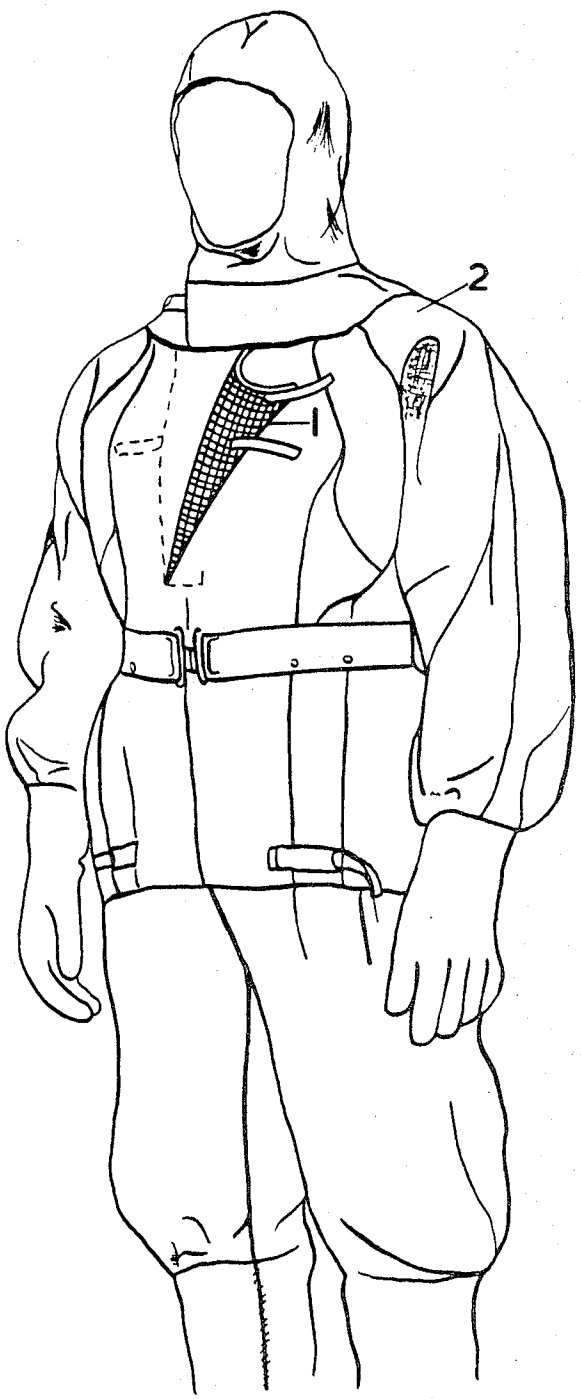
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PROTECTIVE CLOTHING

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PROTECTIVE CLOTHING

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ABSTRACT OF THE DISCLOSURE

Protective clothing is made of highly air-permeable cloth that has been treated with an oleophobic and hydrophobic compound and a lining of absorbent charcoal lying on the surface of the cloth inside the garment. The proportions of liquid repellent and charcoal applied to the cloth are sufficient to provide an effective barrier to the inward passage of corrosive or toxic chemicals—both liquids and gasses—from the outside but insufficient to reduce seriously the air permeability or to prevent the outward passage of the wearer's perspiration from the inside. The clothing material is made by first treating the highly permeable cloth with a known oleophobic and hydrophobic fluorocarbon compound; excess of this material is squeezed out and the treated cloth dried, and then a non-penetrating adhesive surface coating of a vehicle containing particles of activated charcoal is sprayed onto one side of the cloth. The clothing material may then be given a known fireproofing treatment. Such material and clothing is a protective barrier against corrosive or toxic sprays or mists in liquid or vaporised form.

This application is a continuation of application Ser. No. 580,076, filed Sept. 16, 1966, and now abandoned.

The invention relates to clothing material and garments, and to a method of making the clothing material, forming a barrier to the passage of certain offensive chemicals.

The manufacture and use of certain dangerous chemicals such as pesticides involves dealing with corrosive or toxic liquids in a particulate form, e.g. sprays or mists, from which it is important to protect personnel. Although a reasonable degree of safety may be achieved by good design of manufacturing plant and by the issue of comprehensive safety instructions, it is highly deisrable to equip personnel with clothing which will protect them against exposure due for example to a mistake in handling or to an unexpected plant failure.

