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⑤④ **High voltage electrical apparatus.**

⑤⑦ Electrical apparatus in which a body of insulating material is subjected to an electrical stress along its surface of at least 10^4 V/m is distinguished in that the body comprises particulate calcium carbonate dispersed in a compatible thermoplastic or elastomeric matrix based on a carbon-chain polymer. Surprisingly this inexpensive white and apparently inert filler is capable of providing compositions that have a failure voltage (according to the tracking resistance test set out in ASTM specification D-2303) of 3.0 kV and above.

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HIGH VOLTAGE ELECTRICAL APPARATUS

This invention relates to electrical apparatus in which a body of insulating material is subjected to an electrical stress along its surface of at least
5 10^4 V/m.

The use of plastics materials for such bodies, especially out of doors, is severely inhibited by the liability of many such materials to failure by "tracking" (the formation of conductive paths by carbonisation of the
10 organic constituent(s) of the plastics material), rapid erosion, or flame.

A number of rigid materials that avoid premature failure of this kind have been developed, but availability of flexible materials is very limited; the most popular
15 flexible materials currently commercially available are expensive materials based on the use of alumina trihydrate filler either in very large amounts or in combination with iron (III) oxide (which presumably catalyses some reaction that competes with carbonisation). Large amounts of
20 filler limit physical properties that can be achieved, whereas iron (III) oxide imparts an undesirable intrinsic colour.

In accordance with the present invention, electrical apparatus in which a body of insulating
25 material is subjected to an electrical stress along its surface of at least 10^4 V/m is distinguished by the fact that the said body comprises particulate calcium carbonate dispersed in a compatible thermoplastic or elastomeric carbon-chain polymer matrix in an amount sufficient to

raise the failure voltage of the body (as determined by the tracking resistance test method set out in ASTM specification D-2303) to a value not less than 3.0 kV.

By the use of the present invention, ultimate
5 breakdown voltages in the range 4-6.2 kV have been attained; it is entirely surprising that such excellent tracking resistance can be achieved by the use of an inexpensive, white and apparently inert filler.

Commercially available filler grades of calcium
10 carbonate, which generally have a mean particle size in the range 0.01 - 50 micrometre (but preferably below 10 micrometre) can be used, and comparable results are obtained with natural and synthetic (precipitated) types. Relatively coarse crushed limestone is also effective in
15 raising failure voltage, but may have a detrimental effect on physical properties.

The polymer matrix may be of any carbon-chain polymer (by which is meant a polymer not having any significant number of hetero-atoms in its main chain) or
20 carbon-chain polymer mixture that is sufficiently inert and capable of accepting the loading of calcium carbonate required to achieve the specified tracking resistance. Preferred are hydrocarbon-chain polymers with side-chain hetero-atoms to enhance compatibility and loading
25 capacity, and the most preferred side-chains are esters and other carboxylic groups. Typical preferred polymers are the semi-crystalline copolymers of ethylene with vinyl acetate, ethyl acrylate, methyl acrylate, butyl acrylate and acrylic acid; amorphous copolymers of this class as

well as ethylene-propylene copolymer rubbers and ethylene-propylene-diene terpolymer rubbers can also be used.

The minimum loading required and the maximum acceptable will vary to some extent with the type of polymer matrix and with the size, shape and surface condition of the calcium carbonate particles. Usually however a loading of at least 40 parts by weight for each hundred parts by weight of polymer matrix (hereinafter abbreviated to phr) will be needed to achieve the defined tracking resistance and a loading over 120 phr is likely to result in poor mechanical properties. 50-90 phr is usually recommended and 80 phr may be considered a starting point for optimisation.

The calcium carbonate particles may be coated with a dispersing agent, such as calcium stearate or with a coupling agent, such as a silane or titanate, or an organic material polymerised in situ on the particles.

The polymeric matrix may have been crosslinked, preferably by irradiation, with or without the use of promoters (such as triallyl cyanurate, trimethylolpropane trimethacrylate, ethylene glycol dimethacrylate, or triallyl trimellitate); conventional crosslinking reagents, e.g. peroxides, can usually be used alternatively, with or without the same type of promoter.

Other inorganic fillers can be used if needed to achieve special requirements for flame retardance or other properties, but the content is preferably kept to a minimum; active fillers such as alumina trihydrate, magnesium carbonate or dolomite are likely to be

acceptable up to about half the calcium carbonate loading (provided the total loading is not thereby made excessive) and inert fillers such as silica flour or talc up to about 20 phr (subject to the same proviso).

5 Minor amounts of other conventional additives may be present, important examples being antioxidants, U.V. stabilisers, flame retardants and processing aids. Pigments can also be used but need to be chosen with care as some (notably titanium dioxide) have a deleterious
10 effect on tracking properties.

Formulations in accordance with the invention may be used for the whole, or a superficial layer of, extruded and injection moulded components for insulators, cable joints and terminations (including heat-shrinkable
15 components for these applications), switchgear and overload cut-outs.

