HORIBA Scientific

Application Note

Surface Area of Bentonite

AN247

Bentonite is a widely used natural clay material which originates from past volcanic ash deposits. For industrial purposes, two main classes of bentonite are recognized: sodium and calcium bentonite. Sodium bentonite is the more valuable, but calcium bentonite is more common. Just a few years ago, more than half of the production of bentonite was used for drilling applications.

Introduction

Bentonite belongs to a group of clay minerals known as smectites, with the primary mineral being montmorillonite. Bentonite deposits are typically found in areas with past volcanic activity, where volcanic ash has settled and undergone weathering. Bentonite is known as a swelling clay as it can absorb water up to eight times its volume.

Common Uses:

- Drilling Fluids: Bentonite is widely used in the oil and gas drilling industry as a key component of drilling fluids or muds. It helps lubricate and cool the drill, flush out cuttings, and sealing boreholes to prevent fluid loss and well collapse.
- Foundry Industry: In foundry applications, bentonite is used as a binder for molding and casting processes. It helps improve the plasticity and green strength of molds and sand cores.
- Environmental Cleanup: Bentonite is used in environmental remediation to control groundwater pollution. It can be introduced into contaminated groundwater to adsorb heavy metals and other pollutants, reducing their mobility. Of course, it is also useful to simply filter water.
- Absorbent: Also, related to its absorbency, bentonite is used for clarifying wine, liquor, cider, beer, mead, and vinegar.

Other Applications:

- Cosmetics and Personal Care
- Pharmaceuticals
- Papermaking
- Detergents and Soaps

Figure 1. Example of bentonite powder.

The specific type and grade of bentonite used varies depending on the intended application.

The surface area of bentonite is important because it significantly influences its reactivity, adsorption capacity, and effectiveness in various applications. Bentonite clay can have a high surface area due to its unique layered structure and microscopic particle size.

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 bentonite 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 0.12g 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	12.12	12.35	12.85	12.44	2.45
Test 2	11.81	12.21	12.74	12.25	3.11
Test 3	11.92	12.3	12.53	12.25	2.05
Average of 3 Tests	12.0	12.3	12.7		
CoV (%)	1.07	0.47	1.04		

Multi-Point*

	Channel 1	Channel 2	Channel 3	Average of 3 Channels	CoV (%)
Test 1	12.02	12.32	12.74	12.36	2.39
Test 2	11.64	12.49	12.5	12.21	3.30
Test 3	11.85	12.59	12.48	12.31	2.65
Average of 3 Tests	11.8	12.5	12.6		
CoV (%)	1.31	0.89	0.94		

*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 bentonite 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 bentonite or other powdered samples.