

[DESCRIPTION]

[Invention Title]

ELECTROCONDUCTIVE THERMOPLASTIC RESIN COMPOSITION AND  
5 PLASTIC ARTICLE

[Technical Field]

The present invention relates to an electrically  
10 conductive thermoplastic resin composition and a plastic  
article. More specifically, the present invention relates to  
an electrically conductive thermoplastic resin composition  
which enables realization of an electrically conductive  
thermoplastic resin with improved electrical conductivity and  
15 a plastic article.

[Background Art]

Thermoplastic resins are plastics which are softened and  
20 plasticized by heating and are hardened by cooling.  
Thermoplastic resins are divided into: common plastics such as  
polyethylene, polypropylene, acrylic, styrene, and vinyl  
resins; and engineering plastics such as polycarbonate,  
polyphenylene ether, polyamide, polyester, and polyimide

resins.

Thermoplastic resins are widely utilized in applications, including various household supplies, office automation equipment, and electric and electrical appliances, owing to their superior processability and formability. There has been a continuous attempt to use a thermoplastic resin as a high value-added material by imparting specific properties as well as superior processability and formability to the thermoplastic resin according to the kind and properties of products in which the thermoplastic resin is used. In particular, there have been various attempts to impart electrical conductivity to a thermoplastic resin, and utilize the electrically conductive thermoplastic resin for the applications of automobiles, electric apparatuses, electronic assemblies, and electrical cables with electromagnetic wave shielding performance.

The electrically conductive thermoplastic resin is commonly prepared from an electrically conductive thermoplastic resin composition obtained by mixing a thermoplastic resin with a conductive additive, such as a carbon black, a carbon fiber, a metallic powder, a metal-coated inorganic powder or a metallic fiber. To ensure a desired level of the electrical conductivity of the electrically conductive thermoplastic resin, the conductive

additive must be used in a considerably large amount.

Meanwhile, there is an attempt to impart superior electrical conductivity to a thermoplastic resin by means of carbon nanotubes as a conductive additive.

5           However, when an electrically conductive thermoplastic resin is prepared by mixing a thermoplastic resin with carbon nanotubes and injecting the composite resin mixture in an injection molding equipment, the carbon nanotubes may undergo aggregates or unexpectedly oriented due to shearing stress  
10           occurring during the injection. As a result, the carbon nanotubes contained in the electrically conductive thermoplastic resin are not well dispersed, thus making it difficult to ensure sufficient electrical conductivity of the thermoplastic resin.

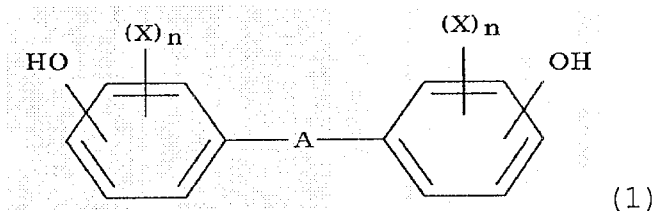
15           [Technical Solution]

          In accordance with one aspect of the present invention, there is provided an electrically conductive thermoplastic  
20           resin composition comprising: 80 to 99 parts by weight of a thermoplastic resin; 0.1 to 10 parts by weight of carbon nanotubes; and 0.1 to 10 parts by weight of an organo nanoclay.

          In the electrically conductive thermoplastic resin

composition, the thermoplastic resin may be selected from polyacetal, acrylic, polycarbonate, styrene, polyester, vinyl, polyphenylene ether, polyolefin, acrylonitrile-butadiene-styrene copolymer, polyarylate, polyamide, polyamide imide, polyarylsulfone, polyether imide, polyethersulfone, polyphenylene sulfide, fluorine, polyimide, polyetherketone, polybenzoxazole, polyoxadiazole, polybenzothiazole, polybenzimidazole, polypyridine, polytriazole, polypyrrolidine, polydibenzofuran, polysulfone, polyurea, polyphosphazene, liquid crystal polymer resins, and a copolymer or mixture thereof.

