



EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
24.05.2023 Bulletin 2023/21

(21) Application number: **21915837.5**

(22) Date of filing: **29.12.2021**

(51) International Patent Classification (IPC):
D01F 6/04 (2006.01) **D01D 5/088** (2006.01)
D01D 5/098 (2006.01) **D02J 1/08** (2006.01)
D02G 3/44 (2006.01)

(52) Cooperative Patent Classification (CPC):
D01D 5/088; D01D 5/098; D01F 6/04; D02G 3/44;
D02J 1/08

(86) International application number:
PCT/KR2021/020200

(87) International publication number:
WO 2022/146040 (07.07.2022 Gazette 2022/27)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **30.12.2020 KR 20200188253**

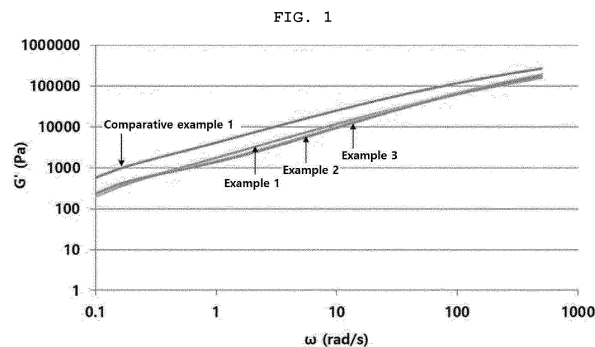
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(54) **CUT-RESISTANT POLYETHYLENE YARN**

(57) Provided is a cut-resistant polyethylene yarn, and more particularly, a cut-resistant polyethylene yarn which allows manufacture of a product having excellent cut resistance and providing excellent wearability.



Description

[Technical Field]

5 **[0001]** The following disclosure relates to a cut-resistant polyethylene yarn, and more particularly, to a cut-resistant polyethylene yarn which allows manufacture of a product having excellent cut resistance and providing excellent wearability.

[Background Art]

10 **[0002]** Those who work in high-risk industrial fields such as metal and glass working shops and butcher shops or those who work in the security and disaster fields such as police, military, or firefighters wear cut-resistant gloves or clothing in order to protect the human body from deadly weapons or sharp cutting tools such as knives.

15 **[0003]** In general, as a means of imparting cut resistance, products formed of high-strength spun yarn such as aramid fiber have been developed, but they do not have sufficient cut resistance to be used in the sites of a high-risk group. Meanwhile, various products using metallic yarn have also been developed, but they lack flexibility and may not be substantially applied to work sites where workers' hands are often used.

20 **[0004]** Thus, as disclosed in Japanese Patent Laid-Open Publication No. 2002-180324, a glove using polyethylene fiber having high elastic modulus and strength has been suggested, but since its cut resistance is not good enough to be substantially used in the industrial fields of a high risk group, its usability is poor.

25 **[0005]** In addition, polyethylene fiber (yarn) which has been developed with a focus only on strength improvement as such may provide a protective product with satisfactory cut resistance, but causes a serious problem of poor wearability. That is, protective gloves or clothing manufactured from polyethylene yarn is excessively stiff, so as to impede the wearer's movement (for example, in the case of the glove, finger movement) and reduce work efficiency. The uncomfortable wearability as such causes wearing of the protective product to be avoided, increasing the risk of injury.

[Related Art Documents]

[Patent Documents]

30 **[0006]** (Patent Document 1): Japanese Patent Laid-Open Publication No. 2002-180324

[Summary of Invention]

[Technical Problem]

35 **[0007]** An embodiment of the present invention is directed to providing a polyethylene yarn which allows manufacture of a product having excellent cut resistance and providing excellent wearability.

[Solution to Problem]

40 **[0008]** In one general aspect, a cut-resistant polyethylene yarn having the following properties is provided: in a graph of a storage modulus (G') according to an angular frequency (ω), the storage modulus of 50 Pa to 500 Pa at the angular frequency of 0.1 rad/s, and the storage modulus of 1000 Pa to 2000 Pa at the angular frequency of 1 rad/s; and in a graph of $\tan\delta$ according to an angular frequency (ω), an average gradient of -0.25 to 0.8 at the angular frequency of 0.2 rad/s to 5 rad/s.

45 **[0009]** In the cut-resistant polyethylene yarn according to an exemplary embodiment of the present invention, in the graph of $\tan\delta$ according to the angular frequency (ω), an inflection point may be shown at the angular frequency of 0.3 rad/s to 0.8 rad/s.

50 **[0010]** In the cut-resistant polyethylene yarn according to an exemplary embodiment of the present invention, in the graph of $\tan\delta$ according to the angular frequency (ω), $\tan\delta$ may be 1.5 to 7 at the angular frequency of 0.1 rad/s.

[0011] In the cut-resistant polyethylene yarn according to an exemplary embodiment of the present invention, in the graph of $\tan\delta$ according to the angular frequency (ω), a local minimum may be shown in a section of the angular frequency of 0.1 rad/s to 0.5 rad/s, and a $\tan\delta$ value may be 100 rad/s to 300 rad/s at the angular frequency of 0.8 rad/s to 1.2 rad/s.

55 **[0012]** In the cut-resistant polyethylene yarn according to an exemplary embodiment of the present invention, in a graph of a loss modulus (G'') according to the angular frequency (ω), a loss modulus may be 400 Pa to 1000 Pa at the angular frequency of 0.1 rad/s.

[0013] In the cut-resistant polyethylene yarn according to an exemplary embodiment of the present invention, in the

graph of a complex viscosity (η^*) according to the angular frequency (ω), the complex viscosity may be 4500 Pa·s to 8000 Pa·s at the angular frequency of 0.1 rad/s, and a gradient may be -2000 to -3000 in a section of the angular frequency of 0.1 rad/s to 1 rad/s.

[0014] In the cut-resistant polyethylene yarn according to an exemplary embodiment of the present invention, in a graph of a phase angle according to a multiple shear modulus (G^*), the phase angle may be 60 to 80° at the multiple shear modulus (G^*) of 350 to 1000 Pa.

[0015] In another general aspect, a cut-resistant fabric includes the cut-resistant polyethylene yarn as described above.

