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Project Summary

Characterization of Carbon Fiber Emissions from Current and Projected Activities for the Manufacture and Disposal of Carbon Fiber Products

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Carbon and graphitic fibers emitted during fiber or composite manufacture, handling, and disposal were characterized according to mass concentrations, number concentrations, and size distributions; chemical, optical and morphological properties; and electrical and physical properties that cause problems in electrical and electronic devices. Samples were collected from air streams that controlled fiber release from manufacturing operations, or near such operations when no air flow control existed. Operations studied included fiber winding, prepregging, and weaving, as well as composite cutting, grinding, drilling, machining, sanding, and incineration.

The rate of fiber mass released per unit of material processed in the operation ranged over several orders of magnitude, with the largest releases associated with weaving and incineration. In most cases, control of emissions seemed to be effective.

This Project Summary was developed by EPA's Environmental Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Carbon and graphitic fibers are chemically inert, resistant to high temperatures and thermal shock, light weight, good electrical conductors, and have good mechanical strength. Because of these properties, composites formed from the fibers combined with a binder material (such as epoxy or various plastics) are being used in an increasing number of aerospace, military, commercial, and industrial applications. Carbon fibers are made by heating organic fibers (natural or synthetic) at high temperatures without oxygen. The long lengths of synthetic fibers make them adaptable for lay-up and woven products.

Whenever carbon fibers are produced, handled, woven, or impregnated with a binder, the manufacturing operations provide some opportunity for the fibers to break off and to be released into the ambient air. In manufacturing operations with the composite materials such as cutting, sanding, or machining, opportunities again exist for fibers to be released. Finally, release of fibers can occur during the use of composites or more significantly during disposal of the products through incineration.

Because of their physical properties, carbon fibers released to the ambient air may pose special problems, such as the potential for carbon fiber interference with or shorting out of electrical and electronic devices. Although much is known about the carbon fibers as used in manufacturing operations, the release rates or characteristics of the released fibers are not well established. Manufacturers, processors, and end-product users are usually aware of problems

associated with carbon fiber release and in most cases use good housekeeping practices and protective or removal techniques to eliminate excessive carbon fiber emissions.

The original fiber diameters were maintained in the emitted material to improve control methods and to determine typical release incineration where fiber diameters were reduced slightly by burning. Fiber lengths varied over wide ranges from tens of thousands of micrometers. Incineration experiments suggested that mechanical agitation and air flow in the incinerator would strongly affect releases.

Chemical characterization indicated that, as expected, the fibers were composed almost entirely of carbon with only a few percent or less by weight being hydrogen and nitrogen. Analyses of samples collected from the manufacturing operations indicated that particles other than the fibers were characteristic of materials normally present in the ambient atmosphere. Electrical characterization of the fibers demonstrated that fibers will move and form chains in electrical fields and that for low power electronic equipment, the intrusion of fibers could cause significant damage or disruption of normal operation.

Conclusions

Based on the sampling and analyses of carbon fibers, experimental evaluation of their electrical properties, and studies of their burning characteristics, the following conclusions have been reached:

1. Of the manufacturing operations or processes investigated, drilling and weaving release the most carbon fibers
2. The amount of carbon fiber released and the distribution of fiber lengths are highly dependent upon the particular machining or manufacturing operation. Fiber diameter is not significantly affected by any operation except incineration.
3. Releases of carbon fibers during incineration of composites will depend on the degree of mechanical agitation of the burning material and on the air flow rate in the combustion region. A typical emission rate of carbon fibers from the burning zone in a municipal incinerator would be approximately one percent of the composite being burned.
4. Composites made with epoxy binder materials are expected to give a greater fiber release during combustion than those made with phenolic binder materials.
5. The burning rate for carbon fiber composites is a sensitive function of temperature with the burning rate increasing rapidly with temperatures ranging from 500 to 700°C (1,000 to 1,250°F).
6. The resistance of graphitized carbon fibers ranges between about 1×10^3 and 25×10^3 ohms per centimeter of fiber length, and fibers between 0.6 and 1.25 cm long will conduct currents of about 5 to 15 ma befo burning with power inputs of 0.2 0.5 W
7. Fibers orient in electrical fields a will form chains to bridge gaps th are longer than individual fibers.
8. Carbon fibers will move in t direction of increasing field streng in nonuniform electrical fields, a in uniform fields will move back a forth between plate electrodes the fibers are charged, attracte and discharged successively with the field and on contact with t electrodes.
9. The risk to electrical and electror equipment increases as the a borne concentration and carb fiber length increase and as t distance between circuit elemer decreases.
10. Only sudden infusion of large nu bers of fibers would cause any ri to most electrical systems operati at 110 V and greater than 1 however, electronic equipment ope ating at low power levels could damaged or be made unreliab perhaps insidiously, by only a sing critically located fiber.

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The complete report, entitled "Characterization of Carbon Fiber Emissions from Current and Projected Activities for the Manufacture and Disposal of Carbon Fiber Products," (Order No. PB 84-149 632; Cost. $10.00, subject to change) will be available only from:

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