การผลิตและตรวจสอบเอกลักษณ์เฉพาะของผงซิลิกาจากเถ้าชานอ้อย
Production and Characterization of Silica Powder from Sugarcane Bagasse Ash

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อผลิตซิลิกาจากเถ้าชานอ้อยด้วยใช้สารละลายโซเดียมไฮดรอกไซด์ ที่ความเข้มข้นต่างๆ คือ 2.0 2.5 และ 3.0 โมลาร์ ตามลำดับ ด้วยวิธีรีฟลักซ์และตรวจสอบเอกลักษณ์ ผลการทดลองพบว่าความเข้มข้นของสารละลายโซเดียมไฮดรอกไซด์ 2.5 โมลาร์เป็นความเข้มข้นที่เหมาะสม เป็นสภาวะที่ผลิตซิลิกาจากเถ้าชานอ้อยได้ประมาณ 55 เปอร์เซ็นต์ ผงซิลิกาถูกตรวจสอบเอกลักษณ์โดยใช้ข้อมูลสเปกตรัมอินฟราเรดสนับสนุน ผลปรากฏว่า พบหมู่ฟังก์ชั่นกลุ่มไฮโดรเจนในกลุ่มซิลานอลและกลุ่มไซโลเซนซึ่งเป็นอันตรกิริยาหลักในผงซิลิกา ตรวจสอบสัณฐานซิลิกาจากการวิเคราะห์โดยกล้องจุลทรรศน์อิเล็กตรอนแบบส่องกราด (SEM) พบว่าอนุภาคจับกันเป็นก้อนมีขนาด 100 นาโนเมตร พื้นที่ผิวจำเพาะเท่ากับ 120 ตารางเมตรต่อกรัม ผงซิลิกามีโครงสร้างเป็นอสัณฐาน ซิลิกาเมื่อศึกษาลักษณะเฉพาะโดยใช้เทคนิคเอกซเรย์ดิฟแฟรกชัน

คำสำคัญ: ผงซิลิกา เถ้าชานอ้อย การผลิต การตรวจสอบเอกลักษณ์

Abstract

This work was aimed to produce silica from sugarcane bagasse ash by using sodium hydroxide solutions at various concentrations of 2.0, 2.5 and 3.0 M, respectively by refluxing method and characterized their characterizations. The result from that 2.5 M NaOH is an optimum concentration. The condition can be produced silica from sugarcane bagasse about 55 %. Silica powder was characterized using infrared spectra data supports and shown that the hydrogen bonded silanol group and the siloxane groups are main interactions in silica powder. The morphology of silica was analyzed by scanning electron microscope (SEM). The results showed that the produced silica powder were agglomerate particle with dimension of 100 nm with specific surface area of 120 $m^2 g^{-1}$. The silica powder composed of amorphous structure when investigated characterization by using X-ray diffraction technique.

Keywords: Silica powder, sugarcane bagasse ash, production, characterization

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Introduction

Thailand is main agricultures and sugarcane is as a major source for sugar production. Sugarcane bagasse is used as fuel in the cogeneration process to produce steam and electricity in sugar industries. When bagasse is burnt in combustion boiler under controlled burning, reactive amorphous silica is formed in the residual ashes[1]. Due to increment of sugar consume high amount of sugarcane were produced, accordingly a large number of residue sugarcane baggasse ashes have grow-up day by day. Among the consequences of rapid growth are environmental disorders and pollution problems[2]. Sugarcane bagasse ash is a hazardous solid waste generated large amount. In this research, the works are focused mainly on the sugar cane wastes. At the present, the development of new procedures for its productive reuse is relevant. Actually, the accumulation of this waste is quartz-abundant which can be avoided by employing as a silicon source. By means of an alkali fusion extraction method, quartz particles can be dissolved and used as a silicon source for synthesizing silica-based materials such as zeolites Fyfe *et al.,* 2011[3] and nanosilica (Sasipriya *et al.,* 2009)[4].