The thermoplastic resin may include a polycarbonate resin, and the polycarbonate resin may be an aromatic polycarbonate resin, which is prepared by reacting phosgene, halogen formate or diester carbonate with a diphenol compound represented by Formula 1 below:



wherein A represents a single bond, C<sub>1</sub>-C<sub>5</sub> alkylene, C<sub>1</sub>-C<sub>5</sub> alkylidene, C<sub>5</sub>-C<sub>6</sub> cycloalkylidene, -S- or -SO<sub>2</sub>-; X is a halogen; and n is 0, 1 or 2.

The thermoplastic resin may include a polycarbonate

resin having a weight average molecular weight of 10,000 to 200,000 g/mol.

In the electrically conductive thermoplastic resin, the carbon nanotubes may be single-walled carbon nanotubes or multi-walled carbon nanotubes.

The carbon nanotubes may have a diameter of 1 to 50 nm and a length of 0.01 to 10  $\mu\text{m}$ .

The carbon nanotubes may have an aspect ratio of 100 to 1,000.

In the electrically conductive thermoplastic resin, the organo nanoclay may be an organic-modified layered silicate having the distance between adjacent layers of 9 to 14 Å.

The layered silicate may be selected from montmorillonite, hectorite, bentonite, saponite, magadiite, synthetic mica, and a mixture thereof.

The organo nanoclay may be a layered silicate which is organic-modified with an organic phosphate or ammonium salt substituted with a C<sub>12</sub>-C<sub>36</sub> alkyl group or an aromatic group.

In accordance with another aspect of the present invention, there is provided a plastic article produced from the electrically conductive thermoplastic resin composition.

In accordance with yet another aspect of the present invention, there is provided a plastic article comprising: a thermoplastic resin; and carbon nanotubes and an organo

nanoclay dispersed in the thermoplastic resin.

Details of other aspects and exemplary embodiments of the present invention are encompassed in the following detailed description.

5

[Best Mode]

Now, the present invention will be described in more detail with reference to the following Examples, such that those skilled in the art easily practice the present invention. These examples are provided only for illustrating the present invention and should not be construed as limiting the scope and spirit of the present invention.

According to one embodiment of the present invention, there is provided an electrically conductive thermoplastic resin composition comprising: 80 to 99 parts by weight of a thermoplastic resin; 0.1 to 10 parts by weight of carbon nanotubes; and 0.1 to 10 parts by weight of an organo nanoclay.

As described above, the electrically conductive thermoplastic resin composition comprises organo nanoclay, in addition to carbon nanotubes. Accordingly, during injection of the resin composition, the organo nanoclay prevents the carbon nanotubes from being unexpectedly oriented and enables

the carbon nanotubes to be uniformly dispersed in the thermoplastic resin. Thus, in a case where even a small amount of the carbon nanotubes is used as an additive, the carbon nanotubes can impart considerable electrical conductivity to the thermoplastic resin after injecting. In addition, the relatively reduced content of carbon nanotubes inhibits deterioration of the basic mechanical properties of the thermoplastic resin caused by the inclusion of excessive carbon nanotubes.

Hereinafter, each constituent component of the electrically conductive thermoplastic resin composition will be described in detail.

The electrically conductive thermoplastic resin composition comprises 80 to 99 parts by weight of a thermoplastic resin.

Any thermoplastic resin may be used without any particular limitation so long as it is applicable to extrusion or injection molding. All thermoplastic common and engineering plastics may be used herein without any particular limitation.

