Hyperion Catalysis

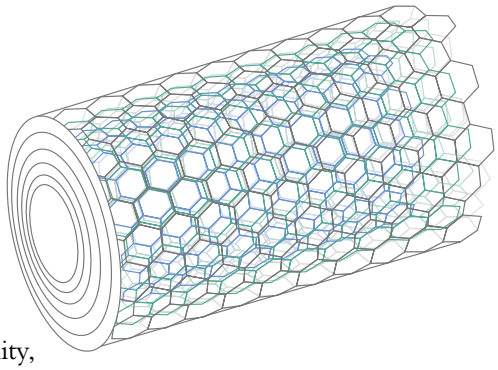
THE LEADER IN NANOTUBE TECHNOLOGY

FIBRIL™ Nanotube *Technology*

FIBRIL™ nanotubes are multiwall, hollow carbon structures that are 10-12 nm in diameter - more than 5,000-times thinner than a human hair - and 10-15 µm long. These products are graphitic in structure; graphitic carbon is an excellent electrical and thermal conductor, as well as being relatively inert. Hence, Hyperion's nanotubes provide many of the benefits of graphite in a strong, small, and light form-factor. Due to their unusually high aspect ratio (1,000+:1), they form a highly effective, electrically conductive network when compounded with non-conductive materials such as plastics, even at low loadings.

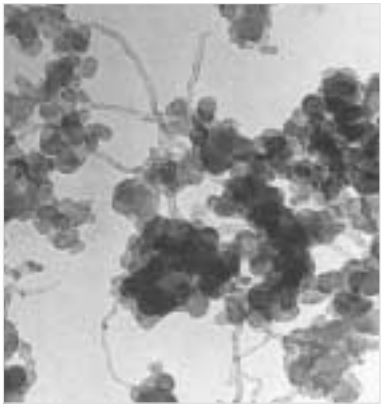
FIBRIL™ NANOTUBES VS. OTHER CONDUCTIVE ADDITIVES

Typical usage levels of FIBRIL™ nanotubes range from 1-5% vs. 8-12% for chopped or milled carbon fiber, nickel-coated graphite, or metal fibers, and 8-20% for carbon black. Because of their lower loading levels, nanotubes minimize impact on the physical, mechanical, and processing properties of the base polymer compared to other electroconductive additives. Additionally, the small size of



FIBRIL™ nanotubes (shown below next to carbon fiber and carbon black, respectively) yields excellent molded-part quality, meeting the automotive industry's Class-A surface requirements and the electronics industry standards for minimal sloughing.

FIBRIL™ nanotubes are nonreactive and chemically pure. Unlike carbon fiber or carbon black, they use no organic sizing agents and contain no detectable sulfur, either of which can damage delicate microelectronics. Finally, unlike other conductive fibers (e.g. nickel-coated graphite, carbon fiber, and stainless steel), FIBRIL™ nanotubes do not break when compounded, molded, or when parts are recycled. Further, FIBRIL™ nanotubes do not cause part warpage, will not abrade tools during molding, and have a lower specific gravity.



NOT ALL NANOTUBES ARE CREATED EQUAL

Several key features distinguish Hyperion's multiwall nanotubes from other nanotube technologies.

High-Volume, Repeatable, Scalable Production Process. Hyperion was the first company to manufacture nanotubes on a commercial scale and today the company is the world's largest and only tonnage nanotube producer. All other manufacturers are still restricted to laboratory-scale volumes. Because Hyperion produces its nanotubes via a continuous, vapor-phase catalytic

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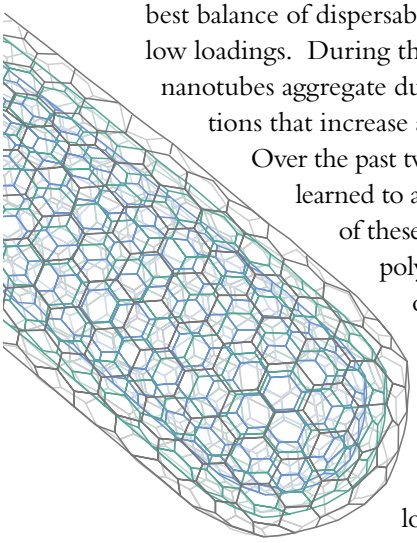
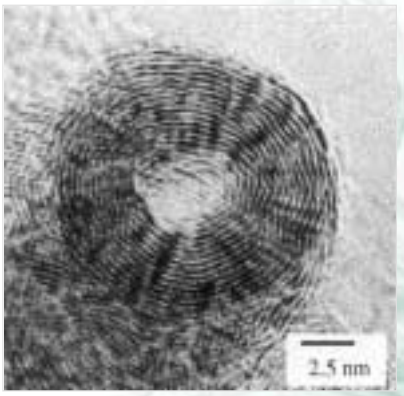
process - the way virtually all products are made in the petrochemical industry - its nanotubes are very uniform and consistent. Other nanotubes are produced in non-catalytic or batch processes, which yield products that can vary considerably in range of diameter, length, and number of walls. Hyperion's continuous process is scalable, so additional production capacity can be added on demand.

Free of Pyrolytic Carbon Coatings, Dispersing Agents, & Surfactants. The clean, high-efficiency process used by Hyperion to manufacture its products produces nanotubes free of amorphous (non-graphitic/non-crystalline) pyrolytic carbon coatings. Not only are these coatings less conductive, but also they are more reactive - undesirable qualities in applications requiring high degrees of chemical cleanliness or inertness, such as are found in the electronics market. Finally, there are no dispersing aids or surfactants on Hyperion's high-purity products as there can be with other nanotubes.

Commercially Viable Morphology. Hyperion's nanotubes have the ideal morphology to provide the best balance of dispersability and high conductivity at low loadings. During the production process, all nanotubes aggregate due to van der Waals attractions that increase as particle size decreases. Over the past two decades, Hyperion has learned to achieve very good dispersion of these aggregates in its family of polymer masterbatches. Most other multiwall nanotubes are larger than Hyperion's products. That means their aspect ratio (ratio of length/diameter) is one to two orders of magnitude lower, so they are not as efficient at creating conductive networks, necessitating higher loading levels that can impact properties of the base polymer. In contrast, single-wall nanotubes are smaller in diameter than Hyperion's nanotubes and thus form strong rope-like aggregates that are very difficult to disperse with commercial-scale technology.





Superior Electrical Conductivity. Structurally, Hyperion's nanotubes consist of concentric cylinders of graphitic carbon, each cylindrical layer a single carbon-atom thick. Electronic conductivity along a layer (parallel to the tube axis) is several orders of magnitude higher than it is between layers. Thus, conductivity of FIBRIL™ nanotubes from Hyperion is higher than that of alternative carbon nanotubes in which the carbon layers do not lie parallel to the axis (for example, concentric cones) which require frequent electron transfer between layers in order to conduct a charge.

POLICIES REGARDING FIBRIL™ NANOTUBES

Hyperion maintains a comprehensive, global patent estate that covers products, processes, and applications.

Hyperion has established a policy of only providing FIBRIL™ nanotubes in "platforms" rather than as "neat' or "bare" nanotubes. The current commercial platforms are thermoplastic masterbatches and compounds containing dispersed nanotubes. Company scientists are also working on other platforms for use in emerging markets and technologies.

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