Synthesis V-doped ZnO Using Sonication Method

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***Abstract*- ZnO is one of the compounds widely used as a photocatalyst material which has a band gap of about 3.2 eV, as a results this material will work at ultraviolet area. Improvement the photocatalytic properties can be done by doped ZnO with vanadium. In this study, V-doped ZnO was synthesized using sonication method with dopant concentrations is 0%, 1%, 3%, and 5%. *X-ray Diffraction* (XRD) data showed that ZnO wurtzite was successfully crystalitized in *P*63*mc* space group. IR spectra of sample showed the specific vibration mode at ~440 cm^{-1} which related to the stretching vibration mode of Zn-O.**
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Keywords—Zinc oxide (ZnO); sonication method; photocatalyst; vanadium dopant.

I. INTRODUCTION

The development of the industrial sector, causing the environment to be polluted by organic waste causes problems in the world. The most effective method to overcome this is to use photocatalysts. Photocatalyst is a chemical reaction process involving solid catalyst material with the help of light, photocatalysts are widely developed to overcome environmental problems because they can decompose organic compounds and inorganic compounds into harmless compounds such as carbon dioxide and water [1, 2]

The photocatalyst process it involves semiconductor materials, such as ZnO metal oxides. ZnO is one compound that is widely used as a photocatalyst material which has a band gap of around 3.2 eV, good chemical stability, large surface area, and is able to absorb UV light strongly from the solar spectrum. Eventought, ZnO photocatalyst material is less active in the visible radiation region which is the largest component of sunlight. So it needs to be modified to improve the efficiency of light absorption [3]. In order to improve photocatalytic activity of ZnO, several modification methods have been developed. Among the incorporation of the transition metal (TM) or metal cation has considerable attention [4]. One dopant that can increase photocalysis activity is by vanadium doping. After vanadium doping showed particle size and ZnO lattice parameters decreased [5]. Beside that doping an effective method to inhibit the recombination rate because can act as eletron trapping agents and can decrease band gap energy [6].

In this work a series vanadium doped zinc oxide with varied vanadium weight percentages was prepared in the same condition by sonochemical method.The synthesized powders were charaterizazed by XRD and FTIR.

II. MATERIAL AND METHOD

Synthesis of vanadium doped zinc oxide were prepared by sonochemical method using 8.13 g of zinc acetate dehydrate in a 74 L of isopropanol. After 10 min of magnetic stirring at room temperature, then the pH of the mixture was adjusted from 9.0 to 13.0 by using 1.0 M NaOH aqueous solution. After that (0 ; 0.0189; 0.0569; and 0,0951 g) of vanadium acetyl acetonate was added. After stirred for 10 min, the mixture was then irradiated with low-intensity ultrasound (100W, 42 kHz) at room temperature in ambient air for 30 minute. After irradiation, the precipitate was centrifuged and washed by isopropanol for several times. The resulted product was dried at 110 ◦C for 2 h. The obtained powder was make pellet then annealed in furnace for 2 h at 500 ◦C. For undoped vanadium, the procedure is sawe without adding vanadium acetyl acetonate.

III. RESULTS AND DISCUSSION

Based on the experimental synthesis, ZnO using sonochemical methods should result in the formation of a white precipitate. The reaction between NaOH and zinc acetate will form $Zn(OH)_2$ which is the core of ZnO formation. Then when heating $Zn(OH)_2$ makes the hydroxyl groups (-OH) bonds break up. The overall chemichal reaction to form ZnO as follow in Eq. (1):

$$Zn(CH3COO)_2.2H_2O(s)+2NaOH(s) \rightarrow Zn(OH)_2(s)+2CH3COONa(l)+2H_2O(l) \quad (1)$$
$$Zn(OH)_2(s) \rightarrow ZnO(s)$$

XRD patterns of pure ZnO and V-doped ZnO are presented in Fig.1. The results obtained can be identified that the ZnO synthesis diffractogram has typical the structure of ZnO wurtzite and high purity due to the absence of peaks other than wurtzite characters and . Based on data from ICSD ZnO No. 82028 position 2 theta around 36.24º has the highest intensity which is a characteristic of the diffraction pattern on ZnO in the field hkl 101. The results of the diffractogram obtained

were enlarged at the highest position of the three peaks so it can be seen that there nis a shift in the peak position towards 2 besar which is greater in the variation of dopant concentration 3% and 5%. This peak shift can be related to defects in the crystal lattice because vanadium ions incorporation into the lattice of ZnO [6,7].

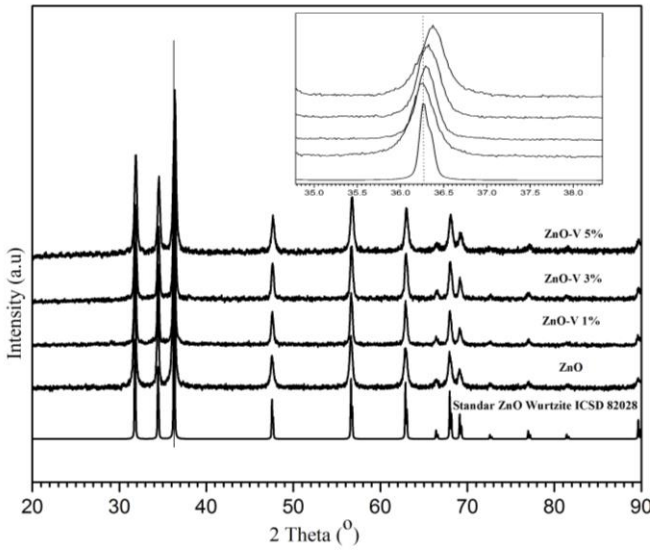

Fig. 1. XRD pattern of ZnO and V-doped ZnO particles

The calculated values for the lattice parameters a and c, volume, and crystallite size are shown in table1. The average crystallite size obtained from Debye Scherer formula calculated for (101) peaks hows that the pure ZnO and V-doped ZnO material obtained has a size below 50 nm and belong to nanocrystal. Nano-sized photocatalysts, which are 1-100 nm will provide good catalytic activity. Ultrasonic wave irradiation generally gives a smaller particle size due to the cavitation process [8].

