

# PARACLETE ENERGY

High Capacity Silicon with  
The Price & Stability of Graphite

## Why Buy Si Oxide When You Can Have Si Metal?

Silicon Oxide	or	Silicon Metal
1,550 mAh/g		3,575 mAh/g

Paraclete's **SM-Silicon™** is Si Metal that...  
is **air stable**,  
is much **higher FCE** than SiO<sub>x</sub>,  
is **>2X capacity** than SiO<sub>x</sub>,  
is **stable** with >5X Si than SiO<sub>x</sub>, and  
is **priced ≤ graphite** @ \$/kWh.

- Enables 25% silicon metal with similar to better cycle stability of 5% SiO<sub>x</sub>
- Air and moisture stable nanoparticle silicon metal for manufacturing process (no SiO<sub>x</sub> surface required)
- Priced less than graphite from a dollar per kilowatt-hour with annual supply agreement
- The SM or Surface Modifier acts as artificial SEI, thereby diminishing negative electrolyte interaction

## If You Are Going to Use Silicon, We Are Going to Help You Get It Right!

Paraclete means: "to come alongside". Paraclete Energy manufactures air and water stable nanoparticle 3,575 mAh/g silicon metal and prelithiated silicon for the graphite and Li-ion battery industry. All of Paraclete's products are available from tons and kilograms for production to grams for R&D.

Paraclete's premier silicon product is **SM-Silicon™**. The SM stands for Surface Modified. This surface modifier functions as an artificial SEI that negates the negative effects of electrolyte interaction and thereby enables both cycle stability approaching that of graphite and very high loadings of silicon well beyond the ~5% limit of silicon oxide.

The cycle stability of **SM-Silicon™** acts to compound the benefits to customers given now they can replace many times as much graphite with a silicon metal that has over double the capacity of silicon oxide. Paraclete's **SM-Silicon™** can be priced from a dollar per kilowatt-hour perspective at less than graphite. The surface modifier is also what makes Paraclete's silicon safe to handle in a battery manufacturing facility.

Paraclete's air and water stable prelithiated **SM-Silicon/PL™** can be seamlessly integrated into customer's standard aqueous slurry techniques and thereby enable much higher first cycle

efficiency and much lower cost and time for production. The surface modifier not only acts as an artificial SEI for cycle stability but, with **SM-Silicon/PL™**, also acts as a protective shell from air and moisture.

Paraclete's **Rapid Prototyping Services** enable our customers to expeditiously test and validate their Li-ion batteries with Paraclete's **SM-Silicon™** metal and **SM-Silicon/PL™** air and water stable prelithiation product set.

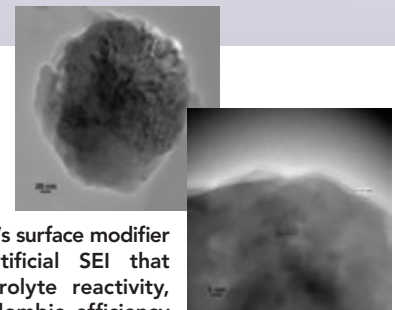
Paraclete's **Prototyping Services** include the utilization of **Rapid High Precision Coulometry** to accurately predict the lifetime of cells within weeks, not months will be used along with comparing highly engineered binder, cathode, graphite, and electrolyte systems with a customer's preferred off-the-shelf systems. Customers will see the full benefit they could potentially receive by having their batteries include Paraclete's **SM-Silicon™** family of products, to include **SM-Silicon/PL™**.

Paraclete's existing customers range from graphite companies (to enable them to integrate **SM-Silicon™** into their offerings in order to offer a premium, high-capacity product), to users, OEMs, and manufacturers of batteries.

What can Paraclete Energy's SM-Silicon™ do for your electric vehicle TODAY?  
\* per 18650 battery

	Graphite	SM-Silicon™	Improvement	USCAR
\$/kWh	\$145	\$92	37%	\$100
\$/Wh	\$0.15	\$0.09	37%	\$0.10
Wh/kg	260.6	335.1	29%	350
Wh/L	740.6	952.2	29%	750
W/kg	766.6	797.9	4%	700
W/L	2178.3	2267.2	4%	1,500
Ah	3.4*	4.2	24%	-
Wh	12.3*	15.8	29%	-
Add'l Miles	265.0	340.7	29%	-

Based on Panasonic NCR18650GA. (Similar advantages in nearly any application)



Paraclete Energy's surface modifier acts as an artificial SEI that decreases electrolyte reactivity, resulting in coulombic efficiency to nearly that of graphite!

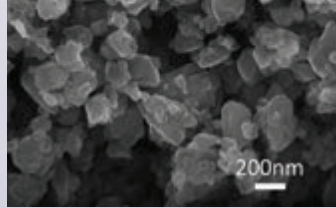
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Paraclete Energy also sells other silicon-based composites. The products are based on  $\geq 99.5\%$  raw metal silicon nanoparticles.

## Paraclete Energy's Products

All of Paraclete's products are available from tons to kilograms for production to grams for R&D.

