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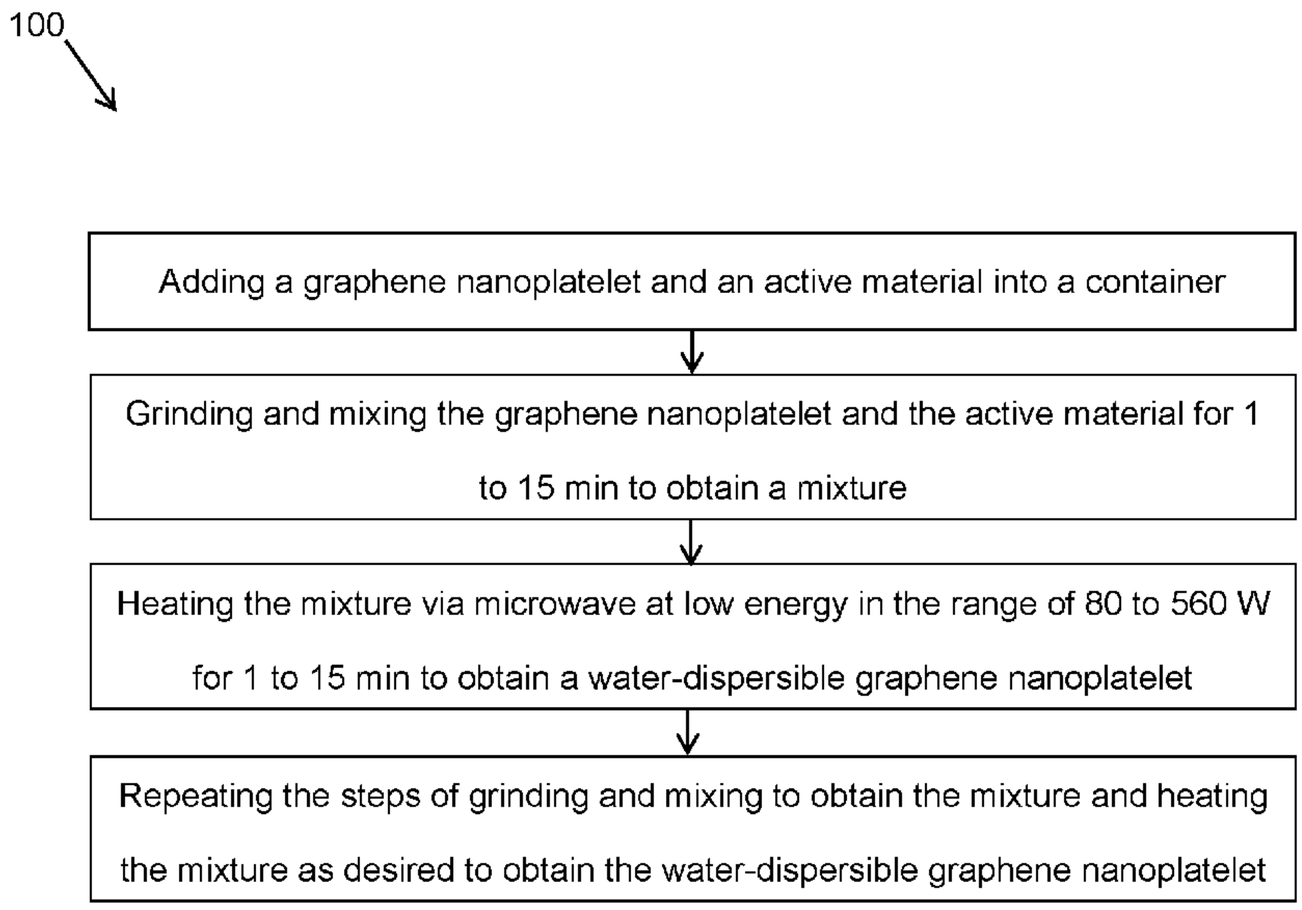

Fig. 1

(57) Abstract: The present invention relates to a method (100) of preparing a water-dispersible graphene nanoplatelet comprises the steps of adding a graphene nanoplatelet and an active material into a container, grinding and mixing the graphene nanoplatelet and the active material for 1 to 15 min to obtain a mixture and heating the mixture via microwave at medium energy in the range of 80 to 560 W for 1 to 15 min to obtain the water-dispersible graphene nanoplatelet. More particularly, the active material is a mixture comprising a sulfonate structure having an aromatic or a non-aromatic ring, a polymer having formaldehyde, a salt and a solvent. Further, the present invention also relates to an application of the water-dispersible graphene nanoplatelet in preparing a composite with a hydrophilic polymer including a rubber, a synthetic polymer and a natural polymer.

