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Synthesis and Characterization Fe Doped $BaBi_4Ti_4O_{15}$ Prepared via Molten Salt Method

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Abstract. The four-layer Aurivillius compound $BaBi_4Ti_4O_{15}$ is reportedly applied as photocatalyst material with a band gap energy of 3.2 eV (387.5 nm). As a result, it works in the ultraviolet light range. The strategy to expand its work function is to decrease the band gap energy by doped with metal elements like Fe atoms. In this research, we synthesised Fe-doped $BaBi_4Ti_4O_{15}$ ($BaBi_4Ti_{3.95}Fe_{0.05}O_{15}$; $BaBi_4Ti_{3.90}Fe_{0.1}O_{15}$; $BaBi_4Ti_{3.85}Fe_{0.15}O_{15}$; and $BaBi_4Ti_{3.80}Fe_{0.2}O_{15}$) with the purposes to decreases its band gap energy. The diffractogram of samples showed the doped $BaBi_4Ti_4O_{15}$ compound was successfully formed and had no impurity phase with space group $A2_1am$. Micrograph scanning electron microscopy (SEM) showed plate-like morphology particles and still found agglomeration occurs. The result calculation of Kubelka-Munk showed that Fe doped can decrease the band gap energy of $BaBi_4Ti_4O_{15}$.

INTRODUCTION

Aurivillius compounds have a general formula $(Bi_2O_2)^{2+}$ $(A_{m-1}B_mO_{3m+1})^{2-}$ and consist of a bismuth layer $(Bi_2O_2)^{2+}$ and *pseudo-perovskite* layer $(A_{m-1}B_mO_{3m+1})^{2-}$, with m is the number of perovskite layers [1]. A is monovalent, divalent, and trivalent cations (K^+, Na^+, Ba^{2+}, Ca^{2+}, Sr^{2+}, Pb^{2+}, or Bi^{3+}), while B is tetravalent, pentavalent, hexavalent, or metals transision (Ti^{4+}, Nb^{5+}, Ta^{5+}, atau W^{6+}) [2]. Aurivillius compounds have some interesting properties, such as Ferroelectric [3], photocatalyst [4], piezoelectric [5], and photoluminescence [6]. Some Aurivillius compound opportunity as a photocatalyst material such as $BaBi_4Ti_4O_{15}$ [7], $Bi_5Ti_3CrO_{15}$ [8], $Bi_4V_2O_{11}$ [9], $Bi_{4.15}Nd_{0.85}Ti_3FeO_{15}$ [10], $Bi_2ASrTi_2TaO_{12}$ (A= Bi, La) [11], and Bi_3TiNbO_9 [12]. Four layers of Aurivillius compound $BaBi_4Ti_4O_{15}$ (BBT) are reported to be applied as photocatalyst material but have a high band gap energy of 3.2 eV (387.5 nm) [7]. Qi et al. (2019) reported the BBT compound was able to degrade 15% rhodamine B under ultraviolet-visible light for 3.5 h [7].

To expand the work function of BBT in the visible light range can be done by decreases its band gap energy. One technique to decrease band gap energy is doped with metal elements such as Ni [13], La [14], Co [15], Fe, Nb [16], Cr [17], W [18], and Mn [19]. The application of Fe metal as a dopant of material photocatalyst of Aurivillius compound has been studied by Liu et al. (2016) and resulted that Fe^{3+} doped $Bi_4Ti_3O_{12}$ have low band gap energy. As a result, it can work in the visible light region [20], and Yang et al. (2020) reported that Fe (III) dopant can decrease the band gap energy of Bi_2MoO_6 and show the wavelength shift in the visible light region [21].

The molten salt method (MSS) is one of the synthesis methods that produced a unique morphology of the Aurivillius compound. In addition, MSS has some advantages such as a) high homogeneity, b) high product purity, c) can control particle size [22], f) environmentally friendly, simple salt can be easily applied and removed [23], can be control morphology [24], using low temperature and short reaction duration [25]. Gu et al. (2011) successfully synthesised $BaBi_4Ti_4O_{15}$ via the molten salt method of K_2SO_4/Na_2SO_4 with plate-like morphology [26]. Materials with plate-like morphology have prospect as photocatalysts because they have a good active face and a great potential applied to photocatalyst activity of a semiconductor [27], and then the plate-like morphology shortens migration distance of e^-/h^+ pairs to reactive sites, and the result can increase photocatalyst activity in visible-light region [28]. They also reported that obtaining a unique morphology is expected to increase the photocatalyst activity of $BaBi_4Ti_4O_{15}$. Based on the description in this research, synthesised Fe-doped $BaBi_4Ti_4O_{15}$ compound ($BaBi_4Ti_{3.95}Fe_{0.05}O_{15}$; $BaBi_4Ti_{3.90}Fe_{0.1}O_{15}$; $BaBi_4Ti_{3.85}Fe_{.15}O_{15}$; $BaBi_4Ti_{3.80}Fe_{0.2}O_{15}$).

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