

WHITE PAPER

**Bentonite desiccants –
The natural, sustainable desiccant
solution for moisture-controlled packaging**

BUSINESS SEGMENT
CARGO & DEVICE PROTECTION
BU ADSORBENTS & ADDITIVES

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Desiccants are hygroscopic (moisture-adsorbent) substances that are packaged and used to protect a wide range of products from mold, corrosion, and other forms of moisture-related degradation and damage. Desiccants are critical to maintaining product quality and shelf life. Two of the most widely used and well-known desiccants are bentonite clay and silica gel, which are used to protect products ranging from textiles, leather goods, electronics, metal components, and foods to pharmaceuticals, nutraceuticals, and medical devices.

Packaging engineers responsible for ensuring the quality and shelf life of packaged products face a range of considerations when it comes to sourcing the desiccant that is right for their applications. This paper will compare bentonite clay and silica gel in a variety of categories essential to making a well-informed sourcing decision: Material Composition, Performance, Production, Environmental Impact, and other factors.

Material Composition

Bentonite clay is an abundant and naturally-occurring mineral that results from the weathering and



sedimentation of volcanic ash deposits. Its principal ingredient is calcium montmorillonite, a highly adsorbent, chemically inert and non-corrosive substance. When mined from the ground, then processed and dried into the form of free-flowing granules, bentonite clay attracts and binds water vapor readily within its complex and highly layered structure, making it a highly effective desiccant.

Silica gel is a synthetic material, a highly porous form of amorphous silicon dioxide that is typically



produced in the form of transparent beads, about 2-3 mm in size. Silica gel adsorbs water vapor in an internal network of random, intersecting channels of various diameters. Silica gel is manufactured on a large scale through a multi-step chemical process.

The current primary global source for silica gel is China, so silica gel desiccants are generally shipped worldwide in bulk or individual package form.

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Performance

In terms of their capabilities and performance as desiccants, these two materials have numerous similarities. Both are highly adsorbent materials. This means that even at full water vapor capacity, both remain dry and free-flowing, without any apparent change in size, shape or texture. And, both of these desiccants can be “reactivated” by oven-drying them to remove retained water vapor between uses.

They are also quite similar in terms of “unit” weight and relative adsorption performance. Desiccants are measured in “units” according to military and industry specifications, including MIL-D-3464 (U.S), DIN 55473 (Germany), and AFNOR NF H00-321 (France). The MIL and DIN specifications define a unit as the amount of desiccant that will, at a temperature of 25° C, adsorb 3 g of water vapor at 20% relative humidity and 6 g of water vapor at 40% relative humidity. By this standard, a unit of bentonite clay desiccant weighs about 33 grams, while a unit of silica gel weighs about 26 grams. Both will adsorb water vapor equivalent to between 30 and 40 percent of their unit weight. (Note: the AFNOR NF H00-321 specification defines a desiccant unit with 100 g moisture adsorption.)

Although the adsorption properties of bentonite clay and silica gel desiccants are comparable on a unit-for-unit basis, tests show that bentonite clay offers higher adsorption capacity in the most common and relevant package conditions. The adsorption capacity of bentonite is substantial at low humidity levels and increases with increasing relative humidity. Silica gel behaves similarly but becomes even more adsorbent at higher levels of relative humidity. At these higher humidity levels, its very high rate of adsorption can, at times, make silica gel more difficult to handle.

