

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



AEROXIDE® 

# AEROXIDE® Fumed Metal Oxides

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## 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.

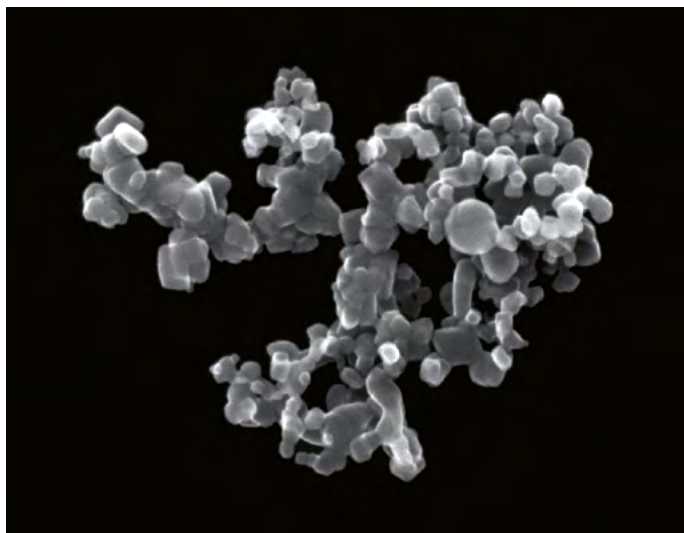
## APPLICATIONS

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- Protective dry coating for cathode materials
- High performance LIB separator coating
- Nanostructured ceramic fillers inside separators
- Additive for electrolyte immobilization (gel polymer type)

# Properties of AEROXIDE® Fumed Metal Oxides

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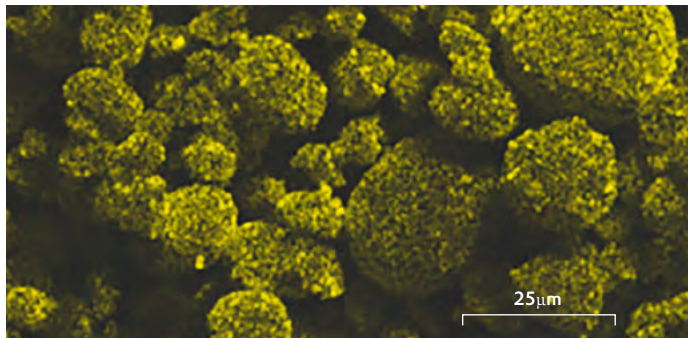


The SEM image shows a single AEROXIDE® TiO<sub>2</sub> P 25 aggregate

Property	Unit	VP Alu 45	AEROXIDE® Alu C	AEROXIDE® Alu 130	AEROXIDE® Alu C 805	AEROXIDE® TiO <sub>2</sub> P 25
<b>BET surface area</b>	m <sup>2</sup> /g	30–60	85–115	110–150	75–105	35–65
<b>pH</b> (4 % eq. Dispersion)		4.5–6.0	4.5–5.5	4.4–5.4	3.0–4.5	3.5–4.5
<b>Loss on drying</b> (2h at 105 °C )	%	≤2.0	≤5.0	≤5.0	≤2.0	≤2.0
<b>Tamped density</b>	g/l	approx. 80	approx. 50	approx. 50	approx. 50	approx. 140

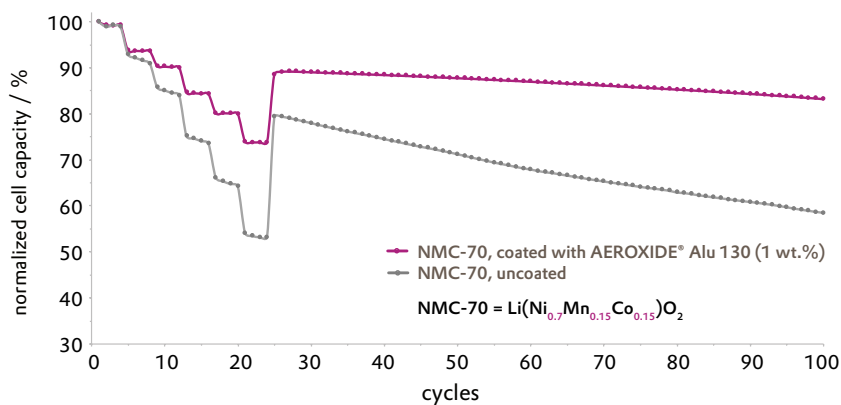
Physico-chemical data of fumed aluminum and titanium oxides.  
The data represent typical values, no product specification.