[0016] The cut-resistant fabric according to an exemplary embodiment of the present invention may have a cutting Force of 5.5 N or more as measured according to the standard of ISO13997:1999.

[0017] In still another general aspect, a protective product includes the cut-resistant fabric described above.

[0018] The protective product according to an exemplary embodiment of the present invention may be a cut-resistant glove.

[Advantageous Effects of Invention]

[0019] Since the cut-resistant polyethylene yarn according to the present invention has excellent cut resistance, it allows manufacture of fiber products which may be substantially applied to industrial and disaster sites of a high risk group.

[0020] In addition, the cut-resistant polyethylene yarn according to the present invention allows manufacture of products having excellent wearability.

[Brief Description of Drawings]

[0021] FIGS. 1 to 5 are graphs of results of measuring rheological properties of the cut-resistant polyethylene yarn according to an exemplary embodiment of the present invention.

[Description of Embodiments]

[0022] Technical terms and scientific terms used in the present specification have the general meaning understood by those skilled in the art to which the present invention pertains unless otherwise defined, and a description for the known function and configuration obscuring the gist of the present invention will be omitted in the following description and the accompanying drawings.

[0023] In addition, the singular form used in the present specification may be intended to also include a plural form, unless otherwise indicated in the context.

[0024] In addition, units used in the present specification without particular mention are based on weights, and as an example, a unit of % or ratio refers to a wt% or a weight ratio and wt% refers to wt% of any one component in a total composition, unless otherwise defined.

[0025] In addition, the numerical range used in the present specification includes all values within the range including the lower limit and the upper limit, increments logically derived in a form and span in a defined range, all double limited values, and all possible combinations of the upper limit and the lower limit in the numerical range defined in different forms. Unless otherwise defined in the specification of the present invention, values which may be outside a numerical range due to experimental error or rounding of a value are also included in the defined numerical range.

[0026] The term "comprise" in the present specification is an open-ended description having a meaning equivalent to the term such as "is/are provided", "contain", "have", or "is/are characterized", and does not exclude elements, materials, or processes which are not further listed.

[0027] Cut resistance means durability against cuts by a blade of a knife or an object with sharp portions such as a blade, and those who work in high-risk industrial fields such as metal and glass working shops and butcher shops or those who work in the security and disaster fields such as police, military, or firefighters wear cut-resistant gloves or clothing in order to protect the human body from deadly weapons or sharp cutting tools such as knives.

[0028] Conventionally, a cut-resistant fiber product using a polyethylene yarn having high elastic modulus and strength has been developed, but since its cut resistance is not good enough to be used substantially in the industrial fields of a high risk group, its usability is poor.

[0029] In addition, the polyethylene yarn (fiber) which has been developed with a focus only on strength improvement may cause a serious problem of reduced wearability. That is, the protective glove or clothing manufactured from the polyethylene yarn is excessively stiff, so as to impede the wearer's movement (for example, in the case of the glove, finger movement) and reduce work efficiency, and the uncomfortable wearability as such causes wearing of the protective product to be avoided, increasing the risk of injury.

[0030] Thus, the present applicant intensively conducted a study for a long time in order to develop a polyethylene yarn having excellent cut resistance, and as a result, found that a yarn having specific rheological properties allows

manufacture of a product having excellent cut resistance and providing excellent wearability, and thus, deepened the study, thereby completing the present invention.

[0031] In the present specification, the polyethylene yarn may include a plurality of filaments. As an example, the polyethylene yarn may include 40 to 500 filaments each having a fineness of 1 to 3 denier, and may have a total fineness of 100 to 1,000 denier.

[0032] In the present specification, rheological properties refer to a storage modulus (G'), a loss modulus (G''), $\tan\delta$, a complex viscosity (η^*), and a phase angle ($^\circ$).

[0033] In the present invention, unless otherwise defined, the rheological properties refer to those measured using DHR-2 (TA Instrument), and a geometry used in the measurement measures a storage modulus (G'), a loss modulus (G''), $\tan\delta$, a complex viscosity (η^*), and a phase angle ($^\circ$) depending on an angular velocity change, measured with a plate-plate (parallel plate, PP). Unless otherwise defined, the rheological properties may be measured at a temperature of 250°C under a nitrogen atmosphere, and a measurement specification (sample dimension) may be a diameter of 25 mm, a gap point of 1.0 mm, and a strain of 10%.

[0034] The cut-resistant polyethylene yarn may have the following properties: in a graph of a storage modulus (G') according to an angular frequency (ω), the storage modulus of 50 Pa to 500 Pa at the angular frequency of 0.1 rad/s, and the storage modulus of 1000 Pa to 2000 Pa at the angular frequency of 1 rad/s; and in a graph of $\tan\delta$ according to an angular frequency (ω), an average gradient of -0.25 to 0.8 at the angular frequency of 0.2 rad/s to 5 rad/s, and the polyethylene yarn as such allows manufacture of a product excellent wearability as well as excellent cut resistance.

[0035] The cut resistance of a product including the polyethylene yarn according to the present invention may be determined by not only the strength of the polyethylene yarn but also slippage of the polyethylene yarn, that is, a characteristic in which when a sharp tool such as a blade of a knife passes over the polyethylene yarn, the tool slides along the surface without being caught in the yarn, and rolling of yarns, that is, a characteristic in which when a sharp tool such as a blade of a knife passes over the yarn, the yarn is twisted or curled around the longitudinal axis of the yarn.

[0036] The polyethylene yarn of the present invention has the above ranges in the graphs of the storage modulus and $\tan\delta$ according to the angular frequency, thereby allowing manufacture of a product having excellent slippage and rolling characteristics and having excellent cut resistance.

[0037] Specifically, the polyethylene yarn may have, in the graph of the storage modulus according to the angular frequency, the storage modulus of 100 Pa to 300 Pa, more specifically 150 Pa to 250 Pa at the angular frequency of 0.1 rad/s, and the storage modulus of 1200 Pa to 1800 Pa at the angular frequency of 1 rad/s.

[0038] In addition, in the graph of the storage modulus according to the angular frequency, when the angular frequency (ω) and the loss modulus (G'') values are converted into logarithmic values, the average gradient of the storage modulus ($\log G'$) may be 0.8 to 1 in the section of the angular frequency ($\log \omega$) of 0 to 1 rad/s.