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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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A METHOD OF PREPARING A WATER-DISPERSIBLE GRAPHENE NANOPLATELET AND USES THEREOF

TECHNICAL FIELD

The present invention relates to a method of preparing a graphene nanoplatelet, more particularly to a method of preparing a water-dispersible graphene nanoplatelet. In addition, the present invention relates to a method of preparing a composite with a hydrophilic polymer by applying the prepared graphene nanoplatelet.

BACKGROUND ART

Graphene, a single layer two-dimensional sp2 carbon lattice, is well-known for its excellent electrical, mechanical and chemical properties. More specifically, graphene nanoplatelets, which consists of small stacks of graphene with an average overall thickness of approximately 5 to 10 nm has attracted a great attention nowadays due to its effectiveness in providing barrier properties, excellent electrical and thermal conductivities, as well as in improving mechanical properties such as stiffness, strength, and surface hardness of a product. In addition, there is an increasing demand for water-dispersible graphene nanoplatelets due to its dispersion stability that can be utilized in various applications. The water-dispersible graphene nanoplatelets are conventionally produced via an electrochemical exfoliation method.

In addition, graphene including graphene nanoplatelets has recently been applied into the other formulations such as formulation of rubber-based products to produce a graphene-rubber composite in order to improve the electrical and mechanical properties of the produced products.

However, it still remains a challenge to produce high quality graphene nanoplatelets via simple, low cost and environmental-friendly method that can be

applied for a scalable production of graphene nanoplatelets. In addition, graphene nanoplatelets are widely known for its non-dispersible properties and water-dispersible graphene nanoplatelets having high dispersion stability is difficult to be produced and mixed with other formulations such as rubber formulations.

There have been a number of solutions provided for preparing a graphene, specifically water-dispersible graphene nanoplatelets and applying graphene in producing products, in which few of them are discussed below:

JP 2016117639 A disclosed a method for producing a graphene nanoplatelet aqueous dispersion, comprising dispersing cellulose nanoplatelets in water using a cellulose nanofiber aqueous dispersion as a dispersant. The prior art enables dispersion of the graphene nanoplatelet in water at high concentration. In addition, sedimentation of the graphene nanoplatelets was not observed over 3 months, proving its excellent dispersion stability which due to the use of the cellulose nanofiber aqueous dispersion as the dispersant. However, the prior art does not disclose a method of preparing a graphene-rubber composite from the produced graphene nanoplatelet aqueous dispersion.

WO 2018036425 A1 relates to a three dimensional graphene-modified rubber composite material that is prepared via a simple preparation process and can be implemented for a large-scale production. The three dimensional graphene-modified rubber composite material comprises 100 parts of rubber, 0.01 to 10 parts of three-dimensional graphene, 0.5 to 5 parts of vulcanizing agent, and 8 to 12 parts of rubber compounding agent by weight. The prior art also relates to preparation of graphene oxide via a modified Hummers method, which is divided into pre-oxidation, oxidation and exfoliation. Although the Hummer's method is generally known for synthesizing graphene oxide, the Hummer's method is also known for its use of toxic chemicals and explosive risks that leads to safety concerns.

CN 108477713 A disclosed appliances for labor protection technical field, more

particularly to graphene gloves that comprises an external protection and an inner protective layer. The graphene gloves are produced to overcome the problem of internal bacteria breeding due to prolonged use by utilizing graphene powder, which has antibacterial properties. However, the prior art does not disclose that the gloves are produced by mixing graphene with the rubber formulation of the gloves, where in this prior art, the graphene powder acts as a separate material used to provide the desired antibacterial properties to the prepared gloves.

Accordingly, it can be seen in the prior arts that there exists a need to provide an improved and more effective, yet simpler and safer method of preparing water-dispersible graphene nanoplatelets. In addition, there exists a need to have a method of preparing a graphene-rubber composite that applies the water-dispersible graphene nanoplatelets, where the water-dispersible graphene nanoplatelets are stable and mixable with other formulations, which in turn, can be used for producing products from a composite comprising the water-dispersible graphene nanoplatelet.

SUMMARY OF THE INVENTION

The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented later.

