Size matters.
n-ZrO$_2$
nanoscaled zirconia
No compromise.

Outstanding material properties, exceptional quality, unprecedented price.

Unique material properties
There are no buts with our high performance nanocrystalline zirconia. All individual properties are top of the range. And this is what makes our product so unique. The material is fully crystalline with very small particle size and narrow distribution. Our products are completely free of agglomerates unfolding the full power of the nanoparticles. The enormous internal surface area opens up new innovation horizons. 50 g of our material incorporate an entire soccer field of internal surface.

Available in industrial quantities
Unlike many other suppliers of nanomaterials, we speak tons, not kilos or grams. Of course, that is also reflected in our very competitive prices. We guarantee stable product quality. Since we use a continuous production process, interbatch stability is not an issue. Our clients can count on our worldwide support. Buhler is present in more than 140 countries in the world. And with our partner INM – Leibniz Institute for New Materials, Saarbrucken, Germany (www.inm-gmbh.de) – as technology source, we can ensure our clients to stay at the cutting edge also in future.

Tailored surface modification
Surface modification has three goals: First, it prevents the formation of agglomerates; second, it enables agglomerate-free dispersability in matrices such as lacquers and polymers; and third, it acts as functionalization responsible for chemical bonding at the particle-matrix interface. What surface modification one needs is heavily driven by the specific application. Therefore, Buhler offers not only a range of standard products, but also services to tailor the surface modification to a specific application.
**Smaller is better**

The specific surface area of nanoparticles only starts to significantly increase below 100 nm particle size. However, the vicinity volume around the particles, which is the key factor for interface bonding, only considerably increases below 20 nm. With smaller particles, much less filler material leads to higher vicinity volume and therefore to better physical results at lower cost.

**Standard versus tailored products**

The surface modification of Buhler’s standard products ensures agglomerate free suspensions or full redispersability in common solvents. For a variety of applications, these specifications will be appropriate. However, for a range of applications, proper chemical bonding at the particle matrix interface is crucial. Here we can assist your innovation with our surface modification services and the delivery of a tailored product to your exact needs thereafter.

**Fields of application**

- Filler material for lacquers and coatings
- Filler material for polymer granulates
- Compounding additive for polymer processing
- Filler material for adhesives
- Filler material for other product formulations

**Others**

- Dental ceramics
- SOFC (fuel cells) electrolyte
- Oxygen sensors (e.g., screen printing pastes)
- Ceramic membranes for nanofiltration (nano-ceramic tape casted foils)

---

**Properties of n-ZrO₂ as filler in lacquers and polymers.**

**Mechanical properties**

- Increase of E-modulus
- Increase of pressure strength
- Increase of wear resistance
- Adjustment of rheological properties

**Optical properties**

- Tailoring of refractive index in transparent matrix
- Use of the X-ray opacity of Zirconia
- Conservation of transparency or translucence (neglectable scattering when particles < 1/20 wavelength of visible light)

**Thermal properties (only by bonding of phases)**

- Increase of the glass transition temperature
- Increase of shape stability under thermal load

**Specifically for lacquers and coatings**

- Increase of abrasion resistance
- Increase of scratch resistance
- Use of chemical inertness compared to Silica
Sample analysis for commonly used products.

**Z-W0s**
Particle size analysis, TEM and XRD for undoped nanoscaled zirconia Z-W0s. The undoped variety comes as a mix of monoclinic and tetragonal crystal phases, as one can observe by comparing the measured diffraction intensity with the catalogue positions of the peaks of known crystal structures.

- **Particle size analysis**
  - $d_{10}: 8 \text{ nm}$
  - $d_{50}: 10 \text{ nm}$
  - $d_{90}: 16 \text{ nm}$
  - BET: 150 m$^2$/g

- **X-ray diffraction measurement (XRD)**

**Z-W4s**
Particle size analysis, TEM and XRD for nanoscaled zirconia with 4% molar Y-doping. The Yttria stabilization leads to a purely tetragonal crystal phase. Furthermore, the doping with Yttria influences the production process such that somewhat smaller particles with even higher specific surface area are achieved.

- **Particle size analysis**
  - $d_{10}: 7 \text{ nm}$
  - $d_{50}: 8 \text{ nm}$
  - $d_{90}: 9 \text{ nm}$
  - BET: 240 m$^2$/g

- **X-ray diffraction measurement (XRD)**
## Basic product specifications

- Particle size from 4 to 20 nm (depending on doping)
- Narrow particle size distribution
- Specific surface (BET) from 110 up to 250 m²/g (depending on doping)
- Practically fully crystalline (> 95 %)
- Density > 5.4 g/cm³ close to bulk
- Aggregate- and agglomerate-free

## Product tailoring possibilities

- Surface modification (compatibility with a wide range of solvents and matrices)
- pH_{IEP} adjustable
- Doping (Y, Sc, Ca, others)
- Formulation (pastes, slurries)

## Product availability

- Standard products as listed off the shelf
- Tailored products on demand

### Standard product range.

<table>
<thead>
<tr>
<th>Dry agglomerated powder, no surface treatment</th>
<th>Dry powder, redispersable in water, surface modified</th>
<th>Suspension in water, surface modified particles</th>
<th>Suspension in water, surface modified particles with acetic acid</th>
<th>Suspension in ethanol, surface modified particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z-0p 0 % Y-doping</td>
<td>Z-W0p 0 % Y-doping</td>
<td>Z-W0s 0 % Y-doping</td>
<td>Z-W0sa 0 % Y-doping</td>
<td>Z-E0s 0 % Y-doping</td>
</tr>
<tr>
<td>Z-3p 3 % Y-doping</td>
<td>Z-W3p 3 % Y-doping</td>
<td>Z-W3s 3 % Y-doping</td>
<td>Z-W3sa 3 % Y-doping</td>
<td>Z-E3s 3 % Y-doping</td>
</tr>
<tr>
<td>Z-4p 4 % Y-doping</td>
<td>Z-W4p 4 % Y-doping</td>
<td>Z-W4s 4 % Y-doping</td>
<td>Z-W4sa 4 % Y-doping</td>
<td>Z-E4s 4 % Y-doping</td>
</tr>
<tr>
<td>Z-5p 5 % Y-doping</td>
<td>Z-W5p 5 % Y-doping</td>
<td>Z-W5s 5 % Y-doping</td>
<td>Z-W5sa 5 % Y-doping</td>
<td>Z-E5s 5 % Y-doping</td>
</tr>
</tbody>
</table>