Examples 1-13

The following table of examples illustrates the invention; in all cases the composition was moulded into
20 electrically insulating bodies in the form of sheets, crosslinked by irradiation at 200 kGy (20 Mrad) and tested for tracking resistance according to ASTM D-2303:

TABLE

Example No	1	2	3	4	5	6	7	8
Composition: (parts by weight) Ethylene/vinyl acetate copolymer/(28% vinyl acetate) Evatane 28-05	100	100	100	-	-	-	-	-
Ethylene/ethyl acrylate copolymer (15% ethyl acrylate), DPDM 6182	-	-	-	100	100	100	100	100
Calcium Carbonate: Snowcal 7ML	-	80	100	60	-	80	-	100
Winnofil S	80	-	-	-	60	-	80	-
Crushed Limestone (200 mesh)	-	-	-	-	-	-	-	-
Alumina Trihydrate (Hydral 710)	-	-	-	-	-	-	-	-
Dolomite	-	-	-	-	-	-	-	-
China Clay	-	-	-	-	-	-	-	-
Antioxidant Flectol Pastilles	-	-	-	0.5	0.5	0.5	0.5	0.5
Irganox 565	0.2	0.2	0.2	-	-	-	-	-
Lead Phthalate	-	-	-	-	-	-	-	-
Stearic Acid	-	-	-	-	-	-	-	-
Properties: Erosion inception voltage (kV) (mean of 2 or 3 measurements)	3.5	-	3.25	3.25	3.0	> 3.5	3.25	3.5
Ultimate breakdown voltage (kV)	4.0(f)	4.0(t)	>4.25	> 6.25(f)	6.25	> 5.5	6.0(f)	4.0(f)

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TABLE - Continued

Example No	9	10	11	12	13
Composition: (parts by weight) Ethylene/vinyl acetate copolymer/(28% vinyl acetate) Evatane 28-05	-	-	-	-	-
Ethylene/ethyl acrylate copolymer (15% ethyl acrylate), DPDM 6182	100	100	100	100	100
Calcium Carbonate: Snowcal 7ML Winnofil S	120	35	80	150	-
Crushed Limestone (200 mesh)	-	-	-	-	80
Alumina Trihydrate (Hydral 710)	-	-	-	-	-
Dolomite	-	45	-	-	-
China Clay	-	-	10	-	-
Antioxidant Flectol Pastilles Irganox 565	0.5	0.5	0.5	0.5	0.5
Lead Phthalate	-	-	2	-	-
Stearic Acid	2.0	1.5	1.5	2.0	1.5
Properties: Erosion inception voltage (kV) (mean of 2 or 3 measurements)	3.25	> 3.5	3.0	3.25	3.25
Ultimate breakdown voltage (kV)	4.0(t)		3.25(f)		

The calcium carbonates used in the examples are as follows:-

Snowcal 7ML is a superfine whiting grade of natural calcium carbonate with a mean particle size of 2.9 micrometre and a particle distribution (by sieving) as follows:

finer than 25 micrometres - practically 100%
finer than 20 micrometres - 99%
finer than 10 micrometres - 95%
10 finer than 5 micrometres - 75%
finer than 3 micrometres - 53%

Winnofil S is a precipitated calcium carbonate with a nominal particle size of 75 nm, surface coated with calcium stearate to inhibit agglomeration and promote
15 dispersion.

The crushed limestone was specified only as passing 100% through No. 200 British Standard mesh.

In the Table, (t) denotes ultimate breakdown by tracking and (f) ultimate breakdown by flaming; in other
20 cases the mode of ultimate breakdown has not yet been determined.

Example 14

In a further example, a commercially available material (sold in the UK by BXL Plastics Limited under the
25 designation BP D 2979 FR) analysing as 100 parts ethylene-ethyl acrylate polymer, 80 parts of a natural calcium carbonate (estimated range of particle sizes very approximately 0.5-2 micrometre), small amount of Flectol H, was moulded into similar sheet insulators. Comparable

test results were as follows:

erosion inception voltage, 3.5 kV

ultimate breakdown voltage (by flaming) 6.25 kV

The compositions of Examples 1-11 and 14 are
5 extrudable prior to crosslinking; some are useful for
heat-shrink applications when crosslinked.

CLAIMS

1. Electrical apparatus in which a body of
insulating material is subjected to an electrical stress
along its surface of at least 10^4 V/m characterised in
5 that the said body comprises particulate calcium carbonate
dispersed in a compatible thermoplastic or elastomeric
carbon-chain polymer matrix in an amount sufficient to
raise the failure voltage of the body as determined by the
tracking resistance test method set out in ASTM
10 specification D-2303 to a value not less than 3.0 kV.
2. Electrical apparatus as claimed in Claim 1 in
which the matrix is of a hydrocarbon chain polymer with
side-chain hetero-atoms.
3. Electrical apparatus as claimed in Claim 1 in
15 which the polymer matrix is selected from the semi-
crystalline copolymers of ethylene with vinyl acetate,
ethyl acrylate, methyl acrylate, butyl acrylate and
acrylic acid.



European Patent
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EUROPEAN SEARCH REPORT

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Application number

EP 84 30 0116

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
X	GB-A-1 151 405 (FUJIKURA CABLE WORKS LTD.) * Page 1, lines 70-85; table 4; claims 1-5 *	1	H 01 B 3/00
X	FR-A-1 361 890 (SOCIETE INDUSTRIELLE DE LIAISONS ELECTRIQUES) * Claims 1-5 *	1,2	
X	GB-A-1 464 367 (H. CLARKE & CO.) * Page 1, lines 65-71; page 3, lines 20-31; claims 1-5,7 *	1	
X	CHEMICAL ABSTRACTS, vol. 89, no. 16, October 1978, page 662, no. 139331q, Columbus, Ohio, US & JP - A - 78 48 946 (NIPPON STEEL CORP.) 02-05-1978 * Abstract *	1,2	
			TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
			H 01 B 3/00 H 01 B 19/00
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 04-04-1984	Examiner DROUOT M.C.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			