

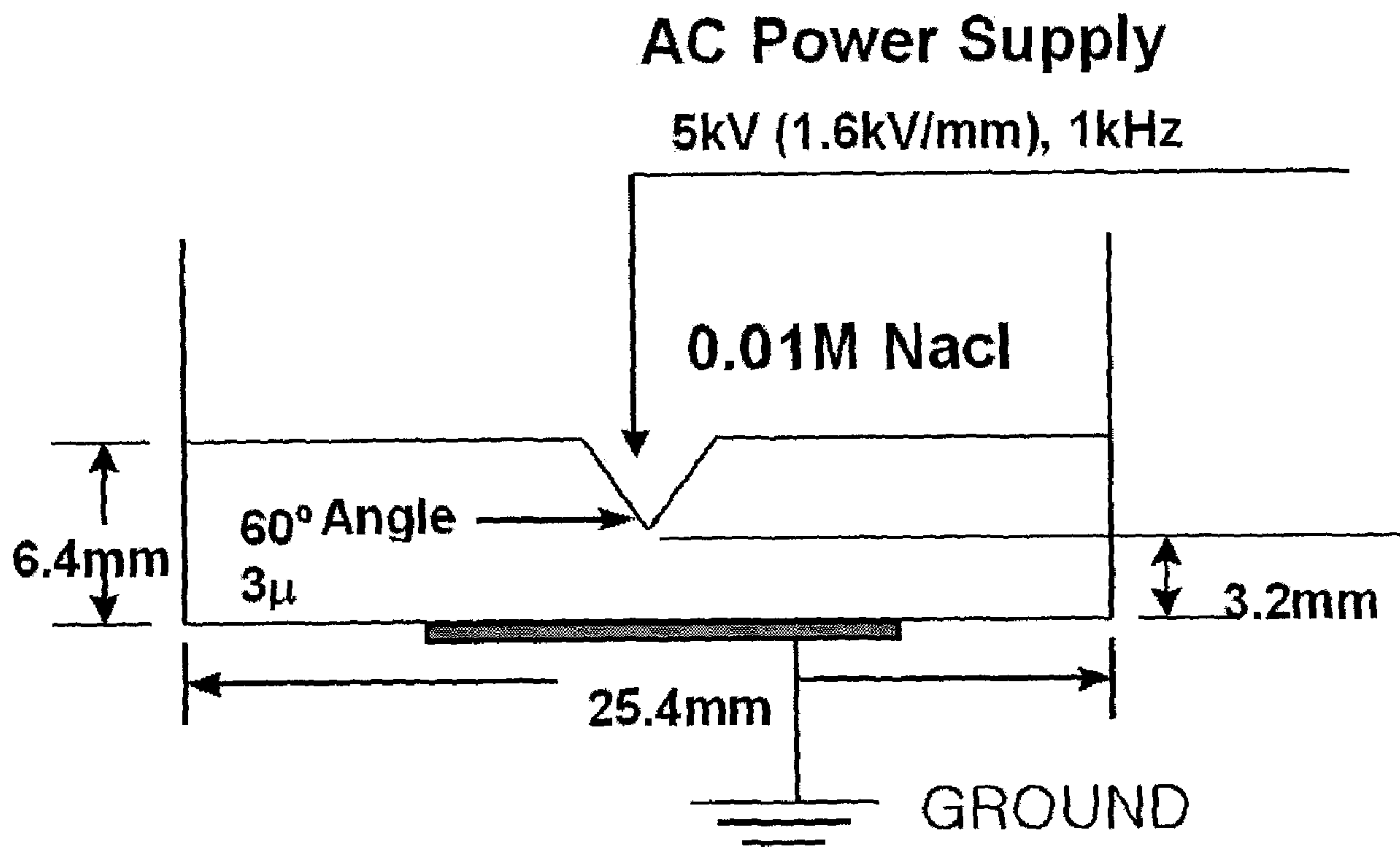


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(54) Title: CROSS-LINKABLE POLYOLEFIN COMPOSITION HAVING THE TREE RESISTANCE



(57) Abrégé/Abstract:

The present invention relates to a tree resistant, cross- linkable polyolefin resin composition for insulation capable of improving electric properties of an insulator of the high voltage power cable and thus improving a long-life stability of an underground distribution cable as having a more superior resistance to water tree deterioration caused by moisture, superior thermal-oxidative stability, superior scorch resistance when extruding as well as obtaining a proper cross- linking degree when cross-linking.

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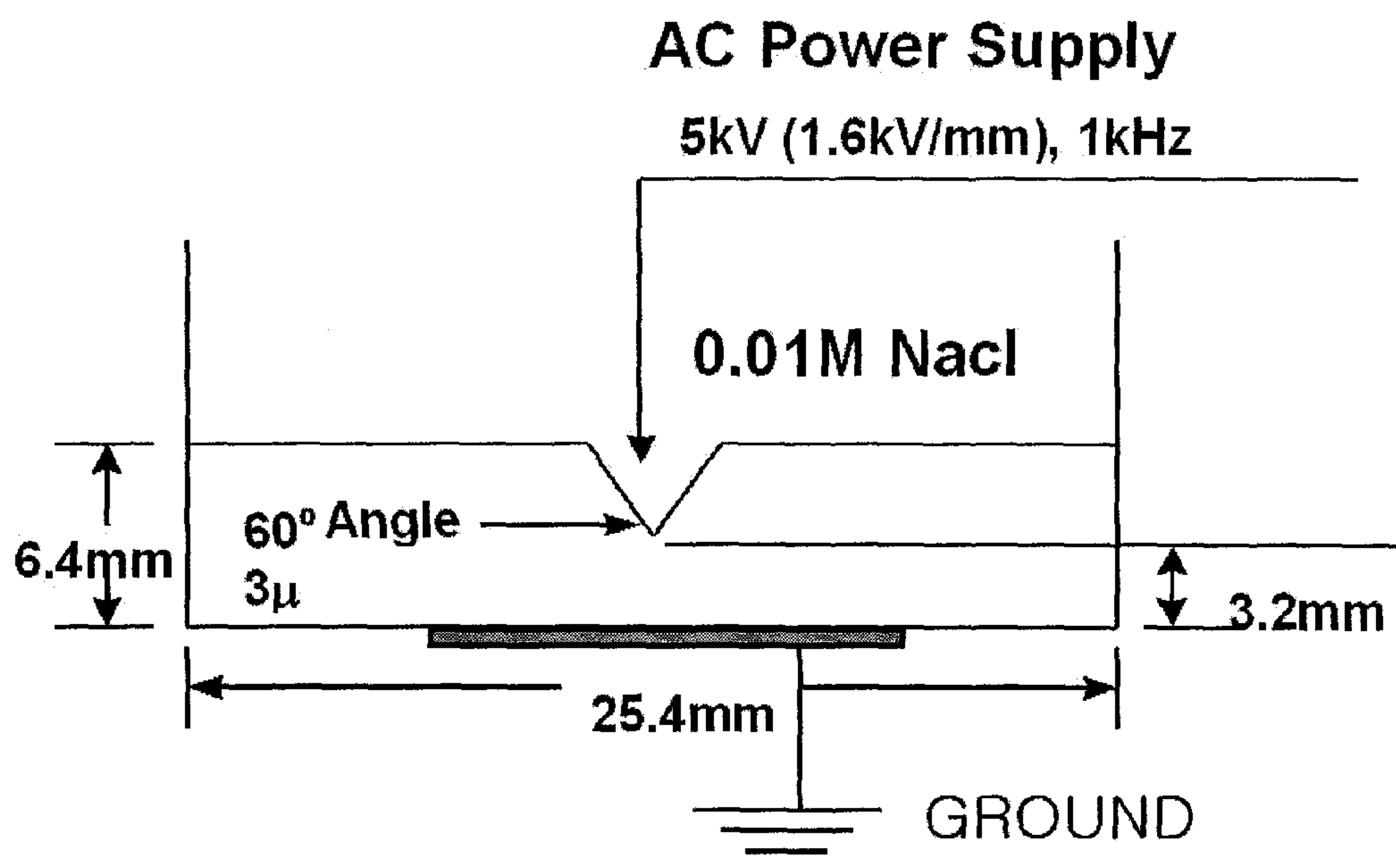
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(54) Title: CROSS-LINKABLE POLYOLEFIN COMPOSITION HAVING THE TREE RESISTANCE



(57) Abstract: The present invention relates to a tree resistant, cross-linkable polyolefin resin composition for insulation capable of improving electric properties of an insulator of the high voltage power cable and thus improving a long-life stability of an underground distribution cable as having a more superior resistance to water tree deterioration caused by moisture, superior thermal-oxidative stability, superior scorch resistance when extruding as well as obtaining a proper cross-linking degree when cross-linking.

