

[DESCRIPTION]

[Invention Title]

ELECTROMAGNETIC WAVE SHIELDING THERMOPLASTIC RESIN
5 COMPOSITION AND 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 electromagnetic wave shielding thermoplastic resin
composition with improved electromagnetic wave shielding
performance and a plastic article produced from the resin
15 composition.

[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 the products in which the thermoplastic resin is used. In particular, there have been various attempts to impart electromagnetic wave shielding performance to a thermoplastic resin and utilize the electromagnetic wave shielding thermoplastic resin for use in automobiles, electric apparatuses, electronic assemblies, electrical cables, etc.

The electromagnetic wave shielding thermoplastic resin is commonly prepared from an electromagnetic wave shielding thermoplastic resin composition obtained by mixing a thermoplastic resin with an additive, such as a metallic powder, a metal-coated inorganic powder, or a metallic fiber. To ensure a desired level of the electromagnetic wave shielding performance of the electromagnetic wave shielding thermoplastic resin, the additive, due to its high specific gravity, must be used in a considerably large amount.

However, such a large amount of the additive used to improve electromagnetic wave shielding performance causes a deterioration in inherent characteristics (e.g., impact resistance) of the thermoplastic resin, thus making it impossible to practically use the electromagnetic wave shielding thermoplastic resin.

[Summary]

In a first aspect, there is provided an electromagnetic wave shielding thermoplastic resin composition comprising:

100 parts by weight of a thermoplastic resin selected from a polycarbonate resin, a polyester resin, and a mixture thereof;

1 to 30 parts by weight of stainless steel fiber; and

0.01 to 10 parts by weight of carbon nanotubes.

In a second aspect, there is provided a plastic article produced from the electromagnetic wave shielding thermoplastic resin composition according to the present invention.

In a third aspect, there is provided a plastic article comprising:

a thermoplastic resin matrix made of one selected from a polycarbonate resin, a polyester resin, and a mixture thereof; and

stainless steel fiber and carbon nanotubes, each being dispersed in the thermoplastic resin matrix, wherein the amount of the stainless steel fiber is 1 to 30 parts by weight based on 100 parts by weight of the thermoplastic resin.

In a fourth aspect, there is provided a plastic article comprising:

a thermoplastic resin matrix made of one selected from a polycarbonate resin, a polyester resin, and a mixture thereof; and

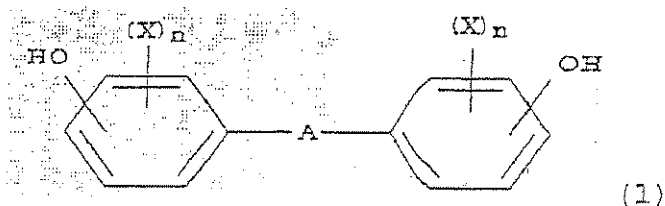
stainless steel fiber and carbon nanotubes, each being dispersed in the thermoplastic resin matrix,

wherein the plastic article has an electromagnetic wave shielding performance of 60 to 90 dB, and a notched IZOD impact strength (1/8") of 5 to 30 kgf·cm/cm measured in accordance with ASTM D256, wherein the amount of the stainless steel fiber is 1 to 30 parts by weight based on 100 parts by weight of the thermoplastic resin.

[Technical Solution]

In accordance with one aspect of the present invention, there is provided an electromagnetic wave shielding thermoplastic resin composition comprising: 100 parts by weight of a thermoplastic resin selected from a polycarbonate resin, a polyester resin, and a mixture thereof; 1 to 30 parts by weight of stainless steel fiber; and 0.01 to 10 parts by weight of carbon nanotubes.

The thermoplastic resin may include 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, C₁-C₅ alkylene, C₁-C₅ alkylidene, C₅-C₆ cycloalkylidene, -S- or -SO₂-; X is a halogen; and n is 0, 1 or 2.

5 The polycarbonate resin may have a weight average molecular weight of 15,000 to 50,000 g/mol.

In the electromagnetic wave shielding thermoplastic resin composition, the stainless steel fiber may include ferritic and austenitic stainless steel fibers.

