ACTIVATED CARBON TEXTILES

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Introduction

Activated carbon can be incorporated in various forms into permeable materials for use in protective clothing. Garments made of these materials are sorptive to chemical vapors and aerosols and could be used to prevent contact of chemicals with skin of personnel in areas where chemicals are manufactured or used. Such garments would thus reduce or eliminate real and potential hazards to chemical plant or laboratory workers who may be exposed to harmful chemicals which can be absorbed through the skin. Garments of this type are generally more comfortable than nonpermeable protective gear because they are air and moisture permeable.

Sorptive textile materials having potential for use in garments can be made in various ways. These include surface coatings with activated carbon powder, impregnation with activated carbon powder, and carbonization and activation of a suitable yarn or fabric precursor.

Surface Coatings

Surface coatings can be applied by dusting the powder onto a fiber, fabric, or porous film but the amount of activated carbon deposited in this manner is severely limited by surface area of the material and low adhering forces. Fabric, of course, holds more of the carbon powder than film or fiber because of particle entrapment between fibers or yarns, but it does not adhere well. One potential solution to this problem is to use a suitable binder with the carbon. Evaluation at the US Army Natick Research and Development Command, Natick, of a carbon/binder mixture applied to a solid monofilament of nylon has indicated that considerable additional research would be required to prevent rupture and flaking of the coatings when the filament bends, and rubs against another. Similar problems were anticipated with film and fabric so this method was abandoned in favor of other approaches.

Impregnation

Impregnation of various materials with an activated carbon powder slurry containing an acrylic latex binder has met with more success than filament coating. Treatments of this type have been applied to woven fabric, non-woven fabric and foam. Each of these types of treated material was prepared from an aqueous slurry of the carbon by immersion of the material in the slurry, squeezing out the excess between two rolls and drying the product. Sometimes more than one immersion is necessary to obtain a desired add-on of the slurry. By varying the amount of carbon in the slurry and the number of immersions it is possible to obtain maximum sorptivity consistent with fabric capacity. A tightly woven fabric has less capacity or void space for such a slurry than does a loosely woven or loosely constructed non-woven fabric. An open celled foam has the largest capacity. Fabrics which have been investigated at Natick for such impregnations are cotton sateen, reinforced nylon non-woven fabric and reinforced polyurethane foam.

Another useful way to impregnate material is to incorporate the activated carbon powder into the base material before the textile material is made. Porous film, porous sheet, filament or yarn containing activated carbon is thus obtainable. Using this method of impregnation polypropylene filament as well as Teflon composite sheets containing high carbon loadings have been prepared by Natick and W. L. Gore and Associates, respectively. The latter material is related to Gore-Tex* fibrillated or expanded Teflon film. Activated carbon has also been mixed with viscose dope and the mixture spun and coagulated into monofilament fibers. As high as 80% carbon has been incorporated into viscose monofilament by this method. Sorptivity of all these materials varies with the amount of carbon which can be incorporated and with the amount of pore blockage. Viscose yarn and fabric and the Teflon porous sheet material containing activated carbon were highly sorptive while polypropylene filament was less sorptive due to an increased diffusion barrier and substantially less carbon content.

Yet another way of incorporating activated carbon in materials is to insert the carbon in the core of a hollow tube or filament. This has been done successfully at Natick on an experimental scale using polyethylene and polypropylene and the resulting filaments have shown a degree of sorptivity in spite of the film barrier between the source of vapor and the carbon.

Carbonization and Activation

A more direct method of obtaining activated carbon textile materials is to carbonize and activate a suitable fabric or yarn precursor such as viscose, phenolic, acrylic, or other material. Activated carbon fabric in a plain weave has been prepared at Natick. The British material may soon be available commercially. Activated felt was prepared by Barnebey Cheney and Carborundum. Roving was prepared by Carborundum. Monofilament yarn was, or is being, prepared from viscose yarn by Union Carbide, 3M Company, and Georgia Institute of Technology under contract with the US Army Natick R&D Command. All of these materials can be made with high surface area, i.e., above $800 m^2/g$ and are highly sorptive but they do not have sufficient textile properties to be used for clothing by themselves. Thus, they must be combined with other textile materials. For this purpose, activated carbon yarns have been incorporated into knitted and woven fabrics and activated carbon fabrics have been attached to other fabrics by stitching or laminating. Some of these composites were described at the 12th Biennial Carbon Conference.

*Trademark of W. L. Gore and Associates, Elkon, MD