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【DESCRIPTION】**【Invention Title】**

CROSS-LINKABLE POLYOLEFIN COMPOSITION HAVING THE TREE
RESISTANCE

5

【Technical Field】

The present invention relates to a tree resistant, cross-linkable polyolefin resin composition having superior electrical insulating property and thermal stability, and more particularly, to a tree resistant, cross-linkable polyolefin composition for an insulation of a high voltage power cable, which is capable of improving electric properties of an insulator of the high voltage power cable and thus improving a long-life stability of an underground distribution cable as having a more superior resistance to water tree deterioration caused by moisture, superior thermal-oxidative stability, superior scorch resistance when extruding as well as obtaining a proper cross-linking degree when cross-linking.

20 **【Background Art】**

In power cables installed in an environment of high humidity or moistness, a deterioration phenomenon of cable insulator occurred by combination of moisture and electric stress were found by Miyasita of Japan in later 1960s from a problem that life of power cables are shortened and were officially named

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as a deterioration due to water trees. After then, many studies for water tree deterioration and its mechanism have been made in order to solve the above problem. The water tree, which is named as it has a tree-like shape, is generally known to be a cause of a deterioration phenomenon due to moisture. The water tree occurs from a void, a defection part or a pollutant, consists of micropores and has a characteristic of growing in a direction of electric field. The water tree grows at a slow speed when it occurs in an inside of a cable insulator or an interface between the cable insulator and semiconducting layer, but finally the water tree leads to decrease in a pressure resisting strength of a cable insulator and thus shortens life of a cable.

Meanwhile, in the case of general underground distribution, a conductor is maintained generally at a temperature from 60°C to 90°C though the temperature may varies as voltage applied. In such the condition, problems in a thermal resistance and a long period thermal-oxidative stability are generated if using a polyolefin having a melting point of 100°C to 120°C as it is to a power cable. Polyethylene is therefore cross-linked in a net-shaped structure by a chemical cross-linking, a water cross-linking and an irradiation cross-linking in order to improve the thermal resistance of the high voltage power cable. In the above mentioned cross-linking methods, the chemical cross-linking causes a residual product such as organic

peroxides, generated from pyrolysis of a chemical cross-linking agent, to form a radical as a cross-linking point to the polyethylene and finally become a cross-link of the polyethylene.

5 A trouble occurred whenever extruding XLPE, which is an insulating material formulated with a chemical cross-linking agent, is an occurrence of a so-called scorch phenomenon (occurrence of partial early cross-linking from insulator during extrusion) when insulating the cable and the scorch
10 occurred during the extrusion acts as a factor that decreases an electric insulating property of the insulating material. It is therefore also important to avoid the occurrence of the scorch to extend the life of the power cable. In order to solve the above problem, an improvement in thermal-oxidative
15 stability and scorch is conventionally obtained by increasing antioxidant and, in this case, an advantage by formulation of the increased antioxidant can be obtained whereas there is an adverse effect of a low cross-linking degree after cross-linking by formulation of the increased antioxidant.

20 In addition, various solutions have been reported in documents for restrict a water tree, which is a kind of a deterioration phenomenon and occurs in an inside of an insulator during use of a power cable, in order that a power cable have the longer life span by improving an electric insulation performance of
25 the power cable. In example, U.S. Pat. No. 4,305,849 discloses

use of polyethylene glycol for resisting water tree and use of 4,4'-thiobis(2-t-butyl-5-methylphenol) as an antioxidant. Furthermore, Korean Patent No.0413016 and U.S. Pat. No. 6,869,995 also propose a method of defining and increasing
5 formulating three kinds of antioxidants including polyethylene glycol for resisting water tree, 4,4'-thiobis(2-t-butyl-5-methylphenol) which is generally used in cross-linkable polyethylene for an insulation of power cables and so on. The method described in the Korean Patent No.0413016 and the U.S.
10 Pat. No. 6,869,995 proposes improvement in thermal stability and scorch resistance with increasing formulating amount of a certain antioxidant, however there is a disadvantage that a cross-linking degree is decreased when simply increasing formulating the antioxidant alone in a cross-link of a
15 composition in relation to a performance of power cables. In other words, a cross-linking efficiency of a cross-linking agent which is formulated for cross-linking a cross-linkable polyolefin is lowered due to an amount of the antioxidant which is increasing formulated and rather a cross-linking
20 degree, a thermal deformation property and Hot value which are after cross-linking properties of the cross-linkable polyolefin are lowered and thus a cable insulating property is degraded as the thermal stability is decreased in non cross-linked portions in the long period. For example, as described
25 in the Korean Patent No.0413016 and the U.S. Pat. No.

6,869,995, an efficient cross-linking property can not be obtained as the proper cross-linking degree can not be obtained in the case of increasing the formulating amount of 4,4'-thiobis(2-t-butyl-5-methylphenol) more than 0.4%.

5 Because polyethylene glycol (hereinafter, referred to as PEG) is weak to heat, it is important to be thermally stable in the case of using PEG. More studies are therefore necessary to apply PEG. In this aspect, the method of increasing formulating antioxidant used in conventional power cables
10 proposed in the aforementioned prior patent has advantages of increasing thermal-oxidative stability as well as increasing scorch resistance when cross-linking by increasing formulation of antioxidant, however has a disadvantage that the proper cross-linking degree can not be obtained in a process of
15 cross-linking cross-linkable polyethylene. The thermal-oxidative stability is rather lowered in the viewpoint of long period, because non cross-linked portions are relatively increased after the cross-linking in the case that the cross-linking degree is low.

20

[Disclosure]**[Technical Problem]**

An object of the present invention, to solve the above problem, is to provide a tree resistant, cross-linkable
25 polyolefin composition for insulation of a high voltage power

cable, capable of improving electric properties of an insulator of the high voltage power cable and a long-life stability of an underground distribution cable as having a more superior resistance to water tree deterioration caused by moisture, superior thermal-oxidative stability and scorch stability as well as a proper cross-linking degree after cross-linking.

【Technical Solution】

10 The present invention relates to a tree resistant, cross-linkable polyolefin resin composition for insulation capable of improving electric properties of an insulator of the high voltage power cable and thus improving a long-life stability of an underground distribution cable as having a more superior
15 resistance to water tree deterioration caused by moisture, superior thermal-oxidative stability, superior scorch resistance when extruding as well as obtaining a proper cross-linking degree when cross-linking. In more detail, the tree resistant, cross-linkable polyolefin composition according to
20 the present invention having superior water tree resistant property, thermal-oxidative stability and cross-linking property, which includes i) 100 parts by weight of polyethylene; and based on 100 parts by weight of the polyethylene, ii) 1 to 4 parts by weight of chemical cross-
25 linking agent; iii) 0.3 to 0.8 parts by weight of antioxidant;

and iv) 0.3 to 1.0 parts by weight of polyethylene glycol having a molecular weight in the range of 5000 to 50000. In addition, the tree resistant, cross-linkable polyolefin composition may further include 0.1 to 1.0 parts by weight of
5 2,4-diphenyl-4-methyl-1-pentene as a cross-linking promoting agent which acts to increase the cross-linking efficiency of the cross-linkable polyolefin.

The polyethylene used in the present invention may be a homopolymer made by polymerization under high temperature and
10 high pressure by free radical initiated reaction in a tubular or autoclave reactor, a copolymer made by copolymerization of ethylene and comonomer by using a Ziegler-Natta catalyst or a metallocene catalyst under low temperature and low pressure or
15 copolymer of at least one alpha olefin selected from the group consisting of 1-butene, 1-hexene, 4-methyl-1-pentene and 1-octene.

