AEROXIDE® Fumed Metal Oxides as performance additives in Li-ion batteries
AEROXIDE® Fumed Metal Oxides

Evonik is a global leader in specialty chemicals. As a worldwide manufacturer of high-quality silica and metal oxides, Evonik offers innovative solutions in the design of ultra-fine nanostructured particles as performance additives in Li-ion batteries.

AEROXIDE® fumed metal oxides from Evonik are used as additives in Li-ion batteries to increase the performance, life-time and safety of the battery.

Applications

- Protective dry coating for cathode materials
- High performance LIB separator coating
- Nanostructured ceramic fillers inside separators
- Rheology additive in new electrolyte formulations (polymer type)
AEROXIDE® fumed metal oxides as dry coating for cathode materials

The AEROXIDE® fumed metal oxide layer acts as defined SEI (solid electrolyte interface). It protects the cathode material from undesired reactions with electrolyte, especially at increased cut-off voltage.

AEROXIDE® fumed metal oxides (Al₂O₃ and/or TiO₂) as dry coating on cathode particles leads to a significant increase in capacity retention of LIB cells!

A successful dry coating of the cathode particles with nano-structured AEROXIDE® is visible in the increase of powder density after coating process.

Left
Powder mixture before dry coating process:
Uncoated cathode powder + 1 wt.-% AEROXIDE® Alu 130

Right
Final product after dry coating process:
1 wt.-% AEROXIDE® Alu 130 coated on cathode powder

Example for stabilization of LCO. Similar effect for Ni rich NMC types (e.g. 811-NMC)
High performance LIB separator coating with AEROXIDE® fumed alumina

AEROXIDE® fumed alumina enables the preparation of ultra-thin (down to 1 µm), homogenous ceramic coatings which is not possible by the use of conventional coarser inorganic particles.

Two concepts for ceramic particle modification

- **Particle coated**
  - Ceramic particles on top of the micro porous membrane
- **Particle incorporated**
  - Ceramic particles throughout the whole interior of a polymer matrix

Particle size distribution of dispersed AEROXIDE® in water

Cross section SEM imaging of an AEROXIDE® coated separator

A thin ceramic coating made of AEROXIDE® fumed alumina strongly reduces the thermal separator shrinkage and thus leads to an increased cell safety.

150 °C: uncoated separator

150 °C: AEROXIDE® coated separator

Thermal shrinkage of membrane → risk of short-circuit!

Micro porous membrane
Properties of AEROXIDE®
fumed metal oxides

- AEROXIDE® fumed metal oxides are produced by flame hydrolysis (AEROSIL® process).
- Available metal oxides are fumed alumina and fumed titania.
- The loose white powder consists of nano-structured aggregates.
- Upon dispersing, small particles with mean aggregate sizes of ca. 100 nm can be obtained.
- AEROXIDE® products provide a very narrow particle size distribution.
- AEROXIDE® products exhibit high chemical purity (total metal trace elements < 200 ppm).

The SEM image shows a single AEROXIDE® TiO₂ P 25 aggregate

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>AEROXIDE® Alu 65</th>
<th>AEROXIDE® Alu C</th>
<th>AEROXIDE® Alu 130</th>
<th>AEROXIDE® Alu C 805</th>
<th>AEROXIDE® TiO₂ P 25</th>
<th>AEROXIDE® TiO₂ T 805</th>
</tr>
</thead>
<tbody>
<tr>
<td>BET surface area</td>
<td>m²/g</td>
<td>55–75</td>
<td>85–115</td>
<td>110–150</td>
<td>75–105</td>
<td>35–65</td>
<td>35–55</td>
</tr>
<tr>
<td>pH (4 % eq. Dispersion)</td>
<td></td>
<td>4.5–6.0</td>
<td>4.5–5.5</td>
<td>4.4–5.4</td>
<td>3.0–4.5</td>
<td>3.5–4.5</td>
<td>3.0–4.0</td>
</tr>
<tr>
<td>Loss on drying</td>
<td>%</td>
<td>≤ 5.0</td>
<td>≤ 5.0</td>
<td>≤ 5.0</td>
<td>≤ 2.0</td>
<td>≤ 2.0</td>
<td>≤ 1.0</td>
</tr>
<tr>
<td>Tamped density</td>
<td>g/l</td>
<td>approx. 50</td>
<td>approx. 50</td>
<td>approx. 50</td>
<td>approx. 50</td>
<td>approx. 140</td>
<td>approx. 200</td>
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</tbody>
</table>
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