Ceramic particles obtained using W/O nano-emulsions as reaction media

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Abstract

Monodisperse ceramic particles can be produced from water-in-oil (W/O) nano-emulsions by hydrolysis and condensation of ceramic alkoxides into aqueous droplets, thereby yielding nanoparticles of controlled size and shape. This study addressed both the formation of W/O nano-emulsions and the resultant ceramic particles obtained in reaction media. Nano-emulsions were prepared by adding water or catalyst aqueous solution to a mixture of decane and surfactants. Droplet size was determined by dynamic light scattering, with mean sizes ranging from 30 to 120 nm. Higher water concentrations resulted in larger droplets. Ceramic nanoparticles were prepared by adding ceramic alkoxides in W/O nano-emulsions. Tetraethyl orthosilicate and tetraisopropyl orthotitanate were used to obtain silica and titania nanoparticles, respectively. Ceramic nanoparticles were characterized by scanning electron microscopy (SEM), atomic force microscopy (AFM), and dynamic light scattering (DLS). Particles with average size from 30 to 230 nm were obtained. Particle sizes correlated with droplet sizes of those nano-emulsions were used as reaction media.

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1. Introduction

Over the last several years, a number of studies on the formation, characterization and application of emulsions have been carried out. Emulsions are thermodynamically unstable liquid/liquid dispersions that are stabilized, in general, by surfactants, polymers or solids particles [1]. As non-equilibrium system’s emulsion properties depend not only on physicochemical variables (nature of components, composition, temperature and pressure), but also on preparation methods and the order in which components are added [1–4]. More recently, a new class of emulsions, with droplet sizes ranging in the nanometers and similar to microemulsions, has been reported [5–7]. These emulsions, termed nano-emulsions, mini-emulsions or ultra-fine emulsions, are transparent or translucent (with droplet sizes between 50 and 200 nm) or milky (up to 500 nm) [8–12] and exhibit high kinetic stability.

Nano-emulsions are a subject of increasing interest in both theoretical discussions and practical applications due to their singular properties, namely extremely small droplet size, kinetic stability and transparency. In addition, they present several advantages over conventional emulsions, owing principally to their similar characteristics to microemulsion ones [12]. For example, nano-emulsions offer the possibility of using microemulsion-like dispersions without need of high surfactant concentrations. Additionally, nano-emulsions boast a wide variety of diverse applications in the chemical (polymerization), cosmetic, and pharmaceutical industries, etc. [13]. One of the earliest chemicals applications of O/W nano-emulsions was in the preparation of latexes [5,10,14–19] by polymerization. Ugelstad et al. [14] found that the mechanism involved in miniemulsion polymerization was quite different from that of emulsion polymerization, suggesting that the main locus of nucleation for the latter was monomer droplets versus micelles [14]. While so-called miniemulsion polymerization is a broad term used to designate all polymerization processes performed in nano-emulsion (miniemulsion) media, it is also used in a more restrictive sense, referring to instances when...