SYNTHESIS OF ORGANIC-INORGANIC HYBRID NANO PARTICLES

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We have been developed supercritical hydrothermal synthesis method for nano particle production. In the method, metal salt aqueous solution is mixed with high temperature water to rapidly increase the temperature of the metal salt solution and thus reduce the reactions and crystallizations during the heating up period. By using this method, we succeeded in the continuous and rapid production of nanocrystals.

In this paper, we will propose a new method to synthesize organic-inorganic fused materials based on the methods of supercritical hydrothermal synthesis. By introducing organic materials in a reaction atmosphere of supercritical hydrothermal synthesis, nanoparticles whose surface was modified with organic materials were synthesized. In supercritical state, water and organic materials form a homogeneous phase, which provides an excellent reaction atmosphere for the organic modification of nanoparticles. Modification with bio-materials including amino acids was also possible. By changing organic modifiers, particle morphology and crystal structure was changed.

This surface modification provides a various unique characteristics for the nanoparticles: Dispersion of nanoparticles in aqueous solutions, organic solvents or in liquid polymers can be controlled by selecting hydrophilic or hydrophobic modifiers. Polymer-like materials can be formed probably by the self-assembly of amino acid modified nanoparticles.

INTRODUCTION

Nanotechnology is defined as a technology where the dimension is in the range of 0.1-100 nm. In this kind of size, a number of physical properties of nanoparticles change. Two major properties of nanoparticles are the size effect of particles and the increase in the ratio of surface to volume as surface or interface induced effect. The size effect in particular the quantum size, is mainly considered to describe physical properties (the quantum size effect appears where the normal bulk electronic structure is replaced by a series of discrete electronic levels). While the surface or interface induced effect plays an important role for chemical processing [1]. For example, the increase in the performance of catalysis and structures such as electrodes for the improvement of such technologies as fuel cells and batteries is because of the surface or interface induced effect. However in the size effect, when the size of nanoparticles is lower than critical wavelength of light (less than 100 nm),

a useful property as transparent which can be applied in packaging, cosmetics and coating will be appeared [2]. Cell labeling by fluorescent nanoparticles and local heating by magnetic nanoparticles are interested as applications of nanoparticles in biomedical aspects as well [1].

Production of nanoparticles can be carried out by chemical and physical methods. We proposed an original method of supercritical hydrothermal synthesis to produce nano particles [3, 4, 5]. Hydrothermal synthesis of metal oxides from aqueous solutions is typically utilized at temperature ranging from 373K to 473K and in a batch-type autoclave reactor. In the proposed method with a flow type tubelar reactor, metal salt aquesous solution was mixed with high temperature water to increase the solution temperature rapidly up to the supercritical state. Because of the high reaction rate of hydrothermal synthesis and low solubility of metal oxides, extremely high supersaturation degree is attaned at the mixing point. This leads to the formation of nano size particles[3, 4, 5].

Successful application of nanoparticles such using inorganic nanoparticles as filler in polymers to improve barrier properties, electrical conductivity and refractive index depends on their proper disperse into the fluids [6]. While metal oxide nanoparticles due to the presence of hydroxyl groups on their surface, can not easily be dispersed in a non-polar organic material, unless a dispersing agent is used. Then a proper modifier can prevent this reaction and surface modification of nanoparticles improves dispersion property as well as chemical, electrochemical resistance and optical appearance properties [6]. If metal oxides can be modified very well, a large number of new or improved engineering products can be produced. Furthermore, once the nanoparticles is modified with amino acids, peptides, proteins, or DNA, the particles can be specifically combined with other proteins or DNA, which leads to the applications to new IT devices using programmed assembly of semiconductor nano particles.

There are such different methods as silane coupling for surface modification of oxides. In silane coupling, the oxides must be dipped into an organic solution. Since the surface of metal oxide nanoparticles is surrounded by hydroxyl groups (hydrophilic) then, they can't easily be dispersed in that solution for surface modification. Another method as CNBr activation can't be used for surface modification because the reaction media is acidic and can dissolve metal oxide nanoparticles [7]. Then these methods can't be used as suitable manner for surface modification of metal oxide nanoparticles.

In this paper, we will describe in situ surface modification of nanoparticles in sub-critical and supercritical conditions at 200°C, 300°C and 400°C by hydrothermal synthesis as an attractive method for production of metal oxide nanoparticles.