[0039] The yarn having the physical properties as such may show sufficient elasticity to have cut resistance and have relatively excellent strength. Specifically, when the storage modulus is higher than the above range, the strength is improved but stiffness is also raised, and thus, when a fabric is manufactured by weaving or braiding, the fabric is stiff, so that it is difficult to process the fabric into a desired product and a product wearer may feel uncomfortable.

[0040] The polyethylene yarn may have, in the graph of $\tan\delta$ according to the angular frequency (ω), the average gradient of specifically -0.1 to 0.2 in the section of the angular frequency of 0.2 rad/s to 5 rad/s. That is, in the graph of $\tan\delta$ according to the angular frequency (ω), the present invention has a relatively low gradient value. This means that the polyethylene yarn as such maintains a ratio of the storage modulus (G') showing elasticity and the loss modulus (G'') showing viscosity in the section of a low angular frequency, and by having such rheological properties, the polyethylene yarn may have low entanglement between high molecular chains, and excellent slippage and rolling properties.

[0041] In addition, according to an exemplary embodiment of the present invention, the polyethylene yarn may have, in the graph of $\tan\delta$ according to the angular frequency (ω), an inflection point at the angular frequency of 0.3 rad/s to 0.8 rad/s, specifically, 0.4 rad/s to 0.7 rad/s. By having the inflection point in the range of the angular frequency, $\tan\delta$ may have both a local minimum and a local maximum. Specifically, even in the case in which there is a certain degree of entanglement between high molecular chains or gel, the viscous and elastic behaviors of high molecular chains are reversed in a narrow range of the angular frequency, whereby the entanglement between high molecular chains or gel may be preferably oriented in a flowing direction. Having no inflection point in a range of a high angular frequency and having an inflection point in a range of a low angular frequency mean that entanglement between high molecular chains or gel is easily oriented in a flowing direction even at a low shear stress, and thus, the entanglement between high molecular chains or gel present in the polyethylene yarn does not act as a defect and imparts local toughness to the high molecular chains to show better rolling characteristics and cut resistance.

[0042] Here, the present invention may have, in the graph of $\tan\delta$ according to the angular frequency (ω), $\tan\delta$ of 1.5 to 7, specifically 2 to 5 at the angular frequency of 0.1 rad/s, but is not limited thereto.

[0043] More specifically, in the graph of $\tan\delta$ according to the angular frequency (ω), a local minimum may be shown in a section of the angular frequency of 0.1 rad/s to 0.5 rad/s, specifically 0.1 rad/s to 0.3 rad/s, and a local maximum may be shown in a section of the angular frequency of 0.7 rad/s to 8 rad/s, specifically 1 rad/s to 4 rad/s.

[0044] The angular frequency at a $\tan\delta$ value of 0.8 to 1.2 may be 100 to 300 rad/s, specifically 150 to 250 rad/s. Since the section of the angular frequency with the $\tan\delta$ value of 1 is relatively large, the viscosity is better than the viscosity of the polyethylene yarn commonly used in the art, and the polyethylene yarn may have substantially no entanglement between polyethylene high molecular chains and have excellent high molecular chain arrangement. Since the yarn as such has excellent arrangement between high molecular chains, it allows manufacture of a fabric having better slippage and rolling characteristics. The fabric manufactured from the yarn as such has excellent cut resistance, thereby preventing damage of fabric by pilling in which lint occurs of even when repeated external force is applied by a blade of a knife or a sharp object.

[0045] The yarn of the present invention may have, in the graph of the loss modulus (G'') according to the angular frequency (ω), the loss modulus of 400 Pa to 1000 Pa, specifically 500 Pa to 700 Pa at the angular frequency of 0.1 rad/s, and the average gradient of 2000 to 4000, specifically 3000 to 3800 in the section of the angular frequency of 0.1 rad/s to 1 rad/s.

[0046] In addition, in the graph of the loss modulus according to the angular frequency, when the angular frequency (ω) and the loss modulus (G'') values are converted into logarithmic values, the average gradient of the loss modulus ($\log G''$) may be 0.66 to 0.8 in the section of the angular frequency ($\log \omega$) of 0 to 1 rad/s.

[0047] In addition, the yarn of the present invention may have, in the graph of the complex viscosity (η^*) according to the angular frequency (ω), the complex viscosity of 4500 Pa·s to 8000 Pa·s, specifically 5000 Pa·s to 7000 Pa·s at the angular frequency of 0.1 rad/s, and the gradient of -2000 to -3000, specifically -2100 to -2700 in the section of the angular frequency of 0.1 rad/s to 1 rad/s.

[0048] In addition, the present invention may have, in the graph of the phase angle according to the multiple shear modulus (G^*), the phase angle of 60 to 80°, specifically 65 to 75° at the multiple shear modulus (G^*) of 350 to 1000 Pa.

[0049] By having the loss modulus and the complex viscosity as such, the yarn of the present invention may have a melt viscosity allowing easy melt spinning and may suppress defect occurrence by a spinning process.

[0050] The polyethylene yarn of the present invention may have a weight average molecular weight (M_w) of 80,000 g/mol to 180,000 g/mol, specifically, 100,000 g/mol to 170,000 g/mol, and more specifically, 120,000 g/mol to 160,000 g/mol, but is not limited thereto.

[0051] In addition, the polyethylene yarn may be a high-density polyethylene (HDPE) having a density of 0.941 to 0.965 g/cm³, and a crystallinity of 55 to 85%, preferably 60 to 85%.

[0052] In addition, the polyethylene yarn of the present invention may have a polydispersity index (PDI). The polydispersity index (PDI) is a ratio (M_w/M_n) of a weight average molecular weight (M_w) to a number average molecular weight (M_n), and is also referred to as a molecular weight distribution index (MWD). When PDI is less than 5, flowability is not good due to a relatively narrow molecular weight distribution and has poor processability at the time of melt extrusion, resulting in thread trimming due to non-uniform discharge. On the contrary, when PDI is more than 9, melt flowability and processability at the time of melt extrusion are better due to a large molecular weight distribution, but a low molecular weight polyethylene is included too much, which may reduce tensile strength.

