The Dynamic Mobility of Spherical Particles

Abstract

Describes an important characteristic of spherical particles called the *dynamic mobility,* and shows how the AcoustoSizer from Colloidal Dynamics can be used to measure this characteristic.

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1 Introduction

The electroacoustic method used in the AcoustoSizer involves application of an electric field of very high frequency (in the megahertz -10^6 cycles /se - range). This causes the electrically charged colloidal particles in the suspension to oscillate backwards and forwards and so generate a sound wave of the same frequency. It is this sound wave which is picked up by a transducer and analyzed to calculate the motion of the particles. How that is done need not concern us for the moment.

The important characteristic of the particles is what is called their *dynamic mobility,* which measures how they respond to the electric field. The dynamic mobility is a complex quantity, which means it requires two numbers to specify its value at each frequency. One number is called the *magnitude* and the other is called the *phase angle* or *argument* of the mobility. As the frequency increases, the magnitude falls from its normal value in a d.c. electric field and will ultimately reach zero at high enough frequencies. The phase angle measures how far the particle's motion lags behind the oscillations of the field. It is zero at low frequency and increases to a maximum of one eighth of a cycle (45^o) at the highest frequencies.

2 Dynamic Mobility and the AcoustoSizer

The AcoustoSizer is the only instrument that is able to measure both the magnitude and phase angle of the dynamic mobility over a wide range of frequencies. It measures from 0.2 to about 20 MHz, which is the range required to see most clearly the effects of particles with sizes ranging from about 0.07 to 10 µm. We then use the theory developed by Dr Richard O'Brien of Colloidal Dynamics to calculate the zeta potential and size of the particles from the dynamic mobility.

The effectiveness of that theory can be gauged from Figure 1, which shows a comparison of the theory with experimental measurements on a sol consisting of uniform spherical silica particles.

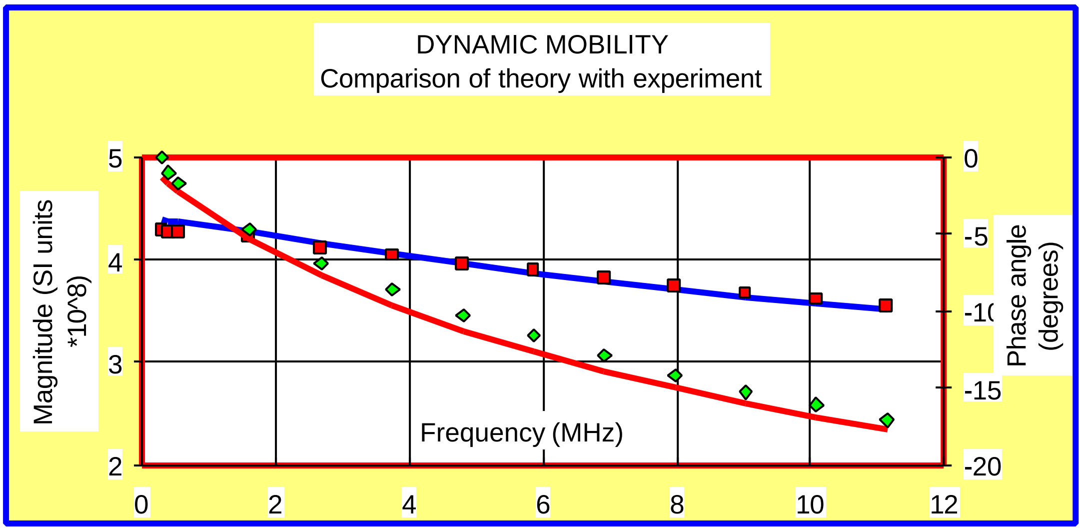

FIGURE 1: DYNAMIC MOBILITY COMPARISON – THEORETICAL MAGNITUDE IS SHOWN IN BLUE AND THEORETICAL PHASE IS SHOWN IN RED

These particles were only about 300 nm in diameter so the magnitude decreases from about 4.3 to 3.5 SI units over the frequency range. The phase angle changes from near zero to about 17 degrees (of lag). Larger particles show a bigger effect in both magnitude and phase.

The theory has been extended to cover spheroidal particles, which means it can cover rods or disks, and it turns out that there is little difference in the behaviour of particles of different shape. The method therefore yields an ‘equivalent spherical radius’ for systems with irregular particles. The dynamic mobility can be measured at any particle concentration and assessments of both particle size and zeta potential can be made at concentrations up to at least 40% by volume and, in some cases, as high as 60%.