Conductivity Agents
based on quaternary ammonium compounds.
Since the 1980s our product range has included our own antistatic additives for coatings and plastics. Conductivity agents and antistatic agents based on quaternary ammonium compounds have been used for various tasks and are trusted and established products in the coatings, cosmetics and biocides industries. Our Deuteron conductivity products are used for applications that range from improved spray performance of coatings to the antistatic treatment of shoe soles and floor coverings.

The buildup of electrostatic charge is caused primarily by friction between non-conductive materials. Electrons are removed from one material and deposited on the other. When the materials are separated, this electrical imbalance results in negatively and positively charged particles. The resultant electric field in the materials remains indefinitely until there is a possibility of equalising the charges.

Effects of electrostatic discharge (the equalisation of charges upon touch of two differently charged items) range from an unpleasant feel to the destruction of electronic components, the ignition of a fire or even explosions.

To prevent damage from electrostatic discharge there are a number of methods of antistatic treatment for non-conductive materials. First, static charging can be minimised by choosing a suitable material. Another approach is to modify the inherent electrostatic characteristics of a material by the use of additives. The possibilities range from metallic powder or fibres through conductive pigments (including carbon black) to quaternary ammonium compounds.

All these products can be incorporated into plastics or coatings. Correct dosing combined with the proper choice of additives enables electrostatic charging to be minimised or even eliminated. The hazards arising from electrostatic charging are thus practically averted.
Our conductivity agents are based on quaternary ammonium compounds and are supplied in solid or liquid form. For over thirty years our antistatic agents have been used by our customers across the world in a wide range of applications: from improved spray performance of coatings to antistatic treatment of shoe soles and floor coverings. Profit from both the flexibility and the economic efficiency of our conductivity agents.

/ Advantages at a glance:

- Value for money / profitable.
- Easy to work with at room temperature (supplied in liquid form).
- Easy to dilute.
- Suitable for colourless and light-coloured systems.
- Good compatibility.
- Can be combined with many other fillers and fibres.
All additives that we supply have particular advantages and disadvantages. For each specific application, consideration should be given as to which compromises are acceptable in order for the visual, economic and, above all, the functional requirements to be satisfied. There is thus no single “perfect” additive, but rather only the “most suitable” additive.

**/ Resistance measurement**

In order to find the correct solution for your requirements, simple experimental systems can be set up at the development stage to determine the volume and surface resistances by means of a series of comparative measurements.

To perform the measurements all that is required is a suitable resistance meter and suitable electrodes for measuring volume and surface resistance. Suitable measurement devices, which also allows measurement at variable voltage, are for example the Metriso C or Metriso 2000 from Gossen-Metrawatt GmbH.

The following standards for the measurement of antistatic surfaces apply:

- Surface resistance $R_s$: IEC 61340-2-3, IEC 61340-5-1, ESD STM 1.11, ASTM-D257 VDE 0300 part 5-1 / 2-3
- Point-to-point surface resistance $R_{pp}$: IEC 61340-2-3, IEC 61340-5-1
- Resistance to ground $R_{g}$: IEC 61340-2-3, IEC 61340-4-1, EN 1081
- Volume resistance $\rho_v$: IEC 61340-2-3, VDE 0300 part 2-3, EN 14041

Comparison of the conductivity at different concentrations.

Measurements of surface resistances.
Quaternary ammonium compounds contain quaternary nitrogen atoms, that means all four hydrogen atoms in the ammonium ions are replaced by organic components. Our conductivity agents are amine type NR₄+X⁻ salts. These substances are cationic surfactants with a long alkyl group which, because of its permanent positive charge, strongly adsorbs on surfaces and particles. The products of the Deuteron LE-series are based on tetraalkylammonium ethyl sulphate. They are water soluble and soluble in polar solvents but not soluble in nonpolar organic solvents. The following theory explains the effects of Quats as antistatic agents. The substances migrate partially to the surface. The active molecules are oriented in a way that the hydrophilic groups protrude from the polymer surface. A conductive layer builds up by absorbing water from the air due to the polar groups of the antistatic agent, which is increasing the wettability and usually acting hygroscopically. Under normal atmospheric humidity, the conductivity is sufficient, e.g. to prevent dusting by electrostatic attraction.

**Restrictions of use:** Quaternary ammonium salts create conductive surfaces. But they are not conductive substances! In the case of requirements such as low surface resistances even in dry air or desired values below 100 MΩ, combinations of different antistatic additives need to be used that evince a proper conductivity that is independent of humidity.

Due to the fact that these substances are capable of migrating, it must be assumed that, depending on the overall system, the effect is potentially non-permanent. This differs in every system and must be checked based on the specific regulations that apply.

In epoxy resin coatings, conductivity agents based on quaternary ammonium compounds are usually ineffective as a sole additive. Instead, a combination of conductive pigments or carbon fibres is suggested. Other limitations arise in aliphatic preparations.

**General structural formula**

![Structure of a quaternary ammonium compound.](image)

**Schematic description of the effect of quaternary ammonium compounds.**

A) Immediately after Application
B) Orientation / Migration to surface
C) Water / Humidity attraction
For example, the anti-static preparation of mineral oils or lubricants is mostly impossible. Such systems tend to separate relatively quickly due to insolubility. Quats are neither perfectly soluble in aromatic systems; however the products are emulsified in finest drops, which leads to opalescence of the preparation.

**Preperation:** With the exception of Deuteron LE 512 the conductivity additives can be incorporated into the system that needs the antistatic treatment in their delivered form at room temperature or even lower without difficulty and without heating. Deuteron LE 512 needs to be molten before use to provide a homogenous distribution. A special product is our Deuteron LE 100 LV, which is liquid at room temperature with 100% active content and free of solvents.

<table>
<thead>
<tr>
<th></th>
<th>LE 80</th>
<th>LE 50*</th>
<th>LE 50 UV*</th>
<th>LE 151</th>
<th>LE 829</th>
<th>LE 100LV</th>
<th>LE 512</th>
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<tbody>
<tr>
<td>Active content</td>
<td>80</td>
<td>50</td>
<td>50</td>
<td>85</td>
<td>85</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Solvent</td>
<td>Butanol</td>
<td>Butanol</td>
<td>DPGDA</td>
<td>1.2-Ethandiol</td>
<td>1.4-Butandiol</td>
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<tr>
<td>Delivered as</td>
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<td>liquid</td>
<td>liquid</td>
<td>liquid</td>
<td>liquid</td>
<td>liquid</td>
<td>solid</td>
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<tr>
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<td>20</td>
<td>150</td>
<td>300</td>
<td>400</td>
<td>3500</td>
<td>-</td>
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<tr>
<td>Melting point approx.</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>88 °C</td>
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<tr>
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<td>0.89</td>
<td>1.05</td>
<td>0.99</td>
<td>0.98</td>
<td>1.05</td>
<td>0.96</td>
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<td>2.6</td>
<td>7</td>
<td>&lt;7</td>
<td>&lt;7</td>
<td>13</td>
<td>3</td>
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<td>-</td>
<td>8</td>
<td>8</td>
<td>8.5</td>
<td>7.5</td>
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</table>

*= Low dosage version of Deuteron LE 80 with less critical labeling.