An objective of the present invention is to provide a simple method of preparing a water-dispersible graphene nanoplatelet with short processing time, yet provides high yield, hence it can be applied for a scalable production of the water-dispersible graphene nanoplatelet. More particularly, the method is a solid–state synthesis, which is an environmentally friendly method.

It is also an objective of this invention to provide a method of preparing a water-dispersible graphene nanoplatelet, which is safer by replacing the conventional

hazardous organic solvents to a benign aqueous medium, more particularly to mild active material.

A further objective of the present invention is to provide a method of preparing a water-dispersible graphene nanoplatelet, where the prepared water-dispersible graphene nanoplatelet has high dispersion stability in water. Preferably, the properties of the prepared water-dispersible graphene nanoplatelets ease the mixing with other product formulations.

In addition, an objective of the present invention is to provide a method of preparing a water-dispersible graphene nanoplatelet, where the prepared water-dispersible graphene nanoplatelet is used to prepare a composite with a hydrophilic polymer including a rubber, a synthetic polymer and a natural polymer.

Another objective of the present invention is to use the prepared water-dispersible graphene nanoplatelet in preparing a graphene-rubber composite for producing stable graphene-rubber composite based products such as gloves, condoms, tires and mats. More particularly, the graphene-rubber composite based products have improved conductivity properties, thermal conductivity, mechanical properties such as tensile strength, and cut resistance.

Accordingly, these objectives may be achieved by following the teachings of the present invention. The present invention relates to a method of preparing a water-dispersible graphene nanoplatelet comprises the steps of adding a graphene nanoplatelet and an active material into a container, grinding and mixing the graphene nanoplatelet and the active material for 1 to 15 min to obtain a mixture and heating the mixture via microwave at medium energy in the range of 80 to 560 W for 1 to 15 min to obtain the water-dispersible graphene nanoplatelet. More particularly, the active material is a mixture comprising a sulfonate structure having an aromatic or a non-aromatic ring, a polymer having formaldehyde, a salt and a solvent. Further, the present invention also relates to an application of the water-

dispersible graphene nanoplatelet in preparing a composite with a hydrophilic polymer including a rubber, a synthetic polymer and a natural polymer.

The foregoing and other objects, features, aspects and advantages of the present invention will become better understood from a careful reading of a detailed description provided herein below with appropriate reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWING

So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may have been referred by embodiments, some of which are illustrated in the appended drawing. It is to be noted, however, that the appended drawing illustrates only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

These and other features, benefits, and advantages of the present invention will become apparent by reference to the following text figure, with like reference numbers referring to like structures across the views, wherein:

Fig. 1 is a flowchart illustrating a method of preparing a water-dispersible graphene nanoplatelet in accordance with an embodiment of the present invention.

Fig. 2 is a schematic diagram showing the prepared water-dispersible graphene nanoplatelet after modification with an active material in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

While the present invention is described herein by way of example using embodiments and illustrative drawing, those skilled in the art will recognize that the invention is not limited to the embodiments of drawing or drawings described, and are not intended to represent the scale of the various components. Further, some

components that may form a part of the invention may not be illustrated in certain figures, for ease of illustration, and such omissions do not limit the embodiments outlined in any way. It should be understood that the drawing and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within the scope of the present invention as defined by the appended claim. As used throughout this description, the word "may" is used in a permissive sense (i.e. meaning having the potential to), rather than the mandatory sense, (i.e. meaning must). Further, the words "a" or "an" mean "at least one" and the word “plurality” means “one or more” unless otherwise mentioned. Furthermore, the terminology and phraseology used herein is solely used for descriptive purposes and should not be construed as limiting in scope. Language such as "including," "comprising," "having," "containing," or "involving," and variations thereof, is intended to be broad and encompass the subject matter listed thereafter, equivalents, and additional subject matter not recited, and is not intended to exclude other additives, components, integers or steps. Likewise, the term "comprising" is considered synonymous with the terms "including" or "containing" for applicable legal purposes. Any discussion of documents, acts, materials, devices, articles and the like is included in the specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention.

In this disclosure, whenever a composition or an element or a group of elements is preceded with the transitional phrase “comprising”, it is understood that we also contemplate the same composition, element or group of elements with transitional phrases “consisting of”, “consisting”, “selected from the group of consisting of, “including”, or “is” preceding the recitation of the composition, element or group of elements and vice versa.

