Nanoparticle synthesis via nonaqueous sol-gel chemistry: Recent insights and trends

Prof. Dr. Georg Garnweitner, Institut für Partikeltechnik, Technische Universität Braunschweig, 38106 Braunschweig, Germany

Over the last 15 years, the nonaqueous sol-gel method has been proven to possess high potential for the synthesis of high-quality nanoparticles. In particular, highly crystalline metal oxide nanocrystals can be obtained with relatively narrow size distribution and uniformity in shape at very moderate synthetic conditions. The method is applicable for the preparation of many different binary and ternary metal oxides, and also enables doping of the material. Moreover, the process is experimentally simple and can also be scaled up easily. In contrast, the underlying reaction and particle formation mechanisms have shown to be rather complex, typically involving the initial activation of the precursor via reaction with the medium, the formation of cluster species that act as monomers for particle formation, as well as nucleation and growth processes. After the actual particle formation, there can even be secondary processes like Ostwald ripening, mesocrystal formation or self-assembly as well as agglomeration. Due to these complex mechanisms that highly depend on the chemistry in a particular system, a general understanding of particle formation in nonaqueous sol-gel processes has not been achieved yet. For certain systems, recent studies however allowed to gain deep insights into the mechanisms and predict the influence of different reaction parameters on the properties of the resulting nanoparticles. This represents an important first step to achieve a rational synthesis of highly defined nanoparticles. In addition, the synthesis of non-oxidic nanoparticles such as sulfides and metals has also been presented via the nonaqueous strategy, extending the range of products that can be achieved. This contribution will give an overview of these recent trends and insights, highlighting the great versatility and potential of this synthetic strategy.