A polymerizing of homopolymer under high pressure is described in Introduction to Polymer Chemistry (Wiley and Sons, New York, 1982, pages 149 to 153) and a polymerizing of copolymer by
20 using the Ziegler-Natta catalyst or the metallocene catalyst described in U.S. Pat. Nos. 4,101,445, 4,302,565, 4,918,038, 5,272,2'36, 5,290,745 and 5,317,037.

In addition, The polyethylene can have a density in the range of 0.800 to 0.935 g/cm³, a melt index in the range of about 0.1
25 to 30 g/10min (measured at a temperature of 190°C in load of

2.16Kg), Mw/Mn in the range of 2 to 15 and a weight average molecular weight in the range of 50,000 to 300,000. If the density is lower than this range, the polyethylene is inadequate for the insulating material since its melting point is lowered and thus thermal resistance is reduced; if the density exceeds the range, to the contrary, early decomposition of the chemical cross-linking agent may be caused when extruding the cross-linking composition since the melting point is increased. In addition, if the melt index and the Mw/Mn are lower than each range, an extruding processability of the cross-linking composition is degraded and, if exceeding each range, to the contrary, a superior mechanical property can not be obtained after the cross-linking insulation to the power cable of the composition according to the present invention. If the weight average molecular weight is lower than the above range, the superior mechanical property can not be obtained after the cross-linking insulation to the power cable of the composition according to the present invention; if the weight average molecular weight exceeds the range, to the contrary, the extruding processability of the cross-linking composition is degraded.

The cross-linking agent used in the present invention is an additive which should be used to increase physical property and thermal resistant stability for the purpose of insulation

under high pressure by cross-linking an insulator in a vulcanizing tube when insulating high voltage power cable for an outdoor use, and may be used alone or together with a cross-linking promoting agent. The most widely used cross-linking agent is an organic peroxide such as dicumyl peroxide (DCP), ditertiarybutyl peroxide (DTBP) or ditertiarybutyl peracetate (TBPA) or the like, and the proper amount of usage is 1 to 4 parts by weight based on 100 parts by weight of the polyethylene of the overall cross-linkable polyolefin resin composition. If the amount is lower than the above range, it is impossible to obtain an effective cross-linking efficiency of the composition; if exceeds the range, to the contrary, the extruding processability may be rather degraded by an occurrence of a slipping phenomenon due to a cross-linking agent when extruding the cross-linking polyethylene and a trouble of the extruding processability may occur due to a migration trouble of the cross-linking agent or an electric insulating property of the power cable may be reduced after the cross-linking in a long period of preservation.

Meanwhile, an antioxidant is a mixture including 4,4'-thiobis(2-*t*-butyl-5-methylphenol) and at least one selected from the group consisting of tetrakis[methylene(3,5-di-*tert*-butyl-4-hydroxy-hydrocinnamate)]methane, 4,6-bis(octylthiobutyl)-*o*-cresol and 2,2'-thiobis[ethyl-3-(3,5-di-*tert*-butyl-4-hydrophenyl)]-propionate, and thus a cross-

linkable polyolefin composition having high cross-linking degree as well as superior thermal-oxidative stability and scorch resistance can be obtained.

In other words, the antioxidant used in the present invention
5 is a mixture including polyethylene, and based on 100 parts by weight of the polyethylene, 0.1 to 0.23 parts by weight of 4,4'-thiobis(2-tert-butyl-5-methylphenol) and 0.1 to 0.4 parts by weight of at least one selected from the group consisting of
10 tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-hydrocinnamate)]methane, 4,6-bis(octylthiobutyl)-o-cresol and 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-propionate; preferably 0.15 to 0.22 parts by weight of 4,4'-thiobis(2-tert-butyl-5-methylphenol) and 0.1 to 0.4 parts by weight of at least one selected from the group consisting of
15 tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-hydrocinnamate)]methane, 4,6-bis(octylthiobutyl)-o-cresol and 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-propionate; and proper amount of usage is 0.3 to 0.8 parts by weight based on 100 parts by weight of the polyethylene. In a
20 combination of these antioxidants, 4,4'-thiobis(2-tert-butyl-5-methylphenol) has a disadvantage of separating cross-link as it acts to eliminate a radical which is generated by the cross-linking agent for cross-linking of the polyethylene since it has a superior antioxidation force in a cross-linked
25 product if used more than the proper amount. In order to

overcome the disadvantage and at the same time take the superior antioxidation force which is the advantage of 4,4'-thiobis(2-tert-butyl-5-methylphenol), 4,4'-thiobis(2-tert-butyl-5-methylephenol) is mixed with at least one antioxidant
5 selected from the group consisting of tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-hydrocinnamate)]methane, 4,6-bis(octylthiobutyl)-o-cresol and 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-propionate. The
tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-
10 hydrocinnamate)]methane, 4,6-bis(octylthiobutyl)-o-cresol and 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-propionate should be used in high amount for increasing thermal stability when they are used alone, respectively, and a trouble occurs as an extruding processability of the
15 composition is influenced if used in the high amount.

In the present invention, therefore, at least one antioxidant selected from the group consisting of tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-hydrocinnamate)]methane, 4,6-bis(octylthiobutyl)-o-cresol and 2,2'-thiobis[ethyl-3-(3,5-di-
20 tert-butyl-4-hydrophenyl)]-propionate is mixed with 4,4'-thiobis(2-tert-butyl-5-methylphenol) and used in the above mentioned range of formulating amount and thus it is possible to obtain proper thermal-oxidative stability and high cross-linking efficiency and scorch resistance.

25 To sum up the above description, if the amount is lower than

the above range, it is possible to obtain the high cross-linking degree of the cross-linkable polyethylene whereas thermal-oxidative stability and resistance to scorch phenomenon in which the cross-linking agent is early
5 decomposed when extruding the composition may be reduced. On the contrary, if the amount exceeds the above range, the cross-linking degree is lowered as the cross-linking efficiency of the cross-linking agent is lowered and consequently the after cross-linking property of the cross-linking agent is degraded and a cable insulating property is
10 degraded as the thermal-oxidative stability is decreased in non cross-linked portions in the long period.

2,4-diphenyl-4-methyl-1-pentene used in the present invention is a cross-linking promoting agent which acts to increase the
15 cross-linking efficiency when cross-linking of the cross-linkable polyolefin and also acts to increase a scorch resistance.

Generally, an antioxidant is used for thermal-oxidative stability of the cross-linkable polyolefin. A main function of
20 the antioxidant is to eliminate a radical which generates thermal-oxidation of a polymer resin. However, in order to cross-link a polymer, radical is primarily generated in the polymer by the cross-linking agent and the portions where the radical is generated are connected to become a cross-link.
25 Since the cross-linking agent and the antioxidant have

functions opposite to each other, they should be used in proper amounts so that the cross-linking property finally becomes superior. In the case of using the antioxidant more than the proper amount in order to increase the thermal stability of the cross-linkable polyolefin, the thermal-oxidative stability is rather degraded as the antioxidant acts to reduce a cross-linking efficiency of the cross-linking agent and thus the cross-linking degree of the cross-linkable polyolefin is lowered. In addition, in the case of using high amount of the cross-linking agent and formulating the antioxidant lower than the proper amount, partial cross-linked portions such as a scorch are formed when extruding by early thermal decomposition of the excessive amount of the cross-linking agent, whereby finally lead to a decrease in dielectric strength which is an electric property of the power cable insulator.

Conventionally used cross-linking promoting agents have a function of increasing decomposition speed of the cross-linking agent as well as the cross-linking efficiency. The cross-linking promoting agent, however, has superior cross-linking efficiency since it promotes decomposition speed of the cross-linking agent whereas has a disadvantage of lowering of the scorch resistance as occurrence of early cross-linking. The 2,4-diphenyl-4-methyl-1-pentene (DMP), however, has advantages of increasing cross-linking efficiency when cross-

linking thereby increasing density of net-shaped structure of the cross-linkable polyethylene having a cross-linkable structure and increasing the scorch resistance when used in proper amount.