Figure 1: Comparing desiccant performance

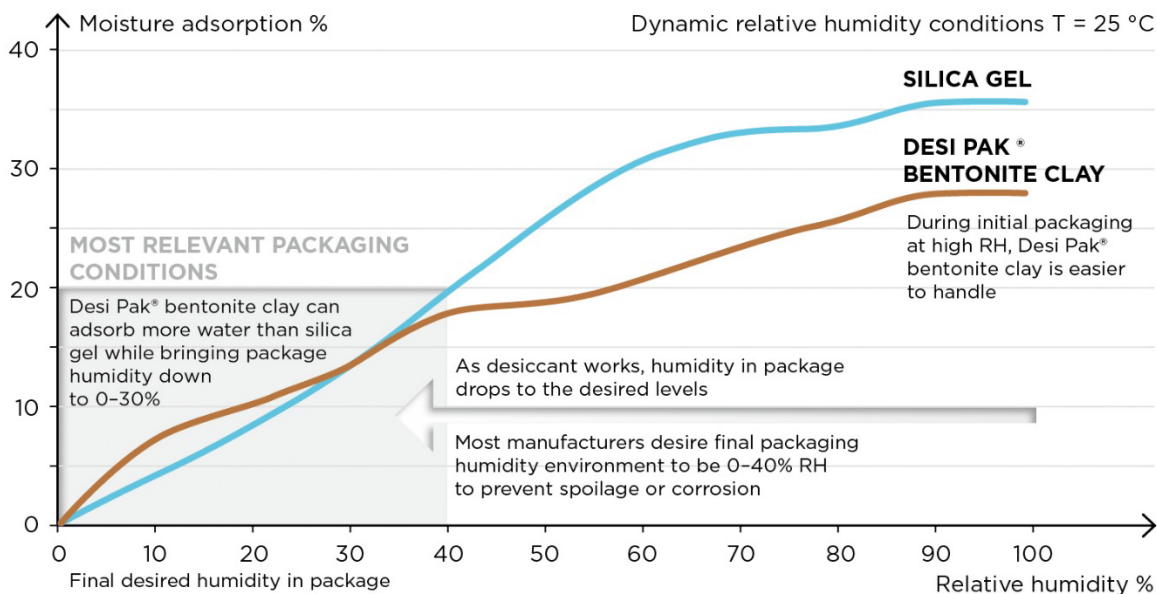


Figure 1 compares the adsorption capacity of bentonite and silica gel at various relative humidity levels. In package conditions below 30 percent relative humidity, bentonite adsorbs more humidity than the equivalent amount of silica gel. Package conditions below 40% relative humidity are by far the most commonly required.

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Production

Though bentonite clay is abundant and readily available, Clariant selects and uses only top grades of bentonite clay that meet demanding adsorption requirements. After locating these top-grade deposits, Clariant manages all aspects of mining and processing this mineral into desiccants at numerous sites worldwide.

Generally, desiccant-quality bentonite clay is found in deposits that are in the top about 40 feet (10 m) of the earth's crust. To obtain the mineral, Clariant conducts surface mining operations that expose and extract the mineral. When the deposit is exhausted, Clariant manages the reclamation and recultivation of the mined site to its own high environmental and ecological sustainability standards.

After mining, bentonite clay is transported to a Clariant desiccant processing facility. There, the bentonites is processed into a high-performance desiccant material. It is put through a mechanical process of extrusion, dried to a suitable moisture content and then graded (by screening) into finely granulated material of uniform size, ready for packaging.

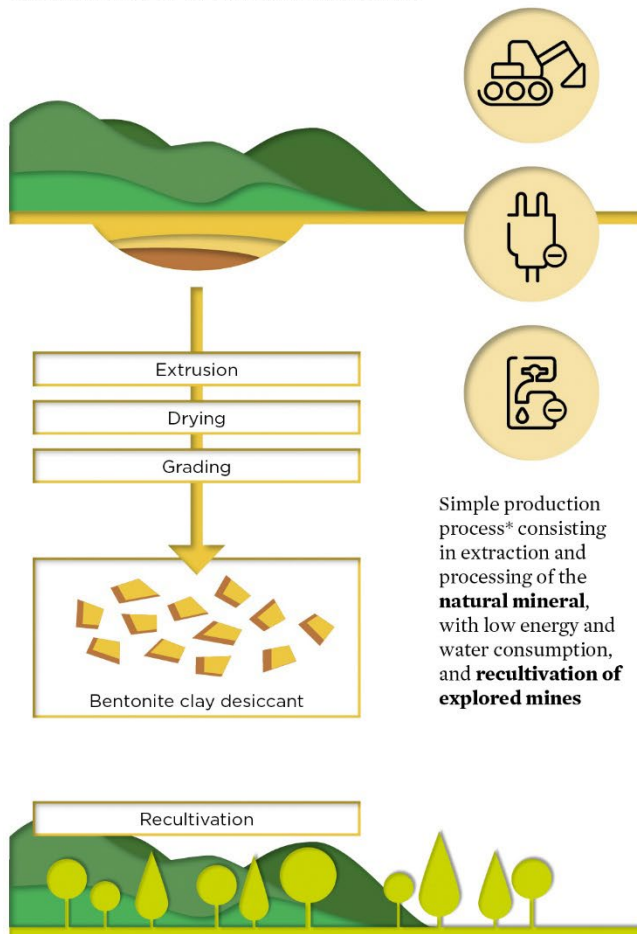
The production of silica gel desiccant involves a far more complex, multi-step process. The process begins with a raw material, sand, plus sodium carbonate, a chemical feedstock. These are combined in an energy intensive furnace or hydrothermal process, followed by additional processing, to produce an intermediate material—sodium silicate. The sodium silicate is then combined with sulfuric acid in a reaction vessel to produce sodium sulfate and amorphous silica gel. Following removal of the sodium sulfate and process effluent and subsequent extensive washing, the remaining silica gel is ready for processing into desiccant material. It is washed down with water to a desired conductivity level, heat-dried to a moisture content of 3% or less, and then graded prior to packaging.

