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Synthesis of ZnO nanoparticles by hydrothermal method in aqueous rinds extracts of *Sapindus rarak* DC

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ABSTRACT

The use of aqueous extract of *Sapindus rarak* as medium in the synthesis of ZnO nanoparticles by the hydrothermal method has been carried out at moderate conditions. The current conditions produced the desired ZnO nanoparticles with difference shapes and crystallinity depending on the concentration of aqueous extract of *S. rarak*.

1. Introduction

Zinc oxide (ZnO) nanoparticles are materials which have wide applications in several different industries, such as luminescence material for fluorescent tube, the laser active medium, sensors and antimicrobial [1–3]. Therefore, the synthesis of ZnO nanoparticles is of great interest to the researcher. In the chemical methods, there are some methods that have been used in the synthesis of ZnO nanoparticles such as sol–gel, sonochemical, solvothermal, hydrothermal and mechanochemical methods [4]. Some problems that are often experienced in synthesizing metal nanoparticles are stability and aggregation of nanoparticles, control of crystal growth, morphologies, sizes and distribution, which are important issues and continue to be solved [5]. To control the stability and aggregation of nanoparticles, some capping agents were used. The presence of capping agents, for example starch or polyvinylalcohol, can also modify the structural and optical properties of nanoparticles [6–8].

Recently, the synthesis of ZnO nanoparticles by the hydrothermal method using zinc acetate dihydrate and NaOH as precursors in the presence of a surfactant of cetyl trimethylammonium (CTAB) was reported [9]. On the other hand, the use of biomaterials such as organism's body part in the synthesis of nanomaterials with the desired morphologies and sizes has become a major focus of researchers in recent years [5].

In line with the green and environment friendly synthesis of nanomaterials, to the best of our knowledge, there is no report on the synthesis of ZnO nanoparticles using natural surfactant of *S. rarak* DC rinds extract. Therefore, we would like to report our current studies regarding the utility of aqueous rinds extract of *S. rarak* on the synthesis of ZnO nanoparticles and their characteristics.

2. Materials and methods

S. rarak was obtained commercially from Bogor, Indonesia. Some aqueous rinds extracts of *S. rarak* DC were obtained by extraction of the rinds using demineralized water with some weight variations of 2.5, 5.0, 7.5, and 10.0 g of the rinds slurry. The extract was obtained by stirring the mixture at 70 °C for 1 h, which after was filtered using Whatman paper No. 1. The extract of *S. rarak* rinds was mixed with zinc acetate 0.1 M in Erlenmeyer, followed by the addition of NaOH 0.1 M (100 ml). The mixture was heated in an oven at 95 °C for 8 h. The resulting mixture was filtered using Whatman paper No.42 and dried at 95 °C for 8 h. Morphology of the samples was examined by Scanning Electron Microscope (JEOL, JSM 5360LA). The crystal structure of the samples was characterized by an X-ray diffractometer using Cu-Kα radiation (PAN-analytical PW3373). All measurements were carried out at room temperature.

3. Results and discussion

The aqueous rinds extracts of *S. rarak* were obtained by heating the rinds of slurry in demineralized water. After filtration of the mixture to remove unnecessary solid materials, the clear brown solution was obtained and subsequently was used as medium for

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synthesis of ZnO nanoparticles. Synthesis of ZnO nanoparticles was carried out in *S. rarak* rinds extracts with concentration variation of the extracts (2.5%, 5.0%, 7.5% and 10.0%). After heating zinc acetate in the corresponding medium at 95 °C for 8 h the ZnO nanoparticles were obtained following the hydrothermal mechanism that was reported by previous results [7] which explained that the zinc acetate dissociated to Zn^{2+} and reacted with OH^- from NaOH. After drying they formed nano-sized ZnO. The color of ZnO powders are brown that formed from water extract of *S. rarak* DC rinds.

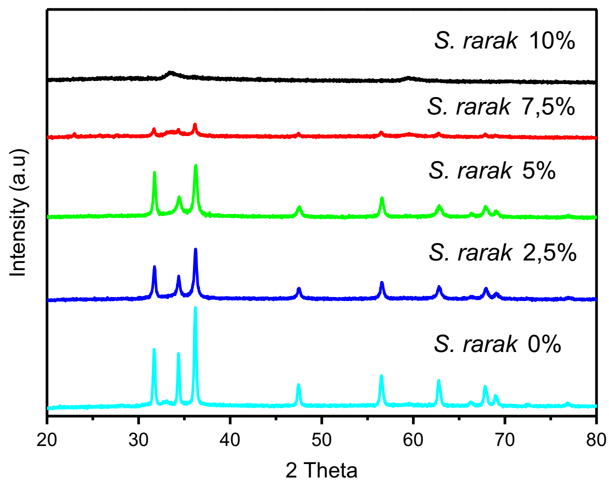

Fig. 1. X-ray diffraction pattern of ZnO with various concentrations of *S. rarak* extract of 0%; 2.5%; 5%; 7.5%; and 10%.

