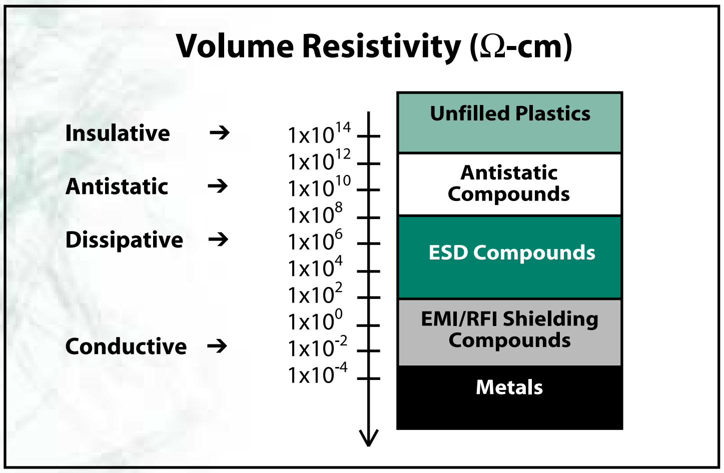
Solutions

INNOVATION

Hyperion Catalysis

THE LEADER IN NANOTUBE TECHNOLOGY

Electrical Resistivity in *Amorphous Polymers* as a Function of **FIBRIL™ Nanotube** Loadings



WHAT THE DATA SHOW

Polymeric materials are inherently electrical insulators. However, addition of conductive additives (like FIBRIL™ nanotubes) can impart electrical conductivity to plastics. The percolation curves on the back of this flyer provide information on how the volume resistivity of various amorphous polymers changes with FIBRIL™ nanotube loading. Because FIBRIL™ nanotubes are so conductive and have such a high aspect ratio (length/diameter (L/D)), they form conductive networks far more efficiently than other conducting additives. Thus, far less additive is needed to achieve a given level of resistivity. The lower nanotube loading preserves more of the inherent toughness of the matrix resin. In addition, the substantially smaller size of nanotubes vs. other conductive additives yields parts with smoother surfaces, superior aesthetics, and better mechanical properties.

HOW THE DATA WERE COLLECTED

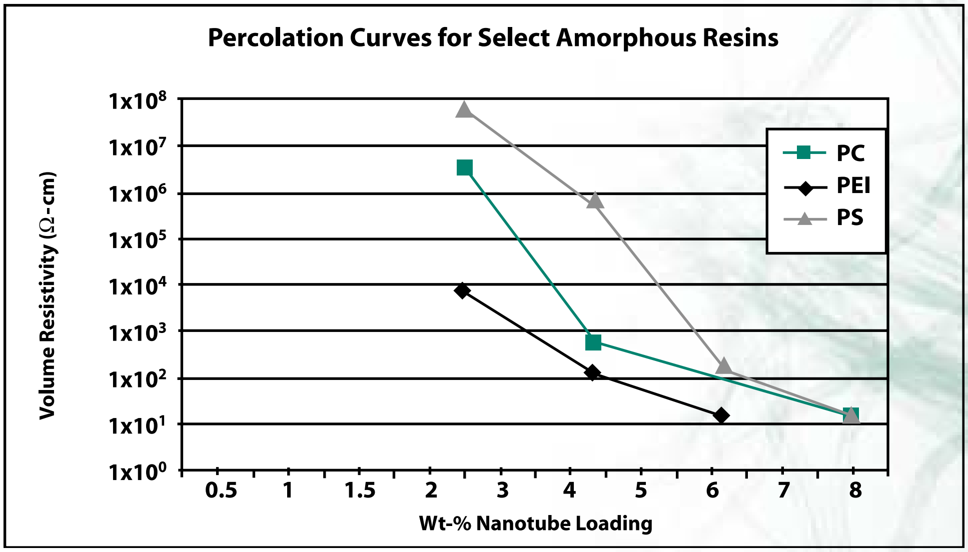
The volume resistivity data presented here were measured according to ASTM D4496. To reduce skin effects, the ends were cut off of injection-molded Izod bars prior to testing. Silver paint was applied to the surface of the cut ends to ensure the test probe made intimate electrical contact with the sample regardless of probe angle.

FACTORS THAT CAN IMPACT THE VALUES AS MEASURED

Electrical resistivity values measured on plastic parts containing FIBRIL™ nanotubes can be impacted by several factors. Chief among these is the degree of melt-mixing achieved between the high-viscosity nanotube masterbatch and the letdown (dilution) resin. Such compounding should occur under high shear conditions (via a twin-screw extruder) to ensure good mixing. Failure to achieve good mixing yields compounds with poor nanotube distribution and hence parts with poor conductive efficiency.

Choice of test method used to measure resistivity is another factor, due to inherent differences between test methods and sources of variation within a given method. A final factor affecting resistivity values is the condition under which the part was molded/extruded. Given these variables, the percolation curves presented here are intended solely as guidelines to indicate performance that can be achieved with formulations based on carbon nanotubes and should not replace the reader's own evaluations and experimentation. Manufacturers should conduct their own testing to ensure performance is adequate for a given application.

DESIGNING WITH FIBRIL™ NANOTUBE-FILLED AMORPHOUS MASTERBATCHES



For designers seeking various levels of conductivity, values of $1x10^8$ Ω-cm and higher provide antistatic properties; values between $1x10^3$ Ω-cm and $1x10^8$ Ω-cm provide electrostatic dissipative (ESD) properties; and values of $1x10^3$ Ω-cm and below provide electromagnetic interference/radio frequency interference (EMI/RFI) shielding properties. Data shown represent the loading levels where the most practical range of performance was achieved during testing. Because of the variables that can influence volume resistivity testing, each user should perform his/her own tests to ensure that the compound selected provides adequate conductivity for a given application.

For the amorphous polymers represented above, loading levels to achieve comparable resistivity typically run a few percentage points higher than for semi-crystalline resins and fluoropolymers. This is because the structure of amorphous polymers, as the name suggests, is without form (from the Greek, *amorphos*) and does not feature regions of crystallites found in fluoropolymers and semi-crystalline thermoplastics. As crystallites grow, they occlude (push out of the way) all additives including nanotubes due to the rigid spacing requirements that characterize crystalline regions of the polymer. Since the plastic matrix is an electrical insulator, and electrons move from one nanotube to another, the higher the crystalline structure of a resin, the lower the volume of nanotubes required to complete the conductive array.

Although amorphous resins do require slightly higher nanotube-loading levels, they tend to be tougher, have lower creep, and maintain mechanical properties at higher temperatures without the need for fiberglass reinforcement vs. their more crystalline counterparts.

For more information or to purchase FIBRIL™ nanotube masterbatches or compounds for amorphous resins such as polycarbonate (PC), polyetherimide (PEI), or polystyrene (PS), contact:

HYPERION CATALYSIS INTERNATIONAL, INC.

38 Smith Place, Cambridge, MA 02138 USA
Phone: +1.617.354.9678 Fax: +1.617.354.9691
Web: www.hyperioncatalysis.com