The present invention is described hereinafter by various embodiments with

reference to the accompanying drawing, wherein reference numerals used in the accompanying drawing correspond to the like elements throughout the description. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiment set forth herein. Rather, the embodiment is provided so that this disclosure will be thorough and complete and will fully convey the scope of the invention to those skilled in the art. In the following detailed description, numeric values and ranges are provided for various aspects of the implementations described. These values and ranges are to be treated as examples only and are not intended to limit the scope of the claims. In addition, a number of materials are identified as suitable for various facets of the implementations. These materials are to be treated as exemplary and are not intended to limit the scope of the invention.

The present invention relates to a method (100) of preparing a water-dispersible graphene nanoplatelet, **characterized in that** the method (100) comprising the steps of: adding a graphene nanoplatelet and an active material into a container; grinding and mixing the graphene nanoplatelet and the active material for 1 to 15 min to obtain a mixture; and heating the mixture via microwave at medium energy in the range of 80 to 560 W for 1 to 15 min to obtain a water-dispersible graphene nanoplatelet; wherein the steps of grinding and mixing to obtain the mixture and heating the mixture are repeated as desired to obtain the water-dispersible graphene nanoplatelet; and wherein the active material is a mixture comprising a sulfonate structure having an aromatic or a non-aromatic ring, a polymer having formaldehyde, a salt and a solvent.

Referring to the drawings as shown in Fig. 1 and 2, the invention will now be described in more detail.

Fig. 1 is a flowchart illustrating the method (100) of preparing the water-dispersible graphene nanoplatelet in accordance with an embodiment of the present invention. The method (100) begins with adding the graphene nanoplatelet and the

active material into the container, followed by grinding and mixing the graphene nanoplatelet and the active material for 1 to 15 min to obtain the mixture. The method (100) is completed by heating the mixture via microwave at medium energy, preferably in the range of 80 to 560 W, for 1 to 15 min to obtain the water-dispersible graphene nanoplatelet. In addition, the steps of grinding and mixing to obtain the mixture and heating the mixture are repeated more preferably two times or as desired to obtain the water-dispersible graphene nanoplatelet. Preferably, the water-dispersible graphene nanoplatelet is dispersible in either a polar or non-polar mixture.

More preferably, the method (100) is, but not limited to, a solid-state synthesis. The method (100) is preferably performed under a mild reaction condition, due to the use of the selected active material.

In addition, the method (100) produces high yield of the water-dispersible graphene nanoplatelets, which preferably corresponds to a high concentration of graphene dispersions in 10 to 50 kg. More preferably, the water-dispersible graphene nanoplatelet is having a dispersion range of 5 to 80 % in water, while the ratio of graphene nanoplatelet to the active material is in the range of 1:1 to 1:20, and 1:1 to 20:1. Further, the method (100) performed under small-scale production requires shorter processing time of less than 10 min, which improves efficiency of production.

Fig. 2 is a schematic diagram showing the prepared water-dispersible graphene nanoplatelet after modification with an active material in accordance with an embodiment of the present invention.The active material is a mixture comprising the sulfonate structure having an aromatic or a non-aromatic ring, a polymer having formaldehyde, a salt and a solvent. Preferably, the active material is a benign aqueous medium, which replaces the conventional hazardous organic solvents. Alternatively, the active material is also applied in, but not limited to, an electrochemical exfoliation, for obtaining the water-dispersible graphene

nanoplatelet.

In accordance with an embodiment of the present invention, the sulfonate structure comprised in the active material is naphthalenesulfonic acid.

In accordance with an embodiment of the present invention, the salt comprised in the active material is selected from sodium salt and sodium sulfate.

In accordance with an embodiment of the present invention, the solvent comprised in the active material is formaldehyde.

In accordance with an embodiment of the present invention, the active material is 1 to 30 wt % sodium salt of naphthalene-sulfonic acid solution.

Alternatively, the prepared water-dispersible graphene nanoplatelet can be used immediately without requiring an initial storing.

In accordance with an embodiment of the present invention, the water-dispersible graphene nanoplatelet is preferably used to prepare a composite with a hydrophilic polymer including a rubber, a synthetic polymer and a natural polymer.

In accordance with an embodiment of the present invention, the synthetic polymer including, but not limited to, polyvinyl alcohol and the natural polymer including, but not limited to, chitosan.

Preferably, the water-dispersible graphene nanoplatelet is used in various applications including an enhancement of rubber products such as, but not limited to, the production of graphene-rubber composite based products.

