Soteras™ MSi is a unique binder for high-capacity silicon-based anodes in lithium ion batteries. It can easily be processed using standard industry practices. Soteras MSi binder’s ability to control swelling results in superior cycle performance at capacities greater than 400 mAh/g when used with silicon oxide (SiOx), silicon composite (SiC), silicon oxide composite (SiOxC), or silicon graphene (Si-Gr) technologies.

**Soteras™ MSi benefits**

1. **Significant expansion/contraction management**
   - Flexible and strong binder
   - Functional groups of binder that can interact physically/chemically with Si particles and/or Si/C composites

2. **Electrochemical stability**

3. **Compatible with current industry processing requirements**

4. **Good slurry properties and stability**

We at Ashland are **passionate, tenacious, solvers** who thrive on developing practical, innovative, and elegant solutions to complex problems in lithium ion battery manufacturing, always pushing the boundaries of what’s possible, and advancing the competitiveness of our customers in the battery industry.

Our people bring exceptional product knowledge, technical support and industry insights to help our customers amplify the **efficacy**, refine the **usability**, add to the **allure**, ensure the **integrity**, and improve the **profitability** of their products and applications.

**Improved performance at high C-rate**

Independent data from Münster Electrochemical Energy Technology (MEET): SiC anode of 700mAh/g with FEC electrolyte additive

![Graph showing specific capacity vs cycle number](image)
Why Soteras MSi is the binder of choice for silicon-containing anodes

Better capacity retention for multiple silicon types

**Silicon oxide composite anode of 420 mAh/g**

Cycle performance of SiOxC 420 mAh/g anode:
- Soteras™ MSi binder vs CMC+SB

**Silicon composite (SiC) anode of 450 mAh/g**

Cycle performance SiC 450 mAh/g anode:
- Soteras™ MSi binder vs CMC+SB

**Silicon-Graphene (Si-Gr) anode of 600 mAh/g**

Cycle performance of Si-Graphene 600 mAh/g anode:
- Soteras™ MSi binder vs CMC+SB

Product Specifications

Commercially available Soteras™ MSi binder grades

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Component</th>
<th>Appearance</th>
<th>Viscosity (cPs)</th>
<th>pH</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soteras™ MSi Binder</td>
<td>MSI-A</td>
<td>White Powder</td>
<td>7,000-11,000° (2% solution)</td>
<td>6.5-8.5</td>
<td>0-10</td>
</tr>
<tr>
<td></td>
<td>MSI-B</td>
<td>Clear Liquid</td>
<td>1,550-2,150° (100% solution)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1 Brookfield, spindle #4 at 30 rpm

Ashland Soteras™ MSi binder is a 2-component system, which can be used to replace conventional CMC and SB binder systems.

- Suggested Dosage: 2.5-5 wt% of anode active material, depending on target capacity
- Ratio: Soteras™ MSi-A (95%); Soteras™ MSi-B (5%)
- Soteras™ MSi-B is NOT a latex

A detailed slurry preparation guide is available upon request.
Ensures less swelling
Soteras MSi binder controls swelling as determined by SEM after first full lithiation

The cells with Soteras MSi binder have less swelling, thus are able to handle the large volume change of Si-based anode during Li+ insertion.

Soteras MSi controls swelling compared to reference CMC+SB binder in a silicon oxide composite anode of 1500 mAh/g

Using a cell with a sensitive micrometer enables insight on cycling
Connected to a BTS channel to permit electrochemical and in-situ thickness information
Control of cell expansion:
- minimizes degradative mechanisms
- minimizes new SEI formation for better cycle life

Better Adhesion Contributes to Longer Cycle Life
SEM image of Si-Gr anode after first lithiation

LiB coin cell using Si composite

<table>
<thead>
<tr>
<th>Soteras MSi</th>
<th>CMC+SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 cycles smooth</td>
<td>100 cycles delaminated</td>
</tr>
</tbody>
</table>

LiB coin cell using Si graphene

<table>
<thead>
<tr>
<th>Soteras MSi</th>
<th>CMC+SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 cycles smooth</td>
<td>100 cycles delaminated</td>
</tr>
</tbody>
</table>
Ashland locations supporting the LiB industry

Electrode coating and coin cell testing lab
- Initial efficiency (SEI formation)
- Cycle life (Capacity retention)
- C-rate dependence
- AC impedance
- Cyclic voltammetry

The information contained in this brochure and the various products described are intended for use only by persons having technical skill and at their own discretion and risk after they have performed necessary technical investigations, tests and evaluations of the products and their uses. Certain end uses of these products may be regulated pursuant to rules or regulations governing medical devices, drug uses, or pesticidal or antimicrobial uses. It is the end user’s responsibility to determine the applicability of such regulations to its products.

All statements, information, and data presented herein are believed to be accurate and reliable, but are not to be taken as a guarantee of fitness for a particular purpose, or representation, express or implied, for which seller assumes legal responsibility. No freedom to use any patent owned by Ashland, its subsidiaries, or its suppliers is to be inferred.