The X-ray diffraction patterns of ZnO with variation of the concentration of *S. rarak* rinds extract are shown in Fig. 1. The XRD pattern for ZnO produced from the medium with concentration of the extract of 2.5% and 5% shows strong intensities that are comparable with the XRD pattern of ZnO produced without any additive. These results indicated that the ZnO was showed good crystallinity [10]. When the concentration of *S. rarak* was increased to 7.5% and 10.0%, the XRD pattern shows lower intensity and it was assumed that the crystallinity decreased when the concentration of *S. rarak* rinds extract increased by more than 5%. Although the exact reasons of this phenomenon could not be explained due to the fact that X-ray diffractometry detects the diffraction only in the bulk phases. The components located in surface layer at the interfaces remain undetected by this diffractometry method [11]; however, the presence of the rarasaponin as a known major compound in *S.rarak* may affect the crystallinity of the ZnO. The saponins have active OH functional groups that may inhibit the

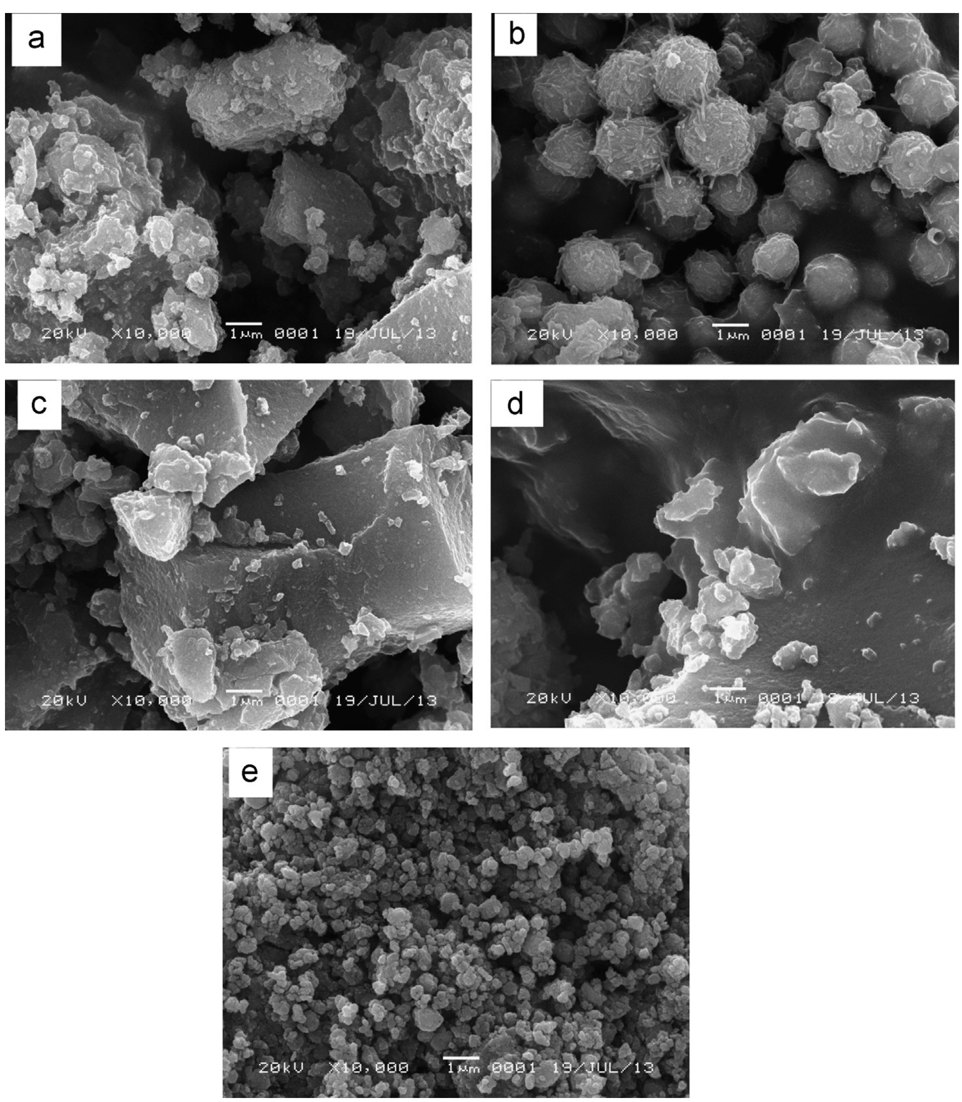

Fig. 2. Scanning electron microscope images of ZnO nanoparticles with various concentrations of *S. rarak* rinds extract of 0%, 2.5%, 5%, 7.5%, and 10%.

formation of ZnO by the formation of a complex compound with Zn^{2+} ion or Na^{+}. Thus, the increase in the concentration of the saponin compound may inhibit the formation of ZnO in specific shape of lattice [5]. The morphology of ZnO nanoparticles with various concentrations of *S. rarak* rinds extract was examined by Scanning Electron Microscope and the results are shown in Fig. 2.

Fig. 2 shows that the morphology of the ZnO was dependent on the concentration of *S. rarak* rinds extracts. The micrographs also revealed that the obtained materials are indeed nanograined and contain grain boundaries and free surfaces. They also contain numerous twin boundaries. This is due to the influence of the addition of the surfactant *S. rarak* on the growth of ZnO nanoparticles. Although the exact non-trivial behavior of ZnO nanocrystals could not be described, the properties may be driven by the grain boundaries in studied samples [12]. On the other hand, the SEM analysis also confirms that ZnO nanoparticles have different morphologies by varying the concentration of the medium. The ZnO nanoparticles with concentration capping agent 2.5% form like agglomeration (Fig. 2a). When the concentration of the extract was 5%, the morphologies of ZnO nanoparticles become spherical (Fig. 2b). While at higher concentration of capping agent, ZnO formed like agglomeration. When the results were compared to the ZnO produced without the addition of any extract (Fig. 2e), it was clear that the presence of *S. rarak* rinds extract had some effect on the morphologies of ZnO. Therefore, we can say that the ZnO morphology is influenced by the presence of the current natural surfactant.

In summary, we have successfully synthesized ZnO nanoparticles in a medium using aqueous rinds extract of *S. rarak* DC. The concentration variation of the extracts that was used (2.5%, 5%, 7.5% and 10%) affects the crystallinity and morphologies of the ZnO. The best condition to result in good crystallinity and morphology of ZnO was when the reaction was conducted in the extract concentration of 5%.

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