10 The stainless steel fiber may have a thickness of 4 to 25 μ m and a length of 3 to 15 mm.

In the electromagnetic wave shielding thermoplastic resin composition, the carbon nanotubes may be single-walled carbon nanotubes or multi-walled carbon nanotubes.

15 The carbon nanotubes may have a thickness of 1 to 50 nm and a length of 1 to 25 μ m.

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

20 In accordance with yet another aspect of the present invention, there is provided a plastic article comprising: a thermoplastic resin matrix made of one selected from a polycarbonate resin, a polyester resin, and a mixture thereof; and stainless steel fiber and carbon nanotubes dispersed in

the thermoplastic resin matrix.

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

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[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 electromagnetic wave shielding thermoplastic resin composition comprising: 100 parts by weight of a thermoplastic resin selected from a polycarbonate resin, a polyester resin, and a mixture thereof; 1 to 30 parts by weight of stainless steel fiber; and 0.01 to 10 parts by weight of carbon nanotubes.

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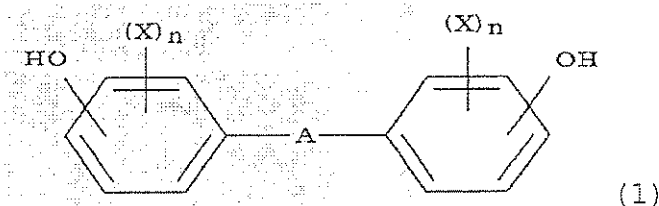
As described above, the electromagnetic wave shielding thermoplastic resin composition comprises the stainless steel fiber and carbon nanotubes as well as the thermoplastic resin selected from a polycarbonate resin, a polyester resin, and a

mixture thereof. The stainless steel fiber interacts with the carbon nanotubes, creating a synergic effect. As a result, even a relatively small amount of these constituent components can impart considerably improved electromagnetic wave shielding performance to the electromagnetic wave shielding thermoplastic resin. In addition, a relative reduction in content of these components decreases deterioration of the inherent characteristics (e.g., impact resistance) of the electromagnetic wave shielding thermoplastic resin.

Hereinafter, each constituent component of the electromagnetic wave shielding thermoplastic resin composition will be described in detail.

The electromagnetic wave shielding thermoplastic resin composition comprises a thermoplastic resin selected from a polycarbonate resin, a polyester resin, and a mixture thereof.

Examples of the thermoplastic resin include 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, C₁-C₅ alkylene, C₁-C₅

alkylidene, C₅-C₆ cycloalkylidene, -S-, or -SO₂-; X is a halogen; and n is 0, 1 or 2.

Examples of the diphenol compound of Formula 1 include 4,4'-dihydroxydiphenyl, 2,2-bis-(4-hydroxyphenyl)-propane, 2,4-bis-(4-hydroxyphenyl)-2-methylbutane, 1,1-bis-(4-hydroxyphenyl)-cyclohexane, 2,2-bis-(3-chloro-4-hydroxyphenyl)-propane, and 2,2-bis-(3,5-dichloro-4-hydroxyphenyl)-propane. Preferred are 2,2-bis-(4-hydroxyphenyl)-propane, 2,2-bis-(3,5-dichloro-4-hydroxyphenyl)-propane, and 1,1-bis-(4-hydroxyphenyl)-cyclohexane. More preferred is 2,2-bis-(4-hydroxyphenyl)-propane, also called "bisphenol-A (BPA)".

The polycarbonate resin has a weight average molecular weight of 15,000 to 50,000 g/mol.

There is no limitation as to the type of the polycarbonate resin. More specifically, 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 polyester resin, there may be used a homopolycarbonate or copolycarbonate resin, or a combination thereof without any particular limitation.

Alternatively, 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.

The electromagnetic wave shielding thermoplastic resin composition comprises stainless steel fiber. The stainless steel fiber interacts with the carbon nanotubes, creating a synergic effect. As a result, the electromagnetic wave shielding thermoplastic resin can be provided with improved electromagnetic wave shielding performance.