Examples of the thermoplastic resin includes polyacetal, acrylic, polycarbonate, styrene, polyester, vinyl, polyphenylene ether, polyolefin, acrylonitrile-butadiene-styrene copolymer, polyarylate, polyamide, polyamide imide,

polyarylsulfone, polyether imide, polyethersulfone,  
polyphenylene sulfide, fluorine, polyimide, polyetherketone,  
polybenzoxazole, polyoxadiazole, polybenzothiazole,  
polybenzimidazole, polypyridine, polytriazole,  
5 polypyrrolidine, polydibenzofuran, polysulfone, polyurea,  
polyphosphazene, and liquid crystal polymer resins. In  
addition, the thermoplastic resin may be used as a copolymer  
or mixture thereof.

Considering physical properties of the electrically  
10 conductive thermoplastic resin composition or the type of  
product applied, preferred examples of the thermoplastic resin  
include, but are not limited to: polyolefin resins selected  
from polyethylene, polypropylene, ethylene-vinyl acetate  
copolymer and ethylene-methyl methacrylate copolymer resins;  
15 styrene resins; and engineering plastics selected from  
polyamide, polyester (e.g., polyethylene terephthalate and  
polybutylene terephthalate), and polycarbonate resins.

A full detail of polycarbonate, polyester and polyamide  
resins suitable as the thermoplastic resin will be given  
20 hereinafter.

First, the polyamide resin may be used as the  
thermoplastic resin.

The polyamide resin may be a common polyamide resin  
well-known in the art. More specifically, the polyamide resin

may be a Nylon resin selected from polycaprolactam (nylon 6), poly (11-aminoundecanoic acid) (nylon 11), poly lauryllactam (nylon 12), polyhexamethylene adipamide (nylon 6,6), polyhexaethylene azelamide (nylon 6,9), polyhexaethylene sebacamide (nylon 6,10), and polyhexaethylene dodecanediamide (nylon 6,12). In addition, the polyamide resin may be used as a copolymer thereof, e.g., nylon 6/6,10, nylon 6/6,6, or nylon 6/6,12. Alternatively, the polyamide resin may be used as a mixture thereof.

The polyamide resin may have a relative viscosity of 2.4 to 3.5 and a weight average molecular weight of 20,000 to 100,000 g/mol. The polyamide resin can be prepared in accordance with any method well-known to those skilled in the art and commercially obtained. The commercially obtainable polyamide resin includes, but is not limited to, KN-120<sup>®</sup> (available from Kolon Industries, Inc.) and 1021<sup>®</sup> (available from Rhodia Inc.)

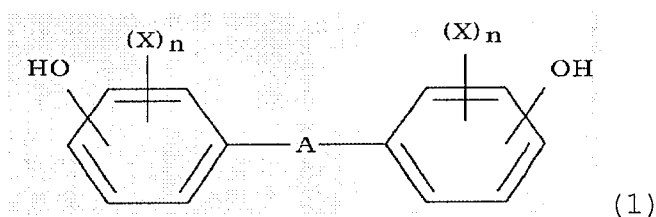
Second, the polyester resin may be used as the thermoplastic resin.

The polyester resin may contain an ester linkage in a polymer chain, and be melted by heating. The polyester resin is obtained by polycondensation of dicarboxylic acid and a dihydroxy compound. There is no limitation as to the preparation method of the polyester resin. Accordingly, there

may be used a polyester resin prepared by employing any method well-known to those skilled in the art. In addition, any polyester resin, such as a homopolyester or copolyester resin, may be used without any particular limitation.

5 Third, the polycarbonate resin may be used as the thermoplastic resin.

Examples of the polycarbonate resin may include an aromatic polycarbonate resin, which is prepared by reacting phosgene, halogen formate, or diester carbonate with a  
10 diphenol compound represented by Formula 1 below:



wherein A represents a single bond, C<sub>1</sub>-C<sub>5</sub> alkylene, C<sub>1</sub>-C<sub>5</sub> alkylidene, C<sub>5</sub>-C<sub>6</sub> cycloalkylidene, -S- or -SO<sub>2</sub>-; X is a halogen; and n is 0, 1 or 2.

