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Development of a small-scale reactor system for bioethanol production from agriculture waste geared towards small industries applications in Malaysia

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Abstract. Bioethanol derived from agriculture can be an alternative fuel source to petroleum-based fuel as the fuel hike and supply depreciation. In Malaysia, agriculture waste materials especially from chip industries (such as banana/yam/tapioca) are potential to be one of the feedstock for producing bioethanol. The utilization of the waste feedstock for biofuel production does not disturb the food chain as it is a *waste-to-energy* concept based. This paper presents the development of an affordable reactor system that is feasible to be applying in Small and Medium Enterprise (SME) in Malaysia. The reactor system concentrated on the fermentation of the feedstock. Based on the experimental results, it is estimated that the yielding percentage of bioethanol is around 14 % for batch production. Moreover, it is estimated that this reactor is able to produce bioethanol around 0.85 L for each batch of production which implied a petrol fuel cost saving for SMEs around 10 % if bioethanol is blended with the fossil fuel.

Key words

Bioethanol, Agriculture waste, Waste-to-energy, Bioreactor system

1. Introduction

At present, the importance of alternative energy source has become even more crucial matter not only due to the continuous depletion of limited fossil fuel stock but also for the safe, better and greener environment [1]. According to Lang *et al.* [2], bioethanol is an oxygenated fuel that contains 35% oxygen, which reduces particulate and NOx emissions from combustion. In addition, the toxicity of the exhaust emission from bioethanol is much lower compared to the petroleum sources [3]. Bioethanol derived from biomass is the only liquid transportation fuel that does not contribute to the green house gas effect. As a result, the production of bioethanol or ethyl alcohol could be one of the alternatives to replace fossil fuel in the future.

This paper mainly discussed the production of the bioethanol from starch feedstock namely yam, tapioca and banana, under laboratory conditions, via utilizing the yeast and microorganism. Besides, a few design parameters which are crucial for implementing bioreactor in small cottage industries were mentioned. Economical feasibility of the bioethanol is also studied by estimating the quantity of sugar generated and the bioethanol yield. In addition, some recommendations for future development are drawn.

2. Generation of the Biofuel

Throughout the years, numerous researches had been done on the biofuel technology [1-3]. As the technology evolved, the biofuel generally can be classified into two major categories by the feedstock nature itself. The first generation biofuel (conventional biofuel) is mainly referred to the fuel that had been derived from sources like starch, sugar, animal fats and vegetable oil. However, the first generation biofuel cannot produce enough biofuel without threatening food supplies and biodiverstiy [4]. As a results, second generation biofuel is developed to extend the amount of biofuel that can be produced sustainably by using biomass consisting of the residual non-food parts of current crops, such as waste agriculture stems, leaves, husks and skins that are left behind once the food crop has been extracted or process [5]. This subsequent generation of biofuel can expect to supply large quantity of biofuel which provide sustainably, affordably and with greater environmental benefits, especially for cottage industries applications.

3. Experimental Setup

Fig. 1 shows the experimental setup of a portable small-scale reactor system for bioethanol production from agriculture waste. The overall system was constructed by using used metals and waste materials in order to reduce cost.

As in Fig. 1, the ferment tank is used to sustain the cultivation tank's volume and feedstock tank's volume. The slurry flow in the reactor system is pumpless, viz. based on gravitational force. Besides, the temperature is control by using an aquarium heater (12 V) as the brewing of yeast required constant 30 °C throughout the experiment. The ferment tank has a stirrer operated by using a low energy electric motor to mix the slurry throughout the experiment.