The stainless steel fiber is an alloy fiber using iron (Fe) as a base metal and using a considerable amount of chrome

(Cr) or nickel (Ni) as a main material. Stainless steel fibers are produced by drawing a bundle of continuous filament fibers from stainless steel through dies. Although stainless steel fiber contains iron (Fe) as a main component, it has ferromagnetism at ambient temperature as well as superior corrosion resistance and heat resistance unobtainable from conventional steel, thereby imparting improved electromagnetic wave shielding performance to the electromagnetic wave shielding thermoplastic resin.

The stainless steel fiber contained in the electromagnetic wave shielding thermoplastic resin composition is preferably a ferritic or austenitic stainless steel fiber, when taking into consideration electromagnetic wave shielding performance of the electromagnetic wave shielding thermoplastic resin.

The stainless steel fibers have a thickness of 4 to 25 μm and a length of 3 to 15 mm. Accordingly, the stainless steel fibers are uniformly dispersed in the electromagnetic wave shielding thermoplastic resin, thereby ensuring uniformity in electromagnetic wave shielding performance of the electromagnetic wave shielding thermoplastic resin.

The stainless steel fiber constituting the electromagnetic wave shielding thermoplastic resin composition is used in an amount of 1 to 30 parts by weight, preferably, 5

to 25 parts by weight, based on the 100 parts by weight of a thermoplastic resin selected from a polycarbonate resin, a polyester resin, and a mixture thereof. The content of stainless steel fiber less than 1 part by weight may make it difficult to ensure sufficient electromagnetic wave shielding performance of the electromagnetic wave shielding thermoplastic resin prepared from the resin composition. Meanwhile, the content of stainless steel fiber exceeding 30 parts by weight may cause a deterioration in inherent characteristics (e.g., impact resistance) of the electromagnetic wave shielding thermoplastic resin.

The electromagnetic wave shielding thermoplastic resin composition further comprises the carbon nanotubes. The carbon nanotubes interact with the stainless steel fiber, creating a synergic effect. As a result, the electromagnetic wave shielding thermoplastic resin can be provided with improved electromagnetic wave shielding performance.

The carbon nanotubes exhibit a superior mechanical strength, a high initial Young's modulus, and a large aspect ratio. In addition, carbon nanotubes have superior electrical conductivity and thermal stability. Based on these characteristics, the mixing of carbon nanotubes with the thermoplastic resin imparts superior electromagnetic wave shielding performance 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
5 limitation as to the synthesis method of the carbon nanotubes. Accordingly, carbon nanotubes synthesized by employing any method may be used for the electromagnetic wave shielding thermoplastic resin composition without any particular limitation.

10 Carbon nanotubes are divided into single-walled carbon nanotubes, double-walled carbon nanotubes and multi-walled carbon nanotubes, based on the wall number constituting thereof. Any carbon nanotubes may be utilized in the electromagnetic wave shielding thermoplastic resin composition
15 without any particular limitation.

Carbon nanotubes have a thickness of 1 to 50 nm, and a length of 1 to 25 μm . Accordingly, the carbon nanotubes are uniformly dispersed in the electromagnetic wave shielding thermoplastic resin, thereby ensuring uniformity in
20 electromagnetic wave shielding performance of the electromagnetic wave shielding thermoplastic resin.

The carbon nanotubes constituting the electromagnetic wave shielding thermoplastic resin composition are used in an amount of 0.01 to 10 parts by weight, preferably, 0.5 to 5

parts by weight, based on 100 parts by weight of a thermoplastic resin selected from a polycarbonate resin, a polyester resin, and a mixture thereof. The content of carbon nanotubes less than 0.01 parts by weight makes it impossible to ensure sufficient electromagnetic wave shielding performance of the electromagnetic wave shielding thermoplastic resin prepared from the resin composition. Meanwhile, the content of carbon nanotubes exceeding 10 parts by weight causes a deterioration in mechanical properties of the thermoplastic resin.

The electromagnetic wave shielding thermoplastic resin composition may further comprise an additive suitable for the intended use, in addition to the aforementioned constituent components. Examples of additives include lubricants, release agents, stabilizers, inorganic additives, pigments and dyes. The additive is used in an amount of not more than 5 parts by weight, preferably, 0.1 to 2 parts by weight, based on 100 parts by weight of the thermoplastic resin.

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

resin.