5 The 2,4-diphenyl-4-methyl-1-pentene, which is a cross-linking promoting agent used in the present invention, is therefore used to solve the above problem and acts to increase thermal-oxidative stability of the cross-linkable polyolefin as it increases antioxidant formulation and thus raise the thermal-oxidative stability, and to decrease the scorch phenomenon
10 which is an early cross-linking phenomenon and resist a function of decreasing the cross-linking efficiency of the cross-linking agent.

An amount of the 2,4-diphenyl-4-methyl-1-pentene used in the present invention is 0.1 to 1.0 parts by weight based on 100
15 parts by weight of polyolefin; if the amount is lower than 0.1 parts by weight, cross-linking promoting effect is low, and if the amount exceeds 1.0 parts by weight, the cross-linking efficiency is rather lowered to lead to decrease in a cross-linking degree after the cross-linking.
20

Preferably, a mixing ratio of the cross-linking promoting agent and the antioxidant is 1:0.5 to 1:1.5 and a mixing ratio of the cross-linking agent such as dicumyl peroxide (DCP), ditertiarybutyl peroxide (DTBP) or ditertiarybutyl peracetate
25 (TBPA) or the like is 12:1 to 4:1.

In addition, polyethylene glycol used in the present invention for resisting water tree is the polyethylene glycol having a molecular weight in the range of 5,000 to 50,000 and is a polar polymer made by copolymerization of ethylene and
5 ethylene glycol. The polyethylene glycol has a molecular formula of $\text{HO}(\text{C}_2\text{H}_4\text{O})_n\text{H}$ and n of 100 to 1000; this means the molecular weight is in the range of 5,000 to 50,000. If the molecular weight is lower than the above range, a trouble may occur since the molecular weight is low and thus the thermal
10 stability is not good; if the molecular weight exceeds the range, to the contrary, compatibility with nonpolar polyethylene is not good and thus uniform dispersion may not be obtained when kneading

An usage amount of the polyethylene glycol is 0.3 to 1 parts
15 by weight per based on 100 parts by weight of polyolefin; if the amount is lower than 0.3 parts by weight, effective water tree resistance can not be obtained, and if the amount exceeds 1 parts by weight, a melting point of the polyethylene glycol is low, which causes a non-uniformity in an extrusion by the
20 polyethylene glycol when extruding a composition added with the polyethylene and thus result in a non-uniformity in an insulation thickness when insulating a cable, and a long period thermal stability may be lowered by thermally unstable polyethylene glycol.

25 A method for measuring a water tree resistance property of

polymer insulating material such as polyethylene is described well in U.S. Pat. No. 4,144,202. The method for measuring a water tree resistance property proposed in the above mentioned patent is a method for measuring and evaluating relatively the water tree resistance property of polyethylene with the water tree resistance property in relation to polyethylene without the water tree resistance property. The term used for such relative water tree resistance property is "water tree growth rate" (WTGR). The method for measuring a water tree resistance property of polymer insulating material proposed in the above mentioned patent was more specified to be established as an official test method ASTM D 6097 (see Fig. 1) and is currently employed as a standard test method in various countries. In the present invention, a test specimen for evaluating the water tree resistance property was prepared according to ASTM D 6097 in order to evaluation for the water tree resistance property of the cross-linkable polyethylene. The test to the water tree resistance property was performed under ASTM D 6097 at AC 4.5kV (1.6kV/mm) and 1kHz; a concentration of salt water is in condition more severe than 0.01M which is the standard test salt water concentration (increasing concentration of the salt water to 0.5M); test period was fixed to 30days in every tests.

Mechanical property at room temperature of the cross-linkable polyolefin after the cross-linking was measured according to

ASTM D 638 after preparing test specimen by former at a temperature of 180°C and for 20 minutes of cross-linking time. In addition, Hot value after the cross-linking was measured based on ICEA T-28-562 (Hot value is a value, which is expressed as %, of an extended length for the original length when pulling the specimen with a 20N/cm² of load in an oven which is maintained at 200°C and the higher cross-linking degree is, the higher the Hot value), and a tensile property after thermal aging was measured in accordance with ASTM D 638 test method after thermally oxidizing the specimen for 3 weeks (21 days) in an air circulating oven which is maintained at 150°C. In addition, the cross-linking degree of the test specimen after the cross-linking was measured in accordance with ASTM D 2765A. Measurement for MH which is a cross-linking behavior of the cross-linkable polyolefin (a maximum torque indicating degree of cross-linking when cross-linking) and scorch time which notifies an information for early cross-linking when cable insulation of the cross-linkable polyolefin was analyzed at 180°C using MDR (Moving Disc Rheometer) device.

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【Description of Drawings】

Fig. 1 is a diagram schematically illustrating concept of ASTM D 6097 test method which is an official method for measuring a water tree resistance property of polymer insulating material.

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[Best Mode]

Hereinafter, the embodiments of the present invention will be described in detail. However, it will be appreciated
5 that those skilled in the art, on consideration of this disclosure, may make modifications and improvements within the spirit and scope of the present invention.

[Example 1]

10 Polyethylene homopolymer, which is a base resin, having a density of 0.920g/cm^3 and a melt index of 2 g/10 min, and based on 100 parts by weight of the polyethylene homopolymer, 0.15 parts by weight of 4,4'-thiobis(3-methyl-6-tert-butylphenol) and 0.15 parts by weight of 4,6-bis(octylthiobutyl)-o-cresol
15 which are antioxidants, and 0.7 parts by weight of polyethylene glycol for resisting water tree, having a molecular weight of 20,000 were put in a Banbury™ mixer which is maintained at 130°C and kneaded for 10 minutes, after then the kneaded mixture was extruded through a single screw
20 continuous extruder which is maintained at 180°C to be formed in a pallet shape. The pallet prepared as above described was put together with 2 parts by weight of dicumyl peroxide which is a cross-linking agent in a Henschel™ mixer which is maintained at 80°C and the Henschel mixer was kept rotated at
25 60 rpm for 30 minutes so that the base resin is impregnate

with the cross-linking agent, and thus finally a cross-linkable polyolefin composition was prepared. After then, the composition was tested for water tree property, mechanical properties at a room temperature and after thermal aging, a cross-linking degree, Hot and cross-linking behavior (MH and scorch time) in accordance with the above mentioned test and evaluating method, and the test results are shown in Table 1.

[Example 2]

10 The same as Example 1, except that a cross-linkable polyolefin composition was prepared using 0.2 parts by weight of 4,4'-thiobis(3-methyl-6-tert-butylphenol) and 0.1 parts by weight of 4,6-bis(octylthiobutyl)-o-cresol which are antioxidants. After then, tests were made for water tree property, mechanical properties at a room temperature and after thermal aging, a cross-linking degree, Hot and cross-linking behavior (MH and scorch time) and the test results are shown in Table 1.

[Example 3]

20 The same as Example 1, except that a cross-linkable polyolefin composition was prepared using 0.2 parts by weight of 4,4'-thiobis(3-methyl-6-tert-butylphenol) and 0.2 parts by weight of 4,6-bis(octylthiobutyl)-o-cresol which are antioxidants. After then, tests were made for water tree property, mechanical properties at a room temperature and after thermal

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aging, a cross-linking degree, Hot and cross-linking behavior (MH and scorch time) and the test results are shown in Table 1.

[Example 4]

5 The same as Example 1, except that a cross-linkable polyolefin composition was prepared using 0.2 parts by weight of 4,4'-thiobis(3-methyl-6-tert-butylphenol), 0.1 parts by weight of 4,6-bis(octylthiobutyl)-o-cresol and 0.15 parts by weight of 2,4-diphenyl-4-methyl-1-pentene which are antioxidants. After
10 then, tests were made for water tree property, mechanical properties at a room temperature and after thermal aging, a cross-linking degree, Hot and cross-linking behavior (MH and scorch time) and the test results are shown in Table 1.

15 [Example 5]

The same as Example 1, except that a cross-linkable polyolefin composition was prepared using 0.2 parts by weight of 4,4'-thiobis(3-methyl-6-tert-butylphenol), 0.1 parts by weight of 4,6-bis(octylthiobutyl)-o-cresol and 0.3 parts by weight of
20 2,4-diphenyl-4-methyl-1-pentene which are antioxidants. After then, tests were made for water tree property, mechanical properties at a room temperature and after thermal aging, a cross-linking degree, Hot and cross-linking behavior (MH and scorch time) and the test results are shown in Table 1.

