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Nanofiber: A Novel Approach to Filtration

DESCRIPTION OF THE TECHNOLOGY

With support from the Environmental Protection Agency's (EPA) Small Business Innovation Research (SBIR) Program, eSpin Technologies has developed and commercialized custom-made non-woven membranes, whiskers, and three-dimensional structures of nanofibers. These fibers can be made from a variety of organic (nylon, polyester, polyaramid, acrylic) or biological (protein, collagen) polymers. Using a proprietary process, eSpin is able to produce minute fibers that are 10-100 times smaller in diameter than fibers produced using conventional textile technologies. eSpin's nanofibers are 20-200 nm in diameter (about 1,000 times smaller than a human hair), have a very high surface area-to-mass ratio, and can be formed into sheet structures with very high porosity.

As filters, nanofiber-based membranes are capable of filtering and separating blood, water, air, beverages, gases, chemicals, oils, paints, etc., while at the same time adsorbing harmful volatile organic compounds and toxic gases. The nanofibers are spun from a solution of polyacrylonitrile in dimethylformamide in the form of a woven mat, which is further processed for conversion into an activated nano-carbon fiber media. The web architecture is tailored to achieve the desired filter performance and gas adsorption by varying fiber diameter, fiber orientation, fiber-packing fraction within the nanoweb, activation level, and nanoweb thickness.

eSpin has successfully developed nanofiber-based high surface area NanoFilters made from activated carbon for the removal of gaseous pollutants. Nanofiberous membranes are ultra-thin products made up of randomly laid nanofibers. Some of the important membrane characteristics are: high porosity, large pore volume, high moisture vapor transport, high surface area, high absorbency, and the ability to perform specific tasks via large numbers of chemically functional groups. Potential applications include the use of nanofibers in filtration products, high-performance structures, barrier fabrics, and biomedical devices.

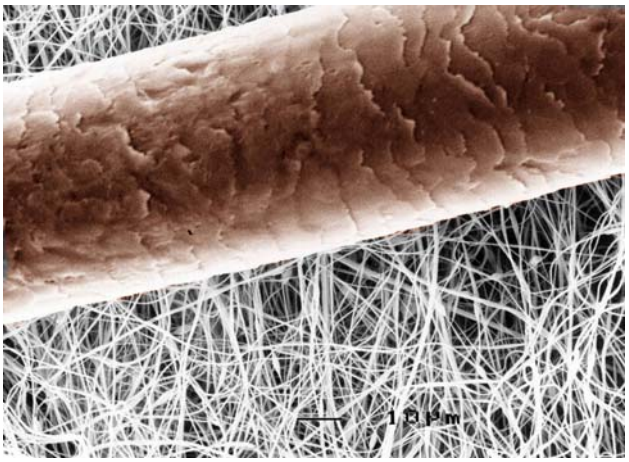
SIGNIFICANCE OF THE TECHNOLOGY

As a platform technology, eSpin's nanofibers have an incredibly broad range of market opportunities in traditional areas such as filtration and cosmetics, and in emerging segments of industries such as aerospace, structural composites, health care, and energy storage. Nanofibers' unusual characteristics can provide orders of magnitude of improvement in critical product properties when combined with existing technologies by innovatively overcoming many technical hurdles faced by incumbent products.

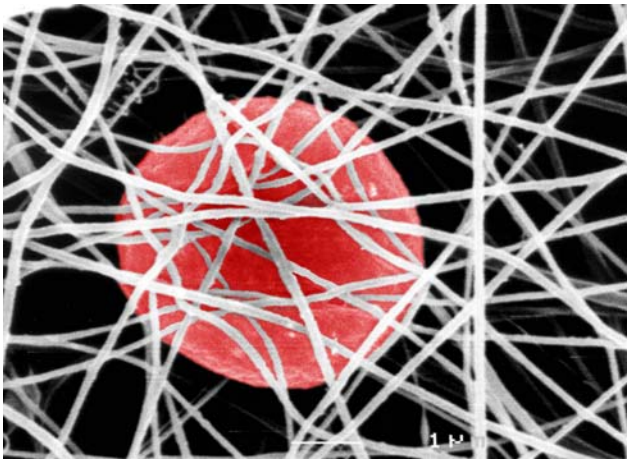
Fine particulate matter, aerosols, and air toxins are being emitted daily from a variety of sources such as automobiles, factories, and power plants. These toxic compounds are complex mixtures of particles, 90 percent of which are smaller than 1 micrometer in diameter. In addition, these particles have hundreds of chemicals adsorbed onto their surfaces, including many known or suspected mutagens and carcinogens. Also, gaseous pollutants contain many irritants, toxic chemicals, and ox-

