Conductive Antistatic Layers

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Static charges cause a number of problems in production operations and in customer applications, including sparks that damage products or ignite solvent vapors, sheet sticking, dust attraction, and electrical shocks. One effective strategy for solving these problems is to design products that do not accumulate static. For example, metallized films rarely have static problems because the metallized layer is electrically conductive, and it dissipates static charge.

Antistatic layers or coatings come in two flavors: conductive layers and charge control layers. Each type of antistatic layer has advantages and drawbacks as summarized in **Table I**. Of course, any product design that includes an additional layer, coating, or additive will have a higher cost. The design challenge is to achieve satisfactory static performance at an acceptable cost.

Table I

Antistatic Layer Comparison

	Conductive Layers	Charge Control Layers
Operating principle	Dissipates static	Minimizes static charging
Materials	Polymeric additives, salts, conductive polymer, fibers & particles	Surfactants, charge control agents
Implementation	Additional layer or coating	Additive to existing layer or coating
Location	Surface layer or internal layer	Must be a surface layer
RH sensitivity	High for ionic conductors, low for electronic conductors	Minimal
Process sensitivity	Low	Performance is material specific
Cost	Higher	Lower

Static charge is a problem when there is too much. Conductive layers dissipate charge before there is enough to cause a problem. The static performance of a layer is determined by its surface electrical resistivity, which has units of ohms per square (Ω/▫). Typically, the surface resistivities of conductive antistatic layers are in the range 10^{+6} to 10^{+12} Ω/▫, which is an exceedingly large design range. A key question is: "What is the maximum allowable resistivity for my product?" The answer depends on two things:

- **Sensitivity** | How sensitive is your product to static? To keep static low for critical applications, lower resistivities are needed.
- **Speed** | What is your line speed or process speed? Processes with higher speeds require lower resistivities.

Table II

Materials for Conductive Layers

Resistivity Range	Candidate Materials	Relative Cost
10^{+11} to 10^{+12} Ω/▫	Additives to polymers before casting or extrusion; water-based coating containing salt	Lowest
10^{+8} to 10^{+11} Ω/▫	Conductive polymers	Middle
10^{+6} to 10^{+8} Ω/▫	Conductive fibers or polymers	Highest

Table II summarizes the broad range of materials available to make conductive layers or coatings. For layers with resistivities in the 10^{+11} to 10^{+12} Ω/▫ range, additives are available that may be combined with the polymer before the film is cast or extruded. These additives migrate to the surface of the polymer to provide conductivity. Water-based coating containing salts are among the first and oldest antistatic layers. The electrical conductivities of films with polymer additives or coatings with salts rely on moisture in the air. So, these layers are sensitive to changes in humidity.

For layers with resistivities in the 10^{+8} to 10^{+11} Ω/▫ range, electrically conductive polymers are available. Finally, for layers with resistivities in the 10^{+6} to 10^{+8} Ω/▫ range, electrically conductive fibers or particles are needed. If color is not important, a coating loaded with carbon particles can be an effective and inexpensive antistatic layer. For transparent layers, carbon nanotubes are emerging as a good choice.

The trend is clear. Higher conductivity costs more.

The location of the conductive layer within a multilayer product is important. The first choice is to locate the conductive layer on the surface. Touching the surface with a grounded conductor dissipates static, and the resistivity of the surface layer is easy to measure for quality assurance. The conductive layer also may be an internal layer. Surprisingly, good static performance is achieved even with no electrical path to ground. For example, resin-coated paper products generally have good static performance that is provided by the conductivity of the paper core. However, internal conductive layers have caused sheet sticking failures in sheeting operations and in customer applications. To avoid these problems, the resistivity of the internal layer must be well controlled.

Product may be designed with antistatic layers to provide good static performance. Conductive antistatic layers work by dissipating electrical charge. The electrical resistivity of the conductive layer can be varied over a broad range to achieve good performance at an acceptable cost.

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