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Photodecomposition Profile of Curcumin in the Existence of Tungsten Trioxide Particles

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Abstract. The purpose of this study was to investigate the stability of curcumin solution in the existence of tungsten trioxide (WO_3) particles under light illumination. In the experimental method, curcumin extracted from Indonesian local turmeric was added with WO_3 microparticles and put into the photoreactor system. The photostability performance of curcumin was conducted for 22 hours using 100 W of Neon Lamp. The results showed that the curcumin solution was relatively stable. When curcumin without existence of WO_3 was irradiated, no change in the curcumin concentration was found. However, when curcumin solution was mixed with WO_3 particles, decreases in the concentration of curcumin was found. The concentration of curcumin with WO_3 after light irradiation was about 73.58%. Based on the results, we concluded that the curcumin is relatively stable against light. However, its light-irradiation stability decreases with additional inorganic material.

1. Introduction

Curcumin (diferuloylmethane) is a polyphenol derived from the plant Curcuma longa, commonly called turmeric.[1] Since curcumin has beneficial health effects on againsting many diseases and modulating immune system, this material is often applied in many different types of food products, including bread, instant rice, and noodles.[2] This substance has also pharmacological potentials as anticancer, antitumor, antioxidant, activities.[3; 4; 5] Although curcumin has widely applied, this material has been less stability. [6] Curcumin is sensitive to bases condition, light, existence of metal ions, enzymes, and temperature.[7] Therefore, the stability of curcumin is considered as one of the attractive challenges in the recent years.

The main decomposition products have previously been identified as feruloyl methane, ferulic acid, and vanillin.[6] A number of studies have reported several factors involving the curcumin decomposition process, such as ultraviolet and visible light radiation [7], alkaline condition [8], solvent [9], oxygen [10], ionic and non-ionic cyclodextrins [6], and the existence of inorganic material such as titanium dioxide.[11] However, investigation of photodecomposition of curcumin in the existence of tungsten trioxide (WO_3) is typically rare.

Here, the purpose of this study was to investigate the stability of curcumin solution by adding the amount of WO_3 particles as a photocatalyst. In the experimental method, we compared the stability of curcumin when interacting with WO_3 microparticles under light irradiation for 22 hours. The results

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showed that no change in the curcumin concentration without existence of WO_3 was irradiated. However, additional WO_3 into curcumin solution had significant impact. It cause decreases in the concentration of curcumin was about 73.58%. We conclude that the curcumin is relatively stable against light. However, its light-irradiation stability decreases with additional inorganic material.

2. Experimental Method

Curcumin was extracted from turmeric, which was collected from Bandung, Indonesia. In short of the process, turmeric was washed, cut into small pieces (size about 1 x 1 mm), then dried at 100^0C to remove the water content in turmeric. Next, the dried turmeric was then grinded, dissolved in aqueous solution, and filtered. The filtered solution is then used as the curcumin solution.

To investigate the photodecomposition process, the concentration of curcumin was set at 100 ppm. Then, 0.411 gram of tungsten trioxide (WO_3) was added into 300 mL of solution of curcumin. In addition, WO_3 was prepared based on our previous work.[12]

The mixed solution was then placed into a home-made photocatalytic reactor to confirm the stability of curcumin under light irradiation. The photocatalytic reactor consisted of a batch-glass reactor (250 mL), a magnetic stirrer (600 rpm), and a bubbler. The mixed material (containing curcumin and WO_3 in the aqueous solution) then irradiated by 100 W of Neon Lamp. The air (1.0 L/min) was bubbled into the reactor during the photodecomposition process in order to keep the oxygen concentration constant. During the photodecomposition process, the concentration was measured using a turbidity analysis based on the light exposed into the mixed solution (containing curcumin and WO_3) using a home-made portable equipment. In short, the home made portable spectrophotometer consisted of light source and an arduino system equipped with a light sensor (lux meter; BH1750FVI, Rohm Co. Ltd., Japan). The spectrophotometer is integrated to computer to analyze the real-time concentration measurement. In addition, several analyses were conducted to support the present study, such as a Scanning Electron Microscope (SEM;JSM-6360LA; JEOL Ltd., Japan), an X-Ray Diffraction (XRD; PANalytical X'PertPRO; Philips Corp., Netherland) and a Fourier Transform Infra Red (FTIR; FTIR-8400 dan Prestige 21, Shimadzu Corp., Japan).