SBIR Impact

- **eSpin produces minute fibers that are 20-200 nm in diameter (about 1,000 times smaller than a human hair), have very high surface area-to-mass ratios, and can be formed into sheet membranes having very high porosity with small pore size.**
- **Nanofiber-based membranes are capable of filtering and separating blood, water, air, beverages, gases, chemicals, oils, paints, etc., while at the same time adsorbing harmful volatile organic compounds and toxic gases.**
- **Potential applications include filtration products, high-performance structures, barrier fabrics, and biomedical devices.**
- **eSpin currently is supplying nanofibers for clean room products, nanocomposites, filtration, surgical gowns, biomedical devices, and specialty fabrics, among others.**



eSpin's nanofibers (background) compared to a single human hair (foreground).



Nanofibers compared to a single blood cell.

ides of nitrogen, which are ozone precursors. The minute size and the abundance of these toxins gives them a greater opportunity to enter our bodies via air and water, with the potential of adverse health effects.

COMMERCIALIZATION SUCCESS

eSpin currently is supplying nanofibers for clean room products, nanocomposites, filtration, surgical gowns, biomedical devices, and specialty fabrics, among others. eSpin's global partners include Fortune 500 corporations, government and military laboratories, research institutions, and select high-tech companies around the world. eSpin's carbon nanofibers are being used for end uses such as thermal insulation, energy storage devices, environmental applications, and lightweight structural composites. The strategic applications targeted are those that require the use of high surface area material and/or high porosity combined with small pore size. These applications are well suited to address the problems of adsorbing gaseous pollutants or filtering particles smaller than 3 microns from effluent gases or liquids economically (where superior efficiency of nanowebs in capturing submicron particles is very attractive). Alternatively, such filters will increase the particle-loading capacity of the filters, or reduce the pressure drop for a variety of filtration end uses.

AWARDS AND COMPANY HISTORY

Founded in 1999, eSpin Technologies, Inc., is a high-tech start-up company based in Chattanooga, TN, and is one of the first commercial producers of nanofibers. In addition to receiving funding through EPA's SBIR Program, eSpin also recently won grants from the National Science Foundation and the Department of Energy for the continued development of nanofiber technology. In October 2002, eSpin received a $2 million award from the Department of Commerce's Advanced Technology Program to fund engineering efforts related to eSpin's nanofiber technology platform for developing a high-throughput process to enable large-scale and economical production of nanofibers. This prestigious award recognizes eSpin's potential to create opportunities for new, world-class products, services, and industrial processes that will benefit not only eSpin, but also other companies, industries, and ultimately, consumers and taxpayers. As one of 40 finalists from 473 companies across the country, eSpin was the first company from the State of Tennessee to win the award. eSpin has been featured in global industry publications such as *Nonwoven World, Chemical Engineering News,* and *Nature*.

What is the SBIR Program?

EPA's Small Business Innovation Research (SBIR) Program was created to assist small businesses in transforming innovative ideas into commercial products. The SBIR Program has two phases—Phase I is the feasibility study to determine the validity of the proposed concept and Phase II is the development of the technology or product proven feasible in Phase I. EPA also offers Phase II Options to accelerate the commercialization of SBIR technologies and to complete EPA's Environmental Technology Verification (ETV) Program. For more information about EPA's SBIR Program and the National Center for Environmental Research, visit http://www.epa.gov/ncer/sbir.