15 Examples of the diphenol compound of Formula 1 include hydroquinone, resorcinol, 4,4'-dihydroxydiphenyl, 2,2-bis-(4-hydroxyphenyl)-propane, 2,4-bis-(4-hydroxyphenyl)-2-methylbutane, 2,2-bis-(3-chloro-4-hydroxyphenyl)-propane, 2,2-bis-(3,5-dichloro-4-hydroxyphenyl)-propane and 1,1-bis-(4-hydroxyphenyl)-cyclohexane. Of these, preferred are 2,2-bis-(4-hydroxyphenyl)-propane, 2,2-bis-(3,5-dichloro-4-  
20 hydroxyphenyl)-propane,

hydroxyphenyl)-propane, and 1,1-bis-(4-hydroxyphenyl)-cyclohexane. More preferred is 2,2-bis-(4-hydroxyphenyl)-propane, also called as "bisphenol-A (BPA)".

The polycarbonate resin has a weight average molecular weight of 10,000 to 200,000 g/mol, preferably, 15,000 to 80,000 g/mol.

There is no limitation as to the type of the polycarbonate resin. For example, the polycarbonate resin may be a linear or branched polycarbonate resin, or a polyester-carbonate copolymer resin. The branched polycarbonate resin may be prepared by using 0.05 to 2 mol% of a tri- or more functional (i.e., polyfunctional) compound, e.g., a tri- or more functional phenol compound, based on the total mole of the diphenol compound. The polyester-carbonate copolymer resin may be prepared by polymerizing polycarbonate in the presence of an ester precursor, such as dicarboxylic acid. The polyester-carbonate copolymer resin may be used singly, or in combination with a polycarbonate.

As the polycarbonate resin, there may be used a homopolycarbonate or copolycarbonate resin, or a combination thereof without any particular limitation.

As mentioned above, suitable examples of the thermoplastic resin include, but are not limited to, polycarbonate, polyester, and polyamide resins. The

composition and preparation method of each thermoplastic resin are already well-known to those skilled in the art.

Meanwhile, the electrically conductive thermoplastic resin composition may further comprise carbon nanotubes. The carbon nanotubes exhibit a superior mechanical strength, a high initial Young's modulus, and a large aspect ratio based on their inherent structural characteristics. In addition, the carbon nanotubes have superior electrical conductivity and thermal conductivity, as compared to copper and gold, which is disclosed in Yakobson, B. I., et al., American Scientist, 85, (1997), 324-337; and Dresselhaus, M. S., et al., Science of Fullerenes and Carbon Nanotubes, (1996), San Diego, Academic Press, 902-905. Also, the carbon nanotubes have a tensile strength of about 100 times as large as that of steel and a weight of one sixth as small as that thereof, which is disclosed in Andrew R., et al., Macromol. Mater. Eng., 287, (2002), 395-403; and Kashiwagi T., et al., Macromol. Rapid Commun., 4, (2002), 761-765. Based on the inherent characteristics of the carbon nanotubes, even a small amount of the carbon nanotubes contained in the thermoplastic resin composition can impart superior electrical conductivity to the thermoplastic resin.

Carbon nanotubes have a structure in which carbon atoms are arranged in a predetermined configuration to form an empty

tube.

Carbon nanotubes are divided into single-walled carbon nanotubes, double-walled carbon nanotubes and multi-walled carbon nanotubes, based on the wall number constitution thereof. Any carbon nanotubes may be utilized in the electrically conductive thermoplastic resin composition without any particular limitation.

Carbon nanotubes have a circumference of an atomic scale and a diameter of several nanometers (nm) to several tens of nanometers (nm). For example, single-walled carbon nanotubes have a diameter of 0.4 to 100 nm, preferably, 0.7 to 5 nm.

