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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :		(11) International Publication Number:
H01B 3/40, C09J 7/02, 7/04	A1	WO 94/09497
		(43) International Publication Date: 28 April 1994 (28.04.94)

(21) International Application Number: PCT/US93/08288

(22) International Filing Date: 1 September 1993 (01.09.93)

(30) Priority data:
07/958,930 9 October 1992 (09.10.92) US

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(81) Designated States: CA, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: EPOXY IMPREGNATED TAPE BACKING

(57) Abstract

The present invention relates to a flexible tape backing comprising a substrate which has coated thereon a photopolymerized epoxy composition containing a plurality of epoxides including at least one selected from the group consisting of bisphenol A epoxides and cycloaliphatic epoxides, and at least one aliphatic epoxide, from 0.1 % to 2 % of at least one organometallic cationic initiator capable of initiating polymerization at wavelengths of from 200 to 600 nm, and at least one accelerating agent, wherein said backing is fully cured after an irradiation of from 1 to 15 seconds, without a heating step.

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EPOXY IMPREGNATED TAPE BACKING

Background of the Invention

The present invention relates to backing materials for tapes comprising flexible substrates which are either coated or impregnated with polymerizable, cationically sensitive compositions. Polymerization is achieved using ionic organometallic compounds as photoinitiators.

Description of the Related Art

The formation of polymerized, crosslinked structures using cationically sensitive species is well known. A variety of methods for polymerizing these species has been disclosed in the prior art, including the polymerization of epoxy materials. The earliest reports of polymerization of epoxy materials relied upon thermal curing using, e.g., polyfunctional amines or anhydrides. See, e.g., Industrial Polymers, Ulrich, Hanser Publishing Co., Copyright 1982, pages 91-94.

Recently, more convenient means of curing epoxies at room temperature have been discovered, i.e., photo-polymerization. These methods rely upon generation of reactive species which initiate polymerization without heating. This is accomplished most frequently by using photoinitiators which react to light at specific wavelengths. Photoinitiators for cationically sensitive species reside in three main classes, i.e., aryldiazonium salts; sulfonium salts, iodonium salts, and related compounds, commonly called "onium" salts, and organometallic compounds; see, Photocrosslinking of Epoxy Resins, Advances in Polymer Science 78, F. Lohse & H. Zweifel, Springer-Verlag Publ., 1986, pages 61-81.

The use of epoxy resins in tape backings is also known in the art.

JAP 61197869 discloses the use of compositions containing a blend of epoxy monomers to permeate a porous

web or substrate. This impregnated web may be cured to a rigid condition by exposure to an ultraviolet energy source.

JP58002372 discloses the addition of flame retardants to provide this desirable characteristic to cured structures.

U.S. Patent 4,704,322 discloses an epoxy impregnated, electrically insulating tape having three layers. An inner layer of mica flakes is sandwiched between two layers of scrim fabric. The composite structure is coated with a low viscosity, fluid, polymerizable, epoxy composition. The epoxy composition comprises three main ingredients; an epoxy resin, a phenolic accelerator and an organic titanate. Coating is accomplished by brush application of the fluid to the tape. The tape absorbs the fluid thereby becoming impregnated with the epoxy composition. Application of heat converts the tape to a B-staged condition. In this condition the structure is stable under normal storage conditions. When desired, it is possible to convert the electrically insulating tape to a rigid, fully cured condition by the application of heat.

United States patent 5,089,536 discloses the use of organometallic photoinitiators for cationic polymerization of a wide range of polymerizable species. However, it does not address the relative rates of curing when compared with other types of cationic polymerization initiators e.g. diazonium or other "onium" catalysts. Nor does it discuss control of the flexibility of articles, such as porous web materials, which may be impregnated with epoxy compositions which are subsequently cured under the influence of suitable actinic radiation. This reference also teaches that solvents are required to provide epoxy compositions of desired viscosity, which is undesirable.

