In line with the rapid development of the modern nanotechnology industry, nano-order particle diameters are now being controlled in materials in various fields. Particle diameter control is a critical factor in the pretreatment process of separation and refinement, in order to achieve a targeted particle preparation and eliminate the effects of contamination.

This paper describes the use of the rate zonal centrifugation, one of the centrifugal separation methods, to separate mixed particles based on differences (typically in size) regarding the sedimentation coefficient (S-value), and confirm the particle diameter of each band of particles by means of a particle size analyzer.

1. Separated samples
   - 20nm, 50nm, 100nm, 150nm latex particles (made of polystyrene, density: 1.050 g/cm³, selling by Thermo Fisher Scientific Inc.)

2. Centrifugation and measurement conditions
   - Centrifuge: CS150GXII micro ultracentrifuge
   - Rotor: S52ST swing rotor (four tubes)
   - Tube: 5PET tube
   - Speed: 52,000 rpm
   - Maximum RCF: 276,000 x g
   - Centrifugation time: 10 minutes
   - Density-gradient fluid: 5-20 wt% sucrose solution 4.5 mL
   - Particle size analyzer: nano Partica SZ-100
     (manufactured by HORIBA, Ltd.)
   - Measuring temperature: 25°C
   - Particle diameter distribution standard: Scattered light intensity standard

3. Results
   - Figure 1 shows a picture of a sample under test before centrifugal separation. Figure 2 shows the plotting of measurement results regarding the particle diameter distribution of the mixed sample before separation. Two kinds of particle diameter distribution have been confirmed by particle diameter measurement before separation.
Figure 3 shows a picture of the sample under test after centrifugal separation. The mixed particles were subjected to ultracentrifugal separation and separated into four bands. Each band was collected and the particle diameter measured on the SZ-100 manufactured by HORIBA, Ltd. The four bands were found to have particle diameters of 20 nm, 50 nm, 100 nm and 150 nm in sequence from the top of the centrifuge tubes downward, thereby confirming the possibility of centrifugal separation by particle diameter using the rate zonal centrifugation.

4. Discussion
Mixed particles varying in size have been separated using the rate zonal centrifugation, one of the centrifugal separation methods. The present method offers a useful tool for refining carbon nanotubes or fractionating fine pigment particles contained in an ink or toner formulation.