Carbon nanotubes of the present invention have a diameter of 1 to 50 nm, preferably, 1 to 20 nm, and a length of 0.01 to 10  $\mu\text{m}$ , preferably, 1 to 10  $\mu\text{m}$ . Based on the diameter and length, the carbon nanotubes may have an aspect ratio (L/D) of 100 or more, preferably, 100 to 1,000.

The nano-scale diameter of carbon nanotubes puts restrictions on electron motion in the circumference direction, thus causing a so-called "low-dimensional quantum phenomenon". Such a low-dimensional quantum phenomenon may be greatly varied depending upon the rolled type of carbon nanotubes. For this reason, carbon nanotubes can exhibit superior electrical conductivity compared(able) to metals or semiconductors. Accordingly, the carbon nanotubes contained

in the electrically conductive thermoplastic resin composition can impart electrical conductivity to the thermoplastic resin.

Carbon nanotubes are synthesized by arc-discharge, pyrolysis, laser ablation, plasma enhanced chemical vapor deposition (PECVD), thermal chemical vapor deposition, electrolysis, or flame synthesis. However, there is no limitation as to the synthesis method of the carbon nanotubes. Accordingly, carbon nanotubes synthesized by employing any method may be used for the electrically conductive thermoplastic resin composition without any particular limitation.

The carbon nanotubes for the thermoplastic resin composition are used in an amount of 0.1 to 10 parts by weight, preferably, 1 to 5 parts by weight. The content of carbon nanotubes ensures an adequate balance of mechanical properties and thermal conductivity of the thermoplastic resin. An amount of carbon nanotubes less than 0.1 parts by weight makes it difficult to ensure that the thermoplastic resin prepared from the electrically conductive resin composition has the desired level of electrical conductivity. An amount of carbon nanotubes exceeding 10 parts by weight causes deterioration in mechanical properties of the thermoplastic resin.

The electrically conductive thermoplastic resin

composition comprises organo nanoclay, in addition to the thermoplastic resin and the carbon nanotubes. The organo nanoclay indicates an organic-modified layered silicate.

5 The organo nanoclay contained in the thermoplastic resin composition prevents the tendency of aggregation of carbon nanotubes or an unexpectedly orientation and enables the carbon nanotubes to be uniformly dispersed in the thermoplastic resin, during injection. Thus, the organo nanoclay interacts with carbon nanotubes, thus leading to  
10 greater improvement in thermal conductivity of the thermoplastic resin. As a result, even a small amount of the carbon nanotubes can impart considerable electrical conductivity to the thermoplastic resin.

The electrically conductive thermoplastic resin  
15 composition comprises not conventional nanoclay, but organo nanoclay, *i.e.*, an organic-modified layered silicate. Since nano-scale layered silicate is basically hydrophilic, it is non-miscible with a hydrophobic polymer, *e.g.*, a thermoplastic resin, thus undergoing a reduction in dispersibility.  
20 Accordingly, organic-modification imparts hydrophobicity to the nano-scale layered silicate, thereby improving not only an intercalation capability of the silicate in a polymer chain, but dispersibility thereof in the thermoplastic resin. Hence, the organic-modified layered silicate can be uniformly

dispersed, thereby obtaining the desired level of physical properties (e.g., electrical conductivity) of the thermoplastic resin.

Organo nanoclay is typically prepared by organic-  
5 modifying a nano-scale layered silicate having the distance between adjacent layers of 9 to 14 Å. At this time, the layered silicate has an average diameter of 50  $\mu\text{m}$  or less, preferably, 25  $\mu\text{m}$  or less, more preferably, 10  $\mu\text{m}$  or less. The layered silicate, which satisfies these requirements and is  
10 thus suitable for use in the organo nanoclay, is selected from montmorillonite, hectorite, bentonite, saponite, magadiite, synthetic mica, and a mixture thereof.