Protective clothing made of a substantially completely impermeable material, such as plastics or oilskin, can give good protection against liquid in contact therewith but can interfere to an incapacitating extent with the heat exchange of the wearer by preventing the egress through the impermeable clothing of heated air and prespiration-derived water vapour from the wearer. Highly air-permeable cloth can be impregnated with absorbent charcoal to such an extent as to afford effective protection against offensive gases and vapors wthout seriously impairing its air-permeability and the absorbent charcoal will allow perspiration to pass but will equally allow passage of offensive liquids.

The present invention provides clothing material which allows adequate ventilation of the wearer whilst at the same time providing ample protection from particulate liquid contaminants and vapours derived therefrom except under such severe conditions as gross contamination or application of liquid contaminants and sufficient pressure to force some liquid contaminant through.

Protective clothing material according to the invention consists of highly air-permeable cloth treated with a liquid repellent and a lining on one side of absorbent charcoal which lies on the surface of the cloth which is to be inside a garment; the proportions of liquid-repelling compound and of absorbent charcoal applied to the cloth are insufficient to prevent the fabric from retaining air permeability but sufficient to provide an effective barrier to the passage through the material of corrosive or toxic chemicals which approach the surface of the cloth remote from the charcoal coating as liquids in a particulate form. An adhering absorbent charcoal coating may be applied to the cloth either before or after the treatment with the liquid-repelling compound, but the latter procedure offers considerable advantages in manufacture, e.g. in limiting penetration of the absorbent charcoal into the cloth.

Cloth which may be used in carrying out the invention includes woven, non-woven, knitted and composite fabrics composed of natural or synthetic fibres, or combinations of these. Such fabrics should have a high permeability to air so that although processing will inevitably reduce the size of a proportion of interstices between the fibres composing the fabric, the final material will still permit free passage of air. The preferred lower limit of air permeability through the fabric initially is about 150 linear feet (45 metres) per minute (i.e. 150 cu. ft. of air/sq. ft. of material/minute) under ½" (1.27 cm.) water guage pressure difference across the fabric, giving a typical permeability value for the final protective material of about 100 linear feet per minute.

Commercially available fabrics having the required degree of air-permeability are generally non-woven fabrics formed by bonding together layers of consolidated fibres. The orientation of the fibers in each layer, and relative to other layers, composing the non-woven fabric may be closely controlled in manufacture to give the fabric a desired air-permeability and to give enhanced strength to the fabric in a chosen direction.

Synthetic fibres are generally stronger, weight for weight, than natural fibres and are consequently the preferred constituents of fibres used in the invention since maximum tear and abrasion resistance in the fabric is desirable to prevent rupture of the treated cloth. Particularly suitable non-woven fabrics containing synthetic fibres comprise a high proportion of polyester or polyamide fibres together with a minor proportion of viscose fibre. A further layer of light weight woven or knitted fabric of natural or synthetic fibrous material may be bonded to the fabric if desired in order to provide additional tear resistance.

The liquid-repelling compound by which the cloth is rendered liquid-repelling should repel both oils and water in order that the protective clothing material is effective against a wide range of possible liquid contaminants. Such oleophobic and hydrophobic liquid-repelling compounds are well-known in the textile industry, and are generally characterised by having a fluorocarbon chain and an end-group capable of being attached to either natural or synthetic fibres by physical or chemical means.

The liquid-repelling property may be conveniently conferred on the cloth by immersion in a bath containing liquid-repelling compound, and any excess liquid-repelling compound may be subsequently removed by expression between squeeze rolls. The fabric is then dried and the coating of dry liquid-repelling compound thus formed on the fibres composing the fabric may often be more permanently bonded to the fibres by heating at an elevated temperature for a short time, during which time some polymerisation of the liquid-repelling compound appears to take place.

It should be understood that alternative ways of applying the liquid-repelling compound to the cloth are within the scope of the invention and also that adequate liquid repellency may be provided by applying the liquid repelling compound to only one surface of the cloth.

The absorbent charcoal coating should be applied to the cloth in such a way that the absorbency of the charcoal is not seriously reduced and the coating is firmly bonded to the fabric. In this specification, the term absorbent charcoal includes charcoal having the property of sorbing liquids and gases by the processes of absorption or adsorption. The preferred form of absorbent charcoal is "activated" charcoal prepared by heating certain organic materials under controlled conditions. A very suitable "activated" charcoal having a high absorbency can be prepared from coconut shell.

