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Nanoseparation Using Density Gradient Ultracentrifugation

Mechanism, Methods and Applications

Springer

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Preface

Since the discovery of unique properties of nanomaterials, colloidal nanoparticles (NPs) with tunable size and shape have attracted vast attention due to their wide applications in catalysis, energy conversion, bioissues, etc. Therefore, size and geometric control of nanomaterials are important to the discovery of intrinsic size-/shape-dependent properties and bottom-up approaches for the fabrication of functional nanodevices. Nowadays, two general strategies have been employed to create size-uniform nanostructures. One method is direct particle size control during synthesis by adjusting growth parameters; however, it usually needs very harsh synthetic conditions to achieve relatively uniform size distributions, this strategy only suits to quite limited systems, and the parameters must be strictly followed, otherwise, in most cases, the products are only roughly “monodisperse” with certain deviations.

As effective complementary process to synthesis optimization, nanoseparation is attracting more and more interest for providing strictly monodisperse NPs. A variety of separation methods, including selective precipitation, magnetic separation, filtration/diafiltration, electrophoresis and chromatographic methods, have been explored as different ways of attaining particle fractions with narrow shape and size distributions. The density gradient ultracentrifugation (DGUC) method, as a general, nondestructive and scalable separation method adapted from biomacromolecular separation technology, has recently demonstrated as a versatile method for acquisition of monodispersed colloidal NPs which are hard to be synthesized. This separation method was applicable to both aqueous (polar) and organic (non-polar) solvents system, and NPs with different size, density and morphology can be separated. Separation objects involve nearly all kinds of materials including metal and metal oxides/sulphides, carbon materials, semiconductors. And the separation based on cluster sizes is also demonstrated. Based on the careful characterization on fractions with “purer colloids”, some key parameters controlling the growth or phase conversion are uncovered.

In this book, the classification and mechanism of DGUC will be introduced, and various separation examples will be discussed to show the versatility of such an efficient separation technique. Synthesis–structure–property relationships would be observed on the separated NPs, which could even guide synthetic optimization. Besides basic DGUC separation, concentration and purification of NPs could be achieved at the same time when water/oil interfaces were introduced into the separation system. Furthermore, by introducing a reaction zone or an assembly zone in the gradient, we can even find the surface reaction and assembly mechanisms of NPs since reaction time could be precisely controlled and chemical environments could be changed extremely fast. Finally, a strict mathematical description and computational optimization model would be given to predict the best separation parameters for a given colloidal system, making the DGUC method an efficient, practical and predictable separation method.

In short, DGUC-based "lab in a tube" method would not only provide an efficient separation tool for various nanostructures, but also pave a way for the researches on synthesis optimization, assembly and surface reactions, which laid the cornerstone of the development of nanotechnology.

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