3. Results and Discussion

Figure 1a shows the FTIR spectra of WO_3 particles prepared with synthesis temperatures of about 800^0C. There is a broad band in the range 500-1000 cm-1.[13] This range is characteristic of the different O-W-O stretching vibrations in the WO_3 crystal lattice.[14]Figure 1b depicts the XRD patterns of WO_3 particles. The detection of diffraction peaks at 2θ peaks of 23.57; 30.00; 35.71; 50.00; and 58.26 suggested that the prepared particles had monoclinic crystal structures type (JCPDS no. 72–1465).[15]

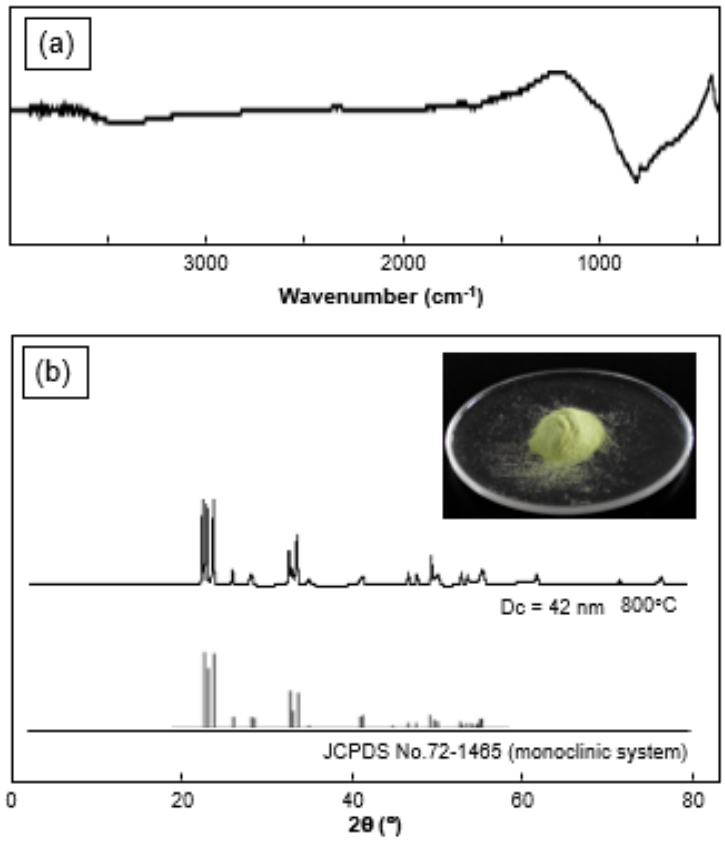


Figure 1. The FTIR (a) and the XRD (b) analysis results of WO_3 particles.

Figure 2 shows the SEM images of WO_3 particles produced using synthesis temperature of 800^0C. Particles with cubical shape are found (Figure 2a). Particle size range of prepared sample was about 20-70 micrometers. The high-magnified SEM image (Figure 2b) shows asymmetric surface particle. [16]