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Figure 2: Comparing production complexity and environmental impact

BENTONITE CLAY DESICCANTS

Calcium-rich montmorillonite clays
PROCESSING OF A NATURAL MINERAL

**SILICA GEL DESICCANTS**

Silicon dioxide
SYNTHETIC PRODUCTION

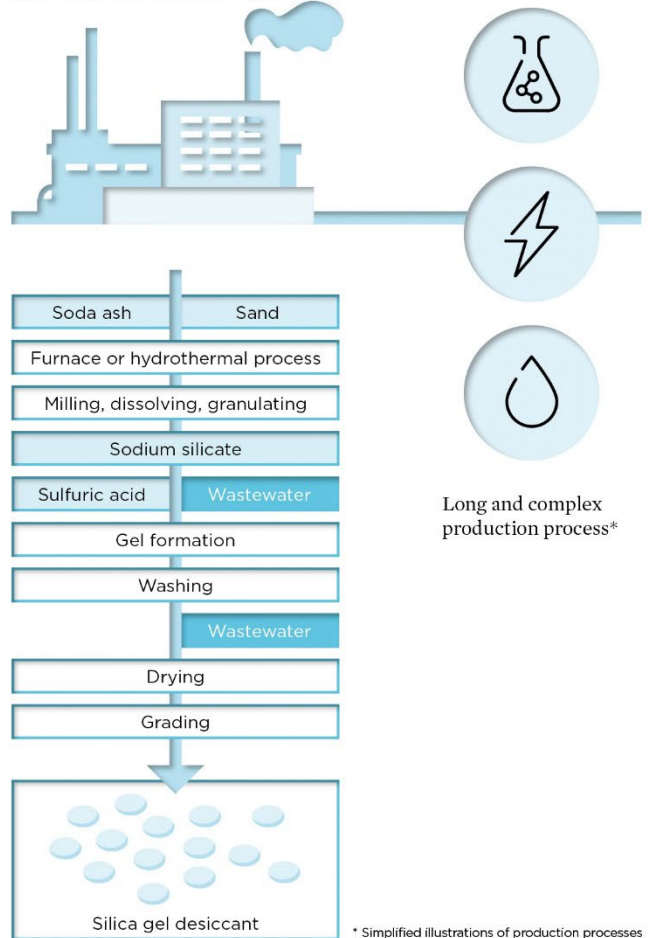


Figure 2 compares the production process requirements and environmental impacts involved in the production of bentonite clay and silica gel desiccants. Because bentonite clay is a naturally occurring compound, all it requires for use as a desiccant is extrusion, drying, grading, and packaging.

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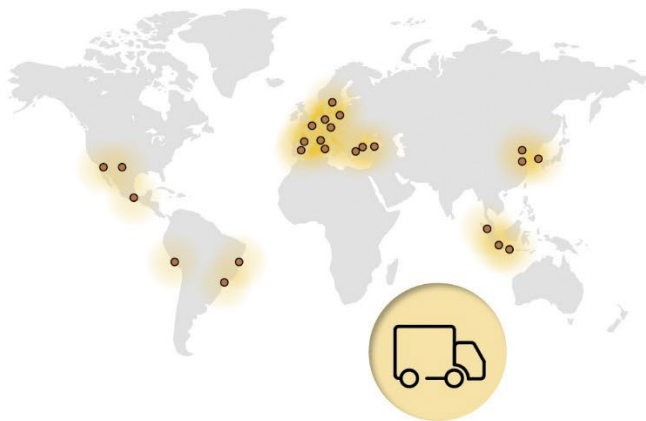
Environmental Impact

Increasingly, manufacturers of a wide range of products consider the environmental impact of their products and packaging materials, actively seeking alternatives that offer excellent performance together with greater sustainability, lower resource consumption, reduced carbon footprint, and reduced environmental impact.

