충격혼합공정에 의한 티타니아 나노입자로 피복 된 폴리스티렌비드의 특성

김종석, 김성종
익산대학 환경공업화학과

Characterization of the Titania Nanoparticles coated Polystyrene bead by Impact Blending Process.

Jongseok Kim and Sungjong Kim
Dept. of Environmental Engineering & Chemical Technology, Iksan National College

Introduction

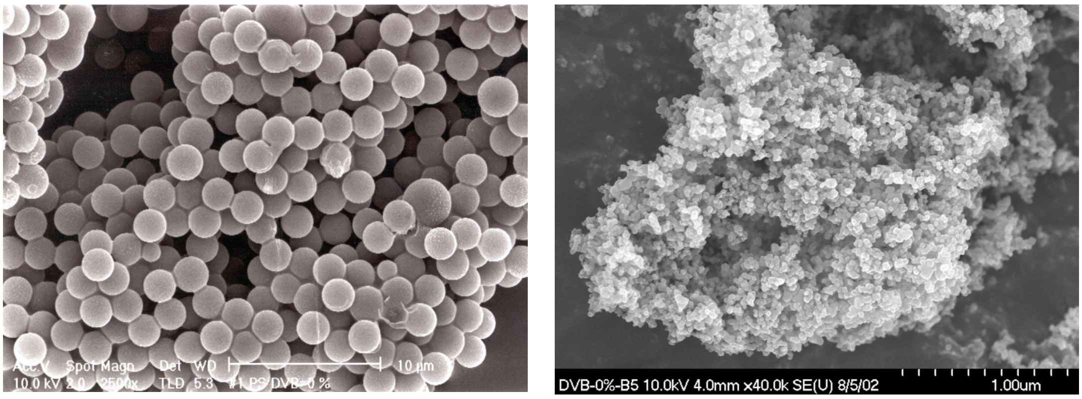
Coating of nanoparticles with a layer of a different material is used as a mean to modify their surface chemical, reactive, catalytic, optical, or magnetic properties[1, 2]. Such core-shell particles can often be prepared by controlled precipitation of inorganic precursors on the core particles, in some cases assisted by coupling agent with the combination silica and silver. A second approach is the layer by layer technique, in which successive layers of anionic particles are deposited, alternated by layers of a cationic polymer. Disadvantages are that a lot of aggregate polymer particles is also incorporated in the shell and that the preparation of nanoparticle coated polymer is complicated. This is why multiple steps are often used to obtained thicker coatings. Particles coated with titania are generally exceptionally difficult to synthesize because the titania precursors are highly reactive, making it difficult to control their precipitation.

Koishi [3] developed a fine particles could be made to adhere to the surface of core particles by a binary particles mixture by using a dry impact blending method. This procedure has been employed for the improvement of powder properties and in mixing homogeneously a small amount of material such as drugs and pigments. It was confirmed experimentally that small particles were fixed on large particles when the ratio of the diameter of the large particles to that of the small particle was larger than 10:1. This easily causes the core particles to aggregate or the titania nanoparticles to form separate particles. Titania coated particles are very useful as catalysts and as white pigments[4]. In this work, titania nanoparticles encapsulation on polystyrene particles, using dry impact blending process is described. The behavior of encapsulation of polystyrene bead study has been carried out using titania nonoparticles as a shell. In the dry impact blending of a binary particles mixture which contains elasticity of polystyrene particles and the action of impulsive forces during the operation were important factors in the effective preparation of the titania particles coated polystyrene bead. In this paper, we describe the important factors for an effective nanoparticles coated polystyrene bead were discussed using scanning electron microscopy (SEM) and particle analyzer.

Experimental

Polystyrene (PS) bead preparation

As the core particles, monodisperse, crosslinlked polystyrene bead were prepared by the dispersion technique. PS particles were synthesized using styrene, poly(N-vinylpyrolidone) (PVP) and azobisisobutyronirile (AIBN), ethyl alcohol for dispersion polymerization, respectively. Divinylbenzene (DVB) were used as cross-linking agent for PS bead. The procedure for the preparation of the PS latex is follows. A 75g amount of styrene 0.4g DVB, 7g of PVP, 270g ethanol were charged into the reactor and heated to 70℃. The initiator solution was prepared from 25g of styrene, 30 g of ethanol, 2g of AIBN. In syntheses requiring the slow delivery of reagent solutions, peristaltic pump was employed. The morphology of the resulting particles was examined by SEM. Typical SEM photographs of PS and titania particles are shown in Figure 1 displaying their uniform shapes and sizes.



(a) (b)

Figure 1. SEM photographs of PS bead and titania nanoparticles: (a) PS bead ; (b) TiO_2

Titania nanoparticles modified PS bead

The dry impact blending preparation method comprises a two-step blending process. The first step is a mechanical blending process named dry blending of the core and fine particles for the preparation of an interactive mixture formed by the adhesion of the fine particles on the surface of the core particles. During this stage, a centrifugal impeller rotating-type batch mixer was used (O.M. Dizer, OMD-10). The fine and core particles were blended at room temperature (10min, 1,000 rpm). The second step is a dry mechanical impact blending process of the interactive mixture. Figure 2 is an impact-type hybridization machine with jacket was used (Hybridizer). The dispersed powder particles hit striking pins rotating at 5,000, 8,000 rpm, which dry impact blending was carried out in 10min. Figure 3 shows a schematic drawing and a fabrication model of blending particles. The mutual harmonization during the dry impact blending treatment, final arranging and controlled composites can be obtained.

