



renewable | biogenic

SandyCal™ Oolitic Aragonite

sustainable agriculture supplement

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Raw, naturally renewable SandyCal™ aragonite is 92-98% pure calcium carbonate. The grains are oolitic (egg-shaped), smooth, and near white in color. It is tasteless, odorless, dustless, non-toxic and easy to handle.



SandyCal™ has been identified as a valuable component in many agriculture uses, such as:

- // Golf Course Plating Sand
- // Lawn & Golf Course Top Dressing
- // Agricultural Spreading Row Crops
- // Agricultural Spreading Vegetables
- // Agricultural Spreading Hay Fields
- // Animal Pasture Fields Top Dressing
- // Animal Feed Calcium Supplement
- // Animal Farm Acid Neutralization



Agricultural Advantages of Aragonite

High Hydraulic Conductivity	Ksat values measured in the 50 plus in/hr indicating excellent drainage capabilities
Extremely High Surface Area	1.7 square meters per gram (20,000 square inches per cubic inch) which means the maximum area for binding locations for the development of a microbial community required for healthy plant growth
Excellent pH Buffer	Maintains stable pH especially with the addition of nitrogen, ammonia and phosphorus fertilizers
Adsorbs Phosphorus	Meaning longer continued efficient use of the fertilizer for the plant root
High Sphericity and Microporosity	High sphericity and microporosity (large surface area) traps moisture but still allows hydraulic conductivity and will not limit air flow through the substrate. This entrained moisture is accessible during dry periods and stabilizes soil temperatures because the water has a larger heat capacity relative to soils. An ideal capillary porosity for root zone mix which contains a nearly equal distribution of air and water filled pore space after good free drainage.
Ease in Spreading	No outdoor covering required and spreads easy both wet and dry, with little to no dust
Efficient Source of Calcium	One ton of aragonite will deliver 28% more calcium than a ton of anhydrous gypsum and 60% more calcium than a ton of hydrated gypsum
Sequesters Suspended Sediment & Nutrients	Sequesters suspended sediment and nutrients in farm, golf course and lawn water runoff, which limits the environmental impact on surrounding natural areas, especially when located next to sensitive habitats.



SandyCal™ Gradation & Composition

Typical Gradation

	micron	mesh	sieve size
median particle size (D50)	350 µm	45	.355mm
particle size range	149 - 420 µm	100 - 40	0.149 - 0.42mm

SandyCal™
Particle Data

Typical Chemical Composition

	minimum	maximum
CaCO ₃ calcium carbonate	92%	98%
SrCO ₃ strontium carbonate	1%	2%
MgCO ₃ magnesium carbonate	0.40%	1%
SO ₃ sulfur trioxide	0.05%	0.50%
NaCl sodium chloride	400 part per million	800 part per million
Ca ⁺⁺ calcium	34%	42%

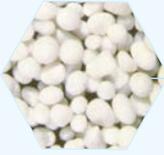
SandyCal™ Composition
(oolitic aragonite percent by weight)



Oolitic Aragonite vs. Calcite/ Limestone

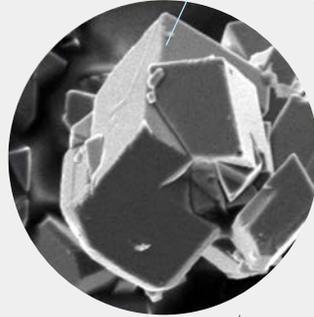
Although calcite/ limestone and oolitic aragonite have the same chemical formula (CaCO_3), each belongs to a different crystal system (morphology) and each has different physical and chemical properties. Differences between these minerals include differences in density, solubility, buffering capacity, Zeta potential microporosity, crystal morphology, trace element composition, surface area (oolites), and brightness. Aragonite exhibits an economic advantage due primarily to its reactivity (Zeta potential), high acicular aspect ratio/crystallinity, and microporosity.