Table 1. The lattice parameters, the unit cell volume (V), and the crystallite sice (D) ZnO and V-doped ZnO.

X (%)	a=b (Å)	C (Å)	V(Å^3)	D (nm)
0	3.248800	5.205400	47.580673	27.29
1	3.248100	5.204400	47.560673	27.94
3	3.248075	5.203467	47.541771	29.18
5	3.245347	5.199724	47.427818	33.90

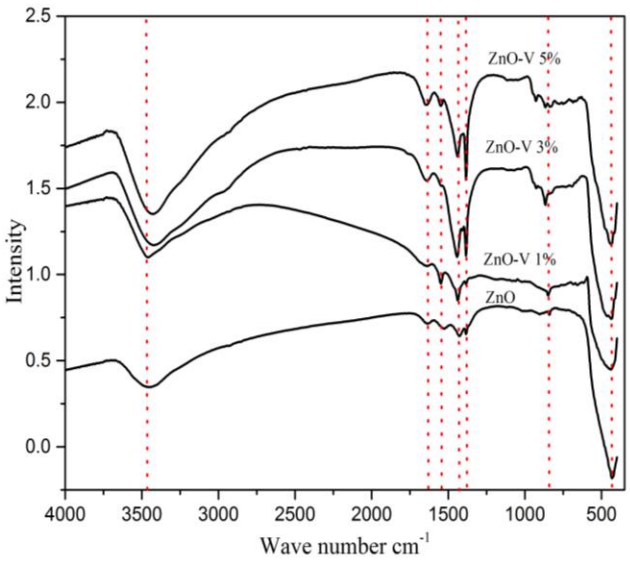

Fig. 2. FTIR spectra of ZnO and V-doped ZnO particles

FTIR spectrum of pure ZnO and V-doped ZnO ia shown in Figure 2. The room temperature shows band in the region ~3400 cm^{-1} due to the presence of adsorbed water molecules or surface hydroxyl group (-OH), absorption band in ~1500-1300 cm^{-1} which correspondend to asymmetric and symmetric C=O stretching modes of zinc acetate [9], respectively. A prominent peak observed around at ~440-480 cm^{-1} is the stretching mode of Zn-O. It show an appreciable variation over range of frequency 20 cm^{-1}. It explain a change in bond length for substitution of vanadium which may be caused by formation covalent bond.

IV. CONCLUSION

Vanadium doped ZnO have been synthesized by a sonochemichal method. The XRD analysis result V-doped ZnO doen't change structure. All synthesized had the wurtzite structure with crystallite size 27.29; 27,94; 29.18; and; 33.90 nm. The absorption band at about ~430 cm^{-1} can be attributed to the stretching modes of Zn-O.

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REFERENCES

[1] Batista, A. P. L., Carvalho, H. W., Luz, G. H. P., Martins, P. F. Q., Goncalves, M., dan Oliveira, L. C. A. O. 2010. Preparation of CuO/SiO_2 and Photocatalytic Activity by Degradation of Methylene Blue. *Enviromental Chemistry Letter*, 2(8): 63-67.

[2] Slamet, Bismo, S., Arbianti, R., dan Sari, Z. 2006. Penyisihan Fenol Dengan Kombinasi Proses Adsorpsi dan Fotokatalisis Menggunakan Karbon Aktif dan TiO_2. *Jurnal Teknologi*, 4(2): 1-7.

[3] N.S. Norberg, K.R. Kittilstved, J.E. Amonette, R.K. Kukkadapu D.A. Schwartz, D.R. Gamelin, J. Am. Chem. Soc. 126, 9387 (2004)

[4] K. Elissa, "Title of paper if known," unpublished.

[5] Krithiga, R., dan Chandrasekaran, G. Ã. 2009. Synthesis, Strucutral and Optical Properties of Vanadium Doped Zinc Oxide Nanograins. *Journal of Crystal Growth*, 311(21): 4610–4614.

[6] Ghoul, R. S. J. El, Ghiloufi, I., dan Mir, K. O. L. El. 2016. Synthesis and Physico-Chemical Studies of Vanadium doped Zinc Oxide nanoparticles and its Photocatalysis. *Journal of Materials Science: Materials in Electronics*, 2(1): 1-8.

[7] M. Young, *The Technical Writer's Handbook.* Mill Valley, CA: University Science, 1989.

[8] Naimah, S., Ermawati, R., 2011. Efek fotokatalisis nano TiO terhadap mekanisme Anti Mikroba *E Coli* dan *Salmonela*. *Jurnal Riset Industri*, 5(2): 113-120.

[9] Maensiri, S. 2007. Synthesis and Optical Properties of Nanocrystallin V-doped ZnO powders. *Optical Material*, 29: 1700-1705.