

Some Case Studies of the Use of Zeta Potential Measurements in Catalyst Characterization

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Introduction

Although finely divided particle technology constitutes an integral part of heterogeneous catalysis, the techniques of colloid chemistry have not been widely applied to catalyst characterization. Small particles suspended in water often contain charged surfaces arising from surface groups ionizing, charged ions adsorbing from solution, or isomorphous cations or anions substituting into the crystal lattice. A layer of counter ions is firmly held to the particle to achieve partial neutrality. Zeta potential measures the potential at the shear plane separating this compact layer from the weaker held diffuse layer. The zeta potential reflects the chemical character of the surface layer of the catalyst and we can monitor surface changes even in relatively concentrated slurries. In this paper we illustrate the application of zeta potential to industrially relevant catalytic problems.

Materials and Methods

Catalyst samples (at 2-10% wt loadings) were loaded into the cell of a Matec 9800 electrokinetic instrument, and stirred. Titrations with dilute NaOH and HCl were performed in order to determine the isoelectric point- i.e. the pH where the zeta potential is zero. Correlations were made with physical strength measurements (Davison Attrition index) as well as catalytic data from model compound acidity tests.

Results and Discussion

We show an excellent correlation between the isoelectric point of a suite of USY zeolites with the surface Si/Al ratio as determined from XPS measurements (Fig. 1), giving us a simple way of monitoring surface changes of zeolites with varying bulk and framework Si/Al ratios. In studies related to controlling the strength of composite FCC catalysts, we derive an excellent correlation of composite particle strength by comparing the zeolite isoelectric point with the pH where the binder sol is most stable. We discuss the meaning and implications of this result.

We will also show how zeta potential measurements can help in understanding metal dispersion on supports by using electrostatic interactions to improve dispersion of the metal precursors. In this case surface modification of amorphous silica alumina supports surface coated with rare earth oxides can dramatically impact the dispersion of the Pt metal particles when the impregnation is controlled by electrostatic interactions.

Finally we use zeta potential measurements to compare differences between surface and bulk changes in zirconia-silica cogel-formed supports. We show how the surface

enrichment with silica correlates with zeta potential measurements as well as the acid properties as measured by the 2-methyl-pentene isomerization acidity test.

Significance

The measurement of zeta potential can provide a powerful tool in understanding issues involving industrially relevant catalysts.

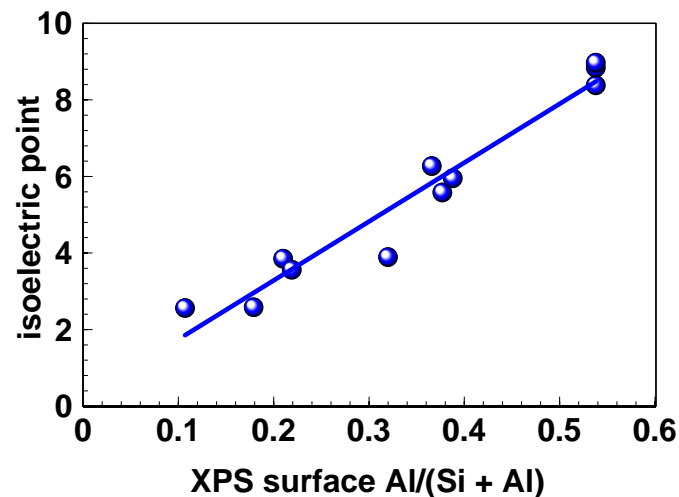


Figure 1. Correlation of isoelectric point with XPS measured fractional surface Al content of a suite of USY zeolites with varying Si/Al bulk ratios.