACT
The aim of this study was to produce a design of a cajaput oil industry that can improve the products of cajaput oil industry based on carbon nanodots (C-dots). The method used in this study was research and development (R&D) with observation at the Sendang Mole cajaput oil factory and simple experiments to produce C-dots-based products from solid and liquid wastes of the cajaput oil factory. The results of this study are samples of C-dots-based products obtained from solid and liquid wastes of cajaput oil factory and also a proposed design of improved cajaput oil industry. The improved cajaput oil industry is represented in the form of a process design (Fig. 3) and a cardboard mock-up of the cajaput oil industry (Fig. 4). The current cajaput oil factory in Sendang Mole produces three kinds of products, i.e.: pure cajaput oil (1st product), briquettes (2nd product), and compost (3rd product). Moreover, by improving the cajaput oil industry according to Figs. 3 and 4, the products can be expanded to an overall 12 products based on the C-dots.

Keywords: *cajaput oil industry, C-dots, liquid wastes, solid wastes.*

1. INTRODUCTION

Industrial and factory wastes are one of the problems in today's industrialization era. Industrial wastes are wastes produced as a result of raw materials processing for the production of new products [1]. Industrial wastes can produce toxic materials, which can pollute the environment, and hence have negative impacts on humans and other environmental components [2]. The wastes generated from the factory can be in the form of solid and liquid wastes. Solid wastes, if not treated properly, can pollute the atmosphere in the form of smoke in burning or heating processes. Organic solid wastes can give off an unpleasant odor [3], while liquid waste can cause pollution towards water and soil resulting in the death of fish, plankton, andthepoisoning of humans and livestock [4].

One of the factories that produces solid [see Fig. 1b)] and liquid [see Fig. 1c)] wastes is cajaput oil factory in Sendang Mole, Playen Gunung Kidul, Yogyakarta [see Fig. 1a)]. Based on the preliminary observation on the 20th May 2020, this factory processes cajaput plants by utilizing fresh twigs and leaves to become cajaput oil through a refining process. This latter process produces refined cajaput oil but alsowastes. The wastes produced are solid wastes of leaves and branches, whereas the liquid waste is produced from the distillation process. The number of leaves and branches that are refined reaches 2,406 tons in 2019 and produces 22,821 liters of cajaput oil (Secondary Data, 2020).

Currently, the Sendang Mole factory uses the solid wastes as fuel for the refining heating process in the form of briquette and also as compost. The process of producing cajaput oil requires 3600 kg of briquettesa day with four times heating processes [5]. This shows that there is still more than half of the solid wastes left after being processed into briquettes. In addition, the

compost and some remaining leaves and branches are still seen piling up at the factory.

On the other hand, wastes can actually be processed to provide benefits so as to generate economic values and benefits, namely not only for the industry, but also for parties with an interest in the wastes [6]. In this case, one way to do this is by processing wastes from the Sendang Mole cajaput oil factory into carbon nanodots (C-dots).

