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RESEARCH ARTICLE

The effect of crystallization time and H_2O/CTAB ratio in the synthesis of mesoporous alumina from bauxite residue (red mud)

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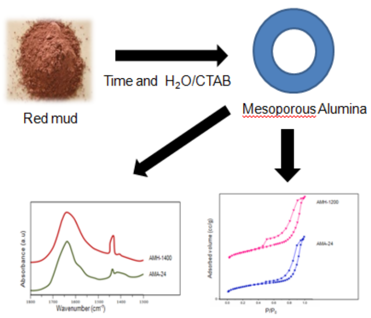
Graphical abstract



Abstract

Mesoporous alumina has been successfully synthesized from bauxite residues (red mud) as raw material and cetyltrimethylammonium bromide (CTAB) as template at room temperature. The effects of crystallization time and molar ratio of H_2O/CTAB on structural and textural properties of mesoporous alumina were investigated. The synthesized product was characterized by XRD, FTIR, SEM-EDX, TEM, N_2 adsorption-desorption and acidity test using pyridine adsorption. The XRD pattern and SEM micrograph showed that the synthesized product possessed an amorphous phase and irregular shapes. From obtained results, it could be observed that crystallization time and H_2O/CTAB ratio influenced the surface acidity of mesoporous alumina.

Keywords: Red mud, mesoporous, alumina materials, surface acidity

INTRODUCTION

Red mud is a waste material or residue derived from the alumina (Al_2O_3) production from bauxite. The Al_2O_3 production uses Bayer Process in which sodium hydroxide (NaOH) is added to produce Al_2O_3 from bauxite, as well as solid residue called red mud (Kumar, 2015). In average, 1-1.5 tons of red mud may be generated after producing 1 ton of alumina (Brunori *et al.,* 2005). Red mud is comprised from some metal oxides such as iron oxides, silicon oxides and undissolved alumina with a wide range that depended on the ore used (Snars and Gilkes, 2009). The concentration of alumina in red mud is about 25-30% (Liang, 2014). Therefore, red mud can be used as an alumina source to synthesize alumina-based materials.

Alumina has been applied as catalyst, ceramic, catalyst support, conductor and strengthener in composite because of its uniform channels, good thermal conductivity, high Lewis acidity and high specific area (Xia *et al.,* 2003). Red mud from Bintan has been successfully used as raw material to synthesize a mesoporous alumina by adding CTAB as template at room temperature using sol-gel method. Mesoporous alumina from Bintan's red mud confirmed to has a mesoporous structure with BET surface area of 241 m^2/g and pore size of 3.820 nm with ratio CTAB/Al of 0.32 as optimal ratio (Ramdhani *et al.*, 2018).

Sol-gel method is an easy yet cheap method to synthesize mesoporous alumina. Some parameters such as time and water content can be used to optimize the synthesis process. It has been reported that the synthesized product with longer time of aging has bigger particle size (Rousseaux *et al.,* 2002). Water content is proven to give effects on the particle size, crystallinity and specific area of synthesized product (Isley and Penn, 2008).

Here, the synthesis of mesoporous alumina using red mud from Bintan as alumina source and CTAB as template was conducted in room temperature. The effects of crystallization time and molar ratio of H_2O/CTAB on surface acidity of the synthesized product were studied.

EXPERIMENTAL

Materials

The starting materials, the powders of red mud were obtained from Bintan Island of Indonesia, cetyltrimethylammonium bromide (CTAB, Merck, 99%), sodium hydroxide (NaOH, Merck, 99%), hydrochloric acid (HCl, SAP, 37%) and deionized water were used in this study. The chemical composition of Bintan's red mud was shown in Table 1.

Preparation of precursor

The process of extraction and synthesis were adopted from Ramdhani *et al.* (2018). Red mud was leached with HCl 6N solution (solid/liquid ratio 1:5 g/mL) at 90 °C under stirring for 2 h, and then filtered and washed with deionized water. The leachate was collected as aluminum source. Then NaOH 5 N solution was dropped into filtrate under stirring. The $NaAlO_2$ was filtered to separate the precipitate of impurities (Fe^{3+}, Ca^{2+}, etc). HCl 6 N was added to the solution with stirring until the precipitate was completely formed. The