Determining the Particle Size of a Suspension or Emulsion

Abstract

The note describes how the AcoustoSizer from Colloidal Dynamics can be used to determine an accurate particle size for a suspension or emulsion.

Table of Contents

1 Introduction

One of the most difficult aspects of particle size measurement in colloidal suspensions is the problem of achieving complete dispersion. A solid in the form of a dry powder must first be suspended in a suitable liquid medium (and we will assume that liquid is water for the present). One must then use one or more chemical reagents to force the particles to separate into their ultimate size. It is usually this size which is most significant, because if the system is *not* completely dispersed then the size can take on practically any value and may also be a function of stirring rate and/or time, among other things.

Finding a suitable dispersion procedure can be a time consuming process and, indeed, entire textbooks have been written on the subject.

The AcoustoSizer can make this process a lot easier because it can simultaneously measure the electric charge on the particle surface and also the particle size. Since all particles normally have the same sign of charge, they will repel one another if the charge is high enough and so the suspension will be well dispersed. By adding a reagent that varies the charge one can follow the resulting size changes and see when the system has reached a minimum size. That will usually correspond to complete dispersion and the size will be the ultimate size of the particles.

2 Example – Titration of Titania

Titanium dioxide (titania, TiO_2) is a typical solid oxide which is widely used in the chemical industry (in making paints and coating fibres and paper). When exposed to water (or moist air) its surface becomes coated with a layer of hydroxyl groups and, as with most oxides, those hydroxyl groups can react with hydrogen (H^+) and hydroxyl (OH^-) ions to produce a positive or negative charge on the particle surface.

All oxides thus tend to be positively charged at low pH and negatively charged at high pH. Obviously, then, there is normally a pH somewhere on the scale where the particles have no charge. That is called the *isoelectric point* or iep. Figure 1 overleaf shows what happens when a suspension of titania is titrated in the AcoustoSizer with acid and base. After each addition of reagent the instrument records both the charge (in the form of the zeta potential) and the particle size (and also the spread of sizes).

Initially the particles had very little charge and showed a rather high apparent particle size (about 0.9 µm median diameter). As the pH is raised, the charge (or zeta potential) becomes more negative and the size falls to its minimum value (0.35 µm). Now when the pH is lowered the charge falls to zero at pH 8.5 (the iep) and then becomes positive. At the same time the size increases to a maximum and then falls to the same minimum value as was recorded at the high pH. It is this reproducibility at either end of the pH scale which gives us confidence that the final estimate of size (in this case 0.35 µm) corresponds to the maximum dispersion.

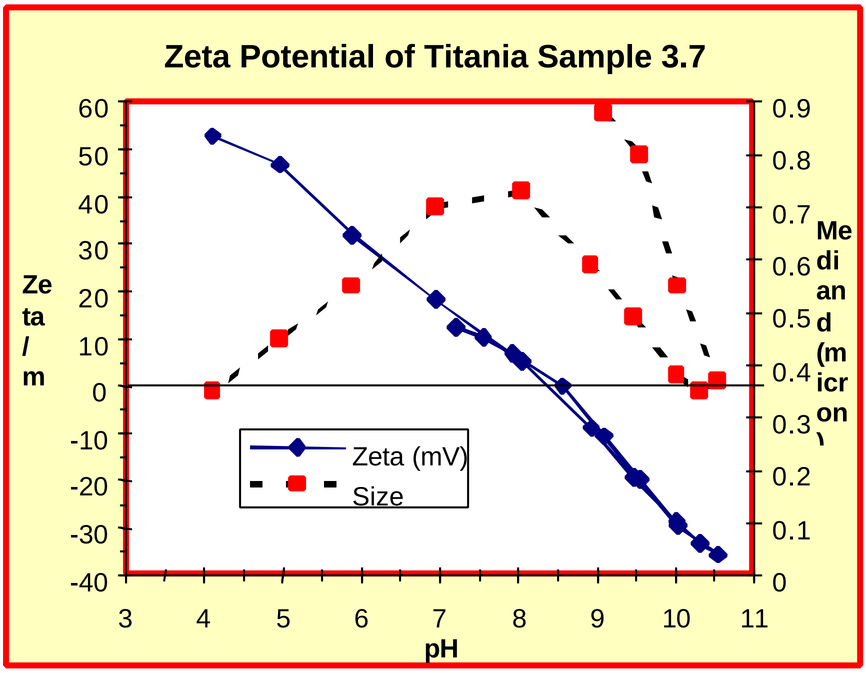

FIGURE 1: ZETA POTENTIAL OF TITANIA SAMPLE

Note also the high degree of reproducibility of the zeta potential in the titration process.