# 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.

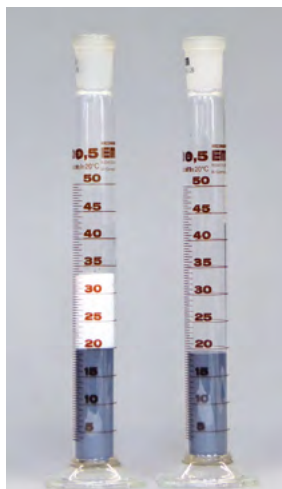
SEM: Al mapping of AEROXIDE® coated NMC particles



AEROXIDE® fumed metal oxides ( $\text{Al}_2\text{O}_3$  and/or  $\text{TiO}_2$ ) as **dry coating** on cathode particles leads to a significant increase in capacity retention and improved rate capability of LIB cells!

Example for stabilization of NMC-70 with AEROXIDE® Alu 130. Similar effect for other types of NMC (e.g. 811-NMC)

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



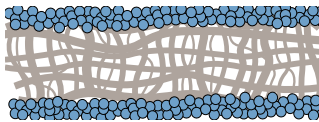
A successful dry coating of the cathode particles with nano-structured AEROXIDE® is visible in the increase of powder density after coating process.

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

# High performance LIB separator coating with **AEROXIDE®** Fumed Alumina

## Two concepts for ceramic particle modification

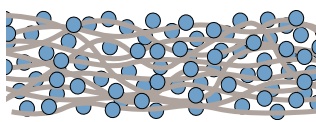
Particle coated



Ceramic particles on top of the micro porous membrane

**AEROXIDE®**  **AERODISP®** 

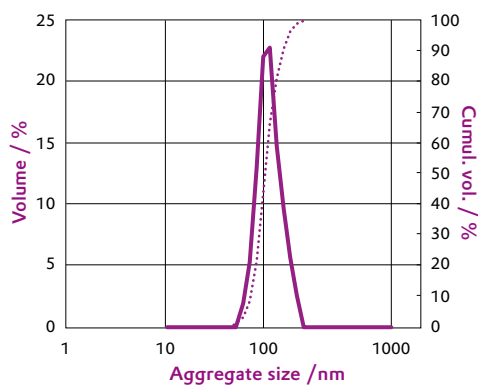
Particle incorporated



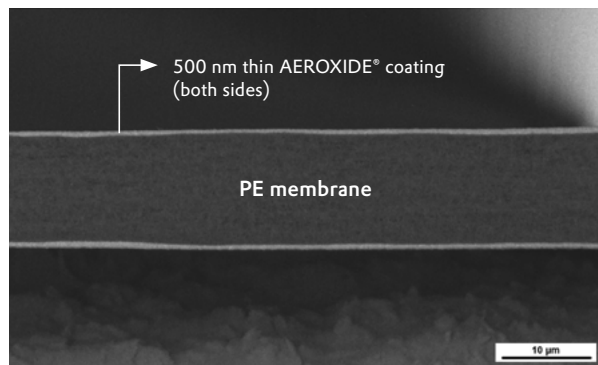
Ceramic particles throughout the whole interior of a polymer matrix

**AEROXIDE®** 

AEROXIDE® fumed alumina enables the preparation of ultra-thin ( $\leq 1\mu\text{m}$ ), homogenous ceramic coatings which is not possible by the use of conventional coarser inorganic particles.

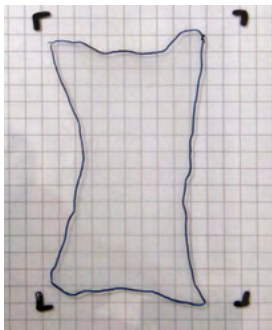


Particle size distribution of dispersed AEROXIDE® in water



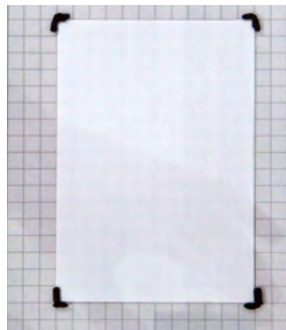
Cross section SEM imaging of an AEROXIDE® coated separator

150°C:  
uncoated separator



Thermal shrinkage of membrane  
→ risk of short-circuit!

150°C:  
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.

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F-4-EN-03-2025/04-HELP

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