Aragonite



SandyCal™
calcium carbonate

Calcite / Limestone



mined
calcium carbonate

harvested vs. mined

	SandyCal™ oolitic aragonite	calcite / limestone
specific gravity	2.8 - 3.0	2.6 - 2.8
mohs hardness	3.5 - 4.0	3.0
crystal structure	orthorhombic	Trigonal
surface area	>1.82 m ² /g	<.55 m ² /g
zeta potential	-33.85mV to -6.65mV	-1.01mV to +11.55mV
crystallinity	high	low
microporosity	very high	low

SandyCal™ Agriculture Uses



- // Agricultural Spreading Row Crops
- // Agricultural Spreading Vegetables



- // Animal Feed Calcium Supplement
- // Animal Farm Acid Neutralization





- // Golf Course Plating Sand
- // Lawn & Golf Course Top Dressing



- // Agricultural Spreading Hay Fields
- // Animal Pasture Fields Top Dressing





SandyCal™ Agricultural Benefits

Purity	92 - 98% pure calcium carbonate
Sustainable	Naturally precipitates in the ocean in a process fueled by photosynthesis within the blooms of cyanobacteria and unicellular green algae
Renewable Resource	USDA confirms oolitic aragonite as a regenerating resource, proven by carbon dating
Cost Effective	Oolitic aragonite effectively delivers greater concentrations of calcium (+40%) by volume
Efficient pH Buffer	With +40% calcium and ability to fluidize, aragonite is a practical and efficient pH buffer
Increased Tolerance	Aragonite's efficient calcium delivery increases tolerance to stressful conditions such as drought and close mowing
Urea Stabilization	By reducing the hydrolysis of urea, aragonite neutralizes volatilization in fertilizers
Processing Quality	Free flowing, applies with little to no dust and does not clog equipment during spreading
Biological Benefits	Unique crystalline structure with a high surface area, stimulates microbial life in soil, making nutrients more readily available for plant nutrition
Increased Absorption	Aragonite's negative zeta potential, in combination with a relatively large surface area, gives aragonite the ability to absorb nutrients efficiently increasing their availability
Supply	Unrestricted supply with exclusive access
FDA Approved	The calcium carbonate in SandyCal™ is FDA approved and GRAS certified.



SandyCal™ Agricultural Benefits

Golf Course Plating Sand

Oolitic aragonite is excellent for golf course construction and outperforms many of the United State Golf Association's (USGA) recommendations for golf course construction materials. Its capillary porosity profile passes a #100 sieve at 3.9%, garnering a saturated hydraulic conductivity value of +50 in/hr, well in excess of the recommended 15 in/hr. Further, aragonite has a high surface area that provides the ideal habitat for microbial communities required for healthy turf. In conjunction with its morphology, aragonite acts a buffering agent with a pH above 8.2, an ideal combination for creating perfect golf course growing conditions. Oolitic aragonite is a high performance material that spreads with little to no dust, and is exquisitely suited for golf course creation and maintenance.





SandyCal™ Agricultural Benefits

Turf Grass Amendments & Potting Soil

Oolitic aragonite is a highly pure source of calcium that acts as a pH control for turf grass amendments and potting soil and is an essential part of a healthy micro-nutrient formulation. Plentiful calcium increases tolerance to stressful conditions such as drought and close mowing. Oolitic aragonite is an exceptionally pure mineral, which is typically over 40% calcium and contains few impurities compared to conventional limestone sources. Aragonite has a unique morphology, which efficiently dissolves and delivers calcium to the soil. In a common soil whose pH is 6, 65% of aragonite will be in the dissolved form. That far outperforms calcite at 10%, anhydrous gypsum at 28% and hydrated gypsum at 5%. In conjunction with its excellent delivery capabilities, aragonite acts a buffering agent with a pH above 8.2, an ideal combination for the cultivation of turf grass and potting soil.





SandyCal™ Agricultural Benefits

Crop Fields

The application of Aragonite is with large lime spreaders, truck casters or fertilizer buggies. To encourage the continual reproduction of the Aerobic bacteria, it is delivered with an approximate 5% moisture content.

Application rates vary at: *recommended for maintenance at:*

// 400 pounds per acre for grasses and small grains

// 500 pounds per acre for soybeans

// 650 pounds per acre for corn

// 750 pounds per acre for back to back applications on corn

- Initial first application may be at higher rates to raise pH and to create a stronger buffer.
 - There are big benefits in the ease of spreading, in the fact that no dust is created due to the low minus 200 mesh material.
 - Distributes extremely well both dry and wet.
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SandyCal™ Agricultural Benefits

Animal Feed

Aragonite has approximately 40% available calcium and is a naturally occurring predigested shell calcium source. The application rate of aragonite for feed supplement is:

- // For chickens while young and developing it is 1% of the grain mix.
 - // For layers it is 8.75% of the grain diet.
 - // For bovine it may be used from 1oz up to 4oz per head per day depending on the forages being fed at the time.
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SandyCal™ Agricultural Benefits

Fertilizer Enhancer

Oolitic aragonite is a highly pure, renewable and biogenic mineral, which is ideally suited to enhance fertilizer performance. Containing approximately 40% calcium and able to dissolve quickly, aragonite is a practical and efficient pH buffer. Further, aragonite has an innate ability to absorb nutrients deliverable into fertilizers, efficiently increasing their availability. This delivery mechanism is made possible because of a negative zeta potential in combination with a large surface area of the aragonite crystal. Aragonite also acts to neutralize volatilization of ammonia by reducing the hydrolysis of urea by delivering free calcium ions within fertilizers, thereby stabilizing the ammonia.