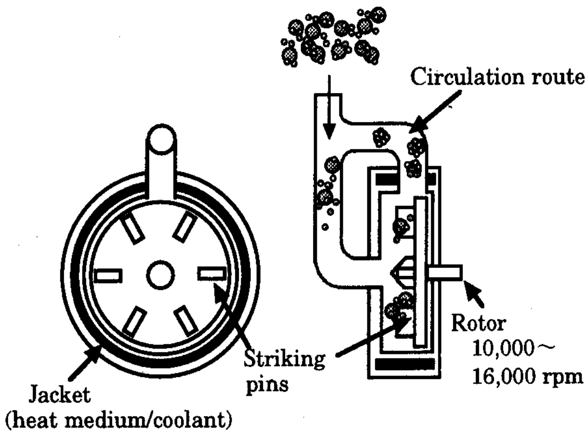


Figure. 2. Schematic diagram of the machine in Hybridizer.

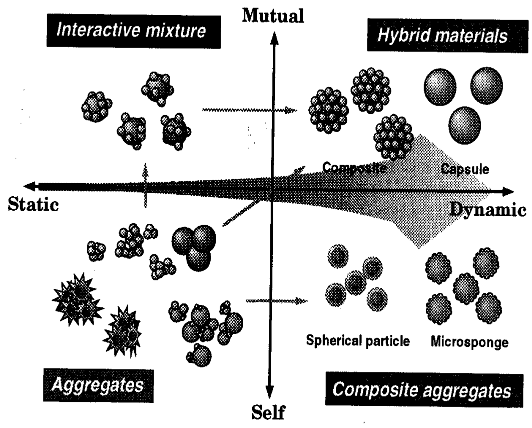
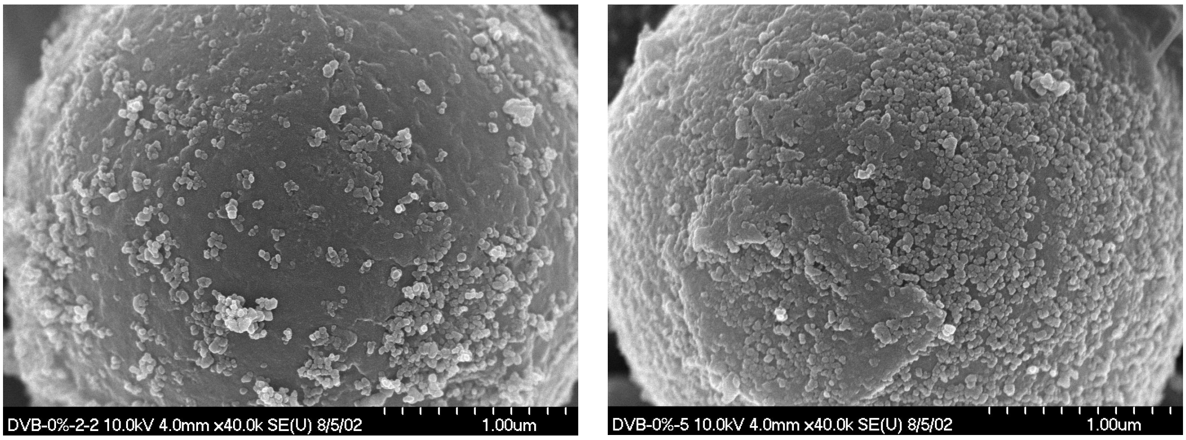


Figure. 3. Schematic drawing and a fabrication model of dry impact blending process.

Results and discussion

Figure 4 shows typical SEM photographs of coated particles prepared by the dry blending and impact blending of titania nanoparticles on the PS particles. Many fine titania fine particles are clearly embedded on the surface of PS particle and are rearranged for particle adhesion by the dry impact blending treatment. During the first step of our experimental results, and interactive mixture of TiO_2 nanoparticles and PS bead was prepared by the dry batch blending method. However, many titania particles randomly adhere to the surface of PS particles in the interactive mixture. Dry batch mixing over 10min did not contribute to the preparation of the titania nanoparticles coated state.

During the second step, 10min of dry impact blending enabled titania fine particles randomly adhered on the surface of the PS particles to rearrange into an ordered state. In the dry impact blending method, it was empirically confirmed that this fixing and arrangement of nanopartices were were achieved when the core particles as shown in Figure 4. However, the arrangement of TiO_2 particles on the surface of the PS did not always form monolayer particle coated. In order to explain the different crosslinking degree of the PS bead to that of the titania particles. Titania shell and PS core have elastic and plastic deformation respectively.



(a) (b)

Figure 4. SEM photographs of TiO_2 nanoparticles coated PS bead prepared by the dry impact blending: (a) 2% ; (b) 5% titania particles on the PS sphere.

Plastic deformation behavior of PS particle without DVB for cross-linking agent is observed during dry impact blending process. On the other hand, the deformation did not occurred on the PS with 1% DVB in a dry batch blend and impact method. The different embedded mechanism due to the mixing method and deformation properties of core particle is possible related to surface deformation of PS bead as the cross-linking extent. These SEM observations show that the nanoparticle itself, the elasticity and viscoelasticity of the core particles, and the action of impulsive forces are important factors in the effective preparation of a nanoparticles coated powder in the dry blending.

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