[0053] The polyethylene yarn of the present invention as such may have a tensile strength of 3.5 to 8.5 g/de, a tensile modulus of 15 to 80 g/de, and an elongation at break of 14 to 55%. When the tensile strength is more than 8.5 g/de, the tensile modulus is more than 80 g/de, or the elongation at break is less than 14%, wearability of the polyethylene yarn is not good, and the fabric manufactured using the yarn is excessively stiff, causing a user to feel uncomfortable. On the contrary, when the tensile strength is less than 3.5 g/de, the tensile modulus is less than 15 g/de, or the elongation at break is more than 55%, lint is formed on the fabric manufactured from the polyethylene yarn when the fabric is continuously used by a user.

[0054] The polyethylene yarn of the present invention may have a circular cross-section or a non-circular cross-section, but it is preferred to have a circular cross-section for excellent slippage characteristics.

[0055] In addition, the polyethylene yarn of the present invention may have a strength of 11 g/d or more, specifically 13 g/d or more so that the product manufactured using the yarn has a cutting Force of 5 or more.

[0056] A method of manufacturing yarn of the present invention is not limited as long as it is a method of manufacturing yarn using polyethylene known in the art. As a specific example, the yarn may be manufactured by including: melting polyethylene chips to obtain polyethylene melt; extruding the polyethylene melt by a spinneret having a plurality of nozzle holes; cooling a plurality of filaments formed when the polyethylene melt is discharged from nozzle holes; sizing the plurality of cooled filaments to form a multifilament yarn; drawing the multifilament yarn at a total drawing ratio of 5 to 20 times and heat setting the drawn multifilament yarn; and winding the drawn multifilament yarn. Here, the drawing step is performed by multi-stage drawing, and a relaxation ratio at the last stage drawing in the multi-stage drawing may be 3% to 8% or less, but is not limited thereto. The relaxation ratio at the last stage drawing refers to a relaxation ratio at the time of drawing which is finally performed after the drawing and before the winding.

[0057] The polyethylene melt is transported to a spinneret having a plurality of nozzle holes by a screw in an extruder, and then is extruded through the nozzle holes. The number of holes of the spinneret may be set depending on the denier per filament (DPF) and the total fineness of the yarn to be manufactured. As a specific example, in order to manufacture

a yarn of 1 to 3 DPF having a total fineness of 100 to 1,000 denier, a spinneret 200 may have 40 to 500 nozzle holes.

[0058] The melting process in the extruder and the extrusion process by the spinneret may be performed at 150 to 315°C, preferably 250 to 315°C, and more preferably 260 to 290°C. When the spinning temperature is lower than 150°C, polyethylene chips are not melted uniformly due to the low spinning temperature, so that the spinning may be difficult. However, when the spinning temperature is higher than 315°C, thermal decomposition of polyethylene occurs, so that high strength expression may be difficult.

[0059] Filaments may be cooled in an air cooling manner. For example, the filaments may be cooled at 15 to 40°C, using a cooling air at a wind speed of 0.2 to 1 m/sec. When the cooling temperature is lower than 15°C, elongation is insufficient due to supercooling so that breakage may occur in a subsequent drawing process, and when the cooling temperature is higher than 40°C, a fineness deviation between filaments is increased due to solidification unevenness and breakage may occur in the drawing process.

[0060] Before the multifilament yarn is formed, in the present invention, an oiling process of imparting an oil agent to the cooled filaments using an oil roller (OR) or an oil jet may be further performed. The oil agent impartment step may be performed by a metered oiling (MO) method.

[0061] In addition, before the multifilament yarn is wound on a winder, an interlacing process by an interlacing device may be further performed in order to improve sizing and weaving of the polyethylene yarn.

[0062] The polyethylene yarn manufactured by the method is braided or woven to manufacture a fabric having cut resistance.

[0063] Specifically, the polyethylene fabric of the present invention may be knitted into a covered yarn. The covered yarn is not limited as long as it contains the polyethylene yarn of the present invention, but as an example, may be formed by including the polyethylene yarn of the present invention, a polyurethane yarn (e.g., Spandex) which spirally surrounds the polyethylene yarn, and a polyamide yarn (e.g., nylon 6 or nylon 66) which spirally surrounds the polyethylene yarn. Depending on the properties of the product to be desired, a polyester yarn (e.g., PET yarn) may be included instead of the polyamide yarn.

[0064] Here, the polyethylene yarn may have a weight of 45 to 85% of the total weight of the covered yarn, the polyurethane yarn may have a weight of 5 to 30% of the total weight of the covered yarn, and the polyamide or polyester yarn may have a weight of 5 to 30% of the total weight of the covered yarn, but are not limited thereto.

[0065] Meanwhile, the fabric of the present invention may be a woven fabric or a knitted fabric having a weight per unit area (that is, surface density) of 150 to 800 g/m². When the fabric has a surface density of less than 150 g/m², fabric compactness is insufficient and many pores exist in the fabric, and these pores reduces the cut resistance of the fabric. However, when the fabric has a surface density of more than 800 g/m², the fabric is very stiff due to the excessively dense structure of the fabric, problems with a user's tactile sensation occur, and problems in use are caused due to its high weight.

[0066] The fabric as such may be processed into a product requiring excellent cut resistance. The product may be any conventional fiber product, but preferably, may be protective gloves or clothing for performing a protective function for the human body.

[0067] The protective product of the present invention has an excellent cutting force of 5 N or more, more preferably 5.5 N to 8.5 N, and also has a low stiffness of 5 gf or less, more preferably 2 to 5 gf, thereby showing excellent wearability.

[0068] Hereinafter, the present disclosure will be described in more detail through the following examples. However, the following exemplary embodiments are only a reference for describing the present invention in detail, and the present invention is not limited thereto, and may be implemented in various forms.

[0069] In addition, unless otherwise defined, all technical terms and scientific terms have the same meanings as those commonly understood by a person skilled in the art to which the present invention pertains. The terms used herein are only for effectively describing a certain exemplary embodiment, and not intended to limit the present invention. Further, unless otherwise stated, the unit of added materials herein may be wt%.

