Controlling the Size and Dispersion of ZnO@SiO₂ Core-Shell Nanostructure by Addition of Triblock Copolymer Surfactant and pH Adjustment during Precipitation and Encapsulation Process

Nofrijon Sofyan¹, Akhmad Herman Yuwono², Boy Steven, Amalia Sholehah, Muhammad Arief

¹Department of Metallurgical and Materials Engineering, Universitas Indonesia, Indonesia
²Department of Metallurgical and Materials Engineering, Universitas Indonesia, Indonesia

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Abstract. The potential use of ZnO nanoparticles for cell labeling application has been improved over past several years. Focusing to overcome the tendency of the nanoparticles to aggregation, in this work ZnO nanoparticles have been synthesized by using surfactant-assisted precipitation method. The samples were then characterized by using XRD and UV-Vis Spectroscope. The results showed that the presence of surfactant could help controlling the crystallite size to become smaller (4.02 nm) as compared to the conventional precipitation method (9.45 nm). ZnO nanoparticles that had been coated by the surfactant was then re-coated again by silica shell to form ZnO@SiO₂ core-shell. The presence of F-127 coating on the surface of the nanoparticles made the dispersion and the stability of crystallite size better in various encapsulation pH value (4.04 – 4.32 nm). The band gap energy of the ZnO nanoparticles (3.145 – 3.085 eV) also showed a good correlation with the crystallite size (4.02 – 10.38 nm). Therefore, the resulting ZnO@SiO₂ core-shell in the present work are potential to be used in cell labeling application.

Introduction

Cell labeling applications by using a fluorescent probe has been commonly used to study the morphological, behavioral and physiological functions of the cell. This technique uses a fluorescent molecule (fluorophore) as a probe to detect cells. In order to produce high quality cell tracking and images, the probe need to be dispersed in water, biocompatible, and has a high luminescent efficiency. Initially, the material used for this probe is organic dye and biological fluorophore (fluorescent protein). However, both materials showed luminescent instabilities, i.e. blinking (fluorescence intensity fluctuations) and photobleaching (fluorescence light fading) that complicate tracking of molecules and long-term studies based on fluorescence [1-2]. The attention was then directed to semiconductor quantum dots (QD) made from cadmium. QD was reported to be more photostable than other fluorescence molecules, but its development was tripped up by the concerns about Cd⁺ ions toxicity that could be dangerous to human health and the environment [3].

In recent years, ZnO nanomaterials have gained special attention for development. For example, because of its wide bandgap semiconductor energy properties, ZnO nanomaterials have gain more attention in the electronic applications. In the field of biology, on the other hand, ZnO nanomaterials have been used in cosmetics and sunscreen industry because of its transparency and its ability to reflect, scatter and or absorb UV radiation [4]. ZnO application for cell labeling has also been developed [5, 6]. ZnO is a promising candidate material for cell labelling because of its cheap price and is non-toxic [5]. In essence, ZnO nanoparticles do not have any visible light emission because its bandgap energy value is outside the range of visible light. Interestingly, it has been found that ZnO nanoparticles were capable of producing green light under UV excitation and thus make it potential for cell labeling applications [3].

In general, there are two problems that limit the use of ZnO for cell labeling applications. The first is it has limited emission of color. Green light emission produced by ZnO nanoparticles is believed to relate to the defects on the surface of the nanoparticles [3, 5]. With this assumption, recent research has focused on modifying the surface of ZnO nanoparticles synthesis through pH