In accordance with an embodiment of the present invention, the water-dispersible graphene nanoplatelet is used to prepare a graphene-rubber composite

for producing a graphene-rubber composite based product including, but not limited to, a glove, condom, tire and mat. More preferably, the graphene-rubber composite based products is having improved properties such as, but not limited to, electrical conductivity, thermal conductivity, mechanical properties such as tensile strength, cut resistance and electrostatic discharge performance; hence, applicable for use in various industries.

Hereinafter, example of the present invention will be provided for more detailed explanation. The advantages of the present invention may be more readily understood and put into practical effect from these examples. However, it is to be understood that the following examples are not intended to limit the scope of the present invention in any way.

Examples

Example 1

Water-dispersible Graphene Nanoplatelets

Water-dispersible graphene nanoplatelets were prepared using the method (100) and the prepared water-dispersible graphene nanoplatelets were then observed. Based on the observation conducted, the prepared water-dispersible graphene nanoplatelets can be added into product formulations without further modifications. Further, the prepared water-dispersible graphene nanoplatelet can be used immediately without requiring an initial storing.

Example 2

Graphene-rubber Composite based Products

The prepared water-dispersible graphene nanoplatelet was used to prepare a graphene-rubber composite, which subsequently used for the production of graphene-rubber composite based products. The graphene-rubber composite was prepared by adding 0.001 to 50 % water-dispersible graphene nanoplatelets as the enhancer into the rubber formulation to obtain the mixture, and then followed by

mixing and stirring the mixture to obtain even mixture of the graphene-rubber composite under mild agitation for 4 to 8 hours. The prepared graphene-rubber composite was observed and it was shown that the water-dispersible graphene nanoplatelets were dispersed uniformly and stably in the rubber formulations.

In addition, the prepared graphene-rubber composite was used to produce different graphene-rubber composite based products based on the rubber formulation used. The rubber formulation used in preparing the graphene-rubber composite including natural rubber, silicone rubber, styrene-butadiene rubber, butadiene rubber, butyl rubber, isoprene rubber, butoxy isoprene rubber, nitrile rubber, ethylene propylene rubber or chloroprene rubber. More specifically, the rubber formulations used are the formulation for producing the gloves, condoms, tires and mats; hence, the produced graphene-rubber composite based products are the gloves, condoms, tires and mats, respectively. In addition, the graphene-rubber composite based products are reported to have improved properties including electrical conductivity, thermal conductivity, mechanical properties such as tensile strength, cut resistance and electrostatic discharge performance; hence, applicable for use in various industries.

(1) Graphene-rubber composite based gloves

More specifically, the formulation of latex compound and the prepared water-dispersible graphene nanoplatelets were mixed together and then followed by the dipping method for producing the graphene-rubber composite based gloves.

In addition, based on the studies conducted, the incorporation of water-dispersible graphene nanoplatelets into the rubber formulation can result in more than 30 % increase in the tensile strength of gloves made from natural and nitrile rubber. Further, it also reduces resistance of the gloves, resulting in an improved electrostatic discharge performance by having anti-static properties; hence, suitable for use in handling electrical appliances to prevent short circuit.

(2) Graphene-rubber composite based condoms

More specifically, a condom former was dipped into the prepared graphene-rubber composite to produce the graphene-rubber composite based condoms.

The above-mentioned method (100) of preparing a water-dispersible graphene nanoplatelet overcomes the problems and shortcomings of the conventional methods. The method (100) allows for small or scalable production of water-dispersible graphene nanoplatelets based on solid-state synthesis that is environmentally friendly and cost effective. The prepared graphene nanoplatelets show higher dispersibility and stability compared to the currently existing graphene nanoplatelets, which eases mixing with other product formulations. In addition, the method (100) replaces the conventional hazardous organic solvents to a benign aqueous medium, particularly the mild active material, to provide a safer method in preparing the water-dispersible graphene nanoplatelet. Further, the method (100) provides high yields of the water-dispersible graphene nanoplatelets, specifically 10 to 50 kg in a small lab scale production under less than 10 min. More specifically, the water-dispersible graphene nanoplatelet is having a dispersion range of 5 to 80 % in water.