Alternatively, the organo nanoclay is prepared by organically modifying a layered silicate with an organic  
15 phosphate or ammonium salt substituted with a  $\text{C}_{12}\text{-C}_{36}$  alkyl group or an aromatic group. Furthermore, it is most preferable to use organo nanoclay prepared by organically modifying montmorillonite with an organic phosphate or ammonium salt substituted with a  $\text{C}_{12}\text{-C}_{36}$  alkyl group or an  
20 aromatic group. In this case, the montmorillonite undergoes a change from hydrophilicity to hydrophobicity, thereby realizing a uniform dispersion in the thermoplastic resin and optimum physical properties of the resin.

The content of the organo nanoclay used in the

electrically conductive resin composition is 0.1 to 10 parts by weight. The organo nanoclay content enables efficient improvement in electrical conductivity of the resin, while causing no deterioration in mechanical properties of the resin.

If necessary, the electrically conductive thermoplastic resin composition further comprises an impact modifier, e.g., a rubbery impact modifier selected from a core-shell graft copolymer, a silicone polymer, an olefin polymer, and a mixture thereof. When such an impact modifier is contained in the resin composition, rubbery particles are dispersed in the thermoplastic resin, thus enabling an improvement in the physical properties (e.g., impact resistance) thereof. The specific composition and preparation method of each rubbery impact modifier are already well-known to those skilled in the art.

The electrically conductive thermoplastic resin composition may further comprise an additive suitable for a targeted use, in addition to the fore-mentioned constituent components. Examples of the additive include vinyl copolymers, lubricants, release agents, plasticizers, nucleating agents, stabilizers, modifiers and inorganic additives.

The electrically conductive thermoplastic resin is

prepared by conventional methods comprising: mixing each constituent component to prepare an electrically conductive thermoplastic resin composition; and melt-extruding the resin composition in an extruder. A plastic article is produced from the electrically conductive thermoplastic resin.

According to another embodiment of the present invention, there is provided a plastic article produced from the electrically conductive thermoplastic resin composition. More specifically, the plastic article may comprise a thermoplastic resin matrix, and carbon nanotubes and organo nanoclay, each being dispersed in the thermoplastic resin matrix.

The plastic article exhibits more enhanced electrical conductivity based on an interaction between the carbon nanotubes and the organo nanoclay which prevents the carbon nanotubes from being unexpectedly oriented and enables an improvement in the degree of dispersion. In particular, the enhanced electrical conductivity may be maintained after the injection molding.

Thus, the use of the carbon nanotubes even in a small amount can impart considerable electrical conductivity to the thermoplastic resin. In addition, even a small amount of the carbon nanotubes can inhibit deterioration of the basic mechanical properties of the thermoplastic resin caused by the

inclusion of excessive carbon nanotubes.

Accordingly, the plastic article is widely utilized in a variety of applications, e.g., impartment of electrical conductivity to automobiles, electric apparatuses, electronic assemblies and electrical cables.

[Mode for Invention]

The present invention will be better understood from the following examples. However, these examples are not to be construed as limiting the scope of the invention.

The further details for (A) a thermoplastic resin (polycarbonate and polyamide resins), (B) carbon nanotubes, and (C) organo nanoclay used in the following examples and comparative examples are as follows:

(A) Thermoplastic resin (polycarbonate resin)

Bisphenol-A polycarbonate having a weight average molecular weight (Mw) of 25,000 g/mol was used as a polycarbonate resin selected from thermoplastic resins.

(A') Thermoplastic resin (polyamide resin)

KN-120<sup>®</sup> (available from Kolon Industries, Inc.) was used

as a polyamide resin selected from thermoplastic resins.

(B) Carbon nanotubes

Multi-walled carbon nanotubes (C-tube 100<sup>®</sup> available  
5 from CNT Co., LTD., diameter: 10-50 nm, length: 1-25  $\mu$ m) were  
used as carbon nanotubes.

(C) Organo nanoclay

Cloisite 30B<sup>®</sup> (available from Southern Clay Products  
10 Inc.,) was used as an organo nanoclay.