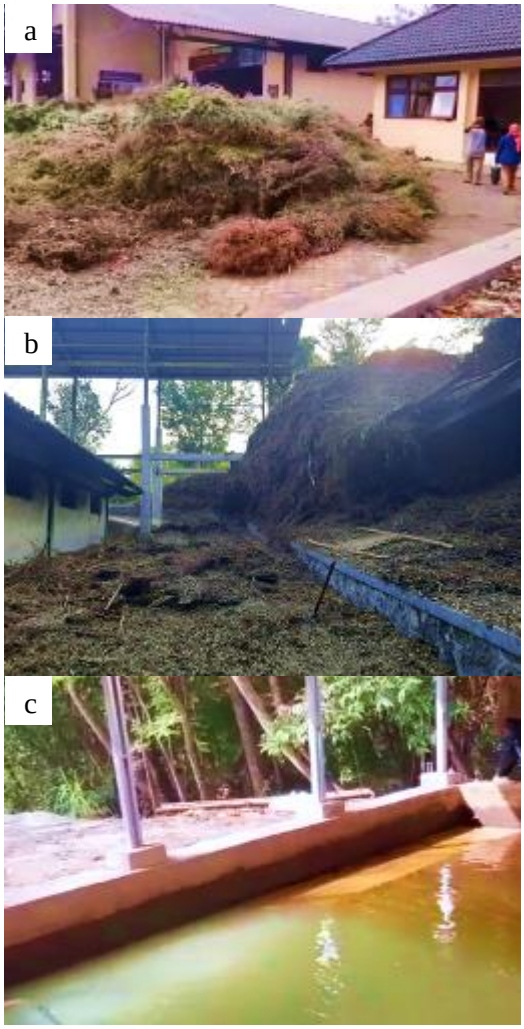

Figure 1. a) Sendang Mole cajaput oil factory, b) solid wastes, and c) liquid waste pool.

C-dots are materials that are currently popular, especially in nanotechnology. C-dots can be obtained from materials that contain carbon atoms. Most organic materials contain carbon so that C-dots can be produced from them such as natural fibers and fruits [7]. One of the studies that has been done to produce C-dots is [8] by utilizing fresh plants of cajaput oil leaves. This shows that C-dots can be produced from fresh cajaput oil plants, which gives the possibility that it can also be produced from the excess of the cajaput oil distillation process.

The addition of C-dots obtained from the excess of cajaput oil refinery can improve the quality of the cajaput oil product itself. This is because adding C-dots provide more benefits than using pure cajaput oil, e.g.: C-dots can reduce the surface tension and viscosity of the cajaput oil [9]. In addition, C-dots have anti-bacterial properties [10], which make the use of cajaput oil safer. In addition, C-dots have good solubility, non-toxicity, and high luminescence [11], so they can be used for various applications, including bioimaging, sensors, drug delivery, catalysts, and photovoltaic devices [12]. This shows that the reprocessing of wastes from the distillation of cajaput plants into C-dots in order to manage wastes in the cajaput oil factory can improve the cajaput oil industry. In other countries, such as Vietnam, Australia, and China, their cajaput oil industry focus only in producing the main product of cajaput oil and using the wastes as fuel [13,14]. To the best knowledge of the authors there has been no mention of reusing the wastes of cajaput plants into C-dots. Hence, the aim of this study is to produce a design of cajaput oil industry that can improve the industry based on C-dots.

2. METHOD

One way to improve the cajaput oil industry is to modify the factory wastes of the cajaput plants. Hence, this was a research and development (R&D) study. This research was first carried out with initial field observation at the cajaput oil factory in Sendang Mole, Playen, Gunung Kidul. The researchers met with the head and a staff of the factory and interviewed them. From the field observation, we obtained samples of solid wastes consisting of compost, dry stems, and dry leaves, as well as liquid wastes from the distillation of the cajaput oil. These samples were then designed and used as the precursor for the production of C-dots to improve the usage value of the residual distillation of the cajaput oil industry. In addition, a simple experiment was carried out to find out whether the carbon atoms from the wastes could be processed into C-dots based on their luminescence property when exposed by violet/ultraviolet (UV) laser.

3. RESULTS AND DISCUSSION

Based on the many benefits of C-dots for various applications, of course, will cause a high demand for these nanomaterial in the future. Hence, this must be supported by the existence of a factory capable of producing C-dots nanomaterial on a large scale. Based on the explanation by Wartono, who is a staff of the Sendang Mole cajaput oil factory, there is 60% of cajaput oil wastes that has not been utilized. In fact, in a day this factory can use 18 tons of raw material consisting of the stem and leaves of cajaput plants. Observing that there is still a large amount of carbon

wastes that are not utilized in the cajaput oil industry, which has the potential to be used as precursor for producing C-dots. The author proposes an idea to improve the design of the cajaput oil industry.

