United States Patent

[11] **3,632,443**

[72] Inventors **Yoichi Kodera; Tomosaburo Kitamura; Etsuro Sawaguchi, all of Kanagawa-ken, Japan**

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[73] Assignee **Sony Corporation Tokyo, Japan**
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[33] **Japan**
[31] **43/28366**

[54] **METHOD OF MAKING POLYPROPYLENE ELECTRETS**
4 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** .... **117/227,** 307/88 ET, 117/93, 117/138.8 E
[51] **Int. Cl.** **C23c 13/00**
[50] **Field of Search** .... 307/88; 179/111 E; 29/592, 25.42

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Primary Examiner—Kathleen H. Claffy
Assistant Examiner—Thomas L. Kundert
Attorneys—Albert C. Johnston, Robert E. Isner, Lewis H. Eslinger and Alvin Sinderbrand

ABSTRACT: An electret which comprises a polypropylene film having a high volume resistivity and having been permanently electrically polarized.

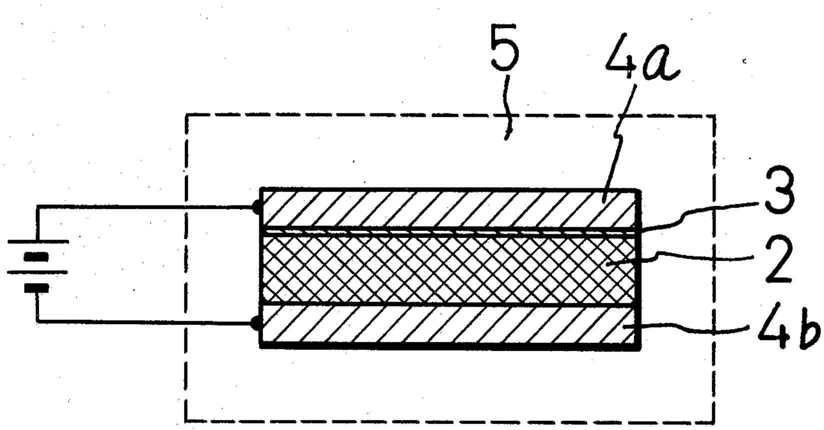
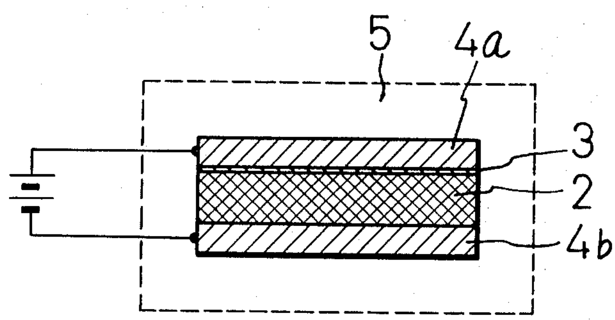