**EXAMPLES 1 TO 5 AND COMPARATIVE EXAMPLES 1 TO 4**

The content of each constituent component used in the  
following Examples 1 to 5 and Comparative Examples 1 to 4 is  
15 shown in Table 1. Respective components were mixed in  
accordance with the composition shown in Table 1, to prepare  
an electrically conductive thermoplastic resin composition.  
The composition was extruded in a double-screw extruder  
(L/D=36,  $\Phi$ =45 mm) and the resulting extrudate was pelletized.  
20 The pellets were injected in an injection machine (10 oz) at  
270°C to prepare a sample for measurement of electrical  
conductivity.

First, the electrical conductivity (surface resistance)  
of each sample was measured with a surface resistance meter

(evaluation for electrical conductivity).

The tensile strength of each sample was measured in accordance with ASTM (American standard test method) D638. At this time, the measurement is based on the conditions of 20 mm/min, the record is made on a unit of kgf/cm<sup>2</sup> (evaluation for mechanical strength).

The measurement results of the electrical conductivity and tensile strength are shown in Tables 1 below.

**Table 1**

|                                            | Ex.              |                 |                  |                 |                 | Comp. Ex.        |                  |                  |                  |
|--------------------------------------------|------------------|-----------------|------------------|-----------------|-----------------|------------------|------------------|------------------|------------------|
|                                            | 1                | 2               | 3                | 4               | 5               | 1                | 2                | 3                | 4                |
| (A) polycarbonate resin<br>(wt. parts)     | 98               | 96              | 95               | 93              | -               | 99               | 97               | 97               | -                |
| (A') polyamide resin<br>(wt. parts)        | -                | -               | -                | -               | 95              | -                | -                | -                | 97               |
| (B) carbon nanotubes<br>(wt. parts)        | 1                | 3               | 1                | 3               | 3               | 1                | 3                | -                | 3                |
| (C) organo nanoclay<br>(wt. parts)         | 1                | 1               | 4                | 4               | 2               | -                | -                | 3                | -                |
| Tensile strength<br>(kgf/cm <sup>2</sup> ) | 650              | 680             | 690              | 700             | 868             | 630              | 670              | 680              | 573              |
| Surface resistance<br>(Ω/sq.)              | 10 <sup>11</sup> | 10 <sup>8</sup> | 10 <sup>10</sup> | 10 <sup>6</sup> | 10 <sup>9</sup> | 10 <sup>15</sup> | 10 <sup>14</sup> | 10 <sup>15</sup> | 10 <sup>15</sup> |

As could be seen from the data in Table 1, the samples of Examples 1 to 5 comprising both of carbon nanotubes and organo nanoclay, in addition to the thermoplastic resins

(polycarbonate and polyamide resins), exhibited improved electrical conductivity, as compared to those of Comparative Examples 1 to 4 comprising only one of carbon nanotubes and organo nanoclay, in addition to the thermoplastic resins. In particular, the samples of Examples 1 to 2 containing organo nanoclay in an amount of only 1 part by weight exhibited improved electrical conductivity, as compared to those of Comparative Examples 1 to 2 containing no organo nanoclay. As could be confirmed from the data of Example 5 and Comparative Example 4, although other thermoplastic resin (e.g., a polyamide resin) was used, it exhibited improved electrical conductivity comparable to those of the afore-mentioned cases. As shown in Comparative Example 1, and Examples 2 and 4, the larger the content of organo nanoclay at a constant amount of carbon nanotubes, the higher the improvement in the electrical conductivity of the sample.

Accordingly, it could be confirmed that the overall samples of Examples 1 to 5 exhibited high mechanical properties, e.g., tensile strength.