Also, most prior art backings containing epoxy monomers are relatively unstable and must be used within

a short time of addition of a curing agent. They must be further processed after polymerization, usually by heating, in order to develop any shelf stability. This is time consuming, and expensive.

The present inventors have now discovered that simplification of the process and an increase in the rate of production of backing materials, as well as backing materials of prescribed flexibility, can be obtained by the use of a blend of epoxides in combination with certain organometallic photoinitiators. The use of organometallic photoinitiators facilitates the cationic polymerization reaction more effectively than previously disclosed cationic polymerization initiators such as "onium" salts.

Preferred compositions of the current invention are stable even with the photoinitiators present, until exposed to suitable actinic radiation. The invention therefore overcomes problems associated with earlier backings constructions by eliminating the need for solvents and providing a faster, less costly method of manufacture which is free from the time consuming post-curing procedures at elevated temperatures.

It has further been discovered that, by varying the coating or impregnating compositions, it is possible to control the flexibility of the resulting backing materials.

Summary of the Invention

The invention provides electrical tape backings useful with various adhesives, having controlled flexibility, along with the requisite electrical and handling properties.

Tape backings of the invention comprise a substrate coated or impregnated with a blend of epoxy materials, at least one organometallic photoinitiator, and at least one accelerating agent.

Specifically, the invention provides a tape backing comprising a substrate which has coated thereon a photopolymerized epoxy composition containing

a) a plurality of epoxides including at least one selected from the group consisting of cycloaliphatic epoxides and bisphenol A epoxides, and at least one aliphatic epoxide,

b) from 0.1% to 2% of at least one organometallic cationic initiator capable of initiating polymerization at wavelengths of from 200 to 600 nm, and

c) at least one accelerating agent,

wherein said backing is fully cured after an irradiation of from 1 to 15 seconds, without a heating step.

Preferred tape backings of the invention comprise a porous substrate, and are therefore impregnated by the photopolymerizable epoxy composition.

In one preferred embodiment of the invention using a polyester substrate, electrical tapes, comprising an adhesive and a flexible backing therefore are provided, said backing comprising a substrate having coated thereon,

a) a photopolymerized polymer containing
a plurality of epoxides including at least one selected from the group consisting of cycloaliphatic epoxides and bisphenol A epoxides, and at least one aliphatic epoxide,

b) at least one organic photoinitiator comprising at least one catalytically-effective amount of an ionic salt of an organometallic complex cation sufficient to effect polymerization, said metal being selected from elements of Periodic Groups IVB, VB, VIB, VIIB, and VIIIB, and

c) at least one accelerating agent,

wherein said tape has a dielectric strength of at least 3.5 kV to 10 kV, and an insulating resistance of at least 1×10^6 Megaohms.

As used herein these terms have the following meanings.

1. The term "photopolymerizable" means that a compound or composition is capable of polymerizing when irradiated by ultraviolet emissions in the range of from about 180 nm to about 420 nm.

2. The term "impregnated" means that a substrate contains porosities which have been filled to the saturation point by the photopolymerizable composition.

3. The term "epoxide" is used to refer to an individual material containing at least one epoxy group. The term "epoxy" is used interchangeably, and also used to refer to a resin containing a blend of epoxides.

Detailed Description of the Invention

Epoxy blends useful in tape backings of the invention can be aliphatic, cycloaliphatic, aromatic or heterocyclic and will typically have an epoxy equivalent of from 1 to 6. Particularly useful are the aliphatic, cycloaliphatic, and glycidyl ether type 1,2-epoxides such as propylene oxide, epichlorohydrin, styrene oxide, vinylcyclohexene dioxide, glycidol, butadiene oxide, glycidyl methacrylate, and the like.