According to another embodiment of the present invention, there is provided a plastic article produced from the electromagnetic wave shielding thermoplastic resin composition. More specifically, the plastic article may comprise a thermoplastic resin matrix made of one selected from a polycarbonate resin, a polyester resin, and a mixture thereof, and stainless steel fiber and carbon nanotubes dispersed in the thermoplastic resin matrix.

The plastic article exhibits more enhanced electromagnetic wave shielding performance owing to the synergic effect between the carbon nanotubes and the stainless steel fiber, both of which are dispersed in the thermoplastic resin matrix, despite the use of these components in a relatively small content. The use of the stainless steel fiber and the carbon nanotubes even in a small amount reduces the deterioration of mechanical properties (e.g., impact resistance) of the thermoplastic resin.

The plastic article exhibits superior electromagnetic wave shielding performance, e.g., 60 to 90 dB. In addition, the notched IZOD impact strength (1/8") of the plastic article measured in accordance with ASTM D256 ranges from 5 to 30 kgf·cm/cm. This indicates that the plastic article has superior impact resistance.

According to yet another embodiment of the present invention, there is provided a plastic article comprising: a thermoplastic resin matrix made of one selected from a polycarbonate resin, a polyester resin, and a mixture thereof; and stainless steel fiber and carbon nanotubes dispersed in the thermoplastic resin matrix, wherein the plastic article has an electromagnetic wave shielding performance of 60 to 90 dB, and a notched IZOD impact strength (1/8") of 5 to 30 kgf·cm/cm measured in accordance with ASTM D256.

Based on superior impact resistance as well as improved electromagnetic wave shielding performance, the plastic article is widely utilized in a variety of applications, e.g., impartment of electromagnetic wave shielding performance to automobiles, electric apparatuses, electronic assemblies, electrical cables, etc.

[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 polycarbonate resin, (B) stainless steel fiber, and (C) carbon nanotubes used in the

following examples and comparative examples are as follows:

(A) Polycarbonate resin

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

(B) Stainless steel fiber

GR-75/C20[®] (available from Bekaert Fiber Technologies.,
10 Belgium, thickness: 11 μ m, length: 6 mm) was used as a
stainless steel fiber.

(C) Carbon nanotubes

Multi-walled carbon nanotubes (C-tube 100[®] available
15 from CNT Co., LTD., thickness: 10-50 nm, length: 1-25 μ m) were
used as carbon nanotubes.

EXAMPLES 1 TO 2 AND COMPARATIVE EXAMPLES 1 TO 5

The content of each constituent component used in the
20 following Examples and Comparative Examples is shown in Table
1. Respective components were mixed in accordance with the
composition in Table 1 to prepare an electromagnetic wave
shielding thermoplastic resin composition. The composition
was extruded in a double-screw extruder (L/D=35, Φ =45 mm) and

the resulting extrudate was pelletized. The pellet was injected in an injection machine (10 oz) at 300°C to prepare a sample for measurement of physical properties and electromagnetic wave shielding performance.

5 The sample was left under a 50% relative humidity atmosphere for 24 hours at 23 °C. Then, the electromagnetic wave shielding performance of the sample with a thickness of 3 mm was measured with a network analyzer (E5071C[®] available from Agilent Technologies Inc.) (evaluation for
10 electromagnetic wave shielding performance).

 The notched IZOD impact strength (1/8") of the sample was measured in accordance with ASTM D256, which is an American standard test method for determining an IZOD impact strength of plastics with a pendulum having a uniform weight
15 (evaluation for impact resistance).

 The measurement results of the electromagnetic wave shielding performance and impact resistance are shown in Table 1 below.

20 Table 1

	Ex.		Comp. Ex.				
	1	2	1	2	3	4	5
(A) polycarbonate resin (wt. parts)	100	100	100	100	100	100	100

(B) stainless steel fiber (wt. parts)	10	20	-	10	20	-	35
(C) carbon nanotubes (wt. parts)	2	1	-	-	-	5	15
Electromagnetic wave shielding performance (dB)	70	80	0	50	60	5	80
IZOD impact strength (1/8") (kgf · cm/cm)	20	15	60	25	20	20	2

As can be seen from the data in Table 1, the samples of Examples 1 and 2 comprising both stainless steel fiber and carbon nanotubes exhibited considerably improved electromagnetic wave shielding performance, as compared to those of Comparative Examples 2 to 4 comprising either stainless steel fiber or carbon nanotubes. In Examples 1 and 2, there was hardly any deterioration in impact resistance.