The absorbent charcoal should be applied in a finely-divided form, the particle size range being typically between about 0.5 micron and 50 microns.

We have found that the best way of applying the coating of absorbent charcoal to the cloth is by spraying and we have developed satisfactory coating mixtures suitable for application by spraying. In accordance with an important feature of the invention, therefore, a process for applying a coating of absorbent charcoal to one side of the cloth, preferably after the cloth has been rendered liquid-repelling as hereinbefore described, comprises spraying one side of the cloth with a coating mixture which comprises an aqueous medium containing a suspension of finely-divided absorbent charcoal particles, a thickening agent which stabilises the said suspension, and a bonding agent capable of bonding the absorbent charcoal particles to the cloth.

A bonding agent which is particularly effective is natural rubber latex, which may be used conveniently at a 60% solids concentration. Since natural rubber latex coagulates under acid conditions it is necessary when using natural rubber latex as a bonding agent to maintain the coating mixture alkaline, if necessary by adding an alkali such as ammonia. Thickening agents which may be used include cellulose ethers, such as methyl cellulose, and casein.

The thickness and density of the absorbent charcoal coating may be varied either by varying the composition of the coating mixture or the volume of the mixture sprayed on unit area of the cloth. If too thin a coating is applied the protective clothing material may be ineffective, whereas if too thick a coating is applied the porosity of the protective clothing material may be insufficient to provide adequate ventilation of a wearer. Typically, a suitable absorbent charcoal coating is achieved by applying 1–1½ ounces of coating mixture (by dry weight) to each square yard of fabric.

In use, material for protective clothing prepared in accordance with the invention provides initial protection by presenting a liquid-repelling surface to contaminants in the form of particulate liquids; such liquid contaminants are deposited on the surface of the material and cannot normally pass through the material in liquid form. However, even liquids of low volatility such as some pesticides and the like will vapourise from the contaminated surface and these vapours may penetrate the liquid-repelling part of the material. Such vapours are then substantially completely absorbed by the absorbent charcoal coating which is on the inside of clothing prepared from the material of

the invention and thus remote from the initial contamination. It will be appreciated that the protective clothing material provided by the invention also offers some protection where the initial contamination is by a gas or vapour, but in these circumstances the liquid-repelling property of the fabric makes no contribution to the protection which is then provided by the absorbent charcoal layer.

It is clearly an asset for protective clothing material to be resistant to burning, and to this end flame retardants such as antimony oxide may be incorporated in the material either during the actual manufacture of basic fabric or at some stage in the process of the invention. Certain bonding agents such as chloroprene, used in the manufacture of non-woven materials exhibit some flame-retardant properties.

It is an important aspect of the present invention that the protective clothing provided is air-permeable and thus allows the wearer a good degree of ventilation. A further feature of the invention is that water vapour may pass through the protective clothing so that, for example, perspiration-derived water-vapour may pass freely through the clothing and thus greatly assist the heat-exchange and comfort the wearer. The effectiveness of the charcoal coating in absorbing contaminant vapours is not significantly reduced in the presence of water vapour since the contaminants almost invariably will be preferentially absorbed by the charcoal coating with consequent displacement of absorbed water.

A particular example of the manufacture of cloth in accordance with the invention will now be described.

A non-woven fabric, consisting of a major proportion of nylon 66 fibres and a minor proportion of viscose fibers bonded with neoprene, reinforced with a light weight cotton scrim, the whole fabric weighing about 5 oz./sq. yd. and having an air-permeability of approximately 150 linear feet/minute, is immersed in a bath containing a hydrophobic and oleophobic liquid-repelling compound, Textile Chemical FC 208 (manufactured by the Minnesota Mining and Manufacturing Company Limited). After removal from the bath the fabric is dried and the liquid-repelling compound is cured by heating for 5 minutes at 150° C., to yield a liquid-repelling fabric impregnated with about 0.6% by weight of the liquid-repelling compound. The liquid-repelling fabric is then sprayed upon one side only of the fabric with an aqueous coating mixture having the following formulation per litre:

Charcoal slurry (containing activated charcoal derived from coconut shell having a particle size range 0.5–50 microns, with a mass median diameter of 8 microns)—170 g. charcoal in 500 ml. water
Methyl cellulose thickening agent (2.5% w./w. aqueous solution)—200 ml.
Aqueous ammonia (density 0.880)—5 ml.
Natural rubber latex bonding agent (60% dry rubber solids)—45 g.
Water to 1 litre.