Representative epoxides include glycidyl ether of bisphenol A, vinylcyclohexene dioxide, 3,4-epoxycyclohexylmethyl-3,4-epoxycyclohexane carboxylate, 3,4-epoxy-6-methylcyclohexylmethyl-3,4-epoxy-6-methylcyclohexane carboxylate, bis(3,4-epoxy-6-methylcyclohexylmethyl)adipate, aliphatic epoxy modified with polypropylene glycol, dipentene dioxide, epoxidized polybutadiene, silicone epoxy, 1,4-butanediole diglycidyl ethylene, polyglycidyl ether of phenolformaldehyde novolak, resorcinol diglycidyl ether, polyglycol diepoxide, polyacrylate epoxide, urethane modified

epoxide, polyfunctional flexible epoxides, and mixtures thereof.

Preferred epoxides include 3,4-epoxy cyclohexyl methyl-3,4-epoxycyclohexane carboxylate, bis(3,4-epoxy cyclohexyl)adipate, polyglycidyl ether of an aliphatic polyol, polyglycidyl ether of castor oil, polyglyol diepoxide and tetrabromo bisphenol A glycidyl ether.

Epoxides of the bisphenol A type, when polymerized to the resin form, will form a relatively rigid structure, as will cycloaliphatic epoxides. This may be modified by the addition of multifunctional aliphatic epoxides which, on their own, normally provide pliable cured resin structures. When both types of epoxides are combined in photocurable compositions it is possible to produce cured resin systems with properties intermediate between those of the pure resin systems.

By varying the proportions of cycloaliphatic epoxide and bisphenol A epoxide to aliphatic epoxide, it is possible to provide a range of resin flexibilities from somewhat rigid to quite flexible. These same characteristics of rigidity or flexibility may be imparted to flexible substrates which are either coated with the photocurable compositions or impregnated with them.

While at least two epoxides are required for control of flexibility it is possible to add others. The additional epoxides may provide other attributes beyond control of flexibility. Such attributes include, e.g. water repellency, flame retardancy, etc. A brominated epoxide, based on bis-phenol A, exhibits flame retardant properties. Some flame retardancy of the brominated bis-phenol A is conveyed to the composition when it is included with other combinations of epoxides.

Tape backings of the invention also comprise at least one catalytically-effective amount of an ionic salt of an organometallic complex cation sufficient to effect

polymerization, said metal being selected from elements of Periodic Groups IVB, VB, VIB, VIIB, AND VIIIB.

Specifically, the ionic salts having the formula: $[L^{1a})(L^{2a})(L^{3a})M^a]_g[L^{1b})(L^{2b})(L^{3b})M^b]_h[L^{1c})(L^{2c})(L^{3c})M^c]_j$ $[L^{1d})(L^{2d})(L^{3d})M^d]_k(L^4)(L^5)(L^6)^{+c}X_f$ wherein M^a, M^b, M^c, and M^d represent metal atoms which may be the same of different selected from the elements of periodic Groups IVB-VIIIB. The photoinitiator may be a mononuclear, binuclear, trinuclear or tetranuclear complex compound comprising the metallic atoms and the attendant ligands, L.

Ligands are provided by any compound having an accessible unsaturated group, i.e., an ethylenic group acetylenic group or aromatic group, which have π-electrons regardless of the total molecular weight of the compound. Such compound must be soluble in a reaction medium for these electrons to be accessible, see e.g., U.S. Patent 5,089,536.

Useful compounds include, but are not limited to, cyclopentadienyl iron (II) hexafluoroantimonate, cyclopentadienyl iron (II) hexafluorophosphonate, cyclopentadienyl iron (II) hexafluoroarsenate and the like.

Preferred electrical tape backings of the invention also comprise an accelerating agent such as a peroxide. Useful peroxides include such as cumene hydroperoxide, tributyl hydroperoxide, methylethylketone peroxide, tributyl cumene peroxide, and triphenyl methyl hydroperoxide.

Useful accelerating agents provide a cured resin which is dry to the touch and therefore will not block when converted into roll form. Unless the accelerator is present, it is frequently necessary to promote complete curing of the epoxy compositions of this invention usually by heating.

Preferred electrical tape backings of the invention also comprise at least one flame retardant. This may be a brominated ether of bisphenol A, as discussed above, or

may be an inorganic flame retardant additive, such as various metal oxides and oxide hydrates, as well as nitrogen or phosphorous containing compounds. Preferred flame retardants include, but are not limited to, oxides of antimony in combination with brominated bisphenol A epoxides.