In addition, the remarkable miscibility of the water-dispersible graphene nanoplatelets acts as an enhancer in rubber formulations and has overcome the immiscibility problems of the currently existing water-dispersible graphene nanoplatelets and hence benefitted various industries, especially rubber-related industries. Hence, the water-dispersible graphene nanoplatelet is applied to prepare composites with hydrophilic polymer including a rubber, a synthetic polymer and a natural polymer that can be used in producing graphene-based composite products such as gloves, condoms, tires and mats. Further, the graphene-based composite products have improved properties such as an improved electrostatic discharge performance, conductivity properties, thermal conductivity, increased mechanical properties such as tensile strength, and cut resistance, which in turns, increases its usability in various industries such as in electrical appliance industry, polymers and

fine chemicals manufactures.

The exemplary implementation described above is illustrated with specific shapes, dimensions, and other characteristics, but the scope of the invention also includes various other shapes, dimensions, and characteristics. Also, the components as described above could be manufactured in various other ways and could include various other materials.

Various modifications to these embodiments are apparent to those skilled in the art from the description and the accompanying drawing. The principles associated with the various embodiments described herein may be applied to other embodiments. Therefore, the description is not intended to be limited to the embodiments shown along with the accompanying drawing but is to be providing broadest scope of consistent with the principles and the novel and inventive features disclosed or suggested herein. Accordingly, the invention is anticipated to hold on to all other such alternatives, modifications, and variations that fall within the scope of the present invention and appended claim.

Although the present invention has been described with reference to specific embodiments, also shown in the appended figures, it will be apparent for those skilled in the art that many variations and modifications can be done within the scope of the invention as described in the specification and defined in the following claims.

CLAIMS:

1. A method (100) of preparing a water-dispersible graphene nanoplatelet, characterized in that said method (100) comprising the steps of:

adding a graphene nanoplatelet and an active material into a container;

grinding and mixing said graphene nanoplatelet and said active material for 1 to 15 min to obtain a mixture; and

heating said mixture via microwave at medium energy in the range of 80 to 560 W for 1 to 15 min to obtain a water-dispersible graphene nanoplatelet;

wherein said steps of grinding and mixing to obtain said mixture and heating said mixture are repeated as desired to obtain said water-dispersible graphene nanoplatelet; and

wherein said active material is a mixture comprising a sulfonate structure having an aromatic or a non-aromatic ring, a polymer having formaldehyde, a salt and a solvent for a solid-state synthesis.

2. The method (100) as claimed in claim 1, wherein said sulfonate structure comprised in said active material is naphthalenesulfonic acid.

3. The method (100) as claimed in claim 1, wherein said salt comprised in said active materials is selected from sodium salt and sodium sulfate.

4. The method (100) as claimed in claim 1, wherein said solvent comprised in said active materials is formaldehyde.

5. The method (100) as claimed in claim 1, wherein said active material is 1 to 30 wt % sodium salt of naphthalene-sulfonic acid solution.

6. The method (100) as claimed in claim 1, wherein said water-dispersible graphene nanoplatelet is used to prepare a composite with a hydrophilic polymer including a rubber, a synthetic polymer and a natural polymer.

7. The method (100) as claimed in claim 1 and 6, wherein said water-dispersible graphene nanoplatelet is used to prepare a graphene-rubber composite for producing a graphene-rubber composite based product including a glove, condom, tire and mat.

8. The method (100) as claimed in claim 1 and 6, wherein said synthetic polymer including polyvinyl alcohol and said natural polymer including chitosan.