[Example 6]

The same as Example 1, except that a cross-linkable polyolefin composition was prepared using 0.2 parts by weight of 4,4'-thiobis(3-methyl-6-tert-butylphenol), 0.2 parts by weight of 5 4,6-bis(octylthiobutyl)-o-cresol and 0.15 parts by weight of 2,4-diphenyl-4-methyl-1-pentene which are antioxidants. After then, tests were made for water tree property, mechanical properties at a room temperature and after thermal aging, a cross-linking degree, Hot and cross-linking behavior (MH and 10 scorch time) and the test results are shown in Table 1.

[Example 7]

The same as Example 1, except that a cross-linkable polyolefin composition was prepared using 0.2 parts by weight of 4,4'-15 thiobis(3-methyl-6-tert-butylphenol), 0.2 parts by weight of 4,6-bis(octylthiobutyl)-o-cresol, and 0.3 parts by weight of 2,4-diphenyl-4-methyl-1-pentene which are antioxidants. After then, tests were made for water tree property, mechanical properties at a room temperature and after thermal aging, a 20 cross-linking degree, Hot and cross-linking behavior (MH and scorch time) and the test results are shown in Table 1.

[Example 8]

The same as Example 1, except that a cross-linkable polyolefin 25 composition was prepared using 0.2 parts by weight of 4,4'-

thiobis(3-methyl-6-tert-butylphenol) and 0.1 parts by weight
of tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-
hydrocinnamate)]methane instead of 4,6-bis(octylthiobutyl)-o-
cresol which are antioxidants. After then, tests were made for
5 water tree property, mechanical properties at a room
temperature and after thermal aging, a cross-linking degree,
Hot and cross-linking behavior (MH and scorch time) and the
test results are shown in Table 1.

10 [Example 9]

The same as Example 1, except that a cross-linkable polyolefin
composition was prepared using 0.2 parts by weight of 4,4'-
thiobis(3-methyl-6-tert-butylphenol) and 0.3 parts by weight
of tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-
15 hydrocinnamate)]methane instead of 4,6-bis(octylthiobutyl)-o-
cresol which are antioxidants. After then, tests were made for
water tree property, mechanical properties at a room
temperature and after thermal aging, a cross-linking degree,
Hot and cross-linking behavior (MH and scorch time) and the
20 test results are shown in Table 1.

[Example 10]

The same as Example 1, except that a cross-linkable polyolefin
composition was prepared using 0.2 parts by weight of 4,4'-
25 thiobis(3-methyl-6-tert-butylphenol), 0.1 parts by weight of

tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-
hydrocinnamate)]methane instead of 4,6-bis(octylthiobutyl)-o-
cresol and 0.15 parts by weight of 2,4-diphenyl-4-methyl-1-
pentene which are antioxidants. After then, tests were made
5 for water tree property, mechanical properties at a room
temperature and after thermal aging, a cross-linking degree,
Hot and cross-linking behavior (MH and scorch time) and the
test results are shown in Table 1.

10 [Example 11]

The same as Example 1, except that a cross-linkable polyolefin
composition was prepared using 0.2 parts by weight of 4,4'-
thiobis(3-methyl-6-tert-butylphenol), 0.1 parts by weight of
tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-
15 hydrocinnamate)]methane instead of 4,6-bis(octylthiobutyl)-o-
cresol and 0.3 parts by weight of 2,4-diphenyl-4-methyl-1-
pentene which are antioxidants. After then, tests were made
for water tree property, mechanical properties at a room
temperature and after thermal aging, a cross-linking degree,
20 Hot and cross-linking behavior (MH and scorch time) and the
test results are shown in Table 1.

[Example 12]

The same as Example 1, except that a cross-linkable polyolefin
25 composition was prepared using 0.2 parts by weight of 4,4'-

thiobis(3-methyl-6-tert-butylphenol), 0.3 parts by weight of
tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-
hydrocinnamate)]methane instead of 4,6-bis(octylthiobutyl)-o-
cresol and 0.15 parts by weight of 2,4-diphenyl-4-methyl-1-
5 pentene which are antioxidants. After then, tests were made
for water tree property, mechanical properties at a room
temperature and after thermal aging, a cross-linking degree,
Hot and cross-linking behavior (MH and scorch time) and the
test results are shown in Table 1.

10

[Example 13]

The same as Example 1, except that a cross-linkable polyolefin
composition was prepared using 0.2 parts by weight of 4,4'-
thiobis(3-methyl-6-tert-butylphenol), 0.3 parts by weight of
15 tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-
hydrocinnamate)]methane instead of 4,6-bis(octylthiobutyl)-o-
cresol and 0.3 parts by weight of 2,4-diphenyl-4-methyl-1-
pentene which are antioxidants. After then, tests were made
for water tree property, mechanical properties at a room
20 temperature and after thermal aging, a cross-linking degree,
Hot and cross-linking behavior (MH and scorch time) and the
test results are shown in Table 1.

[Example 14]

25 The same as Example 1, except that a cross-linkable polyolefin

composition was prepared using 0.15 parts by weight of 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-propionate instead of 4,6-bis(octylthiobutyl)-o-cresol which is an antioxidant. After then, tests were made for water tree
5 property, mechanical properties at a room temperature and after thermal aging, a cross-linking degree, Hot and cross-linking behavior (MH and scorch time) and the test results are shown in Table 1.

10 [Example 15]

The same as Example 1, except that a cross-linkable polyolefin composition was prepared using 0.2 parts by weight of 4,4'-thiobis(3-methyl-6-tert-butylphenol) and 0.1 parts by weight of 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-
15 propionate instead of 4,6-bis(octylthiobutyl)-o-cresol which are antioxidants. After then, tests were made for water tree property, mechanical properties at a room temperature and after thermal aging, a cross-linking degree, Hot and cross-linking behavior (MH and scorch time) and the test results are
20 shown in Table 1.

[Example 16]

The same as Example 1, except that a cross-linkable polyolefin composition was prepared using 0.2 parts by weight of 4,4'-
25 thiobis(3-methyl-6-tert-butylphenol) and 0.3 parts by weight

of 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-
propionate instead of 4,6-bis(octylthiobutyl)-o-cresol which
are antioxidants. After then, tests were made for water tree
property, mechanical properties at a room temperature and
5 after thermal aging, a cross-linking degree, Hot and cross-
linking behavior (MH and scorch time) and the test results are
shown in Table 1.

[Example 17]

10 The same as Example 1, except that a cross-linkable polyolefin
composition was prepared using 0.2 parts by weight of 4,4'-
thiobis(3-methyl-6-tert-butylphenol), 0.1 parts by weight of
2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-
propionate instead of 4,6-bis(octylthiobutyl)-o-cresol and
15 0.15 parts by weight of 2,4-diphenyl-4-methyl-1-pentene which
are antioxidants. After then, tests were made for water tree
property, mechanical properties at a room temperature and
after thermal aging, a cross-linking degree, Hot and cross-
linking behavior (MH and scorch time) and the test results are
20 shown in Table 1.

[Example 18]

The same as Example 1, except that a cross-linkable polyolefin
composition was prepared using 0.2 parts by weight of 4,4'-
25 thiobis(3-methyl-6-tert-butylphenol), 0.1 parts by weight of

2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-
propionate instead of 4,6-bis(octylthiobutyl)-o-cresol and 0.3
parts by weight of 2,4-diphenyl-4-methyl-1-pentene which are
antioxidants. After then, tests were made for water tree
5 property, mechanical properties at a room temperature and
after thermal aging, a cross-linking degree, Hot and cross-
linking behavior (MH and scorch time) and the test results are
shown in Table 1.