Compositions of the invention may also include optional adjuvants such as co-curatives, hardeners, fillers, plasticizers, pigments, antioxidants, surface modifying agents, and the like in amounts such that they do not interfere with the photopolymerization of the epoxides.

Useful substrates for the invention include porous substrates such as glass cloth; papers such as flat back paper, and crepe paper; nonwovens, such as polyester, and cellulose triacetate. Also useful, though less preferred are nonporous substrates, including film-forming polymers, e.g., polyesters, acetates, polyphenylene sulfide, polyimide, and the like.

Tape backings of the invention are made by mixing the epoxides with the photoinitiator, and then coating the photopolymerizable mixture onto a desired substrate and photopolymerizing to a dry state.

The photopolymerization, or curing reaction, for the composites of the invention, will proceed at a faster rate than for compositions lacking the organometallic photoinitiator. When desired, the composite is then fully cured, i.e., irradiated, by exposure to an ultraviolet light having emissions in the range of from about 180 nm to about 420 nm.

Materials of this invention are useful as adhesive tapes, electrical tapes or rigid insulating composite structures.

Depending on the use desired, one skilled in the art can easily select an adhesive for use with the tape backings of the invention. Useful adhesives include, but are not limited to, rubber resin adhesives, synthetic

block copolymers such as styrene-butadiene-styrene, polybutadiene, polyisoprene, styrene-isoprene copolymers, acrylate adhesives such as those disclosed in RE 24,905, and blends of the above, all of which may include tackifiers and other conventional additives. The adhesives may be hot-melt, solution polymerizable, suspension polymerizable, or preferably, ultraviolet radiation polymerizable, such as those disclosed in U.S. Patent 4,181,752.

When an electrical tape is desired, the tape should have a dielectric strength of at least 3.5 kV to 10 kV, an insulating resistance of at least 1 x 10^6 Megaohms. The adhesive may also contain a flame retardant additive such as those described, infra, as useful in the tape backing.

Useful tapes of the invention are made by coating an adhesive mass onto the tape backing by conventional coating methods such as knife coating, gravure coating, meyer bar and the like, and then curing the adhesive by the appropriate means.

Test Methods

Adhesion Test

A strip of adhesive tape (2.54 cm x 25.4 cm) is applied with adhesive contact to the cleaned and polished surface of a Type 302 steel plate (5 cm x 12.2 cm x 0.16 cm). Constant pressure is applied to the tape strip by slowly rolling a 2 kg rubber coated steel roller two passes over the plate at a speed of 5 cm/sec. Approximately 12.2 cm of tape extends beyond one end of the steel plate. The adhesive tape is then conditioned for 20 mins. Adhesion measurement requires that the steel plate is positioned with its length vertically disposed. The tape extension hangs from the lower edge of the plate. The end of the tape extension, farthest away from the steel plate, is folded to cause adhesive-to-adhesive contact and form a tab of approximately 2.54 cm

long. By grasping this tab and lifting vertically, a U-shaped loop, with adhesive on the outer face of the U, may be formed. Further application of force produces tension in the tape loop and causes the tape to separate or peel back from the steel plate. When approximately 1.27 cm of tape has peeled back, the lower end of the steel plate is centrally clamped in the lower jaw of a tensile testing machine, i.e., INSTRON™ Model TM. The 2.54 cm tab is clamped in the upper jaw of the tester. The lower jaw is held in a fixed position while the upper jaw is raised at a speed of 30.5 cm/min.

The average force registered during removal of the tape from the steel plate provides the measure of adhesion to steel.

Two-Bond Adhesion

A 2.54 cm x 12.7 cm strip of double-coated adhesive test tape on a release liner is placed lengthwise, located centrally along a cleaned steel panel (5.1 cm x 12.7 cm x 0.13 cm). The unprotected adhesive coating is used for attachment to the steel plate. The steel panel is placed on a flat surface with the test tape visible on the upper surface of the plate. A 2 kg rubber coated roller is used to apply constant pressure to the tape by rolling along the release liner for several passes.