<Measurement Example>

[0070] The rheological properties were measured using DHR-2 (TA Instrument), and a geometry used in the measurement was a storage modulus (G'), a loss modulus (G''), tanδ, a complex viscosity (η*), and a phase angle (°) depending on an angular velocity change, measured with a plate-plate (parallel plate, PP). The measurement was performed at a temperature of 250°C under a nitrogen atmosphere, and a sample dimension was measured at a diameter of 25 mm, a gap point of 1.0 mm, and a strain of 10%.

[0071] Graphs of results of measuring the rheological properties of the examples and the comparative examples are shown in the following FIGS. 1 to 5.

[0072] Specifically, FIG. 1 shows results of measuring the storage modulus (G'), FIG. 2 shows results of measuring the loss modulus (G''), FIG. 3 shows results of measuring tanδ, FIG. 4 is results of measuring complex viscosity (η*), and FIG. 5 shows results of measuring the phase angle (°) of the examples and the comparative examples.

<Example 1>

[0073] A polyethylene multifilament interlaced yarn including 240 filaments and having a total fineness of 400 deniers was manufactured.

[0074] First, polyethylene chips were added to an extruder and melted. The polyethylene melt was extruded through a spinneret having 240 nozzle holes. The filaments formed by being discharged from the nozzle holes of the spinneret were cooled in a cooling unit, and were sized into a multifilament yarn by a sizer. Subsequently, the multifilament yarn was drawn in a drawing unit and heat-set.

[0075] The drawing step was performed in a multistage drawing, and a relaxation ratio at the last drawing stage of the multistage drawing was 8%. Subsequently, the drawn multifilament yarn was interlaced with an air pressure of 6.0 kgf/cm² in an interlacing device, and then wound on a winder. A winding tension was 0.6 g/d.

[0076] The rheological properties of the manufactured yarn were measured and are shown in the following Table 1 and FIGS. 1 to 5. In addition, the density, the weight average molecular weight, and PDI of the manufactured yarn were analyzed and are shown in the following Table 2.

[0077] Subsequently, the manufactured yarn was spirally surrounded by a polyurethane yarn of 140 denier (Spandex) and a nylon yarn of 140 denier, thereby manufacturing a covered yarn. The weight of the polyethylene yarn was 60% of the total weight of the covered yarn, and the weights of the polyurethane yarn and the nylon yarn were 20%, respectively, of the total weight of the covered yarn. The covered yarn was knitted to manufacture a protective glove.

[Table 1]

Classification		Example 1	Example 2	Example 3	Comparative Example 1
G'	G' value (Pa) ($\omega = 0.1$ rad/s)	194.6	196.6	233.1	568.3
	G' value (Pa) ($\omega = 1$ rad/s)	1732.5	1454.8	1374.2	4074.8
	Gradient (G') ($\omega = 0.1$ -1 rad/s)	1708.8	1398.1	1268	3896
	Gradient (logG') (log $\omega = 0$ -1 rad/s)	0.830	0.843	0.833	0.784
G''	G'' value (Pa) ($\omega = 0.1$ rad/s)	637	538	532	1445
	Gradient ($\omega = 0.1$ -1 rad/s)	3758.7	3449.0	3154.1	7486.9
	Gradient (logG'') (log $\omega = 0$ -1 rad/s)	0.696	0.773	0.777	0.651
tan δ	tan δ value ($\omega = 0.1$ rad/s)	3.2	2.8	2.3	2.5
	Gradient (in the section of $\omega = 0.2$ rad/s to 5 rad/s)	-0.11498	0.091049	0.123556	-0.10735
η^*	η^* value (Pa s) ($\omega = 0.1$ rad/s)	6668	5732	5813	15528
	Gradient (in the section of $\omega = 0.1$ rad/s to 1 rad/s)	-2544.6	-2011.2	-2414.2	-7095.8
Phase Angle (°)	Phase angle (°) (G* = 900 pa)	73	70	65	-

[Table 2]

Classification		Example 1	Example 2	Example 3	Comparative Example 1
Physical properties of PE yarn	Density (g/cm ³)	0.956	0.958	0.960	0.957
	Mw (g/mol)	151,257	151,321	150,421	150,331
	PDI	6.4	6.9	6.7	5.6

<Examples 2 and 3 and Comparative Example 1>

[0078] Protective gloves were manufactured in the same manner as in Example 1, except that the polyethylene yarns satisfying the physical properties of Tables 1 and 2 were used.

[0079] However, in Comparative Example 1, the phase angle was not measured at a point of the multiple shear modulus (G^*) of 900.

[Experimental Examples]

* Cut Resistance

[0080] The cut resistance of the protective glove was measured according to the specification of ISO13997:1999.

* Stiffness (gf)

[0081] A specimen (width: 60 mm, vertical: 60 mm, vertical: 60 mm) was taken from the palm part of the protective glove, and the stiffness of the specimen was measured according to section 38 of ASTM D885/D885M-10a (2014). The measurement devices were as follows:

- (i) CRE-type Tensile Testing Machine(model: INSTRON 3343)
- (ii) Loading Cell, 2 KN [200 kgf]
- (iii) Specimen Holder: a specimen holder specified in section 38.4.3
- (iv) Specimen Depressor: a specimen depressor specified in section 38.4.4

[0082] Specifically, the specimen was placed on the center of the specimen holder so that the outer side of the glove of the specimen faced up and the inner side of the glove of the specimen faces down, and the side adjacent to glove fingers and the opposite side (that is, the side adjacent to a glove wrist) were directly supported by the specimen holder. The specimen was maintained in a flat stage without being bent. At this time, a distance between the specimen supporting part of the specimen holder and the depressing part of the specimen depressor was 5 mm. Subsequently, the specimen holder was raised up to 15 mm while the specimen depressor was allowed to stand motionless, thereby measuring a maximum tension.

[Table 3]

Classification	Example 1	Example 2	Example 3	Comparative Example 1
Cut resistance (N)	5.9	6.9	6.9	5.1
Stiffness (gf)	4.0	4.1	4.5	3.5

[0083] According to Table 3, it was confirmed that the protective gloves of Examples 1 to 3 manufactured using the polyethylene yarn according to the present invention had low stiffness while having excellent cut resistance, thereby having improved wearability as compared with Comparative Example 1.