An improvement of the cajaput oil industry design is conducted to produce cajaput oil and C-dots nanomaterial by modifying the existing cajaput oil industry design. In the present cajaput oil industry, such as in Sendang Mole, Gunung Kidul, the process of extracting cajaput oil until the final product still uses traditional distillation method resulting in carbon wastes that have the potential to be reprocessed into C-dots.

In the current production of pure cajaput oil, there are two forms of wastes that have not been fully utilized, i.e.: solid and liquid wastes. Liquid wastes from the cajaput oil processing is in the form of water used for boiling and still appears after refining. The liquid wastes are currently not fully utilized and only used to cool down the cajaput oil product. Wastes in the form of leaves and branches left over from the extraction process will only be removed from the container or boiler, dried in the sun, and then pressed to become briquettes [15] and the remaining part of it is used as compost. The briquettes are usually used as fuel in the distillation process, while the compost produced is used as fertilizer or sold to the public. However, the compost may only be utilized after one or two years since the distillation process. This is because fresh compost is quite hot, which may not be directly suitable as fertilizer.

In the improvement of cajaput oil industry design, the distillation method for cajaput oil distillation is maintained including the tools used but adding installations to produce the C-dots material. The production of the C-dots utilizes liquid and solid wastes. The addition of the C-dots production process and maintaining the cajaput oil production method causes additional processes in the cajaput oil industry, i.e.: i) solid wastes in the form of leaves and branches are dried in the sun besides being made as briquettes, partially taken as precursor for producing C-dots; ii) the compost, dry leaves, and dry branches wastes are crushed into powder, iii) the powder is heated in an oven at a certain temperature and time duration; iv) the heated powder is then refined again using a grinding tool; v) the powder is then mixed with pure cajaput oil, distilled water, and the liquid waste, respectively, and finally vi) the mixtures produced are then filtered to produce C-dots products. The results of the C-dots products may be observed in Fig. 2.

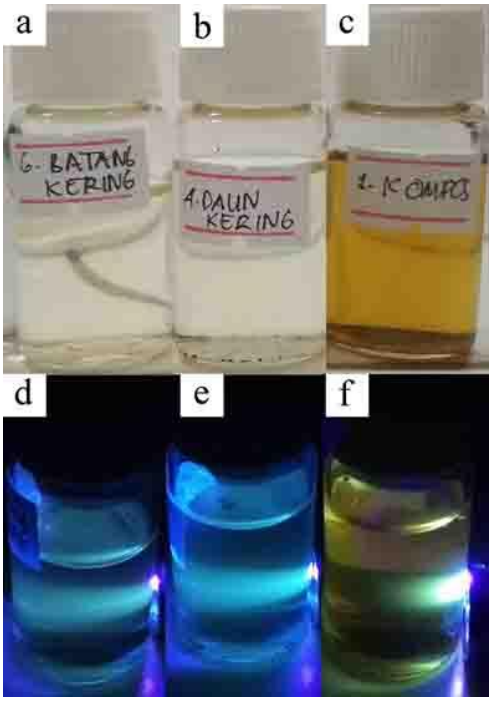

Figure 2. C-dots products made from cajaput oil wastes of a) dried branch, b) dried leaves, and c) compost. Luminescence property of the C-dots from d) dried branch, e) dried leaves, and f) compost.