- **SM-Silicon™** - Nanoparticle silicon metal with a proprietary surface modifier that acts as artificial SEI for cycle stability.
- **SM-Silicon/PL™** - Pre-lithiated nanoparticle silicon metal with a proprietary surface modifier that acts as a protective shell from air and moisture and as an artificial SEI for cycle stability.
- **nSiO** - Silicon metal with oxide on the surface.
- **nSi** -  $\geq 99.5\%$  raw silicon metal with substantially  $< 0.5\%$  impurities metals basis. This product is highly reactive to air.
- **nSi/C** - Nanoparticle silicon metal with carbon on the surface.
- **nSi/Cg** - Nanoparticle silicon metal with graphene on the surface.
- **nSi/Cg/P** - Nanoparticle silicon metal with graphene polymer on the surface.



SEM image of R&D Products

## Characterization for all of Paraclete's silicon\*:

Type/Form = Crystalline Powder

Purity =  $\geq 99.5\%$

Surface Purity = 0% SiO, 0% SiC, highly reactive, air sensitive

Total Metals Impurities =  $< 0.5\%$

APS = 150nm, other custom APS can be achieved - Contact Paraclete for a quote.

BET / SSA =  $30 \text{ m}^2/\text{g}$

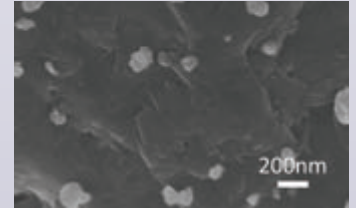
Tap Density =  $0.8 \text{ g}/\text{cm}^3$

Color = Gray to dark gray (except nSiO: yellowish brown)

Morphology = Non spherical

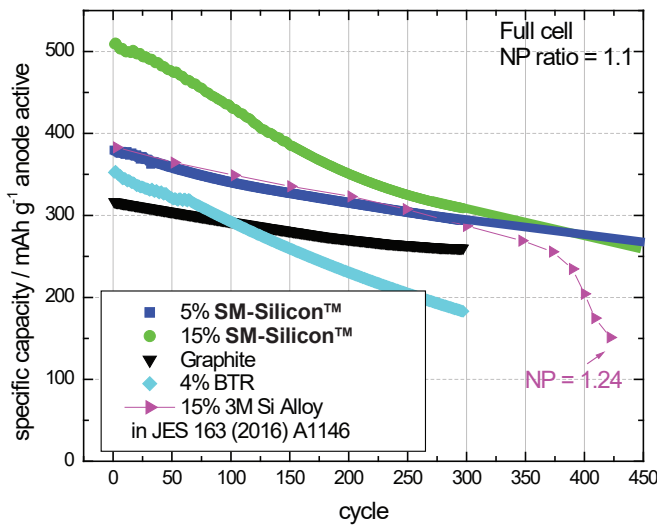
mp =  $1414^\circ \text{C}$

\* The compositions will vary with the application of different surface modifiers so identified for each respective product, (SM-Silicon™, nSi/C, nSi/Cg, nSi/Cg/P, nSiOx) be it custom SM for our SM-Silicon™ or C, graphene, or polymer for the other R&D products.

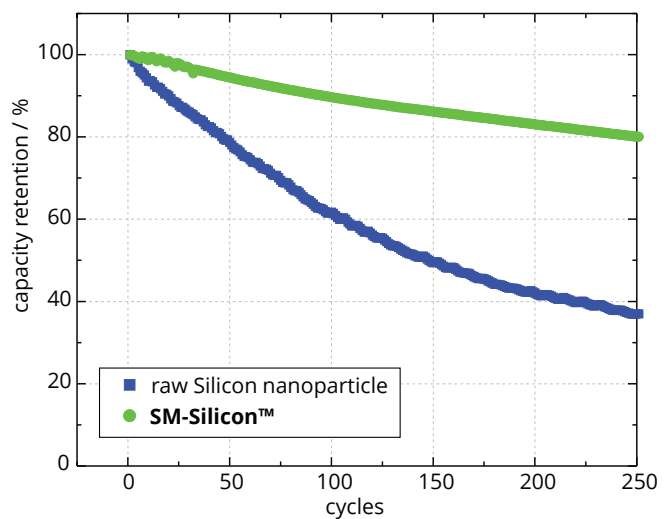


SEM Image of SM-Silicon™ Dispersed in Graphite

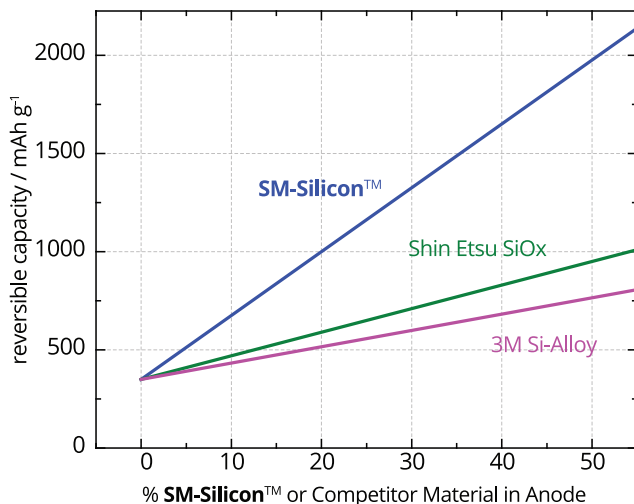
### SM-Silicon™ Cycle Stability vs Graphite and Competitor Silicon



### Surface Modification Doubles Silicon Capacity Retention after 250 Cycles



### SM-Silicon™ Has Two Times the Reversible Capacity of SiOx and Other Si-Alloys



### More Than Double Specific Capacity over Graphite with Just 15% Cycle Stable SM-Silicon™