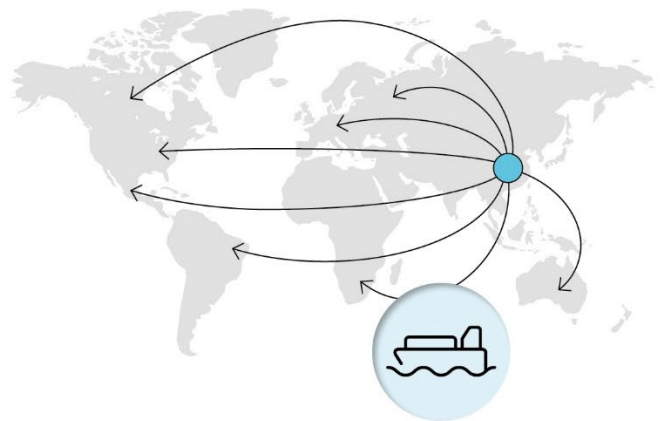
In this regard, bentonite clay represents an extremely positive package desiccant solution. Consider its many environmental and sustainability advantages relative to synthetic silica gel:

- It is abundant and naturally occurring.
- Once mined, its production and processing require no chemical processing and use no chemical additives or solvents.
- Its carbon footprint is small: only a comparatively modest amount of energy is consumed by the equipment required to mine, extrude, dry, and sort bentonite clay for packaging. Clariant is continuously working to reduce the amount of energy consumed even further. For example, through the use of sun drying.
- The global availability of bentonite clay assures an uninterrupted supply, while numerous sites for regional production worldwide reduce the carbon footprint associated with transporting this desiccant to market anywhere in the world.

Bentonite can be sourced from **mines globally**.
Clariant has 40 bentonite mines and a supporting global network allowing **local distribution**.



Silica gel must be manufactured **synthetically**.
Most production comes from China and needs to be shipped, entailing **high environmental costs**.



Global availability of bentonite clay assures an uninterrupted supply, while numerous sites for regional production worldwide reduce the carbon footprint associated with transporting this desiccant to market anywhere in the world. Currently, the primary global source for silica gel is China, so silica gel desiccants are generally shipped worldwide in bulk or individual package form.

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Clariant Desi Pak™: Superior quality bentonite clay desiccants

Clariant manufactures a complete line of bentonite clay desiccants, trade-named Desi Pak™. All Desi Pak ingredients are sourced by Clariant. The process begins with the exploration needed to identify and acquire top-grade bentonite clay deposits, through to the mining (extraction) process, and even to the reclamation/restoration process for areas where our mining is complete. Our commitment to ecological sustainability is clear: Clariant will restore and recultivate all bentonite mining areas to an equal or better state than when our operations began.



Caption: Trees planted at a former Clariant bentonite mine.

Following extraction at some 40 bentonite mining sites globally, bentonite clay is transported to one of the three Clariant production facilities that produce Desi Pak desiccants to meet demanding internal and global standards of quality. These facilities are located in:

- Belen, New Mexico, USA;
- Balıkesir, Turkey; and,
- Zhenjiang, China.



Caption: Clariant Desi Pak™ bentonite clay desiccants

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Your desiccant sourcing decision

When it comes to making decisions about sourcing desiccants, there are many important issues to consider. In addition to the many performance similarities between bentonite clay and silica gel, consider the important differences and what they could mean to the success of your product, your supply chain, your customers, and the impact of your operations on the global environment.

Factor	Bentonite	Silica gel
Supply Chain	Bentonite clay supplies are abundant and available worldwide. Clariant mines bentonite clay and produces Desi Pak desiccants at 3 locations on 3 continents. Production requires no chemical feedstocks or processes.	Silica gel production is currently concentrated at a handful of large plants in China. Production requires chemical feedstocks.
Environmental impact	Production of Clariant Desi Pak bentonite clay desiccants involves: • Low resource consumption • Small carbon footprint for mining, processing • No harsh chemicals • Minimal water and energy consumption	Silica gel production: • Is more energy intensive • Has a larger carbon footprint • Consumes more chemicals and freshwater • Produces significant process effluents/discharges
Regulatory concerns	Reclamation and replanting of mined areas are well understood and are part of Clariant's commitment to ecological sustainability.	As a result of high pollution levels, Chinese regulators are placing increased restrictions on the creation and discharge of industrial pollutants in more than 80 industries. High-polluting plants are subject to closure.

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