[0084] Hereinabove, although the present invention has been described by specific matters, limited exemplary embodiments, and drawings, they have been provided only for assisting the entire understanding of the present invention, and the present invention is not limited to the exemplary embodiments, and various modifications and changes may be made by those skilled in the art to which the present invention pertains from the description.

[0085] Therefore, the spirit of the present invention should not be limited to the above-described exemplary embodiments, and the following claims as well as all modified equally or equivalently to the claims are intended to fall within the scope and spirit of the invention.

Claims

1. A cut-resistant polyethylene yarn having the following properties:

in a graph of a storage modulus (G') according to an angular frequency (ω), the storage modulus of 50 Pa to 500 Pa at the angular frequency of 0.1 rad/s, and the storage modulus of 1000 Pa to 2000 Pa at the angular frequency is 1 rad/s, and

in a graph of $\tan\delta$ according to the angular frequency (ω), an average gradient of -0.25 to 0.8 in a section of the angular frequency of 0.2 rad/s 5 rad/s.

2. The cut-resistant polyethylene yarn of claim 1, wherein

the polyethylene yarn has, in the graph of $\tan\delta$ according to the angular frequency (ω), an inflection point at the angular frequency of 0.3 rad/s to 0.8 rad/s.

3. The cut-resistant polyethylene yarn of claim 2, wherein
the polyethylene yarn has, in the graph of $\tan\delta$ according to the angular frequency (ω), $\tan\delta$ of 1.5 to 7 at the angular frequency of 0.1 rad/s.

4. The cut-resistant polyethylene yarn of claim 2, wherein

the polyethylene yarn shows, in the graph of $\tan\delta$ according to the angular frequency (ω), a local minimum value in a section of the angular frequency of 0.1 rad/s to 0.5 rad/s, and the angular frequency at a $\tan\delta$ value of 0.8 to 1.2 is 100 rad/s to 300 rad/s.

5. The cut-resistant polyethylene yarn of claim 1, wherein
the polyethylene yarn has, in a graph of a loss modulus (G'') according to an angular frequency (ω), the loss modulus of 400 Pa to 1000 Pa at the angular frequency of 0.1 rad/s.

6. The cut-resistant polyethylene yarn of claim 1, wherein
the polyethylene yarn has, in a graph of a complex viscosity (η^*) according to an angular frequency (ω), the complex viscosity of 4500 Pa·s to 8000 Pa·s at the angular frequency of 0.1 rad/s, and a gradient of -2000 to -3000 in a section of the angular frequency of 0.1 rad/s to 1 rad/s.

7. The cut-resistant polyethylene yarn of claim 6, wherein
the polyethylene yarn has, in a graph of a phase angle according to a multiple shear modulus (G^*), the phase angle of 60 to 80° at the multiple shear modulus (G^*) of 350 to 1,000 Pa.

8. A cut-resistant fabric comprising the cut-resistant polyethylene yarn of any one of claims 1 to 7.

9. The cut-resistant fabric of claim 8, wherein
the cut-resistant fabric has a cutting Force of 5.5 N or more as measured according to a specification of ISO13997:1999.