The aim of this work is to produce sugarcane bagasse ash originating from Buriram sugar factory in Buriram province into silica powder at 100 °C and at atmospheric pressure. The products were characterized in terms of mineralogical composition using XRF XRD, FTIR and microstructures using SEM.

Material and Method

Sugarcane bagasse ash was obtained from Buriram sugar factory (in Buriram province) and was washed with water and then dried at 110 °C for 3 h. The mineralogical composition chemical analyses of sugarcane bagasse were accomplished by X-ray fluorescence (Horiba Mesa-500w).

Production of silica from sugarcane bagasse ash

The 10 g of sugarcane bagasse were stirred in 50 mL of sodium hydroxide (NaOH) solutions with 2.0 2.5 and 3.0 M in a boiling flask. The reactants were placed in a water bath and heated at 100 °C for 3 h. The solution filtrated and washed with 100 mL boiling water. The filtrate was cooled down to room temperature. After that, 5 M sulfuric acid was poured into the solution obtained at first step until pH 2 and then ammonium hydroxide was also added in the filtrate to obtain pH 8.5. The filtrate was left for 3.5 h at room temperature and then dried at 120 °C for 12 h to obtain white powder. They were identified by Fourier transformed infrared spectrophotometer (FTIR: Perkin Elmer, Spectrum GX). The structure of silica powder was characterized by means of X-ray diffraction technique while morphology was examined by scanning electron microscopy using a JSM-5910: JEOL. The best product was determined specific surface area by Brunauer-Emmett-Teller (BET) analysis.

Results and Discussion

From table 1, the results from X-ray fluorescence spectrometer (XRF) are summarized the chemical compositions of sugarcane bagasse sample which shown in Table 1. The highest amount of SiO_2 is 82.70 wt.% and then K_2O CaO Fe_2O_3 P_2O_5 are 4.06 3.55 2.48 and 2.47 wt.%, respectively and other components are 4.75 wt.%.

Table 1 Chemical compositions of sugarcane bagasse ash.

Types of oxide	%
SiO_2	82.70
Al_2O_3	1.12
K_2O	4.06
CaO	3.55
P_2O_5	2.47
MgO	1.24
SO_3	1.37
TiO_2	0.42
Mn_2O_3	0.60
Fe_2O_3	2.48

Table 2 Effect of concentration of sodium hydroxide on the percentage yield of white silica powder.

Concentration of NaOH (M)	(%)
2.0	27
2.5	55
3.0	31

As shown in table 2, the suitable concentration of sodium hydroxide was 2.5 M which given yield of silica of 55 %. At a concentration of 2.0 M sodium hydroxide solution, it not enough to make silica forming for precipitation by using sulfuric acid to obtain white silica powder with increase sodium hydroxide up to 3.0 M the percentage yields of silica, slightly increased.

Characterization of silica from sugarcane bagasse ash

The major chemical groups presented in silica were identified by FTIR spectra and shown in Figure 1. The broad band between 2800 and 3750 cm^{-1} was due to silinol OH groups and adsorbed water. The predominant absorbance peak at 1320 cm^{-1} was due to siloxane bonds (Si-O-Si) while 1200 and 700 cm^{-1} are attributed to vibration modes of the gel network (Kalaphathy *et al.,* 2000)[5]. IR spectrum was not clear difference between pure silica from standard chemicals and silica from sugarcane bagasse. Table 2 showed typical infrared spectra and data of the produced silica from sugarcane bagasse compared with the results of Kalapathy *et al.,* 2000 [5] and Xiaoyu Ma *et al.,* 2012[6].

