Monitoring Suspensions using Electrical Impedance Spectroscopy

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Suspensions created in catalyst production are typically inorganic slurries which require tight process control during manufacture to attain the necessary high product quality. The rheology of the suspension has considerable influence on the final form of the catalyst and manufacturing requirements. If the target rheology of the suspension is not reached, this can lead to poor extrusion, mixing and washcoat properties, with consequent impact on porosity, activity and surface area, which are critical to catalyst performance.

Alumina, Al_2O_3, is a model suspension due to the wide range of applications, prior literature and consistent rheology. γ-alumina, the type used in this study, exhibits shear thinning rheology that is highly dependent upon pH. The purpose of this study is to examine the impact of pH, solids content and ionic strength upon suspension structure and determine if these changes can be detected by Electrical Impedance Spectroscopy (EIS). EIS uses the complex resistive properties of electricity as a method of material characterisation, the most informative results are real impedance (conductance), imaginary impedance (capacitance), magnitude and phase angle. A simple analogy for impedance can be drawn with viscoelasticity, where real impedance is the viscous part, imaginary impedance is the elastic part and the phase angle can be compared with the delta value (ratio of storage to loss modulus).

EIS is a non-intrusive method of characterising formulated process intermediates and can be used *in situ* to closely monitor properties of suspensions. Previous work investigating nucleation and crystal growth using EIS was reported by Zhao *et al* [1], the results showed significant differences in impedance imaginary part when solute concentration and temperature are varied. In this work, EIS is used to assess the properties of a model alumina suspension which is stable at room temperature, but sensitive to changes in pH. Hysteretic effects are examined by addition of acid and alkali to take the slurry near to both the iso-electric point (IEP) and peptisation point by raising and lowering the pH.

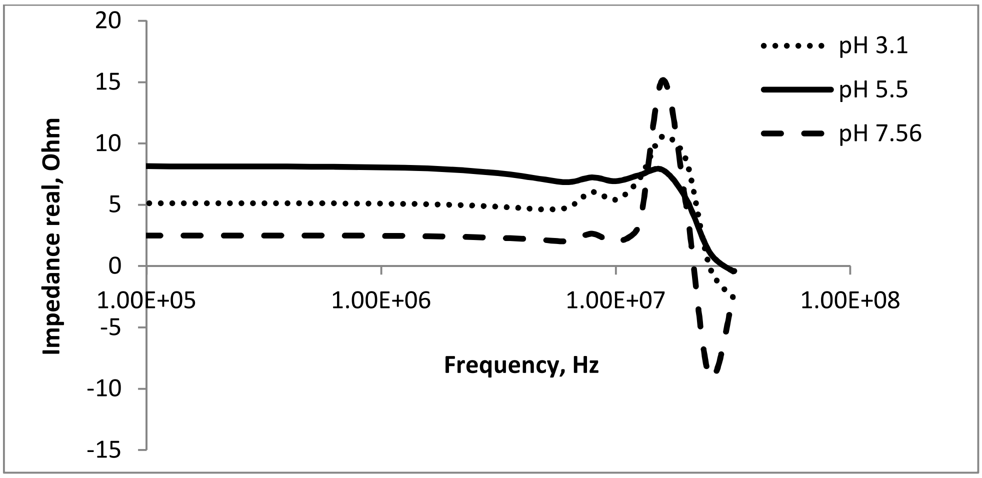

Figure 1 - Impedance Spectra of a model alumina slurry 40wt% solids

When rheology data are compared with EIS, trends in the spectra can be correlated to viscosity to determine whether rheological deformation can be detected by EIS. Certain properties of impedance can be assumed to represent material characteristics; often the imaginary component of impedance is taken as a measure of the storage modulus of a suspension. Therefore not only does EIS offer a qualitative correlation to structural properties but it is able to provide a degree of quantification too.

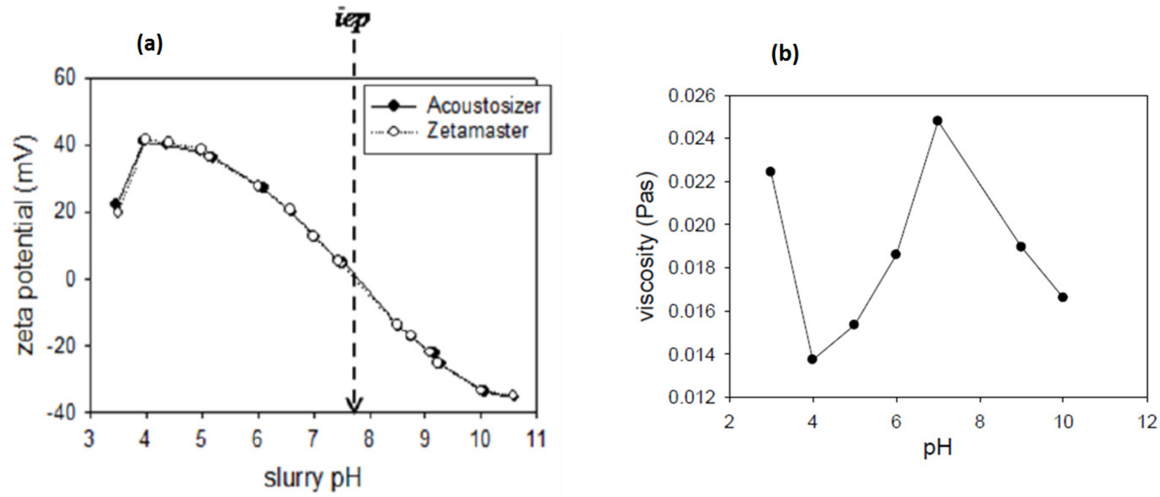

Figure 2 - Structural properties of alumina slurry 40wt% as a function of pH - (a) Zeta Potential (b) Viscosity [2]

Essentially cross-correlations between figure 1 and figure 2 can be examined to determine whether a functional relationship exists between the various components of impedance and the structural properties of the alumina suspension. The work presented in this conference is based around static, stabilised suspensions prepared on a batch basis; future work will investigate the impedance of suspensions under pre-defined shear within a flow.

[1] Zhao Y, Wang M, Hammond RB. Characterization of crystallisation processes with electrical impedance spectroscopy. Nuclear Engineering and Design 2011 Jun;241(6):1938-44.

[2] Adegbite SA. Coating of Catalyst Supports: Links between Slurry Characteristics, Coating Process and Final Coating Quality University of Birmingham; 2010.