10. A protective product comprising the cut-resistant fabric of claim 8.

11. The protective product of claim 10, wherein
the protective product is a cut-resistant glove.

FIG. 1

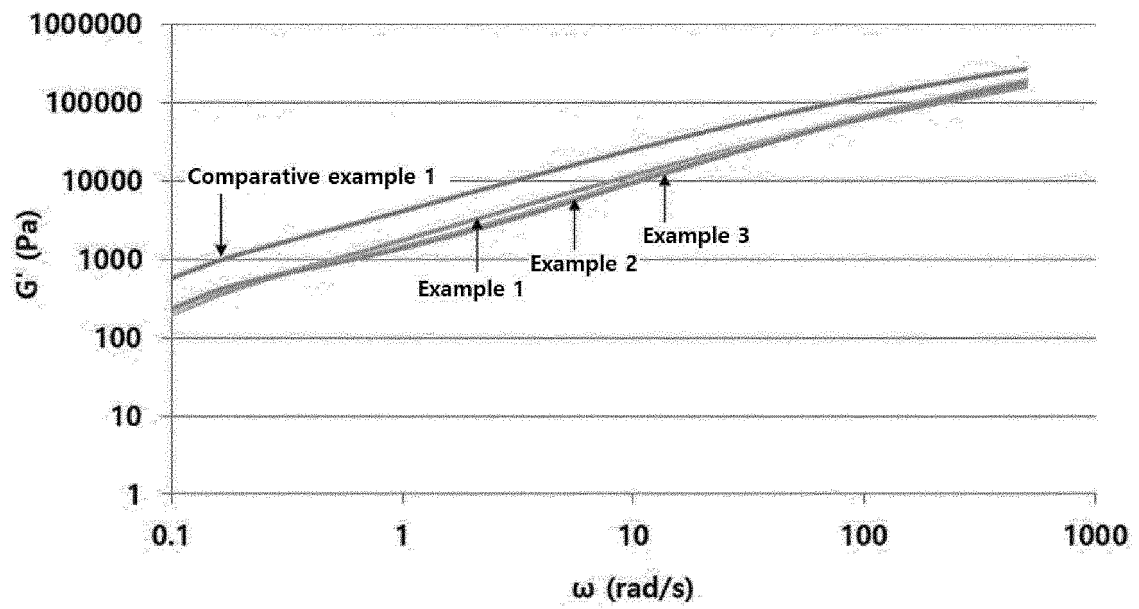


FIG. 2

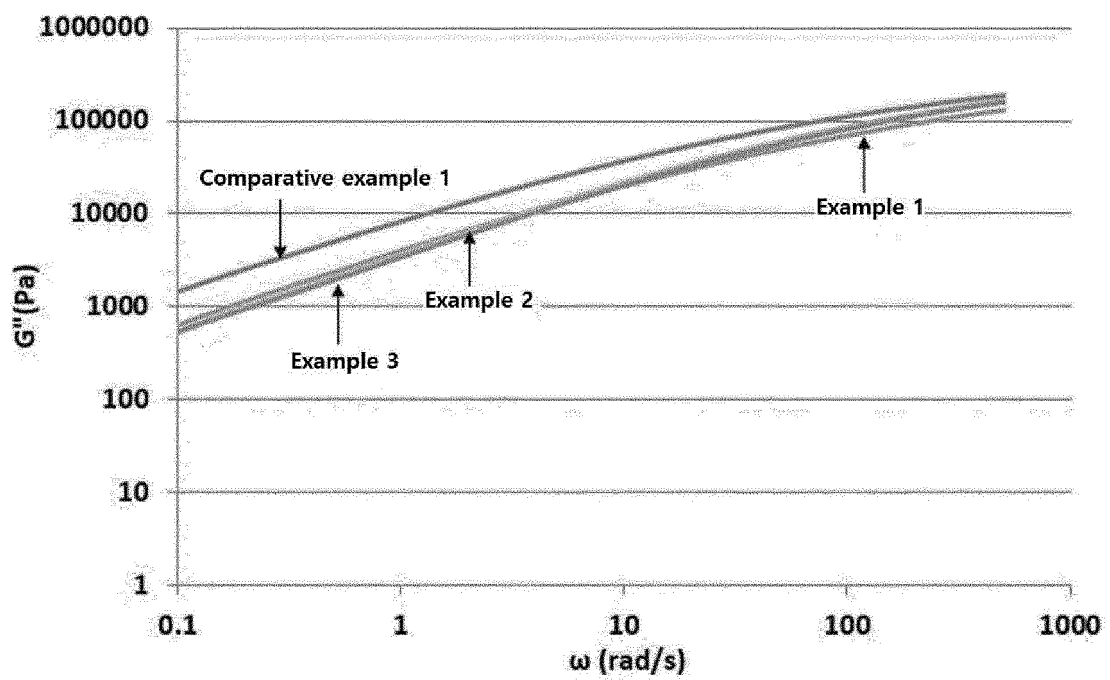


FIG. 3

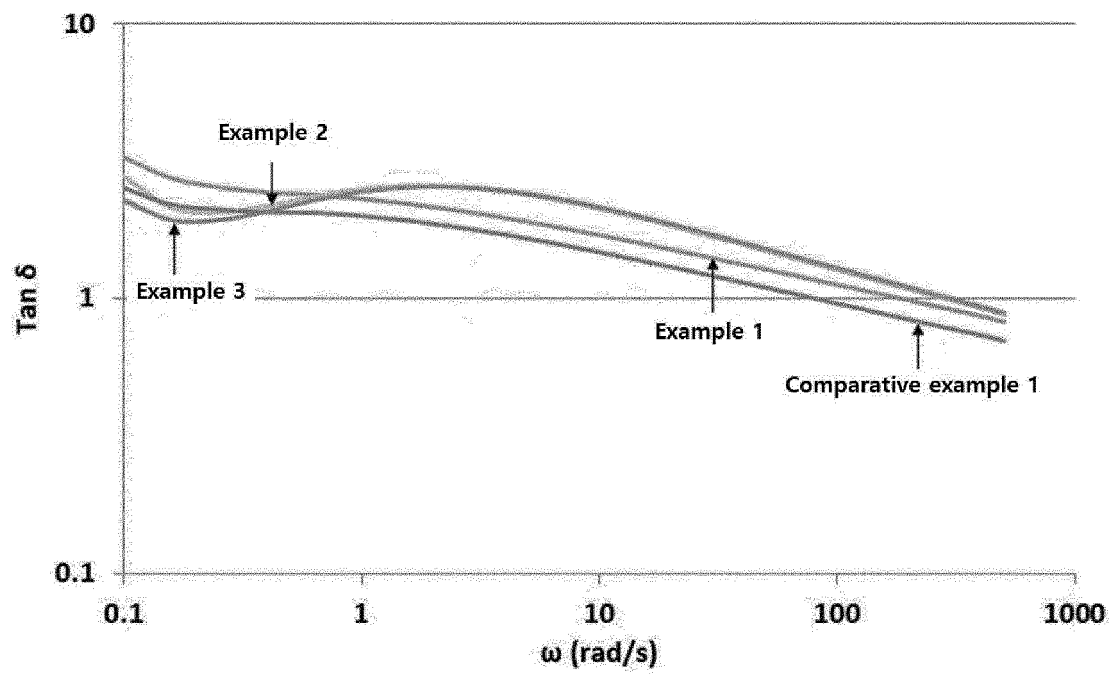


FIG. 4

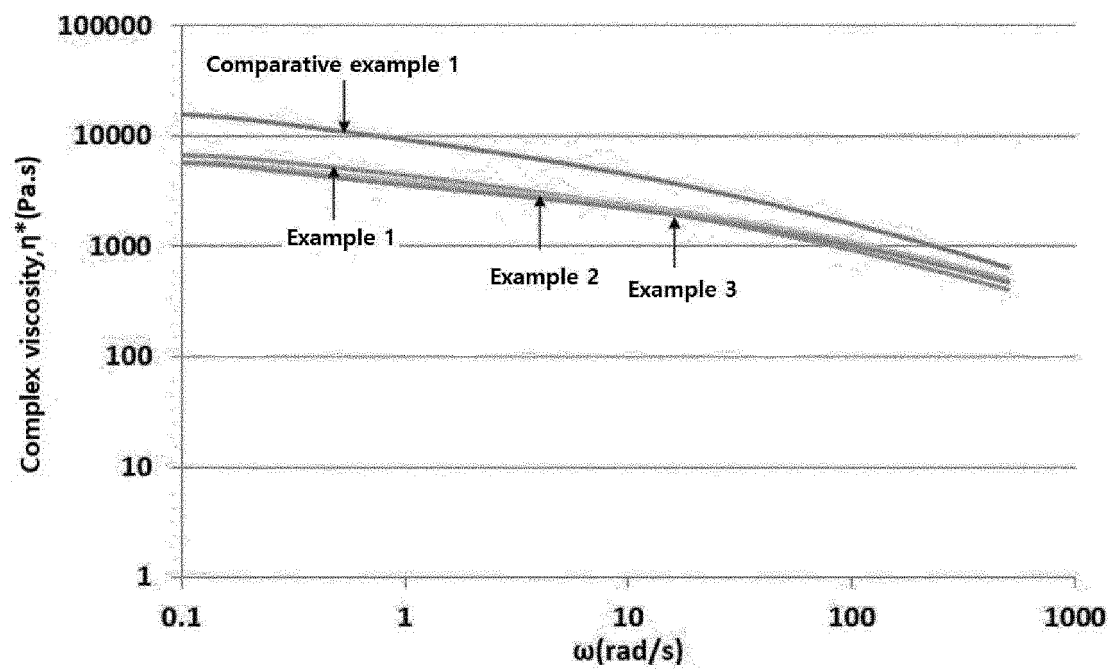
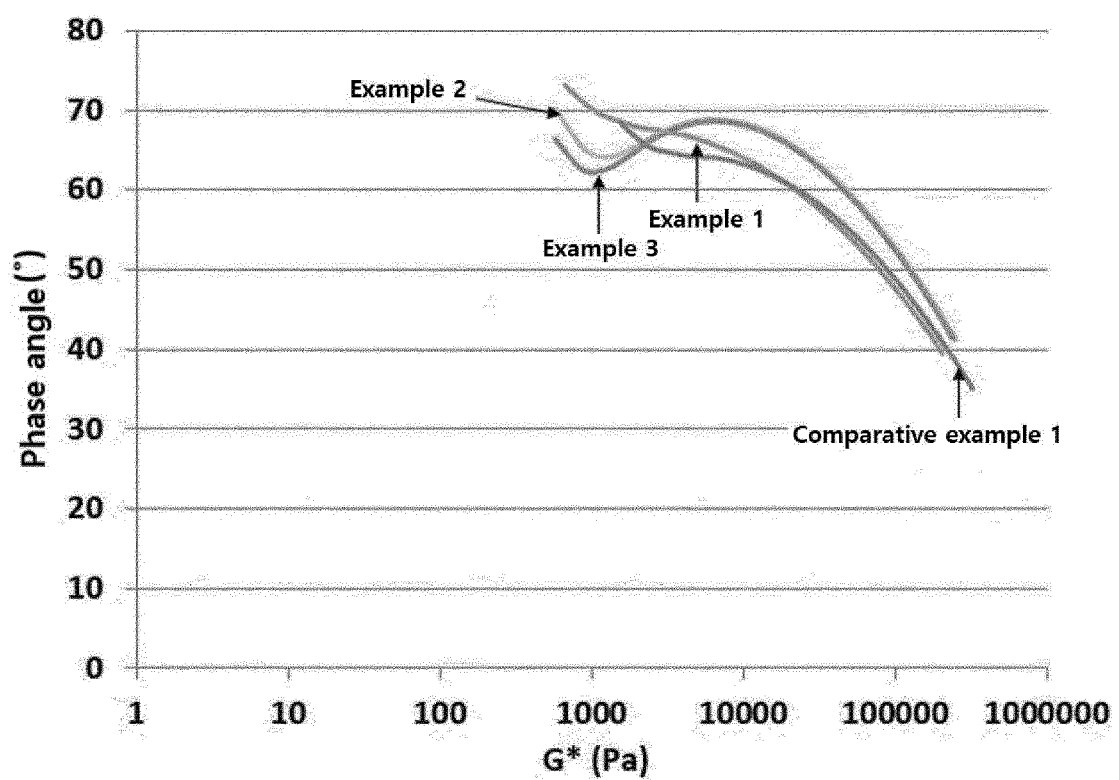


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2021/020200

A. CLASSIFICATION OF SUBJECT MATTER D01F 6/04(2006.01)i; D01D 5/088(2006.01)i; D01D 5/098(2006.01)i; D02J 1/08(2006.01)i; D02G 3/44(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC																		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) D01F 6/04(2006.01); A41D 13/00(2006.01); D01D 5/088(2006.01); D01F 1/10(2006.01) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models: IPC as above Japanese utility models and applications for utility models: IPC as above Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS (KIPO internal) & keywords: 내절창성(cut-resistance), 폴리에틸렌 섬유(polyethylene fiber), 각진동수(angular frequency), 저장탄성률(storage modulus), tanδ, 기울기(slope)																		
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>KR 10-2013-0117872 A (TOYOBO CO., LTD.) 28 October 2013 (2013-10-28) See claims 1, 18 and 19; paragraph [0001]; manufacturing example 1; and table 1.</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>KR 10-1981763 B1 (HUVIS CORPORATION) 27 May 2019 (2019-05-27) See claims 1, 5 and 6; paragraphs [0012], [0040], [0083]-[0087], [0092] and [0110]; and table 3.