## [CLAIMS]

## [Claim 1]

An electrically conductive thermoplastic resin  
5 composition comprising:

80 to 99 parts by weight of a thermoplastic resin;

0.1 to 10 parts by weight of carbon nanotubes; and

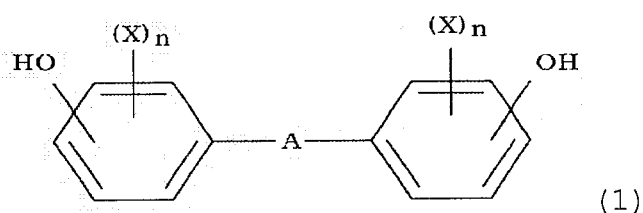
0.1 to 10 parts by weight of an organo nanoclay.

## 10 [Claim 2]

The electrically conductive thermoplastic resin  
composition according to claim 1, wherein the thermoplastic  
resin is selected from polyacetal, acrylic, polycarbonate,  
styrene, polyester, vinyl, polyphenylene ether, polyolefin,  
15 acrylonitrile-butadiene-styrene copolymer, polyarylate,  
polyamide, polyamide imide, polyarylsulfone, polyether imide,  
polyethersulfone, polyphenylene sulfide, fluorine, polyimide,  
polyetherketone, polybenzoxazole, polyoxadiazole,  
polybenzothiazole, polybenzimidazole, polypyridine,  
20 polytriazole, polypyrrolidine, polydibenzofuran, polysulfone,  
polyurea, polyphosphazene, liquid crystal polymer resins, and  
a copolymer or mixture thereof.

## [Claim 3]

The electrically conductive thermoplastic resin composition according to claim 1, wherein the thermoplastic resin includes a polycarbonate resin, and the polycarbonate resin is an aromatic polycarbonate resin, which is prepared by reacting phosgene, halogen formate or diester carbonate with a diphenol compound represented by Formula 1 below:



wherein A represents a single bond, C<sub>1</sub>-C<sub>5</sub> alkylene, C<sub>1</sub>-C<sub>5</sub> alkylidene, C<sub>5</sub>-C<sub>6</sub> cycloalkylidene, -S- or -SO<sub>2</sub>-; X is a halogen; and n is 0, 1 or 2.

[Claim 4]

The electrically conductive thermoplastic resin composition according to claim 1, wherein the thermoplastic resin includes a polycarbonate resin having a weight average molecular weight of 10,000 to 200,000 g/mol.

[Claim 5]

The electrically conductive thermoplastic resin composition according to claim 1, wherein the carbon nanotubes are single-walled carbon nanotubes or multi-walled carbon

nanotubes.

[Claim 6]

5       The electrically conductive thermoplastic resin composition according to claim 1, wherein the carbon nanotubes have a diameter of 1 to 50 nm and a length of 0.01 to 10  $\mu\text{m}$ .

[Claim 7]

10       The electrically conductive thermoplastic resin composition according to claim 1, wherein the carbon nanotubes have an aspect ratio of 100 to 1,000.

[Claim 8]

15       The electrically conductive thermoplastic resin composition according to claim 1, wherein the organo nanoclay includes an organic-modified layered silicate having a distance between adjacent layers of 9 to 14 Å.

[Claim 9]

20       The electrically conductive thermoplastic resin composition according to claim 8, wherein the layered silicate is selected from montmorillonite, hectorite, bentonite, saponite, magadiite, synthetic mica, and a mixture thereof.

[Claim 10]

The electrically conductive thermoplastic resin composition according to claim 8, wherein the organo nanoclay includes a layered silicate organic-modified with an organic phosphate or ammonium salt substituted with a C<sub>12</sub>-C<sub>36</sub> alkyl group or an aromatic group.

[Claim 11]

A plastic article produced from the electrically conductive thermoplastic resin composition according to any one of claims 1 to 10.

[Claim 12]

A plastic article comprising:  
a thermoplastic resin matrix; and  
carbon nanotubes and an organo nanoclay, each being dispersed in the thermoplastic resin matrix.