Solutions

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Hyperion Catalysis

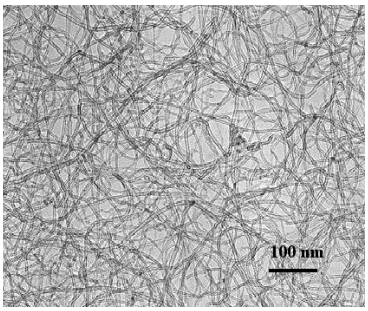
THE LEADER IN NANOTUBE TECHNOLOGY

FIBRIL™ Carbon Nanotubes in Compounds for *Automotive Fuel Systems*

The automotive industry worldwide is moving toward requiring that all plastic parts that touch moving fuel be Electrostatically Dissipative (ESD). This will insure that a continuous path to ground is maintained in order to prevent the build-up and discharge of damaging static electricity. In the United States the Society of Automotive Engineers (SAE) has published J1645 to serve as guidelines for performance and testing of conductive plastic components.

Hyperion FIBRIL multiwall carbon nanotubes have a unique combination of high aspect ratio (1000:1) and small size (12 nanometers diameter) that make them the best performing conductive additive for these demanding fuel systems applications.

- The high aspect ratio means a very low loading is needed to give a conductive network. This lower loading translates into a better preservation of the base resin physical properties.
- Their small size results in a very smooth surface. This smoother surface retains more of the resin's chemical resistance and barrier properties.



Electron Micrograph of Carbon Nanotube Network

Examples of these effects are discussed in the Hyperion Catalysis datasheet titled Preservation of Physical Properties. The following data will give examples of the benefits using FIBRIL nanotubes in specific automotive fuel system components.

ADVANTAGES OF FIBRIL NANOTUBES AS A CONDUCTIVE ADDITIVE FOR FUEL LINES

Shown below are the results of a study comparing FIBRIL nanotubes vs. conductive carbon black in the inner layer of a multiwall fuel line.

Comparative Performance of Multi-Wall Fuel Line			Cold Impact Test at -40°C per ASTM J2043			Surface Resistivity per GM 213M (Ω/sq)			
Layer Structure outside to inside thickness mm	Conductive additive	Loading %	as molded	Sour Gas Ford Spec 1000 hours PN 180 23° C	Sour Gas GM Spec 1000 hours PN 50 40° C	as molded	1000 hours PN 180 23° C	1000 hours PN 50 40° C	Leakage at the quick connector g/day
PA12/PBT/PA12/PA12 0.4 / 0.2 / 0.3 / 0.1	FIBRIL nanotubes	5%	no fracture	no fracture	no fracture	$5x10^3$	$8x10^3$	$2x10^4$	0.11
	Carbon Black	20%	no fracture	failed	failed	$1x10^8$	$1x10^9$	$1x10^{11}$	0.18

- Fuel lines made with FIBRIL nanotubes maintained more of the base resin's ductility. This resulted in improved low temperature performance during impact testing.
- Surface resistivity of the inner layer containing the nanotubes was less affected by immersion in sour gas. Low loading of nanotubes gives a smoother surface that preserves more of the resin's barrier properties.
- Leakage at the quick connect was reduced through utilizing nanotubes vs. carbon black. High loading of carbon black increases the modulus and durometer of the inner layer which compromises the ability of the tube to make a tight seal with the quick connect.

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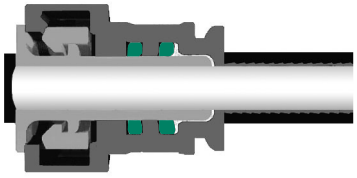
ADVANTAGES OF FIBRIL NANOTUBES AS A CONDUCTIVE ADDITIVE FOR FKM O-RINGS

Fuel line quick connects typically use two 0-rings to maintain a tight seal over a wide temperature range. In order to maintain a continuous path to ground, one of the O-rings needs to be electrostatically dissipative (ESD).



The data below compares two formulations of ESD O-rings made from fluoroelastomer (FKM) by Precix, New Bedford, Mass., www.precixinc.com. Although the exact formulation is proprietary, the loading of nanotubes is significantly lower than carbon black. As in fuel lines, the lower loading preserves more of the base resin properties and gives a smoother surface.

Change in Durometer

Additive	Shore A Durometer	Elongation %
Nanotubes	79	>200
Carbon Black	86	>200

The lower durometer of the nanotube based formulation means a better seal with less leakage and lower insertion force when the quick connect is assembled.

Permeation Rate

85% Fuel C / 15% Methanol after 28 days @ 23°C

Additive	Average Permeation Rate g*mm/m2/day
Nanotubes	3.6
Carbon Black	15.7

The lower permeation rate with nanotubes is critical to meeting tough emissions standards without having to use more expensive high-barrier resins.

Swelling On Exposure to Fuel

Additive	100% Fuel C % vol. change	85% Fuel C / 15% Methanol % vol. change
Nanotubes	+ 2.7	+ 11.3
Carbon Black	+ 8.6	+ 17.7

The lower swell from the 0-ring made with nanotubes means improved long term performance and better chemical resistance.

Effect of Tension and Compression on Resistivity

Additive	Original Volume Resistivity Ohm-cm	Volume Resistivity after 25% stretch Ohm-cm	Change in Resistivity With 10 Pounds Compression
Nanotubes	125	120	-292%
Carbon Black	32	525	+224%

A conductive FKM based on FIBRIL nanotubes gives much more stable resistivity after stretching and becomes more conductive under compression. The carbon black formulation is much less stable under tension and gives a dangerous decrease in conductivity under compression.

HYPERION CATALYSIS IS THE LEADER IN CARBON NANOTUBE TECHNOLOGY AND PRODUCTION

Since 1982, Hyperion has developed both the manufacturing and application technology for carbon nanotubes. By any measure – capacity, production, quality, patents, technology – Hyperion is the industry leader. Products utilizing Fibril™ multiwall carbon nanotubes are found in automobile fuel systems and body panels, electronics, and semiconductor processing applications worldwide.

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