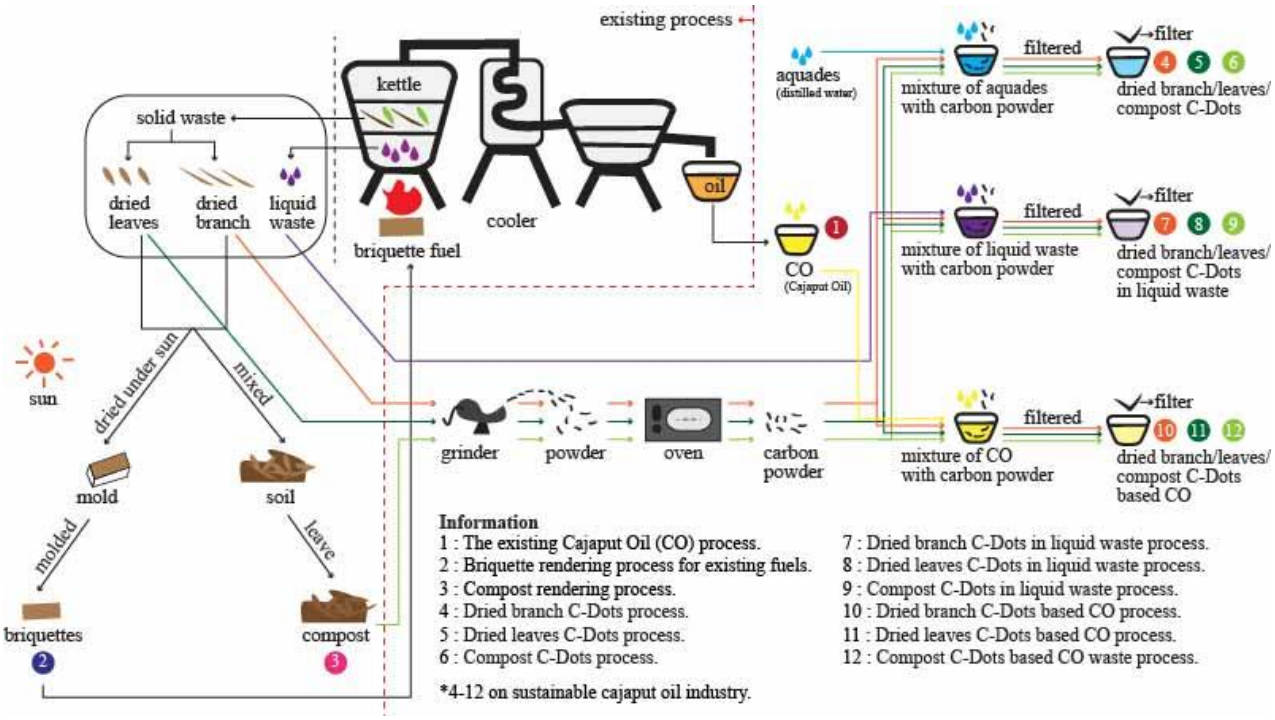

Figure 3. Improving the cajaput oil industry design.

Based on the results of simple experiments carried out, the products of C-dots made from dry branches [Fig. 2a)], the dry leaves [Fig. 2b)], and compost [Fig. 2c)] emit cyancolor [Figs. 2d) to 2f)] when exposed by violet/UV laser. This can be an indicator that cajaput oil wastes can be reused into C-dots based on their ability to emit light at visible range after absorbing light at UV range [16].

The improvement of the cajaput oil industry design is diagrammatically proposed in Fig. 3. The current cajaput oil industry only produces pure cajaput oil products (1st product) and by-products in the form of briquettes (2nd product) and compost (3rd product). In the improvement design, more products are suggested to expand the market opportunities. Other products that can be produced are C-dots from dried branches, dried leaves, and compost, i.e.: 4th, 5th, and 6th products, respectively; C-dots from dried branches, dried leaves, and compost in liquid wastes, i.e.: 7th, 8th, and 9th products, respectively; and C-dots from dried branches, dried leaves, and compost in cajaput oil, i.e.: 10th, 11th, and 12th products, respectively. Moreover, the cardboard mock-up of the cajaput oil factory design with an added processing plant may be observed in Fig. 4.

In this improved cajaput oil industry, there is an improvement of product quality from pure cajaput oil into C-dots-based cajaput oil. This can be viewed by mentioning the advantages and properties of C-dots. C-dots have advantages, including non-toxic, environmentally friendly, low manufacturing costs, and easy to prepare [17]. By improving the pure cajaput oil into C-dots-based cajaput oil, the surface tension of the latter product can be decreased so that the oil is more easily absorbed by the skin. Another advantage of C-dots based cajaput oil is its antiseptic and antibacterial properties [10]. In addition, by using C-dots based cajaput oil the production costs do not increase too high, no significant increase in product toxicity, and does not demand high skilled human resources.