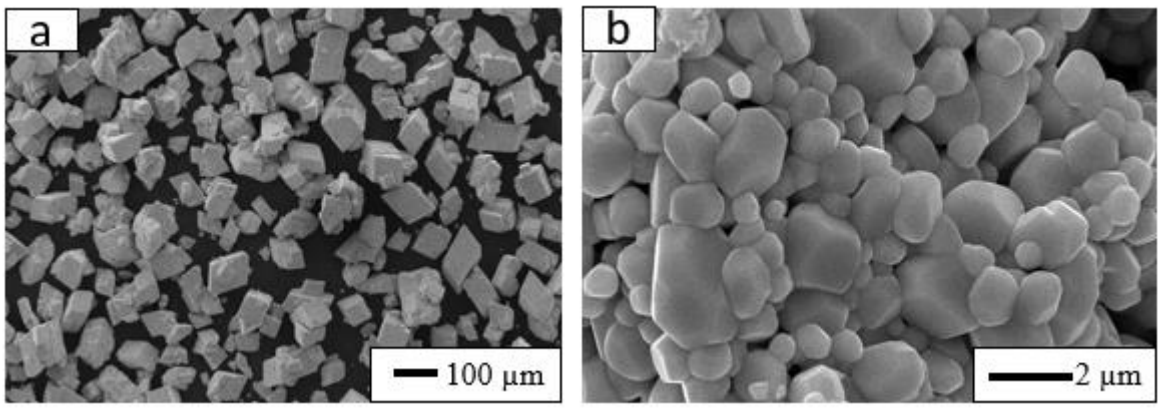


Figure 2. SEM images of WO_3 particles. Figure 2b is the high magnification of SEM images.

Figure 3 shows the photodecomposition profile of curcumin in the existence of WO_3 particles. As a standard comparison, the curcumin only solution was also tested. The result showed that curcumin only solution was relatively stable, while the concentration of curcumin with additional WO_3 gradually

decreased along with increasing time. The concentration of curcumin with additional WO_3 particles was near to 20% after 22 hours of light illumination. This result confirmed that WO_3 is the main reason for the decrease of 73.58% of curcumin concentration.

To ensure the photodecomposition profile, we analyzed the concentration in every hour. We found that the reaction was done in two steps. The first step is the reaction before 13 hours of process, in which the step has an insignificant reaction rate (the slight change in the curcumin concentration). Then, the next step is after 13 hours of the process, in which the curcumin concentration gradually decrease.

The fundamental reason is explained in **Figure 4**. In the common process, curcumin is degraded into ferulic and vanilic (see dashed line in the reaction route). However, for some cases, the reaction must through the formation of intermediate compound (see solid line in the reaction route).[17] This intermediate compound is not identical with the isolated degradation product. The postulated structure was probably formed by ring closure within molecule. Indeed, the additional route in the formation of intermediate makes the reaction route longer, resulting the reaction rate decreases