Meanwhile, the samples of Examples 1 to 2 comprising both stainless steel fiber and carbon nanotubes exhibited considerably improved electromagnetic wave shielding performance, as compared to that of Comparative Examples 1 comprising neither stainless steel fiber nor carbon nanotubes.

The samples of Examples 1 to 2, in which stainless steel fiber and carbon nanotubes are used within a preferable content range, hardly underwent any deterioration in impact resistance. On the other hand, the samples of Comparative

Example 5, in which these two components are used out of the content range, underwent rapid deterioration in impact resistance, thus being unsuitable for practical use.

[CLAIMS]

[Claim 1]

An electromagnetic wave shielding thermoplastic resin composition comprising:

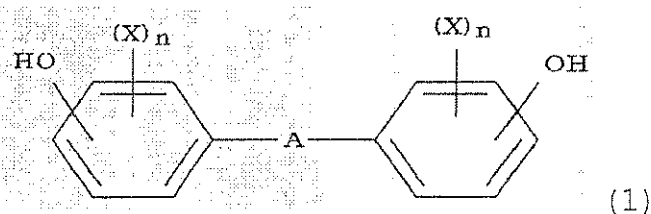
100 parts by weight of a thermoplastic resin selected from a polycarbonate resin, a polyester resin, and a mixture thereof;

1 to 30 parts by weight of stainless steel fiber; and

0.01 to 10 parts by weight of carbon nanotubes.

[Claim 2]

The electromagnetic wave shielding thermoplastic resin composition according to claim 1, wherein the thermoplastic resin includes 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, C₁-C₅ alkylene, C₁-C₅ alkylidene, C₅-C₆ cycloalkylidene, -S- or -SO₂-; X is a

halogen; and n is 0, 1 or 2.

[Claim 3]

The electromagnetic wave shielding thermoplastic resin
composition according to claim 1, wherein the polycarbonate
resin has a weight average molecular weight of 15,000 to
50,000 g/mol.

[Claim 4]

The electromagnetic wave shielding thermoplastic resin
composition according to claim 1, wherein the stainless steel
fiber is ferritic or austenitic stainless steel fiber.

[Claim 5]

The electromagnetic wave shielding thermoplastic resin
composition according to claim 1, wherein the stainless steel
fiber has a thickness of 4 to 25 μm and a length of 3 to 15
mm.

[Claim 6]

The electromagnetic wave shielding thermoplastic resin
composition according to claim 1, wherein the carbon nanotubes
are single-walled carbon nanotubes or multi-walled carbon
nanotubes.

[Claim 7]

The electromagnetic wave shielding thermoplastic resin composition according to claim 1, wherein the carbon nanotubes have a thickness of 1 to 50 nm and a length of 1 to 25 μm .

[Claim 8]

A plastic article produced from the electromagnetic wave shielding thermoplastic resin composition according to any one of claims 1 to 7.

[Claim 9]

A plastic article comprising:

a thermoplastic resin matrix made of one selected from a polycarbonate resin, a polyester resin, and a mixture thereof; and

stainless steel fiber and carbon nanotubes, each being dispersed in the thermoplastic resin matrix, wherein the amount of the stainless steel fiber is 1 to 30 parts by weight based on 100 parts by weight of the thermoplastic resin.

[Claim 10]

A plastic article comprising:

a thermoplastic resin matrix made of one selected from a polycarbonate resin, a polyester resin, and a mixture thereof; and

stainless steel fiber and carbon nanotubes, each being dispersed in the thermoplastic resin matrix,

wherein the plastic article has an electromagnetic wave shielding performance of 60 to 90 dB, and a notched IZOD impact strength (1/8") of 5 to 30 kgf·cm/cm measured in accordance with ASTM D256, wherein the amount of the stainless steel fiber is 1 to 30 parts by weight based on 100 parts by weight of the thermoplastic resin.