3 Example – Adding Polymeric Dispersant

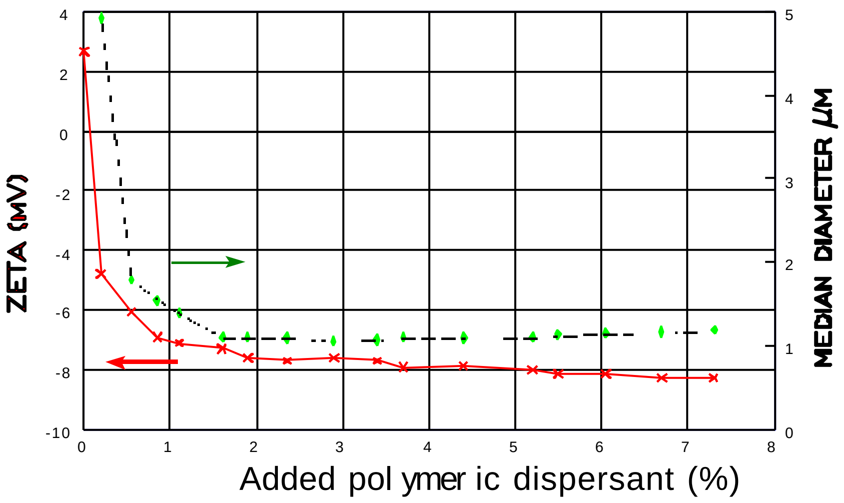

FIGURE 2: ADDING POLYMERIC DISPERSANT

Another popular method of achieving dispersion is to add a polymeric dispersing agent to the suspended material. In this case we were interested only in determining the optimum amount of polymer to be used. It was sufficient to show that it was pointless to add any more than 1.6% by weight of polymer to the solid. This is because any more produced no further reduction in the size of these cement particles, even though the zeta potential was still changing very slowly at the higher addition rates.

4 Example – Effect of Homogeniser

To make emulsions of oil in water with very small particle size (< 2 µm, say) it is usually necessary to pass an emulsion of larger particles through what is called an homogenizer. That is an instrument in which the droplets of oil are forced through a very small tube so that they become distorted. As they emerge from the tube into the water the drops can be shaken apart to form smaller drops. It is a very easy matter to follow with the AcoustoSizer the fate of the emulsion droplets after each pass through the homogenizer.

The size distribution becomes much narrower after each pass through the homogenizer. The minimum size is not much affected but the maximum size is reduced from an initial 2 µm to about 0.5 µm. This is what we would expect because it is much easier for the instrument to squeeze the larger drops to make them smaller.

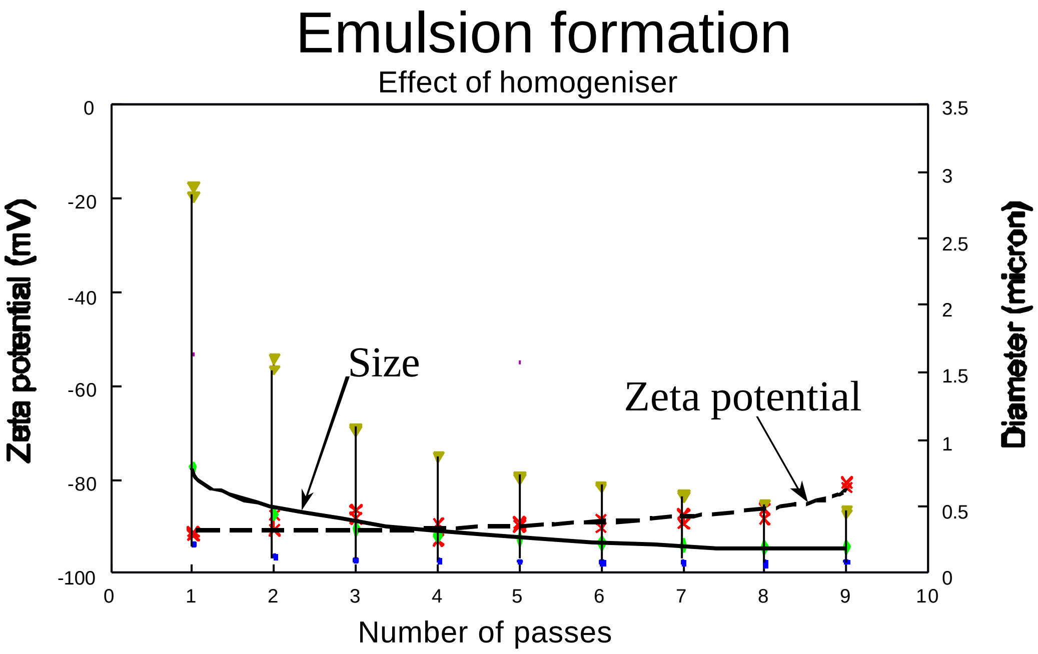

FIGURE 3: EFFECT OF HOMOGENIZER