A single-coated specimen tape (2.54 cm x 12.7 cm), which is subject to property measurement, is prepared for attachment to the test tape. The opposite side of the backing is wiped with a degreasing solvent, and then the release liner is removed from the test tape. The specimen tape is applied lengthwise so that the degreased side is in contact with the newly exposed adhesive surface of the test tape. 7.62 cm strips of a single sided, aggressive adhesive, tape are placed across the width of each end of the steel panel and the specimen tape to hold it in position. An additional strip 30.5 cm long x 1.27 cm wide is placed lengthwise in adhesive-to-

adhesive contact such that approximately 15 cm of the aggressive adhesive tape extends beyond one end of the steel panel. Since the specimen tape is wider than the aggressive adhesive tape, exposed fields of adhesive extend on either side of the latter. These adhesive fields are protected by adhesive-to-adhesive application of strips (12.7 cm long x 1.27 cm wide) of the aggressive adhesive tape. The resulting layered tape structure is compressed with several passes of the 2 kg roller in either direction.

The steel panel is placed with its longitudinal axis in a vertical orientation with the aggressive tape extension hanging from its lower end. The end of the tape, furthest from the plate, is folded back in adhesive contact with itself to form an end tab approximately 1.27 cm long. By grasping this tab and lifting vertically, a U shaped loop is formed with adhesive on the outer face of the U. Further application of force produces tension in the tape loop and causes the aggressive adhesive tape to urge 100% removal of adhesive from the specimen tape. Application of this force is maintained until the tapes are separated for a distance of approximately 2.54 cm. At this point the lower edge of the steel panel is placed in the lower jaw of a tensile testing machine, i.e., INSTRON™ Model TM, and the tab of the tape loop is placed in the upper jaws of this tester.

The force required for separating the specimen and aggressive adhesive tapes for an additional distance of 5 cm is measured as the lower jaw of the test machine is withdrawn relative to the fixed upper jaw.

Tensile and Elongation Tests

Tensile at Break - The stretching force, per unit width, at which a linear test sample fails and ruptures into two distinctly separate portions.

Elongation - Comparison of the increase in length of

a stretched versus an unstretched test sample at the instant that the sample breaks under the applied stretching force.

A sample of backing material 17.8 cm long x 2.54 cm wide is placed between the jaws of an Instron™ TM tensile tester with the longitudinal axis in a vertical orientation such that one end of the sample may be clamped in the upper jaw of the tensile tester and the opposite end of the sample in the lower jaw of the tester.

The test is run by separating the jaws of the tester at 30.5 cm per minute. As the sample stretches, the force applied is increased to a level at which failure and rupture occurs in the central portion of the sample. Measurement of tensile is obtained by determining the maximum force per unit width just before failure. Elongation is measured as the percent increase in length of the sample, under maximum load, before failure.

Roll Unwind Test

A roll of adhesive tape of the invention having a width of 2.54 cm is wound on to 7.62 cm ID cores and limited in length so that the roll diameter does not exceed 16.5 cm. Using a modified tensile tester, Thwing-Albert, Intelect 500 TA, the force to unwind a roll of this tape is measured as follows.

Initially, five laps of tape are unwound from the adhesive roll and discarded. The roll of tape is then placed over an unwind mandrel which is of a size to accommodate the 7.62 cm core, located on the front of the tensile tester. A length of tape is unwound and adhesively attached to a drive roller. The longitudinal axes of unwind mandrel and drive roller are parallel and they are positioned at approximately the same height. Between the unwind mandrel and the drive roller, the tape adopts the form of an inverted U, the apex of which is supported on but not in adhesive contact with the surface

of a freely rotating cylinder. This cylinder is attached to the load cell of the tensile tester, and has a diameter similar to that of the adhesive tape roll. The freely rotating cylinder is positioned above, midway between and in the same vertical plane as the unwind mandrel and the drive roller. With the drive roller in motion, the tape is pulled from the roll of adhesive tape. The force, generated during unwind, between adhesive and backing, is transmitted to the rotating cylinder and thence to the force sensing load cell. During smooth operation of the drive roller (1.27 m/min) over a pre-selected cycle time the force transmitted to the load cell is measured and converted to a number for tape unwind.

