Master Thesis Project

Ultrasonication Induced Shape Shifting

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Background

Sound or acoustic wave is a mechanical longitudinal pressure wave resulting from the back and forth vibration of the particles of the medium through which the sound is moving. Ultrasounds (the sound waves with frequencies higher than the upper audible limit of human hearing) are known to cause acoustic cavitation which is the phenomenon of generation, growth and eventually collapse of the bubbles [1]. These effects generate extremely high temperatures (5,000 K) and pressures (1,000 atm) in the cavitation zone [2]. As ultrasound waves propagate, the bubbles oscillate and collapse which causes thermal, mechanical, and chemical effects. Mechanical effects include collapse pressure, turbulences, and shear stresses, while the chemical effects include generation of free radicals [1]. Moreover, cavitation and shock waves can accelerate solid particles to high speeds and consequently high velocity interparticle collisions can cause surface damage at liquid-solid interfaces [3, 4]. In addition, it has been shown that in the presence of the ultrasonic waves, metal particles can be driven together at sufficiently high speeds to induce effective melting at the point of collision [5].
Ultrasonic irradiation has been seen to dramatically enhance the Ostwald ripening process via acoustic cavitation induced turbulence such as micro streaming and shock waves, which are essential for formation of particles with distributed sizes [5]. Furthermore, the hot spots mechanism in the ultrasonic process causes fluctuation in the local solubility of the salt which can be responsible for the growth behavior of the particles [6].

Research Plan

In this project, as illustrated in figure 1, we will focus on the effect of ultrasonication treatment on shape of the pyrophosphate salts. To investigate the mechanics behind shape shifting, solubility of the salts will be measured. Furthermore, the effect of ultrasonication on the particles size will be analyzed over time. The parameters to look into are temperature, composition of the salts, pH of the solution and power of the ultrasonication source.

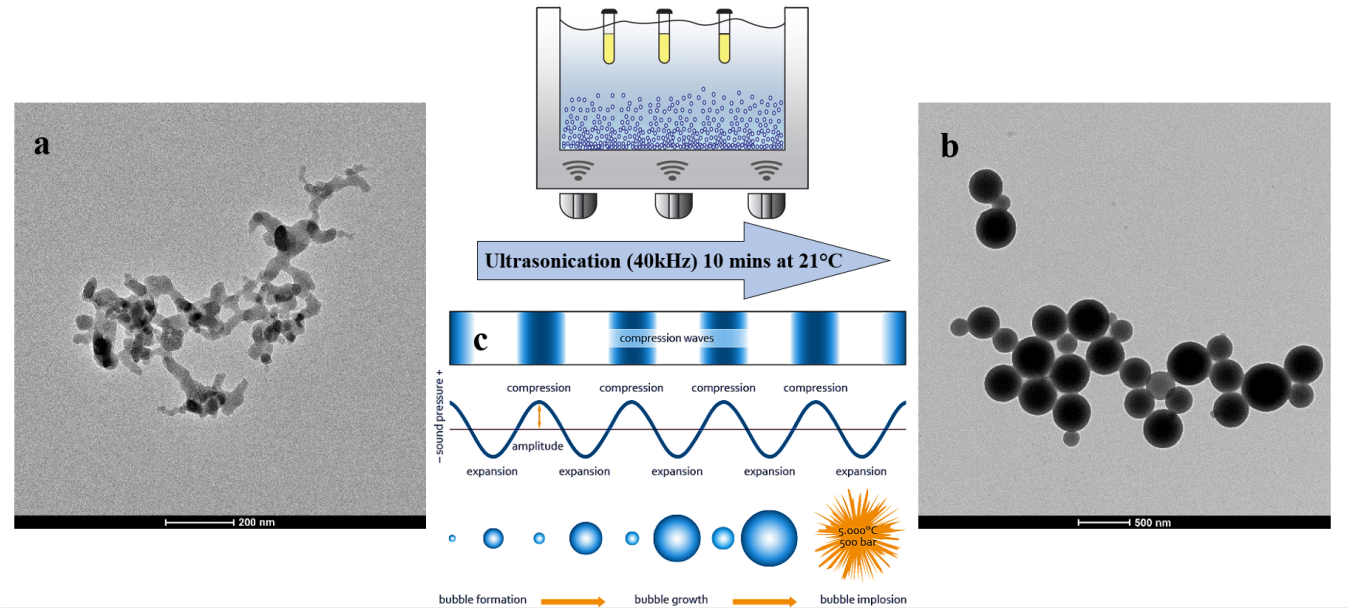

Figure 1: Ultrasonication induced shape shifting

Mixed as well as individual calcium and ferric pyrophosphate salts will be prepared by fast co-precipitation method using water solutions of calcium chloride, ferric chloride and sodium pyrophosphate. Subsequently, water dispersions of the salts will be treated with ultrasonication and the shape shifting phenomenon will be visualized by transmission electron microscopy (TEM) in different durations of time. Inspired by classic nucleation theory, the mechanism behind shape shifting will be investigated theoretically by relating the nucleation energy barrier to ultrasound power. Furthermore, TEM image analysis will be done on size change over time for growth mechanism (coalescence/ostwald ripening).

References

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