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Carbon deposition from biotar by fast pyrolysis of palm empty fruit bunch

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Abstract

This paper presents a technology to recover carbon available in tar vapor produced from fast pyrolysis of oil palm empty fruit bunch, EFB using porous biochar pellets by employing chemical vapor infiltration, CVI method. By combining slow and fast pyrolysis of EFB, a process was developed employing CVI method, to produce a value-added EFB product. In this developed process, porous biochar produced from slow pyrolysis of EFB pellet was introduced as a medium for tar decomposition to take place. Tar vapor infiltrated within biochar pores and then decomposed into carbon and gases where carbon was deposited on the pore surface. Non-condensable gases can be collected and biotar can be recovered in the form of carbon deposit before being utilized as a renewable energy source by itself. The purpose of this work is to investigate the possibility of using EFB-derived biochar as a medium for tar decomposition and carbon deposition during secondary pyrolysis reaction. Temperature 450°C was found to be the optimum temperature for this secondary pyrolysis reaction to take place within the EFB-derived biochar leaving solid carbon within the available pores. The product of this tar filtering process was carbon-deposited biochar – a potential candidate to be used as an alternative fuel source.

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Keywords: Pyrolysis; empty fruit bunch; chemical vapor infiltration; secondary decomposition; carbon deposition

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1. Introduction

Palm oil is bright orange-red oil produced from the fruit of palm trees of species *Elaeis Guineensis,* containing high beta-carotene. The antioxidant content in palm oil is good for beauty and health purposes. Palm oil is widely used in Europe as cooking oil, and may be blended into mayonnaise and salad. Currently, Malaysia is one of the largest palm oil producers and exporters in the world, and it accounts 39% of palm oil production and 44% of world exports[1]. Oil palm trees are being widely planted and grown throughout the country, and the number of plantations is growing bigger in line with the projection by Malaysian government.However, from this palm oil sector, plenty of palm residues are being generated yearly, which raises concerns. It is reported that from every kg of palm oil obtained, 4 kg of dry biomass is produced[2]. In year 2010, approximately 80 million dry tons of biomass was generated from palm industry, and this amount is expected to rise to 100 million dry tons by 2020[3]. This is a very large growing number of dry tons to be generated despite the inefficiency of current waste management, and the solid waste generated most is empty fruit bunch, EFB[4, 5]. Technologies have been employed to utilize the residues, however, there are still lots of these palm wastes are being discarded in landfills due to large and continuous production of palm oil, and high disposal cost. Being left in improper condition, these palm residues causes environmental deterioration[6]. Nevertheless, Malaysian government is aware of this problem and is now working with private sector companies and research institutes to fully utilize these palm residues to gain more revenue from this growing industry.

One of the most prominent biomass utilizations is pyrolysis process, and during this process, biomass is heated to certain temperatures with absence of oxygen, producing biochar, biotar and gases. The parameters in this process can be varied in accordance to the objectives of the particular study. With this, a value-added biomass pyrolysis product is able to be produced, to generally secure a sustainable economy and a viable environment.

The solid product of biomass, biochar, is a highly carbonaceous material making it attractive to be collected as an energy source, and highly porous for chemical reaction to take place within its active sites[7, 8]. Among the advantages to convert biomass into biochar are efficient transportation and storage, and flexible in production and marketing. Currently, biochar is largely being produced for agricultural industry as carbon sequestration in soils, enhancement of water holding capacity, improvement of soil quality, and nutrient retention[9, 10] rather than utilized as an alternative energy source. Biochar has high carbon content and low sulfur content as compared to char produced from the non-renewable coals, and these characteristics are favorable to be used as an alternative fuel source. However, biochar produced from pyrolysis of EFB can only retain a small amount of carbon as compared to other woody biomass. This is due to the fact that a raw EFB contains more than 60% moisture, and lower lignin content than that of woody biomass. This is the reason why EFB biochar is not a common candidate for an alternative energy source.

Besides biochar, biotar is also an important pyrolysis product which contains a mixture of naturally occurring compounds, including carbon, which makes it attractive to be collected and used as a fuel source. Biotar tends to undergo secondary reaction, to decompose into secondary char, and to degrade into lower molecular weight compounds and gases. This decomposition is normally difficult to control and it usually takes place in pipe lines, engines and filters, causing clogging and blockage to the equipment and machines. Therefore, many studies have been carried out to decompose tar into gases by gasification process at high temperatures.

In this study, a process was developed to decompose tar into carbon by employing chemical vapor infiltration, CVI method (Fig. 1) with porous biochar being the medium of reaction, and to deposit carbon on the biochar pore surface. This study aimed to produce high-carbon content EFB-derived biomass product to be used in biofuel application, in the form of solid for a more efficient storage and transportation. The purpose of this study is to investigate the possibility of using EFB-derived biochar as a medium for tar decomposition and carbon deposition by Chemical Vapor Infiltration, CVI.