Dielectric Breakdown Determination

A specimen 15.25 cm in length x 2.54 cm in width is cut from a roll of tape, and one end is inserted between the electrodes of a dielectric tester, e.g., one capable of increasing voltage at a uniform rate of 0.5 kv/sec, with the adhesive surface contacting the upper electrode. The voltage control, Variac, is then zeroed, and the circuit breaker is reset. The tester is then initialized such that the voltage potential across the specimen will increase until the flow trips the circuit breaker. The voltage at which the dielectric breakdown occurs is then recorded. The procedure is repeated at the opposite end of the specimen and at the center. The average of the three individual breakdown voltages is then recorded.

Insulative Resistance Measurement

This test requires 12 polished stainless steel electrodes 0.64 cm x 0.64 cm x 2.54 cm with rounded edges mounted on a solvent cleaned methylmethacrylate test board 2.54 cm apart. (For further information on the test

board, see ASTM D-1000). Several outer wraps are discarded from a roll of tape, and a 23 cm sample is cut. This sample should be handled carefully so that the inner two-thirds is not touched. The sample is placed adhesive side down on top of six cleaned electrodes, and a second set of electrodes and retaining clips are placed thereon to form a sandwich. Any excess sample is then cut off, and the test board is placed on a test chamber capable of maintaining 96% relative humidity at 23°C. with the adhesive toward a glycerine solution having refractive index of 1.336-1.34. Condition the specimen for 18 hours at 23°C and 50% RH. Attach a megometer to the test board, and set at 120V. Measure insulation resistance across each pair of electrode terminals (total 5 readings). Record the average insulation resistance in megaohms.

Flammability

The flammability test involves wrapping a film strip around a wire with a 50% overlap and repeating with another film strip in the opposite direction. The wrapped wire is exposed to an open flame for 30 seconds. The flame is removed and the burn time of the film is measured. Desirable flame retardance would be exhibited by a material that does not begin to burn, or self extinguishes in less than 4 seconds.

The following examples are meant to be illustrative, and are not intended to limit the invention. Persons skilled in the art will easily discern variations within the scope of the invention, which is defined by the claims.

Examples

Example 1

A three necked, round bottom flask having a stirrer and thermometer was charged with 60.0 gm bis(3,4-epoxycyclohexyl)adipate, available as "ERL 4299", from

Union Carbide Inc., and 40 gm polyglycidyl ether of an aliphatic polyol, available as "Heloxy 84", from Rhone Poulenc. This mixture was stirred while being heated to 75°C, and then maintained at this temperature. The photoinitiator, 1.0 gm cyclopentadienyl iron (II) hexafluoroantimonate, was added to the flask. Stirring of the contents continued for one hour with the temperature controlled at 75°C. The hot fluid composition was filtered, and allowed to cool to room temperature. Just prior to coating, 1.5 gm cumene hydroperoxide, available from Atochem, was added. The coating composition had a viscosity of <1000 cps. It was applied to a substrate of glass-cloth, "Burlington Glass Fabric - Style I8026". The fluid composition was absorbed by the glass cloth, impregnating the whole structure with epoxy fluid. The impregnated glass cloth was subjected to ultraviolet rays in the range of 180 - 420nm, for a period of <10 secs using an American UV Company mini-conveyorized curing system, having variable lamp intensity and speed control. The resulting backing material was tested to determine its tensile, elongation and electrical insulation characteristics. These values are shown in Table 1.