Fig. 1



INVENTORS
YOICHI KODERA
TOMOSABURO KITAMURA
ETSURO SAWAGUCHI

BY

ATTORNEYS

Fig. 2A

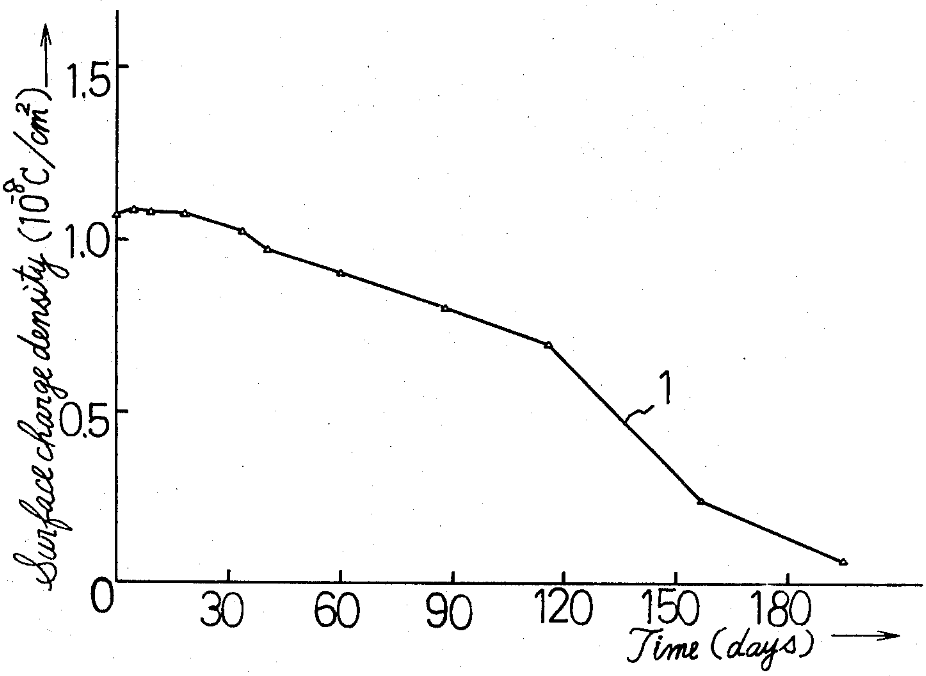
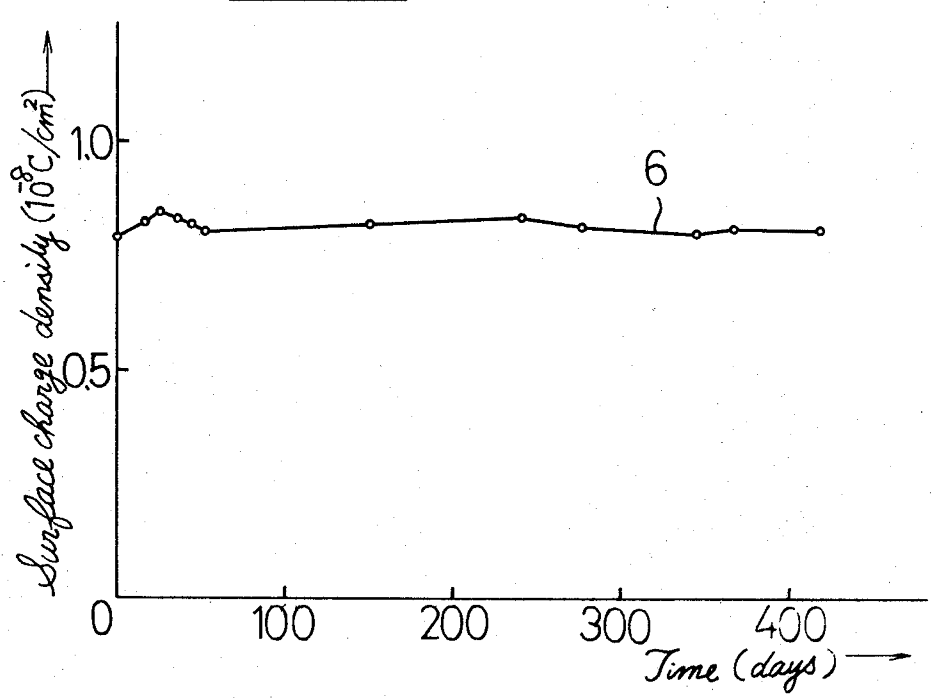