</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>KR 10-2092934 B1 (KOLON INDUSTRIES, INC.) 24 March 2020 (2020-03-24) See claims 1 and 3; paragraph [0004]; example 1; and table 1.</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>JP 2004-019050 A (TOYOBO CO., LTD.) 22 January 2004 (2004-01-22) See claims 1-5.</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>US 2003-0203202 A1 (OHTA, Y. et al.) 30 October 2003 (2003-10-30) See entire document.</td> <td>1-11</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	KR 10-2013-0117872 A (TOYOBO CO., LTD.) 28 October 2013 (2013-10-28) See claims 1, 18 and 19; paragraph [0001]; manufacturing example 1; and table 1.	1-11	A	KR 10-1981763 B1 (HUVIS CORPORATION) 27 May 2019 (2019-05-27) See claims 1, 5 and 6; paragraphs [0012], [0040], [0083]-[0087], [0092] and [0110]; and table 3.	1-11	A	KR 10-2092934 B1 (KOLON INDUSTRIES, INC.) 24 March 2020 (2020-03-24) See claims 1 and 3; paragraph [0004]; example 1; and table 1.	1-11	A	JP 2004-019050 A (TOYOBO CO., LTD.) 22 January 2004 (2004-01-22) See claims 1-5.	1-11	A	US 2003-0203202 A1 (OHTA, Y. et al.) 30 October 2003 (2003-10-30) See entire document.	1-11
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Date of the actual completion of the international search 11 April 2022	Date of mailing of the international search report 11 April 2022																	
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International application No.

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