10 [Example 19]

The same as Example 1, except that a cross-linkable polyolefin
composition was prepared using 0.2 parts by weight of 4,4'-
thiobis(3-methyl-6-tert-butylphenol), 0.3 parts by weight of
2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-
15 propionate instead of 4,6-bis(octylthiobutyl)-o-cresol and
0.15 parts by weight of 2,4-diphenyl-4-methyl-1-pentene which
are antioxidants. After then, tests were made for water tree
property, mechanical properties at a room temperature and
after thermal aging, a cross-linking degree, Hot and cross-
20 linking behavior (MH and scorch time) and the test results are
shown in Table 1.

[Example 20]

The same as Example 1, except that a cross-linkable polyolefin
25 composition was prepared using 0.2 parts by weight of 4,4'-

thiobis(3-methyl-6-tert-butylphenol), 0.3 parts by weight of
2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-
propionate instead of 4,6-bis(octylthiobutyl)-o-cresol and 0.3
parts by weight of 2,4-diphenyl-4-methyl-1-pentene which are
5 antioxidants. After then, tests were made for water tree
property, mechanical properties at a room temperature and
after thermal aging, a cross-linking degree, Hot and cross-
linking behavior (MH and scorch time) and the test results are
shown in Table 1.

10

[Comparative Example 1]

Preparation of a cross-linkable polyolefin composition is the
same as Example 1, except for using 0.2 parts by weight of
4,4'-thiobis(3-methyl-6-tert-butylphenol) which is an
15 antioxidant, no 4,6-bis(octylthiobutyl)-o-cresol and no
polyethylene glycol. After then, tests were made for water
tree property, mechanical properties at a room temperature and
after thermal aging, a cross-linking degree, Hot and cross-
linking behavior (MH and scorch time) and the test results are
20 shown in Table 1.

[Comparative Example 2]

Preparation of a cross-linkable polyolefin composition is the
same as Example 1, except for using 0.2 parts by weight of
25 4,4'-thiobis(3-methyl-6-tert-butylphenol) which is an

antioxidant, 0.3 parts by weight of polyethylene glycol and no
4,6-bis(octylthiobutyl)-o-cresol. After then, tests were made
for water tree property, mechanical properties at a room
temperature and after thermal aging, a cross-linking degree,
5 Hot and cross-linking behavior (MH and scorch time) and the
test results are shown in Table 1.

[Comparative Example 3]

Preparation of a cross-linkable polyolefin composition is the
10 same as Example 1, except for using 0.2 parts by weight of
4,4'-thiobis(3-methyl-6-tert-butylphenol) which is an
antioxidant and no 4,6-bis(octylthiobutyl)-o-cresol. After
then, tests were made for water tree property, mechanical
properties at a room temperature and after thermal aging, a
15 cross-linking degree, Hot and cross-linking behavior (MH and
scorch time) and the test results are shown in Table 1.

[Comparative Example 4]

Preparation of a cross-linkable polyolefin composition is the
20 same as Example 1, except for using 0.2 parts by weight of
4,4'-thiobis(3-methyl-6-tert-butylphenol) which is an
antioxidant, 1.0 parts by weight of polyethylene glycol and no
4,6-bis(octylthiobutyl)-o-cresol. After then, tests were made
for water tree property, mechanical properties at a room
25 temperature and after thermal aging, a cross-linking degree,

Hot and cross-linking behavior (MH and scorch time) and the test results are shown in Table 1.

[Comparative Example 5]

5 Preparation of a cross-linkable polyolefin composition is the same as Example 1, except for using 0.3 parts by weight of 4,4'-thiobis(3-methyl-6-tert-butylphenol) which is an antioxidant and no 4,6-bis(octylthiobutyl)-o-cresol. After then, tests were made for water tree property, mechanical
10 properties at a room temperature and after thermal aging, a cross-linking degree, Hot and cross-linking behavior (MH and scorch time) and the test results are shown in Table 1.

[Comparative Example 6]

15 Preparation of a cross-linkable polyolefin composition is the same as Example 1, except for using 0.5 parts by weight of 4,4'-thiobis(3-methyl-6-tert-butylphenol) which is an antioxidant and no 4,6-bis(octylthiobutyl)-o-cresol. After then, tests were made for water tree property, mechanical
20 properties at a room temperature and after thermal aging, a cross-linking degree, Hot and cross-linking behavior (MH and scorch time) and the test results are shown in Table 1.

[Table 1]

		Examp le 1	Examp le 2	Examp le 3	Examp le 4	Examp le 5	Examp le 6	Examp le 7
* ¹ LDPE		100	100	100	100	100	100	100
* ² DCP		2.0	2.0	2.0	2.0	2.0	2.0	2.0
* ³ Antioxidant		0.15	0.2	0.2	0.2	0.2	0.2	0.2
* ⁴ Antioxidant		0.15	0.1	0.2	0.1	0.1	0.2	0.2
* ⁵ Antioxidant		-	-	-	-	-	-	-
* ⁶ Antioxidant		-	-	-	-	-	-	-
* ⁷ DMP		-	-	-	0.15	0.3	0.15	0.3
* ⁸ PEG		0.7	0.7	0.7	0.7	0.7	0.7	0.7
* ⁹ The length of water tree (μm)		295	290	300	280	315	290	300
* ¹⁰ RWTG		10.8	10.8	10.7	11.4	10.1	10.8	10.7
Tensile strength at a room temp erat ure	Tensi le stren gth (kg/c m ²)	205	200	210	205	210	200	215
	Elong ation ratio (%)	510	500	510	510	510	510	510

* ¹¹ Te nsil e stre ngth afte r ther mal agin g	Tensi le stren gth (kg/c m ²)	More than 75	More than 75	More than 75	More than 75	More than 75	More than 75	More than 75
	Elong ation ratio (%)	More than 75	More than 75	More than 75	More than 75	More than 75	More than 75	More than 75
Cross- linking degree (%)		84	81.5	80.2	81.8	82.7	80.9	81.6
Hot (%)		65	70	75	62	57	72	64
* ¹² Scorch time (Minutes)		78	80	82	81	83	83	85
* ¹³ MH		5.3	5.0	4.5	5.16	5.3	4.71	4.9

	Exempl e 8	Exempl e 9	Exempl e 10	Exempl e 11	Exempl e 12	Exempl e 13
* ¹ LDPE	100	100	100	100	100	100

* ² DCP		2.0	2.0	2.0	2.0	2.0	2.0
* ³ Antioxidant		0.2	0.2	0.2	0.2	0.2	0.2
* ⁴ Antioxidant		-	-	-	-	-	-
* ⁵ Antioxidant		0.1	0.3	0.1	0.1	0.3	0.3
* ⁶ Antioxidant		-	-	-	-	-	-
* ⁷ DMP		-	-	0.15	0.3	0.15	0.3
* ⁸ PEG		0.7	0.7	0.7	0.7	0.7	0.7
* ⁹ The length of water tree (μm)		290	300	280	315	295	300
* ¹⁰ RWTG		10.8	10.7	11.4	10.1	10.8	10.7
Tensi le stren gth at a room tempe ratur e	Tensil e streng th (kg/cm^2)	200	210	200	200	205	210
	Elonga tion ratio (%)	510	510	510	510	510	510

* ¹¹ Tensile strength after thermal aging	Tensile strength (kg/cm ²)	More than 75	More than 75	More than 75	More than 75	More than 75	More than 75
	Elongation ratio (%)	More than 75	More than 75	More than 75	More than 75	More than 75	More than 75
Cross-linking degree (%)		84	81.4	84	85	81.7	82.6
Hot (%)		50	60	47	46	54	51
* ¹² Scorch time (Minutes)		75	80	77	78	81	82
* ¹³ MH		5.79	5.42	5.93	6.14	5.55	5.78

	Examp le 14	Examp le 15	Examp le 16	Examp le 17	Examp le 18	Examp le 19	Examp le 20
* ¹ LDPE	100	100	100	100	100	100	100
* ² DCP	2.0	2.0	2.0	2.0	2.0	2.0	2.0
* ³ Antioxidant	0.15	0.2	0.2	0.2	0.2	0.2	0.2
* ⁴ Antioxidant	-	-	-	-	-	-	-
* ⁵ Antioxidant	-	-	-	-	-	-	-