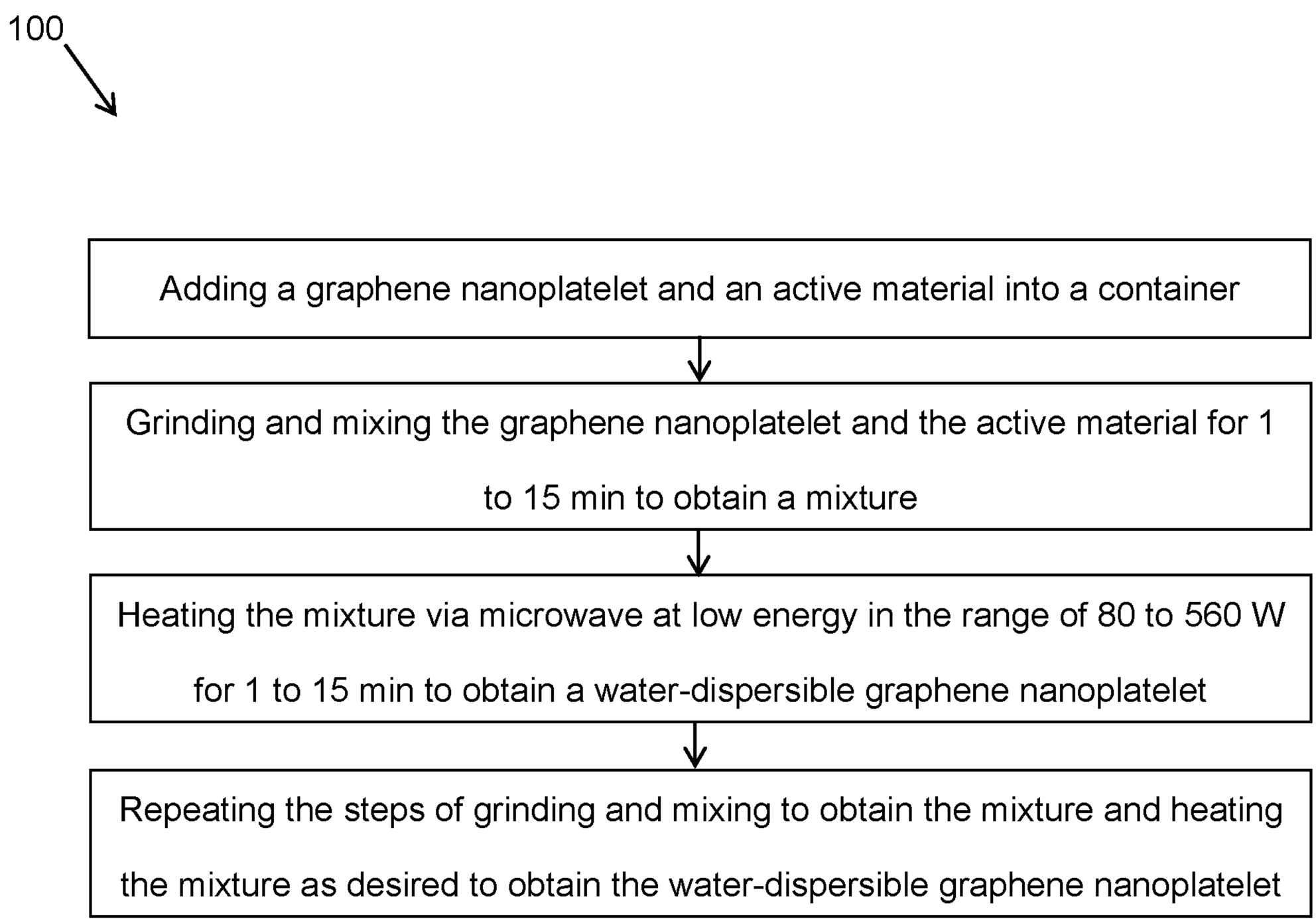
100
Adding a graphene nanoplatelet and an active material into a container
Grinding and mixing the graphene nanoplatelet and the active material for 1 to 15 min to obtain a mixture
Heating the mixture via microwave at low energy in the range of 80 to 560 W for 1 to 15 min to obtain a water-dispersible graphene nanoplatelet
Repeating the steps of grinding and mixing to obtain the mixture and heating the mixture as desired to obtain the water-dispersible graphene nanoplatelet