SandyCal™ Technical Aspects

Oolitic Aragonite versus Calcite

Although calcite/limestone and oolitic aragonite have the same chemical formula (CaCO_3), each belongs to a different crystal system (morphology) and each has different physical and chemical properties. Differences between these minerals include differences in density (aragonite 2.93; calcite 2.71), solubility, buffering capacity, Zeta potential, crystal morphology, trace element composition, surface area (oolites), and brightness.

Aragonite has an Orthorhombic (bipyramidal) crystal structure. The *aragonite* polymorph generally exhibits needle-shaped orthorhombic crystals. The needle shape is called *acicular*, and the ratio of length-to-diameter of the crystals is called aspect ratio. This high *aspect ratio* of aragonite is useful in many applications.

Aragonite specific gravity: 2.95; hardness 3.5 - 4.0

Calcite specific gravity: 2.7; hardness 2.8 - 3.0

Aragonite Melting point 825 °C

Calcite Melting point 1339 °C

Solubility

Aragonite is more soluble because its solubility product constant (K) is larger than the solubility product constant of calcite which means that at equilibrium more of the aragonite solid phase is dissolved than the calcite solid phase would be.

SOLUBILITY PRODUCT CONSTANTS

<u>Compound</u>	<u>Formula</u>	<u>K_{sp} (25 °C)</u>
Calcium carbonate (<i>calcite</i>)	CaCO_3	3.36×10^{-9}
Calcium carbonate (<i>aragonite</i>)	CaCO_3	6.0×10^{-9}

Aragonite versus Calcite Solubility under different environmental conditions. A comparison:

For example what would the difference be between the two forms of limestone in dissolving times in the following conditions:

- + temperatures 14C
- + grain size 60 mesh
- + environment pH 5.5
- + time 30 days

$$3.36 \times 10^{-9} = [\text{Ca}^{+2}][\text{CO}_3^{-2}]$$

$$[\text{Ca}^{+2}] = [\text{CO}_3^{-2}] = 5.80 \times 10^{-5} \text{ moles/liter}$$

$$5.80 \times 10^{-5} \text{ mol/L} \times 100.09 \text{ g/mol} = 0.00580 \text{ g/L}$$

The solubility of Calcite is 5.80 mg/liter

$$6.0 \times 10^{-9} = [\text{Ca}^{+2}][\text{CO}_3^{-2}]$$

$$[\text{Ca}^{+2}] = [\text{CO}_3^{-2}] = 7.75 \times 10^{-5} \text{ moles/liter}$$

$$7.75 \times 10^{-5} \text{ moles/liter} \times 100.09 \text{ g/mol} = 0.00775 \text{ g/L}$$

The solubility of Aragonite is 7.75 mg/liter

Reactivity

Aragonite has a negative surface charge, typically in the range -10 to -35 mV or higher. This is called the zeta-potential. A negative zeta potential is particularly useful in combining with materials of a positive charge or allowing the mineral to stay in suspension as opposed to coagulating.

pH Buffer

Oolitic Aragonite is a perfect substrate, which maintains a higher pH without the constant addition of chemicals. When the pH falls below 8.2, Aragonite snaps into action, breaking down into calcium (great for water hardness), carbonate (your buffer), and various beneficial trace elements like Magnesium. Your pH comes back up and the tank stays healthy, all without ever adding a single chemical. Other types of calcium carbonate don't react until the pH is in the mid 7's or lower. In fact, Aragonite holds the highest pH of any gravel or sand, and has up to 30 times the buffering capacity of Dolomite, Calcite ("crushed corals"), or Oyster shell. Plus, unlike ordinary substrates, Aragonite never needs replacement, buffering automatically for life of the application.

