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APPLICATION NOTE

Using the BAT-1 autotitrator to measure the zeta potentials of Al_2O_3 at different pH

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Alumina (Al_2O_3) can be widely used as wear-resistant material, refractory material, polishing material, thermally conductive material, and other materials due to its excellent mechanical strength, hardness, thermal conductivity, high resistivity, and high melting point.

As a polar compound, the alumina particles tend to form aggregates, which are caused by the interaction of van der Waals force, electrostatic force, etc. Therefore, it is worth investigating the stability of the alumina particle system with different surface modifications.

Zeta potential relies on the chemical composition of the particle surface and the medium environment. Thus, the particle system may show various zeta potentials at different pH. In this application, we used the BAT-1 autotitrator and BeNano analyzer to measure the zeta potential of alumina particles at different pH.

Principle

The technology utilized to measure the zeta potential is called electrophoretic light scattering (ELS). In an ELS experiment, a laser beam irradiates the sample, where the scattered light is detected at a forward angle of 12°. The sample solution or suspension is subjected to an electric field applied to both ends of the sample cell, resulting in the electrophoretic movement of the charged particles in the sample. As a consequence, the frequency of the scattered light shifts compared to the incident light due to the Doppler effect. The phase shift of the scattered light signals is calculated by PALS analysis. By the phase plot, the velocity of electrophoretic movement per unit electric field, which is denoted as the electrophoretic mobility μ, is obtained. Through Henry's equation, one can calculate the zeta potential ζ by electrophoretic mobility μ as follow:

$$\mu = \frac{2\varepsilon_\gamma \varepsilon_0 \zeta}{3\eta} f(\kappa\alpha)$$

where ε_0 is the solvent dielectric constant in the vacuum, ε_γ is the relative dielectric constant, η is the solvent viscosity, f(Kα) is the Henry function, K is the reciprocal Debye length, α is the particle radius, and Kα refers to the ratio between the thickness of the double layer and the particle radius.

The BeNano 90 Zeta (Bettersize Instruments Ltd.) is used for the zeta potential measurement in this application note.

Experimental

The Al_2O_3 powder was dispersed in pure water and stirred for 15min with a magnetic stirrer. Starting from an initial pH of 6.4 with a positive zeta potential, the titration is performed automatically with NaOH titrant by the BAT-1 autotitrator and BeNano analyzer. The pH interval and the tolerance are set to 1 and 0.2, respectively, and the measurement temperature is set to 25°C ± 0.1°C. A single zeta potential measurement was performed at each target pH.

Results and discussion

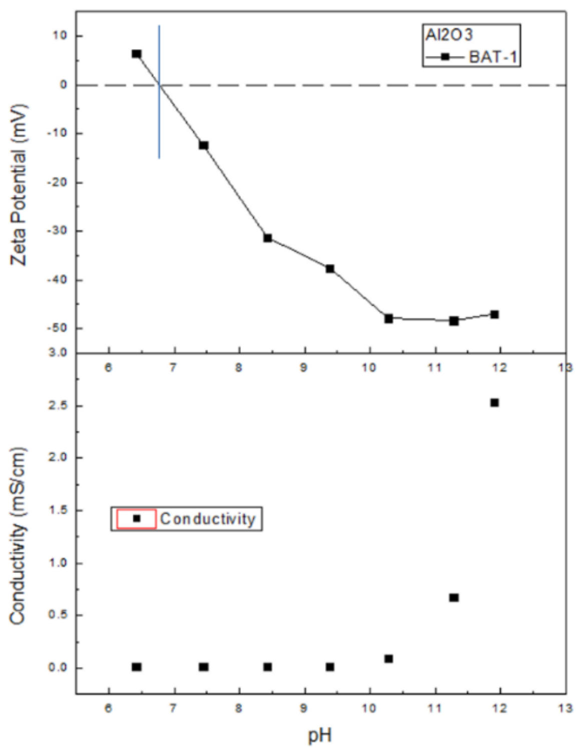

Figure 1. The zeta potential curve (above) and conductivity curve (below) at different pH

Figure 1 shows that at the initial pH, the zeta potential of the sample is positive, which indicates the particles carried positive charges. With the increase of pH, the charges gradually become negative due to the addition of the NaOH titrant. The dispersion reaches the isoelectric point at a pH of 6.8.

Al_2O_3 is an amphoteric oxide, and when it is dispersed in pure water the initial pH is almost neutral, but the titration with base changes the pH and neutralizes the positive charges of particle surfaces and turns them into negative. In the higher pH range (more negative charges on particle surfaces) the magnitude of the zeta potential of suspension is higher, which indicates the system is more stable, and less likely to agglomerate, whereas the magnitude of zeta potential near the isoelectric point is the lowest, leading to poor system stability.

When the pH is higher than 10, the negative charges are almost saturated on the particle surface. Further increasing of pH cannot induce more negative charges on the surface, but the addition of NaOH increases the ionic strength. Consequently, the shielding effect becomes dominant, and the magnitude of zeta potential is decreased.

Conclusion

The zeta potentials of Al_2O_3 at different pH were characterized by the BAT-1 autotitrator and BeNano analyzer. The results show that the isoelectric point of the sample system is 6.8. The magnitude of zeta potential near the isoelectric point is relatively low, indicating the instability of the system. And at the higher pH of 10~12, the magnitude of zeta potential is relatively high, and the sample system is more stable due to the stronger electrostatic force.

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