Fig. 2B



INVENTORS
YOICHI KODERA
TOMOSABURO KITAMURA
ETSURO SAWAGUCHI
BY
ATTORNEYS

Fig. 3

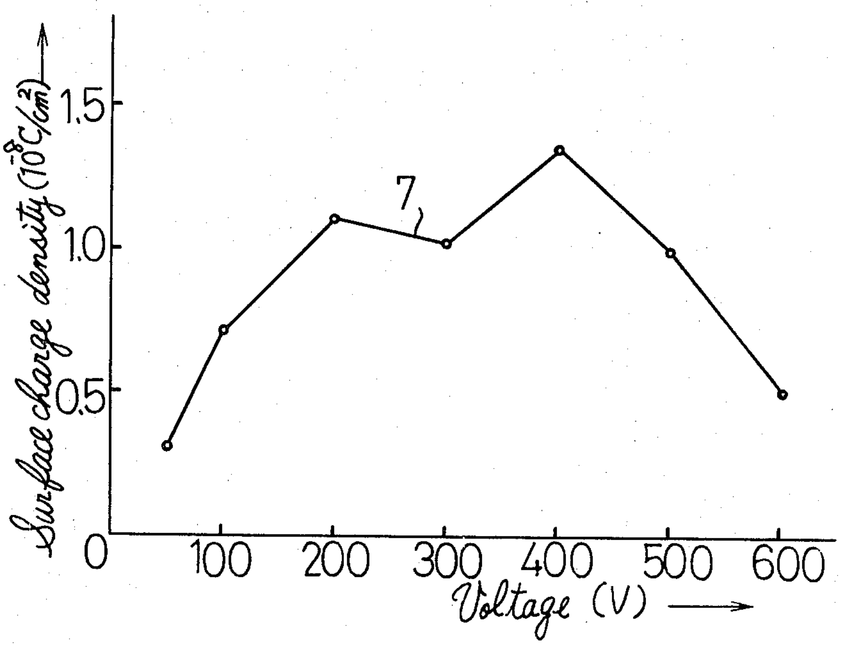
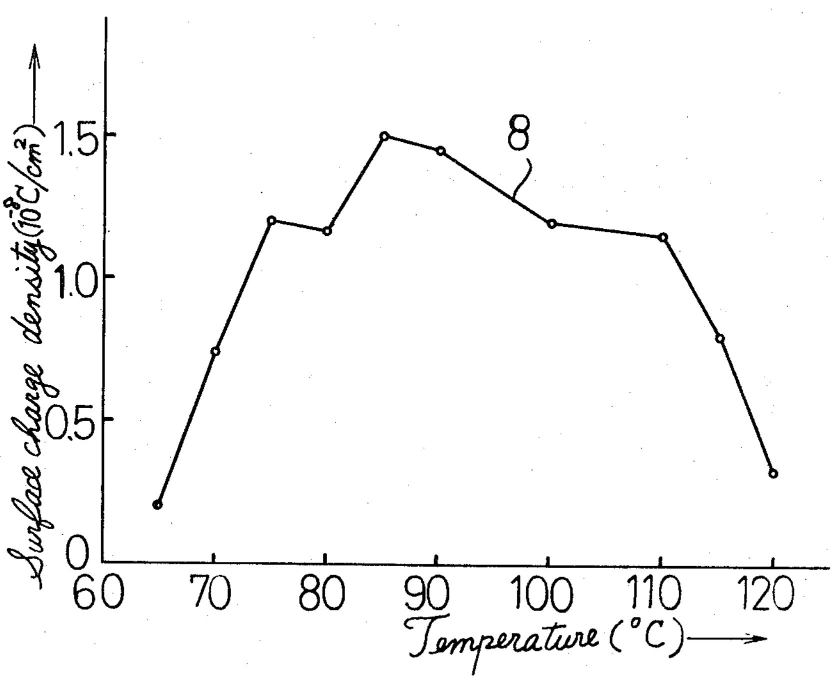


Fig. 4



INVENTORS
YOICHI KODERA
TOMOSABURO KITAMURA
ETSURO SAWAGUCHI

BY

ATTORNEYS

METHOD OF MAKING POLYPROPYLENE ELECTRETS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an electret and a method of making the same, and more particularly to a polypropylene electret for electromechanical conversion devices.

