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Chemical processing for purification and characterization of silica extracted from Gigantochloa albociliata leaves

Abstract

Dry bamboo leaf waste has emerged as a preferred alternative for silica production because of its chemical properties, making it suitable for diverse applications such as absorbents, biomedicine, ceramic production, membrane additives, and composite production. This study aimed to obtain high-purity silica from Gigantochloa albociliata (honey bamboo) leaves (HBL) in two stages. Stage 1 compared three methods for extracting pure silica: thermal (TT-HBL), beneficiation (BT-HBL), and chemical treatments (CT-HBL). Meanwhile, Stage 2 refined and characterized the purity of the CT-HBL silica by reducing the acid molarities (CT0.5-HBL, CT1-HBL, CT1.5-HBL, CT2-HBL, and CT2.5-HBL). Stage 1 revealed that HBL underwent complete carbonization into silica at 650 °C. Elemental analysis revealed that CT-HBL yielded only Si and O, whereas TT-HBL and BT-HBL retained Mg, K, and Ca. XRD data indicated that all treatments produced amorphous silica, with variations in the crystalline phase due to impurities: TT-HBL (cristobalite low), BT-HBL (quartz low and cristobalite low), and CT-HBL (SiO_2). Stage 2 results suggest that a nitric acid (HNO_3) concentration of at least 1.5 M is required to eliminate impurities and produce pure amorphous silica with enhanced hydrophilic properties. XRF oxide testing of CT1.5-HBL confirmed 98% silica content compared to 79% in TT-HBL silica. The existence of contaminants, such as Ca/CaO, explains the conversion of cristobalite low-crystalline and quartz low-crystalline phases into pure amorphous silica, as observed in the XRD analysis for both stages. Thus, this study demonstrated that impurities, such as Ca, can disrupt the silica network, preventing a well-ordered crystalline structure and leading to the generation of pure amorphous silica.

Keywords

Bamboo leaves; Beneficiation treatment; Chemical treatment; Gigantochloa albociliata; Silica; Thermal treatment