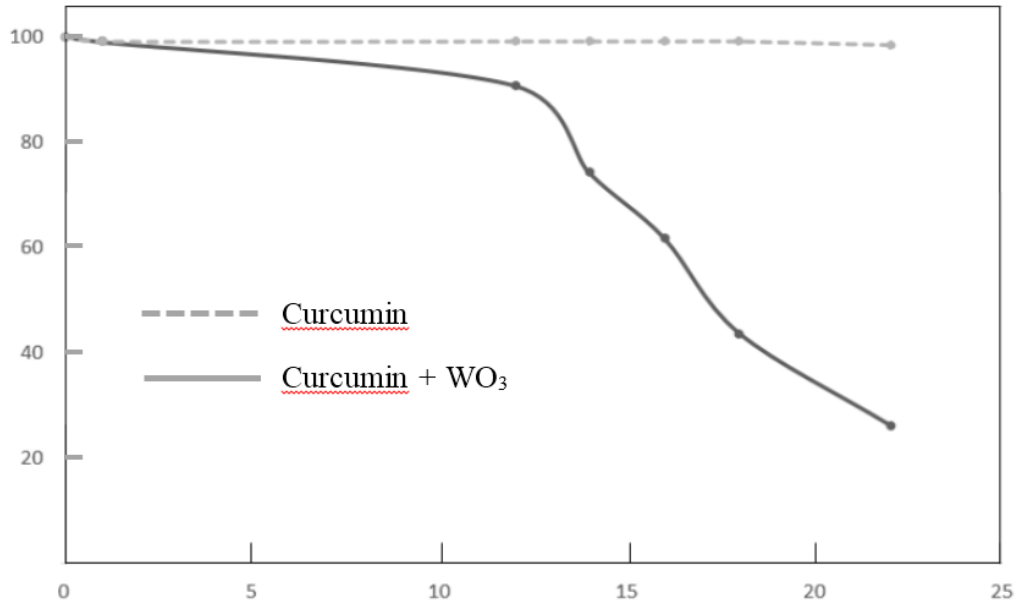


Figure 3. Photodecomposition Profile of Curcumin in the existence of WO_3 particles.

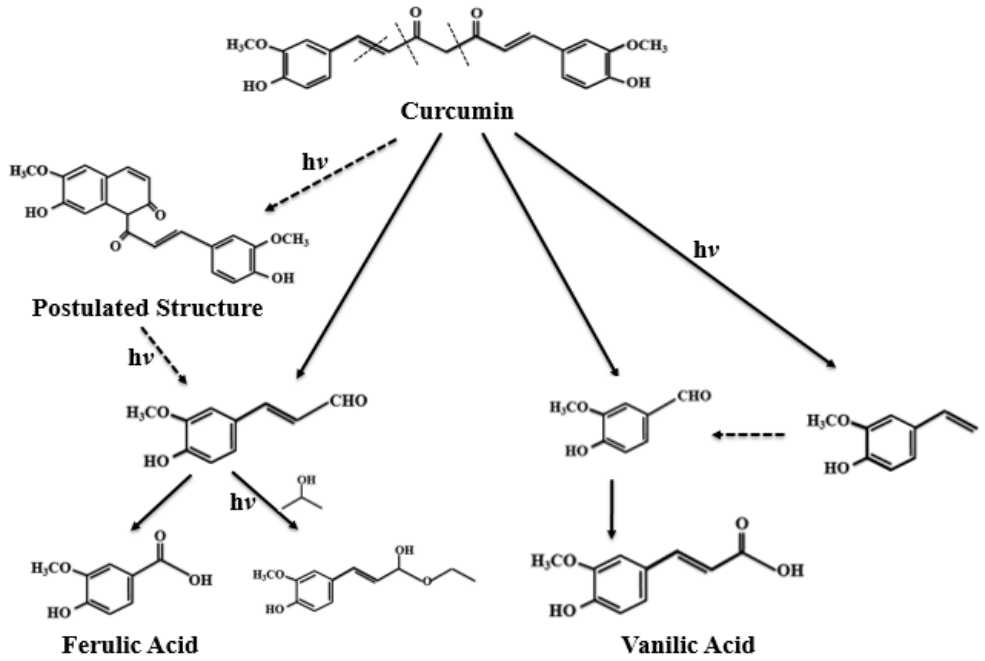


Figure 4. Particles Photochemical degradation of curcumin.

4. Concluslions

This study investigated the photodecomposition behavior of curcumin in the existence of WO_3 particles. In the experiments, curcumin solution was mixed with WO_3 particles and iluminated under light radiation. These materials were placed into the reactor that was integrated to the computer system. To confirm the influence of WO_3 particles on the photodecomposition of curcumin, several analyses were conducted such as a SEM, XRD, and FTIR. The results showed that the concentration of curcumin gradually decreased along with increasing time, while curcumin was stable relatively in the absence of WO_3 particles. The lost curcumin concentration in the existence of WO_3 particles after 22h photodecomposition process were 73.58%. The reaction rate in early 13 hours was not significant. This is probably caused by the forming of the other molecule (intermediate), which is called as postulated structure since this structure was not identical with the isolated degradation product. Based on the results, we can conclude that avoiding contact with WO_3 particles can minimized decomposition of curcumin can be minimized.

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