2. Description of the Prior Art

It is well known in the art that a permanently polarized dielectric material, commonly referred to as an electret can be utilized as a bias power source for condenser microphones, speakers, electrometers and so on. In the prior art the fabrication of the electret usually takes place by the following method. This is, a polar molecule dielectric such as carnauba wax or like natural organic compound or polymethyl metacrylate, polyethylene terephthalate, nylonlike synthetic organic compound having a dipole radical in the molecule is heated up to a temperature exceeding its melting point or secondary transition temperature so as to facilitate rotation of the dipole radical and ion migration; a high DC voltage such as having an electric field intensity of 5 kv./cm. to 50 kv./cm. cm. is impressed to metal electrodes on both surfaces of the dielectric to effect dipole radical orientation and ion polarization; the dielectric is cooled down to room temperature while being subjected to the voltage; and the electric field is removed from the dielectric after cooled down to room temperature to fix the dipole radical orientation and ion polarization, thus achieving permanent electrification of the dielectric. However, the carnauba wax is low in volume resistivity and synthetic high-molecular materials such as polymethyl metacrylate, polyethylene terephthalate, nylon and so on which are composed of polar molecules are high in hydroscopicity, and when they are kept in open conditions decay of electric charge is great, so that they are not suitable for industrial use.

SUMMARY OF THE INVENTION

In view of the foregoing, the present invention is to provide a polarized polypropylene electret for conversion devices which has stable surface charge lasting for a long period of time unaffected by humidity and a method of making the polypropylene electret.

One of the features of this invention resides in that the electret is formed of polypropylene which is a nonpolar high molecule and has a secondary transition temperature of approximately −35° C. Polypropylene has no dipole radical, has high volume resistivity, so that in the electret of this invention decay of the surface charge resulting from the internal electric field is small and, in addition, since polypropylene has substantially no hygroscopicity, decay of the surface charge is small. Accordingly, the electret of this invention can be expected to have a long service life.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram showing in cross section one example of a method of making an electret for conversion devices according to this invention;

FIGS. 2A and 2B are graphs showing changes of the surface charge density of the electret with the lapse of time;

FIG. 3 is a graph showing the relationship between voltage and the surface charge density of the electret; and

FIG. 4 is a graph showing the relationship between temperature and the surface charge density of the electret.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 there is illustrated a method of making an electret in accordance with one example of this invention, in which a relatively thin polypropylene high-molecular dielectric film is sandwiched between two metal electrodes, the resulting structure is placed in an atmosphere held at a temperature of 65° C. to 120° C. and a voltage of 50 v. to 600 v. is applied across the metal electrodes, thus providing an electret for conversion devices.

A description will be given first in connection with one embodiment of this invention as applied to a diaphragm of condenser microphones.

The first step is to prepare a polypropylene film **2**, commercially known under the trademark "TORAYFAN," which is of binary orientation and has a thickness of 15 microns. The next step is to coat an aluminum electrode **3** on one surface of the film **2** by means of vacuum vapor deposition and the resulting assembly is polarized. In this case the adhesion of the electrode to the polypropylene film **2** is poor, and hence the material of the electrode is desired to be excellent in adhesion and not to be deteriorated by gas in the air. It has been found by experiment that aluminum, palladium, silver and a gold-silver alloy exhibit excellent adhesion but that since silver and the gold-silver alloy are chemically affected by gases in the air such as hydrogen sulfide and so on, aluminum and palladium are the best for the purpose in practical use.

Subsequent to the polarization of the polypropylene film **2** having the aluminum electrode **3** deposited thereon, the film **2** is sandwiched between metal electrode plates **4*a*** and **4*b*** and the resulting assembly is immersed in a thermostat **5**.

The thermostat **5** is held at a temperature of 90° C. and a DC voltage is impressed between the electrode plates **4*a*** and **4*b***, under which conditions the sandwiched film **2** is placed for 2 hours, thereafter being cooled down to room temperature in 30 minutes while being exposed to the electric field.

As indicated by a curve **6** in FIG. 2B, the surface charge density of the electret thus produced undergoes less changes in the air but stably lasts for a longer period of time, as compared with that of a conventional electret formed of polyethylene terephthalate (indicated by a curve **1** in FIG. 2A).