The increase in the number products from three products to 12 products, which are C-dots based products, as well as an indication of the quality improvement of cajaput oil products may give the cajaput oil industry to be more competitive and hence obtain a high market share in the future. This is because there are many opportunities to apply C-dots, such as in the fields of technology and health. In addition, the combination of the large potential market share and the number of products produced can encourage the expansion of the cajaput oil industry and cajaput plantations, which have great potential in creating employment opportunities. The potential for job creation and the use of wastes in the cajaput oil industry supports important points in the 2030 Sustainable Development Goals (SDG), namely reducing poverty and commitment to environmental conservation.

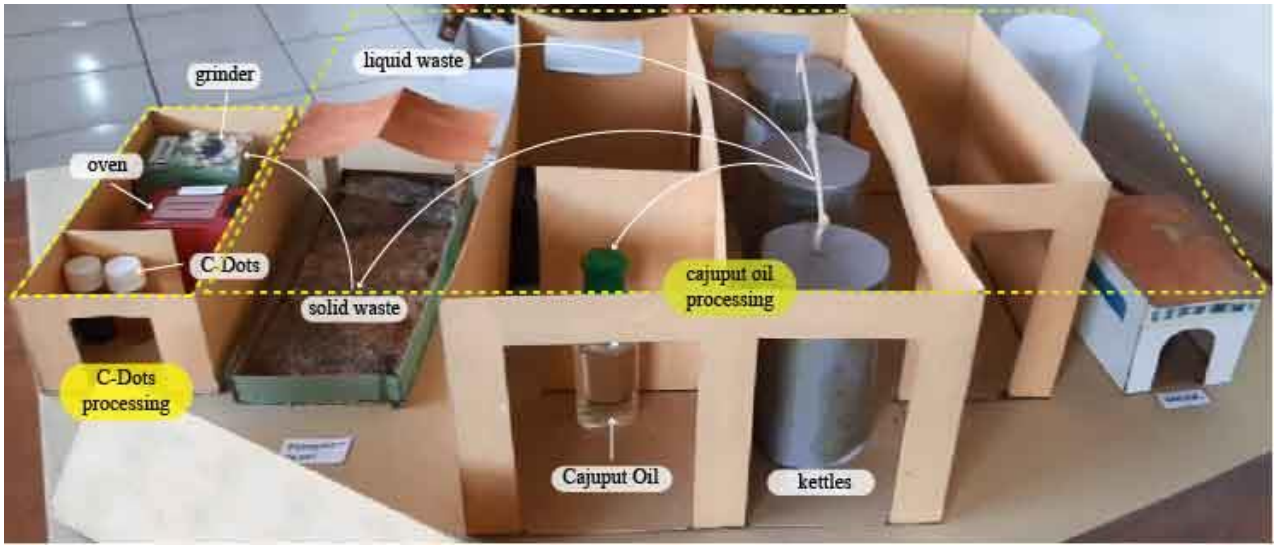

Figure 4. Cardboard mock-up of the cajaput oil industry design by adding a C-dots processing plant.

4. CONCLUSIONS

In summary, this study serves as the basis for increasing the usage value of cajaput oil wastes in the form of an improved industrial design by reusing the residual wastes from cajaput oil distillation into C-dots. We hope that further studies in this important area will be continued by examining the use of C-dots from cajaput oil distillation wastes in different contexts given the opportunities of exploiting theseC-dots material.

AUTHORS' CONTRIBUTIONS

WSBD contributed to the main idea of the manuscript and revising the manuscript, ANAR contributed in data collecting and analysis, and also writing the manuscript, F and PWP contributed equally in the data collecting and analysis of the study.

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