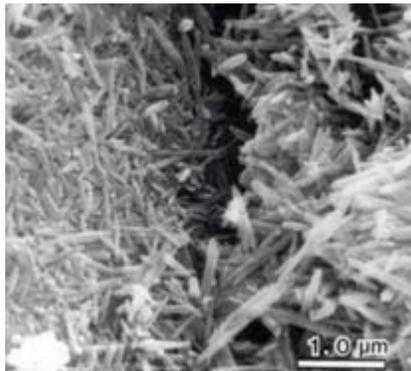
Microporosity

In addition to maintaining the pH, aragonite is also a **high capacity bio-filter**. Aragonite is extremely porous, about 20,000 square inches of surface area per cubic inch! Imagine the beneficial bacteria population you can maintain with it. This is why Aragonite is unsurpassed in reducing nitrates, nitrites, and ammonia, allowing a bio-load many times greater than other substrates.

Adsorption

The advantage that aragonite has as an adsorption agent over calcite is its greater relative surface area. This higher surface area of aragonite is approximately 4x that of typical calcite surface area. The two main advantages of high adsorption are:

1. First, on a micro-scale aragonite crystals are needle-like compared to the much thicker block-like solid that calcite occurs in. The figure below is an electron-microscope picture of the surface of an ooid. Each of the needles has a typical length of approximately 1 micron and a width of approximately 0.1 micron. An oolite will therefore have a huge surface area to volume ratio, thus creating a potential adsorptive surface. This is readily apparent when the material is wet, it can hold a very large amount of water due to adhesion of the water molecule to the crystal structure.



2. The second reason for its high adsorptive capacity is the ooids structure itself. The ooids forms when carbonate ions combine with calcium in solution and envelopes a nuclei suspended in the water. The nuclei can consist of organic matter that this solution crystallizes on. This process forms an Oolite which is in the shape of an egg. These egg-shaped oolites that form can be covered by several layers of the needle-like aragonite crystals resulting a structure that has large interior void spaces that have a large capacity for adsorbing materials.

The adsorptive of capacity aragonite could be taken advantage of for many applications. It could be used as a filtration, adsorbing agent, soils, etc.

Parameters that control adsorptive capacity of oolitic aragonite

There are three main parameters that will control the adsorptive capacity of oolitic aragonite. These are;

- (1) solubility and buffering capacity,
- (2) zeta potential (surface charge), and
- (3) surface area and void ratio.

The solubility and buffering capacity is important because the pH of a system will often determine the form or configuration of chemical species as well as the surface charge. Chemical reactions are often controlled by the pH of a system and thus the reaction may be controlled by the application of aragonite.

The zeta potential of a material is the surface charge that exists on the surface of the material. A positive surface charge will bind negatively charged ions and a negatively charged surface will bind positively charged ions. The zeta potential for CaCO_3 is a function of the pH. Thus at one pH value it may adsorb a positively charge ion (typically $\text{pH} > 8$ for calcium carbonate) while at another it will adsorb a negatively charged ion (typically < 8 for calcium carbonate). Knowledge of the zeta potential will allow for prediction of those ions that could be trapped by the oolitic aragonite. Zeta potential measurements have been made for calcium carbonate in the past and the various forms all have resulted in different outcomes.

Berlin and Khabakov (1961) found that in general CaCO_3 of biogenic origin (like aragonite) resulted in a negative zeta potential while CaCO_3 of mineral origin (mineral calcite) had a positive value.

The first two parameters will control what is adsorbed to the surface of the aragonite while the third will control the adsorptive capacity. In short, the larger the surface area, the more of a material can be adsorbed to the surface.

Using accurate measurements of these three parameters we can assess what materials will bind to the surface of the aragonite under what conditions. For example, if aragonite was used in a filter media to bind nitrate (NO_3^-), a positive surface charge would be necessary to adsorb the nitrate. Thus the pH of the filter media should be held at a lower pH in order to facilitate surface bonding. This process may have agricultural implications as well. At low pH typical of soils (~5-5.5) aragonite would be expected to have a positive zeta potential. Nitrates released into the atmosphere from anthropogenic sources are deposited in rain water. Typically nitrate is extremely soluble and will flow along with the water through the system and out of the root zone. The negative charge of nitrate would favor surface bonding to the aragonite thus restricting movement and providing free fertilizer to the farmer.

Another more complicated potential use of aragonite may be as a top dressing or delivery system for ammonia base fertilizers. When ammonia reacts with water it creates a positively charged ammonium particle and releases a hydroxide ion which raises the pH of the system, which actually favors the reverse of the reaction to ammonia which can volatilize. Research is currently being conducted to determine if aragonite may reduce the volatilization of ammonia from the soil by (1) trapping enough water to favor ammonium ion, (2) buffering the pH to ~8 which will still favor the ammonium ion, and (3) provide a surface for microbial transformation of ammonium to nitrite and then nitrate.



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