Table 1

Insulation Resistance (ohms)	Tensile kg/cm^2	Elongation percent
3×10^{14}	13.26	5.4

This glass cloth backing material was further coated with a rubber based adhesive. This adhesive tape is useful for applications where tape is used for electrical insulation. Measurements, from this tape, of adhesion to steel and unwind are shown in Table 2.

Table 2

	Adhesion to Steel N/dm	Roll Unwind gms/cm
Glass Cloth Backing	16.6	248.4

Examples 2-3

The epoxy fluid of example 1 was coated separately on crepe paper, available as "M-2251" from Mosinee Paper Corporation, Mosinee Wisconsin, and flat-back paper, available as "#525" from Lydell, Inc., Troy, N.Y. Insulation resistance, tensile and elongation for these were tested as described above, the results are shown in Table 3.

Table 3

	Insulation Resistance (ohms)	Tensile kg/cm^2	Elongation percent
Crepe Paper	5×10^{13}	16.65	7.9
Flatback Paper	8×10^{10}	2.3	13.9

These backings were also coated with rubber based adhesives, and tested for adhesion and roll unwind. The results are shown in Table 4.

Table 4

	Adhesion to Steel N/dm	Roll Unwind gms/cm
Crepe Paper	23.9	173
Flatback Paper	28.3	215

Example 4

A flame retardant backing of this invention was prepared by including a flame retardant polymer and a flame retardant pigment in the coating composition.

The composition contained 40.0 gms "ERL 4299", 30.0 gms "Heloxy 84", 30.0 gms Tetrabromo Bisphenol A Diglycidyl Ether, available as Epirez 5163, from Rhone Poulenc, 4.0 gms ultrafine grade antimony trioxide, available from Laurel Industries, 1.0 gm photoinitiator and 1.4 gms cumene hydroperoxide. This composition was applied to a non-woven polyester substrate and subjected

to 180 nm to 420 nm radiation from an ultraviolet light source.

The resulting backing material was tested using UL™ (Underwriters Laboratory), 510 flame test. An average time of 14 seconds was required to extinguish the flame.

Examples 5 and 5C

The following coating compositions were prepared as in example 1, except that the photoinitiator was varied.

	Example 5	Example 5C
ERL 4299	40.0gm	40.0gm
Heloxy 84	30.0gm	30.0gm
Epirez 5163	30.0gm	30.0gm
Antimony Trioxide	4.0gm	4.0gm
Photoinitiator	1.0gm[1]	3.0gm[2]
Cumene Hydroperoxide	1.0gm	0.0gm

[1] Cyclopentadienyliron(II)xylene hexafluoroantimonate

[2] FX 512 - a sulfonium hexafluoroantimonate

Using continuous coating, exposing and wind-up equipment, examples 5 and 5C were applied separately to samples of non-woven polyester substrate material. The epoxy coated web was transported at 180 cm/min past a UV light station, which emitted radiation in the range of 180nm to 420nm at an intensity of 200 watts/in. Example 5, a composition of the present invention, provided a fully cured backing which was dry to the touch. Conversely, Example 5C, a composition outside the scope of the invention, did not cure fully and remained tacky.

The web speed was then reduced to half the original speed, i.e., 90 cm/min, with the lamp conditions unchanged. Example 5C failed to cure completely; Example 5 was fully cured. This demonstrates that compositions of the present invention cure more rapidly than those using catalysts of the "onium" type which have been reported previously. The backings were aged at 100°C for 10 minutes, to completely cure Example 5C, then coated

with rubber adhesive, as described in Example 1, and tested for tensile and elongation. The results are shown in Table 5.

Table 5

	Tensile Strength N/dm	Elongation percent
Example 5	578	26.00
Example 5C	394	35.50

Examples 6-9

These examples were made according to example 1 except that the epoxy ratios were varied as indicated in Table 6.

These backings were coated with a tackfied natural rubber adhesive and an isooctyl acrylate/acrylic acid/methyl acrylate adhesive (7 and 8), and tested for adhesion, tensile and elongation, and flammability. The results are shown in Table 6.

