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Technical paper

Characteristics Analysis of Bio-Based Silica Extracted from Sarawak Palm Oil Waste

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Abstract

Due to high production of palm oil, surplus quantities of palm oil wastes such as empty fruit bunches (EFB) and palm kernel shells (PKS) are generated. This study aims to analyze the characteristics of EFB and PKS ashes and their respective bio-silica content when combusted at different temperatures; 400°C, 600°C and 800°C. Several tests like weight loss, colour and Fourier Transform Infrared (FTIR) analysis are conducted. EFB records higher weight loss compared to PKS for all combustion temperatures, thus implying less silica content compared to the later. Both wastes also show the highest weight loss at 99.20% and 98.51% respectively, when they are burnt at 800°C than those combusted at lower temperatures. This happens because more impurities evaporate at 800°C, thus resulting in greater relative amount of silica in the ash. Colour analysis shows that the whiteness of both EFB and PKS ashes are the highest when combustion occurs completely at 800°C, particularly at 71.56 and 42.40 respectively. Besides, FTIR analysis depicts distinct presence of Si-O and Si-O-Si functional groups in both EFB and PKS ashes for all temperatures. It is also shown that combustion at 400°C are insufficient to remove impurities like hydroxyl groups, CH_2 components and organic compounds.

Keywords: *bio-based silica; colour; EFB; FTIR; PKS; weight*

1. Introduction

Silica or silica gel, is generally used to absorb excess moisture and has put forefront for process industries, refrigerant drying, insulating glass industry, as well as packaging desiccants and desiccant powder. Manufacturing pure silica uses intensive energy by smelting quartz sand with sodium carbonate at 1300°C [1]. Huge amount of energy is needed to operate the furnace in order to extract pure silica which contributes to much loss of heat and deteriorates the environment. In recent years, many researchers were concentrated in producing environment-friendly products to replace fossil fuels with renewable energy sources using biomass feedstock [2]. In conjunction with the increasing environmental issues, several studies are conducted to convert biomass wastes into beneficial products, for instance, the extraction of bio-silica from biomass wastes. The main key of research is to discover the possible alternatives of raw materials that can be burnt at lower temperatures than quartz and are able to produce bio-based silica.

As Malaysia is one of the world's largest producer and exporter of palm oil and palm oil products, the production of surplus quantities of biomass wastes is ample. Approximately 4 million tonnes of palm oil wastes are produced per year [3]. In the palm oil mills, only 10% of the fresh fruit bunches consists of palm oil, while the remaining 90% are discarded as wastes. On an average basis, 1 tonne of crude palm oil can be generated from 5 tonnes of fresh fruit bunches (FFB) [4]. Several researches on silica extraction from agricultural products, mainly rice husk ashes, have been done such as studies by Majumder et al. [5], Prasad and Pandey [6] and Della et al. [7]. However, limited study was found on the effects of temperature on the properties of the silica in the palm oil wastes. Therefore, in this research, the properties of bio-based silica extracted from palm oil empty fruit bunch (EFB) and palm kernel shell (PKS) that are heated at temperatures of 400ºC to 800ºC are investigated.

2. Materials and Methods

The raw materials used as samples in this research are the main wastes from palm oil industries, namely, empty fruit bunch (EFB) and palm kernel shell (PKS). They are collected from Kilang Sawit FELCRA Berhad Samarahan, Kota Samarahan.

2.1. Sample Preparation

Prior to the experiments, all sample materials are prepared via acid washing and oven dyring, as illustrated in Fig. 1. The samples are washed with 1M hydrochloric acid (HCl) until pH 1 solution is obtained, before being dried in the oven at 60°C for 24 hours. The dried samples are then burnt in a furnace for 6 hours at three different temperatures; 400°C, 600°C and 800°C. The physical properties and functional groups of the ash samples are then analyzed.

2.2. Physical Properties Analysis

2.2.1. Weight Loss Analysis

Weight loss of samples after combustion is determined to observe its relationship with the silica content in the sample. To compute this, the basic formula for weight loss as shown in Eq. 1 is used in this research.