Colorado State University

CHEM 372
Physical Chemistry Laboratory

Notes for
Growth Kinetics of ZnO Nanoparticles
Studied by Optical Absorption Spectroscopy

The following is a set of short notes to outline the experiment in question and to provide helpful guidance to those executing the experiment.

A. Amorphous zinc oxide is insoluble in water and can be prepared easily by precipitation from a combination of aqueous solutions containing Zn^{2+} and OH^- ions. Amorphous zinc oxide exhibits a strong and broad UV absorbance.

B. In contrast, if alcoholic solutions containing Zn^{2+} and OH^- ions are combined a colloid of zinc oxide is formed. This colloid consists of nanoscopic zinc oxide particles. This colloid is unstable. The zinc oxide particles repeatedly encounter each other in solution and variously shatter into smaller particles or combine into larger particles. The trend, driven by thermodynamic considerations, is for the particles to grow in size. In other words, it is more thermodynamically favorable for the solution to contain fewer, larger particles than more, smaller particles. This growth in the particle size is one example of the very important Ostwald Ripening process.

C. The UV absorption characteristics of the zinc oxide particles are not the same as for bulk solid, that is, the zinc oxide's electronic configuration is modified by physical confinement. For example, the UV absorbance is narrower than in the bulk solid and a relatively sharp band edge is observed. The position of this band edge is termed the cut-off wavelength of the absorbance and is highly dependent upon the size of the particles. This characteristic can be used to follow the growth of the particles.

D. The experimental procedure described in the accompanying Journal of Chemical Education article and its accompanying Supporting Information (SI) is to be followed with some highly significant exceptions. DO NOT follow the procedure described in the article and SI. Study the procedure described to learn what is described there – especially the chemical composition of the final reaction mixture. Discuss your findings with Teaching Staff.

E. Prepare solutions (100 mL each) of zinc acetate and sodium hydroxide in *i*-propanol in 125 mL polypropylene bottles from the respective solids. Use the concentrations that you have chosen based on your evaluation of the JCE article. Store these solutions at room temperature. Grind the solids finely before weighing and work quickly as they are both hydroscopic (to different degrees). Store a similarly sized sample of *i*-propanol in a similar bottle for blanking the spectrophotometer.

F. The UV-Visible absorbance spectra (roughly 200 in total) of the reaction mixture contained in a temperature controlled cuvette at 65 °C are collected periodically over a two hour period. In preparation for this two tightly stoppered 50-mL Erlenmeyer flasks, each containing one reactant are equilibrated in the circulating water bath used to thermostat the cuvette.

G. The acquired spectra are converted to plain text format using the spectrophotometer program, transferred to a suitable computer and analyzed in Igor. Because of the large number of spectra collected it is necessary to utilize Igor Pro's programming language to create a small program to process them.