HORIBA

Application Note

Surface Area of Kaolinite

AN251

One of the most widely distributed and common clay minerals is Kaolinite. Kaolinite is a soft, earthy, usually white, mineral produced by the chemical weathering of aluminum silicate minerals like feldspar.

Introduction

Kaolinite is composed of tiny plate-like particles that are stacked together in layers. These layers can slide over one another, giving kaolinite its characteristic plasticity and ability to be easily shaped when wet. Most kaolinite is mined as kaolin. The largest deposits are found in moist, warm climates. For example, in the United States the largest deposits are found across middle Georgia. Kaolinite is milled to obtain target particle sizes and surface areas which are key to its use in each different application.

Common Uses

Historically, most of the kaolinite was used in the production of paper. However, primarily due to the development of digital media, paper applications have reduced substantially.

- Paper: Used for paper coatings and as a filler. It can create a glossy surface, smooth the paper, and improve the application of printing ink.
- Ceramics: For whiteware ceramics, kaolin may constitute up to 50% of the raw materials. It aids in the rheological properties for unfired ceramic materials. It can be easily molded and shaped. Due to its high melting point, when heated in a kiln, kaolin also contributes to the uniform shape of the molded ceramic. It can also be used in ceramic glazes.
- Pharmaceutical: Kaolinite is the main ingredient in some upset stomach medicines. It can also be used as an anti-diarrheal medicine.
- Cosmetics: It can be used as a filler in cosmetics. As a paste, it can also be used in facial masks and body wraps.

Other Applications:

- Refractories
- Insulation
- Paint additive
- Abrasives
- Water and wastewater treatment

Figure 1. Example of kaolinite clay in powdered form.

Gas Adsorption Technique

Surface area in this case is measured by a technique known as gas adsorption or physical adsorption (physisorption). Surface area is typically reported as meters squared per gram.

Adsorption takes place on the surface of a material. Gas molecules of known cross sectional area are carefully inventoried as they adhere to the surface. By knowing the number of moles of gas adsorbed and their cross section, the total surface area under test can easily be calculated.

The adsorption process occurs due to surface energy typically described as Van der Waals forces. Left alone, most materials will adsorb water or other vapors to satisfy this surface energy. Thus, to take advantage of these surface forces for measurement, the adsorbed impurities must be removed. This is accomplished through a process known as degassing, whereby a sample is placed in a holder and an inert flow of gas passes through the sample powdered bed as it is gently heated. The applied heat causes the adsorbed impurities to break free of the surface of the material and the flow of gas sweeps them away.

Cleaned in such a way, the sample holder may now be placed on an analysis station where it is cooled (typically to liquid nitrogen temperatures) in a cryogen Dewar as a gas mixture (typically nitrogen in a carrier gas of helium) flows across the surface. As the sample and gas cool, nitrogen molecules in the flowing gas mixture lose energy and are adsorbed onto the sample surface.

Again, monitoring the number of moles of gas adsorbed as a function of gas concentration allows us to calculate several adsorption data points. For more rapid analysis, a single point may be collected. The most common calculation method applied to derive specific surface area is the Brunauer, Emmett and Teller (BET) method.

Experimental

A commercially available kaolinite powder sample was sent to the HORIBA Instruments Incorporated applications lab in Irvine, California for analysis. The sample was analyzed using the new SA-9650 surface area analyzer. Three separate aliquots each weighing approximately 0.25 g were placed in sample tubes. Degassing was performed on the 3 integrated degas stations of the SA-9650 at 300°C for 3 hours. Samples were then transferred to the 3 analysis stations and separate analyses were performed for single point and multi point surface area. Each type of test was repeated 3 times. The results are shown in the table below.

Single Point*

	Channel 1	Channel 2	Channel 3	Average of 3 Channels	CoV (%)
Test 1	8.01	8.19	7.78	7.99	2.10
Test 2	7.79	8.06	7.65	7.83	2.17
Test 3	7.84	8.14	7.66	7.88	2.51
Average of 3 Tests	7.9	8.1	7.7	**All results in m²/g**	
CoV (%)	1.19	0.66	0.77		

Multi-Point*

	Channel 1	Channel 2	Channel 3	Average of 3 Channels	CoV (%)
Test 1	8.19	8.42	7.98	8.20	2.19
Test 2	8.11	8.37	7.95	8.14	2.13
Test 3	7.92	8.36	7.63	7.97	3.77
Average of 3 Tests	8.1	8.4	7.9	**All results in m²/g**	
CoV (%)	1.40	0.31	2.02		

*The difference between single point and multi point analyses are linked to assumptions made in the single point calculation. Multi-point results are typically more accurate. However, in terms of repeatability and reproducibility, either measurement is quite robust and single point measurements are extremely fast – supporting high throughput, production, or quality control environments.

Conclusion

The HORIBA SA-9650 surface area analyzer proved to be an ideal instrument for measuring the surface area of kaolinite both by single and multi-point analysis. The analyses were fast, repeatable and the instrument is robust. The methodology described in this document should be useful as a guide to customers using the SA-9650 for kaolinite or other powdered samples.