Generally, the charge of the electret consists of heterocharge and homocharge and the surface charge appears in terms of the difference between the heterocharge and the homocharge. Polypropylene used in this invention is a nonpolar high molecule and its secondary transition temperature is −35° C. and the motion of the molecular chain is not frozen at room temperature. Accordingly, in the fabrication of the electret the heterocharge is not produced due to the orientation of the dipole radical but instead the homocharge is generated by ions which are yielded by the voltage impressed the electrodes **4*a*** and **4*b*** or by discharge between the surface of the film **2** and the electrode **4*b*** which results from discharge of the charge stored on the film surface when the electrode **4*b*** is peeled off from the film surface. However, the hygroscopicity of polypropylene is as low as less than 0.005 percent and its volume resistivity is as high as $6\times10^{18}\Omega$ cm., so that decay of the surface charge is hard to occur and this appears to suppress the variations in the surface charge density with the lapse of time as described previously.

In the conventional polyethylene terephthalate electret great decay of its surface charge density indicated in FIG. 2A was caused on damp days. This is considered to be due to the fact that polyethylene terephthalate has a hygroscopicity of 0.8 percent and a volume resistivity of $2\times10^{18}\Omega$ cm. and that these factors are inferior to those of polypropylene.

In FIG. 3 there is indicated by curve **7** the relationship between the voltage impressed across the electrode plates **4*a*** and **4*b*** and the surface charge density of the electret mentioned above. The curve **7** became substantially hump-shaped one such that the surface charge density reached a maximum value in the vicinity of approximately 400 v., as indicated. It has been found that, with the impressed voltage being lower than about 50 v. or exceeding about 600 v., the surface charge density of the electret was too low to be used for industrial purposes.

Further, there is indicated by a curve **8** in FIG. 4 the relationship between the surface charge density of the electret and the varying temperature of the thermostat **5** when the impressed voltage across the electrodes **4*a*** and **4*b*** was held at a value of 200 v. The curve **8** became substantially hump-shaped one such that the surface charge density reached a maximum value in the vicinity of approximately 85° C. It has been found that temperatures lower than about 65° C. and exceeding about 120° C. result too low a surface charge density of the electret and that temperatures exceeding 120° C. are not preferred from a viewpoint of the thermal resistance of polypropylene, too.

Where the electret of this invention is applied to a conversion device such as a condenser microphone, the thickness of the polypropylene film must be determined in view of the following points.

Namely, the polypropylene film is desired to be as thin as possible in order for the film to readily respond as a transducer to the driving force. However, too small a thickness of the film introduces lowered mechanical strength of the film and a fatal defect such that the both surfaces of the film are electrically short-circuited by a pinhole which might be produced in the manufacturing processes.

Accordingly, it is preferred from a practical point of view that the thickness of the film is greater than 2 microns but smaller than 50 microns.

In the foregoing the metal electrodes **4*a*** and **4*b*** are provided separately from the polypropylene film **2** and it is also possible to form electrodes on both surfaces of the polypropylene film **2** by means of metal vapor deposition or the like.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of this invention.

We claim as out invention:

1. A method of making an electret comprising the steps of sandwiching a thin polypropylene nonpolar high-molecular dielectric film between two metal electrodes and impressing a voltage of 50 to 600 v. across the metal electrodes in an atmosphere held at a temperature of 65° C. to 120° C.

2. A method of making an electret as claimed in claim **1** wherein the polypropylene nonpolar high-molecular dielectric film has a thickness of 2 to 50 microns.

3. A method of making an electret as claimed in claim **1** wherein prior to the sandwiching of said film between said electrodes, aluminum or palladium is vapor-deposited at least on one surface of the polypropylene nonpolar high-molecular dielectric film.

4. A method of making an electret as claimed in claim **1**, wherein said temperature is approximately 85° C.

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