Table 6

	EXAMPLE NUMBER			
COMPOSITION	6	7	8	9
ERL 4299 - Epoxy	70	60	50	40
Epirez 5163 - Flame Retardant	30	30	30	30
Heloxy 84 - Epoxy	0	10	20	30
Photoinitiator[1]	1	1	1	1
Cumene Hydroperoxide	1.5	1.5	1.5	1.5
Antimony Trioxide	4	4	4	4
Tensile (kg/cm^2)	2.4	2.3	2.4	2.3
Elongation (Percent)	4	13	25	25
2-Bond Adhesion (N/dm)	133	133 (105*)	140 (106*)	111
Adhesion (N/dm)	43	46 (49*)	43 (49*)	39
Dielectric Constant (kV)	5.1	4.9 (4.3*)	4.7 (5.7*)	5.0
Insulation Resistance(Ohms)	$1.2x10^{13}$	$2.9x10^{12}$	$3.3x10^{11}$	$2.0x10^{10}$
Thickness (μm)	135	127.5	127.5	130
Flammability (secs)	13	23	34	<20

[1] Cyclopentadienyliron (II) xylene hexafluoroantimonate

* Asterisked values were obtained from tape constructions having an acrylate adhesive.

What is Claimed is:

1. A flexible tape backing comprising a substrate which has coated thereon a photopolymerized epoxy composition containing

a) a plurality of epoxides including at least one selected from the group consisting of cycloaliphatic epoxides and bisphenol A epoxide, and at least one aliphatic epoxide,

b) from 0.1 to 2% of at least one organometallic cationic initiator capable of initiating polymerization at wavelengths of from 200 to 600 nm, and

c) at least one accelerating agent,

wherein said backing is fully cured after an irradiation of from 1 to 15 seconds, without a heating step.

2. A flexible tape according to claim 1, said tape being suitable for use in electrical applications, wherein said tape has a dielectric strength of at least 3.5 kV to 10 kV, and an insulating resistance of at least 1×10^6 Megaohms.

3. A flexible tape backing according to claims 1 or 2 wherein said epoxides comprise at least one glycidyl ether of bisphenol A.

4. A flexible tape backing according to claims 1 or 2, wherein at least one of said plurality of epoxides is a brominated epoxide.

5. A flexible tape backing according to claims 1 or 2 wherein said cycloaliphatic epoxide contains at least one epoxycyclohexyl group.

6. A flexible tape backing according to claims 1 or 2 wherein said photoinitiator is an ionic salt of an

organometallic complex cation sufficient to effect polymerization, said metal being selected from elements of Periodic Groups IVB, VB, VIB, VIIB, and VIIIB.

7. A flexible tape backing according to claims 1 or 2 wherein said substrate is selected from the group consisting of glass cloth, paper, and nonwovens, and contains a plurality of pores, and said epoxy composition is impregnated into said pores.

8. A flexible tape backing according to claims 1 or 2 wherein said substrate is a non porous film-forming polymer selected from the group consisting of polyesters, acetates, polyphenylene sulfide, and polyimide.

9. A flexible tape backing according to claims 1 or 2 wherein said accelerating agent is a peroxide, said accelerating agent being present in an amount of from 0.1% to 5% of the total epoxy resin.

10. A flexible electrical tape according to claims 1 or 2 wherein said adhesive is selected from the group consisting of rubber adhesives, elastomeric adhesives, acrylic adhesives and isocyanate adhesives.

INTERNATIONAL SEARCH REPORT

Inter ›nal Application No
PCT/US 93/08288

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 H01B3/40 C09J7/02 C09J7/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 H01B C09J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO,A,81 00309 (M.M.M.) 5 February 1981 see page 5, line 30; claims 1,5	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 November 1993	14. 12. 93

Name and mailing address of the ISA	Authorized officer
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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter ional Application No
PCT/US 93/08288

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A-8100309	05-02-81	US-A-	4286047	25-08-81
		CA-A-	1124935	01-06-82
		EP-A,B	0032936	05-08-81