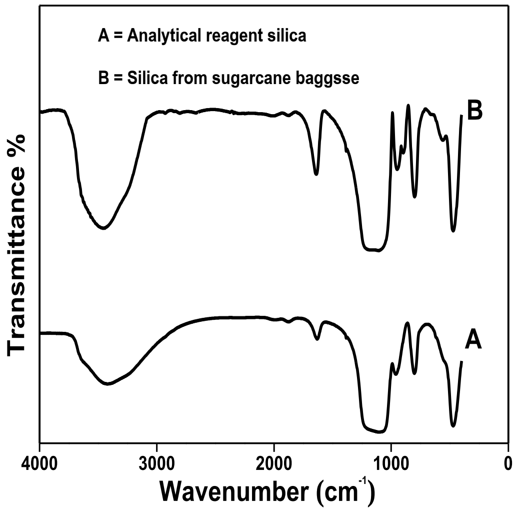

Figure 1 Infrared spectrum of analytical reagent silica (A) and silica produced from sugarcane bagasse ash (B).

Table 2 Infrared data of silica.

Type of stretching	Wavenumber (cm^{-1})		
	sugarcane bagasse	(Kalapathy et. al 2000) [5]	(Xiaoyu Ma et. al 2102) [6]
O-H strength and adsorbed water	3000-4000	3000-3800	3200-3600
O-H bending (molecular water)	1631	1625	1639
Asymmetric Si-O-Si	1050	1115-1050	1059
Si-OH bond strength	800	980-935	799
Si-O bond rocking	475	470-800	467

Figure 2 shows the strong broad peaks of pure silica which was centered range on ≈ 22-23° (2θ), corresponded to characteristic of amorphous SiO_2 (Jo *et al.,* 2007)[7]. Figure 3 shows SEM micrograph of agglomerated nano-silica obtained from re-precipitation of sugarcane bagasse ash. The specific surface area of pure silica powder are 120 m^2 g^{-1}.

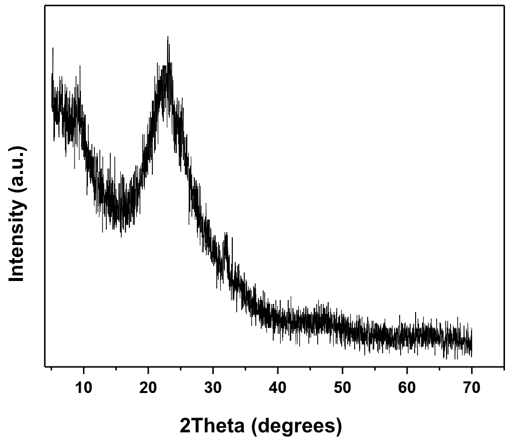

Figure 2 XRD pattern of silica produced from sugarcane bagasse ash.

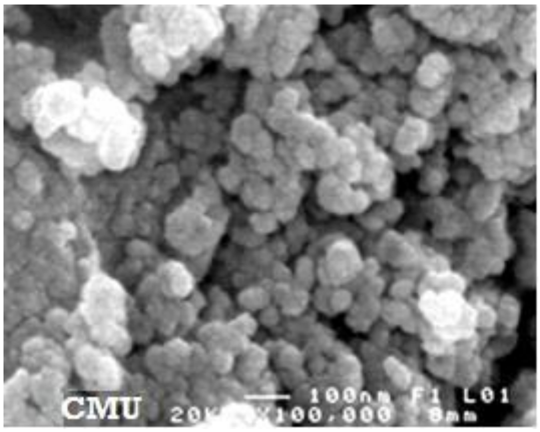

Figure 3 SEM micrograph of silica produced from sugarcane bagasse ash.

Conclusions

Silica is an important material utilized extensively in a wide range of applications. The silica powders and active chemical are successfully obtained through a consecutive preparation method from sugarcane bagasse ash. The silica extraction yield can reach 55 wt.%. The optimal experimental condition is a concentration of 2.5 M with sodium hydroxide solution at 100 °C of activated temperature. Silica composition from FTIR, XRD spectrum peak, morphology and chemical bonding has been reported. The high silica content can be used for silica compound preparation and can minimize the environmental impact of problems for sugarcane bagasse ash disposal.

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