In preparing this coating mixture the natural rubber latex bonding agent is preferably added to a thoroughly stirred mixture of the charcoal slurry, methyl cellulose thickening agent and aqueous ammonia and finally water is added to bring the volume of the coating mixture to one litre.

The amount of charcoal mixture applied to the fabric is about 1–1½ oz./sq. yd. (3–5 mg./cm.^{2}) dry weight after a drying treatment.

Three samples of dried protective clothing material thus produced were tested by placing the protective clothing material over two layers of conventional textile materials, one a 9 oz./sq. yd. sateen and the other a 5 oz./sq. yd. cotton lining cloth to represent ordinary clothing and comparing the protective value of this combination against that of a control consisting of the two conventional textile materials alone. Tri-ethyl phosphate; which is similar in physical properties to a number of

commonly-used toxic organophosphorous chemicals, was applied as ten drops, each of volume 0.05 cu. mm., over an area of 3 cm.^{2} of the protective clothing material and the control material. The percentage of applied tri-ethyl phosphate that had penetrated the materials 24 hours after the application is shown in the following table.

Clothing system	Penetration of tri-ethyl phosphate		
	No. of tests	Mean, percent	Standard deviation
Control (sateen and cotton)	4	13.6	2.8
Protective material (over sateen and cotton):			
Sample A	4	0.90	0.48
Sample B	4	0.56	0.27
Sample C	4	0.49	0.26

It will be appreciated that it may be possible to use material produced by a process in accordance with the invention for a variety of purposes. Thus, the material may be used to construct protective suits in the form of overgarments to be worn over the ordinary clothing or it may be used for protection where only part of the person is in danger of contamination by corrosive or toxic liquids in particulate form as, for example, to cover the head and neck as a hood or to cover the hands as protective gloves or mittens or as a glove material in glove boxes and fume cupboards. An overgarment, including hood and gloves, is shown in the accompanying drawing with the upper portion partly unstrapped and folded back to reveal the lining of absorbent charcoal at **1**, the whole of the outer surface at **2** being liquid repellent.

The material might also be used as a bandage or dressing to prevent unpleasant or harmful emissions from wounds and the like.

It is claimed:

1. A garment for protecting the wearer firstly from externally applied offensive chemicals in particulate liquid form and secondly from vapour therefrom, comprising a highly permeable cloth which has been treated with a liquid repellent compound and has an oleophobic and hydrophobic outer surface and a liner of absorbent charcoal lying on the inner surface of the cloth inside the garment and having limited penetration into the cloth, the proportions of liquid repellent and absorbent charcoal being insufficient to present a substantial barrier to the egress of heat and perspiration from the wearer but sufficient to provide an effective barrier against the inward passage of offensive chemicals in liquid or vapourised form.

2. The process of making air-permeable clothing material present a substantial barrier to the passage of both a liquid form and a vapourised form of an offensive chemical from the first side to the second side which comprises the steps of treating a highly air-permeable cloth with an oleophobic and hydrophobic compound to give the material a liquid-repellent surface on said first side and spraying on an adhering surface coating of particles of absorbent charcoal lying on the surface of only said second side of the cloth, said coating having limited penetration in said cloth.

3. The process according to claim **2** comprising the step of applying the coating by spraying onto the cloth a coating mixture which is an aqueous medium containing absorbent charcoal particles of a size in the range between 0.5 and 50 microns, with a thickener and a bonding agent.

4. The process according to claim **3** wherein the bonding agent is natural rubber latex in an alkaline coating mixture.

5. The process according to claim **2** wherein the permeable cloth is at least in part a non-woven cloth of synthetic fibers.

6. The process according to claim **2** comprising the step of producing the cloth by bonding together a non-woven layer of synthetic fibers and a layer of highly permeable knitted or woven fabric.

7. The process according to claim **2** comprising the step of producing the cloth by taking a non-woven fabric consisting of a major proportion of nylon fibers and a minor proportion of viscose fibers bonded with neoprene and bonding thereto a lightweight cotton scrim as reinforcement.

8. The process according to claim **2** comprising the steps of immersing the cloth in a bath of liquid-repellent compound, passing the cloth so treated through squeeze-rolls to expel excess compound, drying and heating the cloth whereby the compound is at least partly bonded thereto and cured and subsequently applying the absorbent charcoal coating.

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