[illegible]

r ther mal agin g	Elong ation ratio (%)	More than 75	More than 75	More than 75	More than 75	More than 75	More than 75	More than 75
Cross- linking degree (%)		83	81.5	80	82.3	83.5	80.6	81.3
Hot (%)		55	63	70	54	50	57	61
* ¹² Scorch time (Minutes)		76	76	78	78	80	83	86
* ¹³ MH		5.78	5.55	4.93	5.72	5.85	5.2	5.4

	Compar ative Exempl e 1	Compar ative Exempl e 2	Compar ative Exempl e 3	Compar ative Exempl e 4	Compar ative Exempl e 5	Compar ative Exempl e 6
* ¹ LDPE	100	100	100	100	100	100
* ² DCP	2.0	2.0	2.0	2.0	2.0	2.0
* ³ Antioxidant	0.2	0.2	0.2	0.2	0.3	0.5
* ⁴ Antioxidant	-	-	-	-	-	-
* ⁵ Antioxidant	-	-	-	-	-	-
* ⁶ Antioxidant	-	-	-	-	-	-

* ⁷ DMP		-	-	-	0.15	0.3	0.15
* ⁸ PEG		0	0.3	0.7	1.0	0.7	0.7
* ⁹ The length of water tree (μm)		950	570	310	220	300	290
* ¹⁰ RWTG		3.4	5.6	10.3	14.5	10.7	11
Tensi le stren gth at a room tempe ratur e	Tensil e streng th (kg/cm^2)	205	205	210	210	200	205
	Elonga tion ratio (%)	510	500	510	510	510	510
* ¹¹ Ten sile stren gth after therm	Tensil e streng th (kg/cm^2)	More than 75	More than 75	More than 75	Less than 75	More than 75	More than 75

al aging	Elonga tion ratio (%)	More than 75	More than 75	Less than 75	Less than 75	More than 75	More than 75
Cross-linking degree (%)		85	84.7	84	84	80	73
Hot (%)		55	56	55	57	75	125
*12 Scorch time (Minutes)		74	74	74	74	80	100
*13 MH		5.8	5.82	5.76	5.72	4.8	3.9

*1. Low Density Polyethylene: Product of Hanhwa Chemical Corporation

*2. Cross-linking agent: Dicumyl peroxide

*3. Antioxidant: 4,4'-thiobis(3-methyl-6-tert-butylphenol)

5 *4. Antioxidant: 4,6-bis(octylthiobutyl)-o-cresol

*5. Antioxidant: tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-hydrocinnamate)]methane

*6. Antioxidant: 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-propionate

10 *7. 2,4-diphenyl-4-methyl-1-pentene

*8. PEG: Polyethylene glycol having a molecular weight of 20,000

*9. water tree test condition

- applied voltage: 4.5kV/mm

15 - applied frequency: 1kHz

- concentration of salt water: 0.5M

- test period: 30days (720hours)

*10. Resistance to Water Tree Growth (RWTG): L/LWT

5 - L: Length from an end of a conical defect on a specimen
to the opposite surface of the
specimen

- LWT: The Length of the Water Tree

*11. Tensile property measured after thermal aging in an oven
at 150°C for 21days

10 *12 and 13. Measured at 180°C using MDR (Moving Disc Rheometer)

According to Table 1, in the cases of Comparative Examples 3,
5 and 6 using 4,4'-thiobis(3-methyl-6-tert-butylphenol) alone
which is an antioxidant in the state of containing all of
15 polyethylene homopolymer, and based on 100 parts by weight of
the polyethylene homopolymer, 2 parts by weight of dicumyl
peroxide which is a chemical cross-linking agent and 0.7 parts
by weight of PEG, it will be confirmed that if the usage
amount of the antioxidant is increased, the thermal-oxidative
20 stability and scorch resistance become better whereas the
cross-linking degree is markedly lowered from 84% to 73%.
However, Examples 1 to 3, 8, 9 and 14 to 16 using an
antioxidant according to the present invention or a mixture
including 4,4'-thiobis(2-tert-butyl-5-methylphenol) and at
25 least one selected from the group consisting of

tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-hydrocinnamate)]methane, 4,6-bis(octylthiobutyl)-o-cresol and 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-propionate exhibited high cross-linking degree of more than 5 80% as well as a superior thermal-oxidative stability even though the usage amount of the antioxidant is increased.

Meanwhile, in the cross-linkable polyethylene, though scorch resistance can be obtained by increasing the usage amount of the antioxidant, the increased usage of the antioxidant 10 results in a problem of decrease in the cross-linking degree. To solve the above mentioned problem, the present invention further used 2,4-diphenyl-4-methyl-1-pentene which is a cross-linking promoting agent and thus could obtain proper thermal stability and high cross-linking degree at the same time. As 15 can be appreciated from Examples 2, 4 and 6; Examples 3, 6 and 7; Examples 8, 10 and 11; Examples 9, 12 and 13; Examples 15, 17 and 18; Examples 16, 19 and 20, the cross-linking degree and scorch resistance were increased only by increasing formulating 2,4-diphenyl-4-methyl-1-pentene which is a cross- 20 linking promoting agent without increasing formulation of an antioxidant.

In addition, in the case of Examples 2 and 3, lowering in the cross-linking degree from 81.5% to 80.2% as well as MH from 5.0 to 4.5 is exhibited as increasing formulation of an 25 antioxidant, however in the case of Examples 6 and 7 in which

DMP which is a cross-linking promoting agent is formulated after the increasing formulation of an antioxidant, it can be appreciated that the cross-linking degree was increased to 80.9% and 81.6% and MH value is also increased to 4.71 and 4.9.

5 As such, it can be appreciated that lowering in the cross-linking degree as well as MH value is exhibited as described above in the cases of Examples 8 and 9; Example 15 and 16 in which the antioxidant is increasing formulated and increase in the cross-linking degree as well as MH value is exhibited in
10 the cases of Examples 12 and 13; Example 19 and 20 in which DMP as the cross-linking promoting agent is increasing formulated.

From the results showed in the above Examples and Comparative Examples, it can be appreciated that using , as an antioxidant,
15 a mixture including 4,4'-thiobis(2-tert-butyl-5-methylphenol) and at least one selected from the group consisting of tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-hydrocinnamate)]methane, 4,6-bis(octylthiobutyl)-o-cresol and 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-
20 propionate exhibited the superior thermal-oxidative stability and higher cross-linking degree than using 4,4'-thiobis(2-tert-butyl-5-methylphenol) alone, and the cross-linking degree and scorch resistance are increased only by increasing formulating 2,4-diphenyl-4-methyl-1-pentene (DMP) without
25 increasing formulation of an antioxidant by further using as a

cross-linking promoting agent 2,4-diphenyl-4-methyl-1-pentene.

【Industrial Applicability】

The tree resistant, cross-linkable polyolefin composition
5 according to the present invention has superior resistance
properties to occurrence and growth of water tree which causes
deterioration due to moisture, superior thermal-oxidative
stability and cross-linking property and thus is useful to be
adapted to insulate underground distribution cables having
10 superior long-life stability.

What is claimed is:

1. A tree resistant, cross-linkable polyolefin composition having superior water tree resistant property, thermal-oxidative stability and cross-linking property, comprising
 - i) 100 parts by weight of polyethylene; and based on 100 parts by weight of the polyethylene,
 - ii) 1 to 4 parts by weight of chemical cross-linking agent;
 - 10 iii) 0.3 to 0.63 parts by weight of antioxidant which is a mixture including 0.1 to 0.23 parts by weight of 4,4'-thiobis(2-tert-butyl-5-methylphenol) and 0.1 to 0.4 parts by weight of at least one selected from the group consisting of tetrakis[methylene(3,5-di-tert-butyl-4-hydroxyhydrocinnamate)]methane, 4,6-bis(octylthiobutyl)-o-cresol and 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]-propionate;
 - iv) 0.1 to 1.0 parts by weight of 2,4-diphenyl-4-methyl-1-pentene; and
 - 20 v) 0.3 to 1.0 parts by weight of polyethylene glycol having a number average molecular weight (Mn) in the range of 5000 to 50000.
2. The tree resistant, cross-linkable polyolefin composition having superior water tree resistant property, thermal-
- 25

oxidative stability and cross-linking property as set forth
claim 1, wherein the polyethylene is a homopolymer made by
polymerization under high temperature and high pressure by free
radical initiated reaction in a tubular or autoclave reactor, a
5 copolymer made by copolymerization of ethylene and comonomer by
using a Ziegler-Natta catalyst or a metallocene catalyst under
low temperature and low pressure or a copolymer of at least one
alpha olefin.

10 3. The tree resistant, cross-linkable polyolefin composition
having superior water tree resistant property, thermal-
oxidative stability and cross-linking property as set forth
claim 2, wherein the polyethylene has a density in the range of
0.800 to 0.935 g/cm³, a melt index in the range of 0.1 to 30
15 g/10min, Mw/Mn in the range of 2 to 15 and a weight average
molecular weight in the range of 50,000 to 300,000.

4. The tree resistant, cross-linkable polyolefin composition
having superior water tree resistant property, thermal-
20 oxidative stability and cross-linking property as set forth
claim 2, wherein the alpha olefin is at least one selected from
the group consisting of 1-butene, 1-hexene, 4-methyl-1-pentene
and 1-octene.

5. The tree resistant, cross-linkable polyolefin composition having superior water tree resistant property, thermal-oxidative stability and cross-linking property as set forth claim 1, wherein the chemical cross-linking agent is at least one organic peroxide selected from the group consisting of dicumyl peroxide, di-tert-butyl peroxide and di-tert-butyl peracetate.
6. The tree resistant, cross-linkable polyolefin composition having superior water tree resistant property, thermal-oxidative stability and cross-linking property as set forth claim 1, wherein a usage ratio of the 2,4-diphenyl-4-methyl-1-pentene and the antioxidant is 1:0.5 to 1:1.5.
7. A tree resistant, cross-linkable polyolefin composition having superior water tree resistant property, thermal-oxidative stability and cross-linking property, comprising
- i) 100 parts by weight of polyethylene; and based on 100 parts by weight of the polyethylene,
 - ii) 1 to 4 parts by weight of chemical cross-linking agent;
 - iii) 0.3 to 0.63 parts by weight of antioxidant which is a mixture including 0.1 to 0.23 parts by weight of 4,4'-thiobis(2-tert-butyl-5-methylphenol) and 0.1 to 0.4 parts by weight of at least one selected from the group consisting of

tetrakis[methylene(3,5-di-tert-butyl-4-hydroxy-hydrocinnamate)]methane, 4,6-bis(octylthiobutyl)-o-cresol and 2,2'-thiobis[ethyl-3-(3,5-di-tert-butyl-4-hydrophenyl)]propionate;and

- 5 iv) 0.3 to 1.0 parts by weight of polyethylene glycol having a number average molecular weight (Mn) in the range of 5000 to 50000.

8. The tree resistant, cross-linkable polyolefin composition
10 having superior water tree resistant property, thermal-oxidative stability and cross-linking property as set forth claim 7, wherein the polyethylene is a homopolymer made by polymerization under high temperature and high pressure by free radical initiated reaction in a tubular or autoclave reactor, a
15 copolymer made by copolymerization of ethylene and comonomer by using a Ziegler-Natta catalyst or a metallocene catalyst under low temperature and low pressure or a copolymer of at least one alpha olefin.

20 9. The tree resistant, cross-linkable polyolefin composition having superior water tree resistant property, thermal-oxidative stability and cross-linking property as set forth claim 8, wherein the polyethylene has a density in the range of 0.800 to 0.935 g/cm³, a melt index in the range of 0.1 to 30

g/10min, Mw/Mn in the range of 2 to 15 and a weight average molecular weight in the range of 50,000 to 300,000.

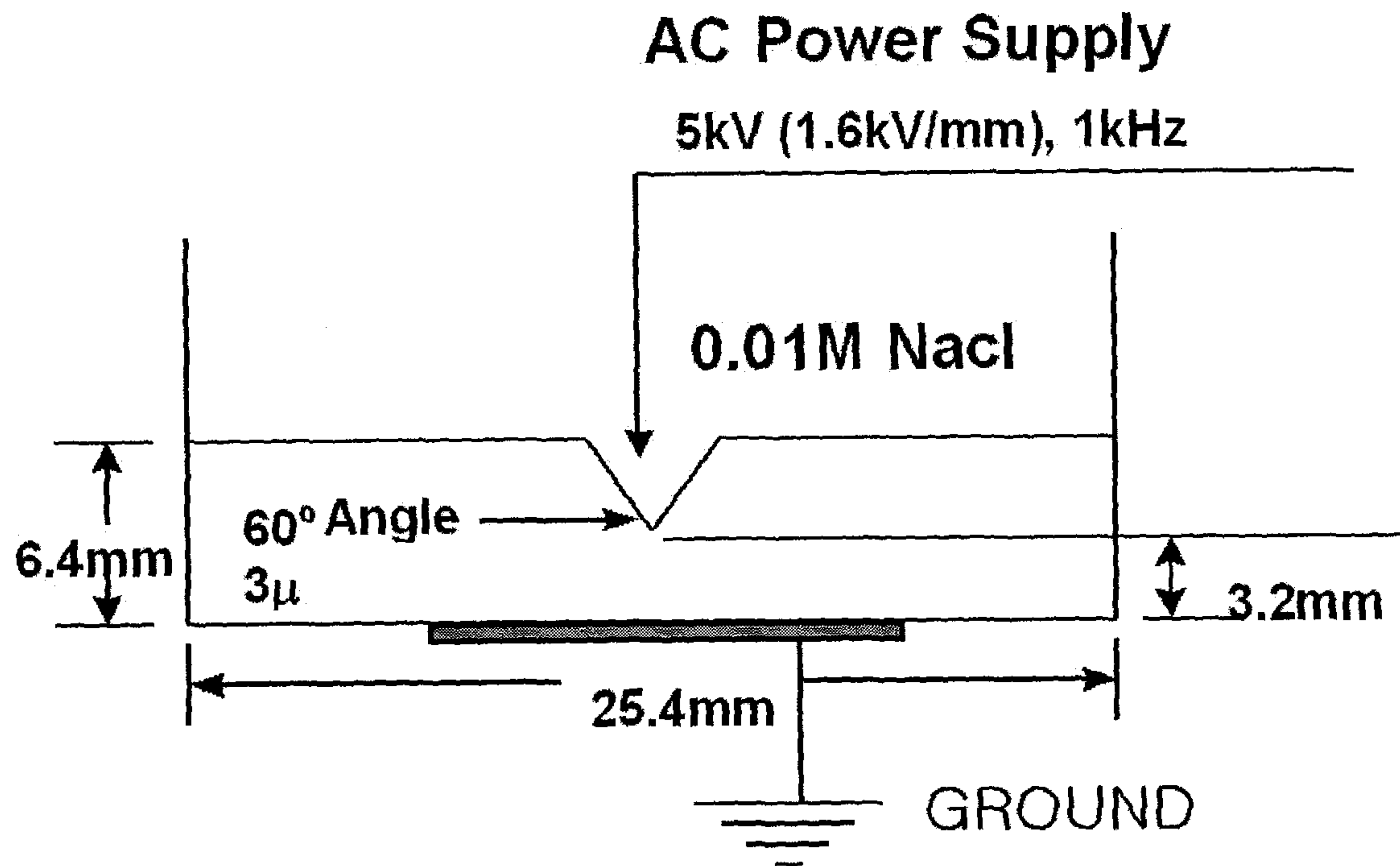
10. The tree resistant, cross-linkable polyolefin composition
5 having superior water tree resistant property, thermal-oxidative stability and cross-linking property as set forth claim 8, wherein the alpha olefin is at least one selected from the group consisting of 1-butene, 1-hexene, 4-methyl-1-pentene and 1-octene.

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11. The tree resistant, cross-linkable polyolefin composition
having superior water tree resistant property, thermal-oxidative stability and cross-linking property as set forth claim 7, wherein the chemical cross-linking agent is at least
15 one organic peroxide selected from the group consisting of dicumyl peroxide, di-tert-butyl peroxide and di-tert-butyl peracetate.

【DRAWINGS】

【Figure 1】



AC Power Supply

5kV (1.6kV/mm), 1kHz