Fig. 1

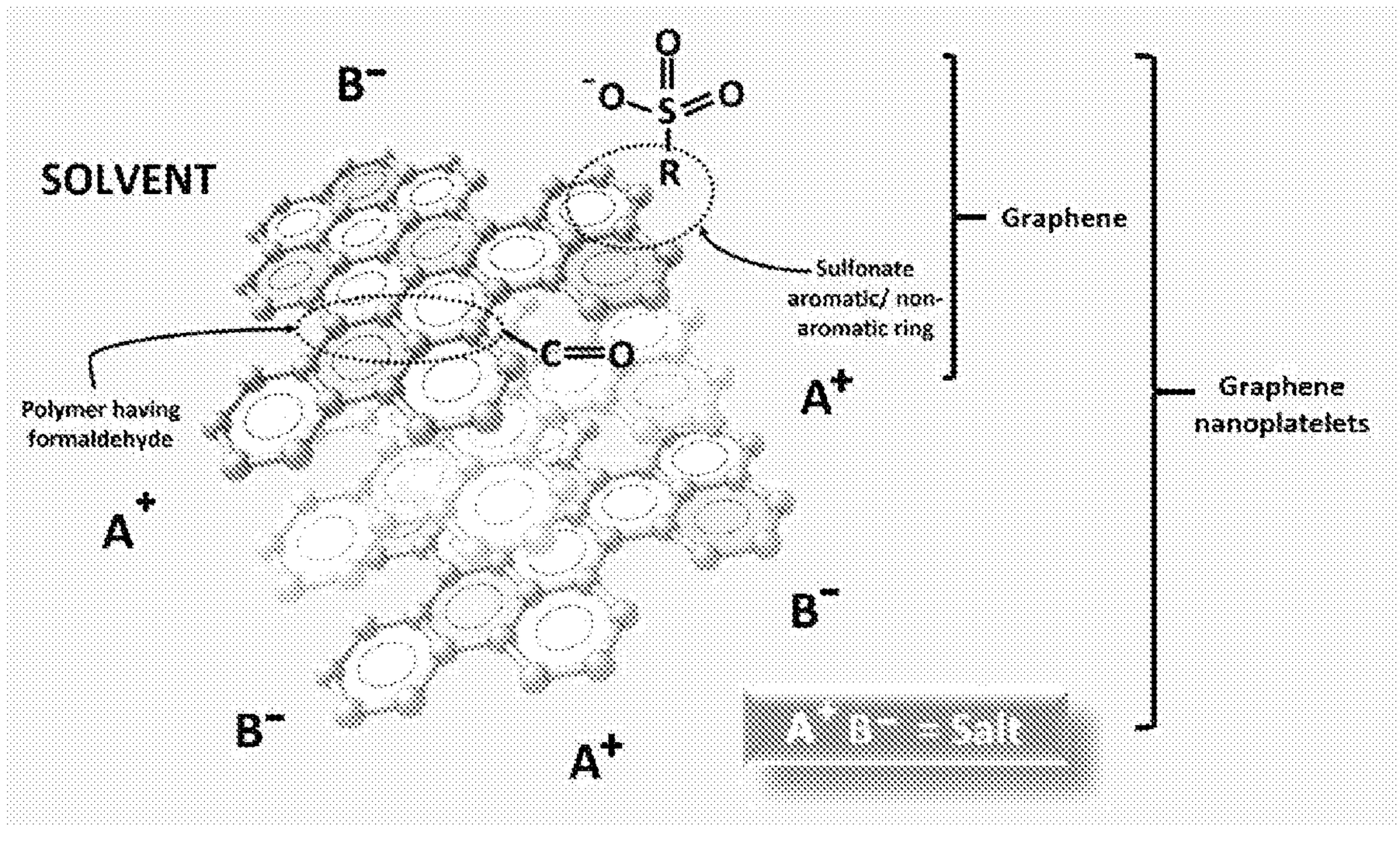
B⁻
O
O
S
O
R
SOLVENT
Graphene
Sulfonate aromatic/ non-aromatic ring
C=O
Polymer having formaldehyde
A+
A+
B⁻
B⁻
A+
Graphene nanoplatelets

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/MY2020/050120

A. CLASSIFICATION OF SUBJECT MATTER

C08K 9/08(2006.01)i; **C08K 3/04**(2006.01)i; **C08L 29/04**(2006.01)i; **C08L 5/08**(2006.01)i; **C01B 32/194**(2017.01)i; **B01J 19/12**(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)

C08K 9/08(2006.01); C01B 31/02(2006.01); C01B 31/04(2006.01); C01B 32/154(2017.01); C01B 32/196(2017.01); C08K 3/04(2006.01); C09D 5/18(2006.01); H01B 1/24(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
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: graphene nanoplatelet, water dispersible, sulfonate, formaldehyde, salt, microwave, grinding, mixing, heating

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2016-0185981 A1 (DIRECTA PLUS S.P.A.) 30 June 2016 (2016-06-30) paragraphs [0023]-[0034], [0055]-[0058], [0085]; claims 2, 12; examples 1, 6	1-6
Y	US 2019-0337807 A1 (KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY) 07 November 2019 (2019-11-07) paragraph [0050]; claim 1	1-6
Y	US 2011-0046289 A1 (ZHAMU, A. et al.) 24 February 2011 (2011-02-24) claim 1	6
A	LOU, H. et al,"Fabrication of High-Concentration Aqueous Graphene Suspensions Dispersed by Sodium Lignosulfonate and Its Mechanism", The Journal of Physical Chemistry C, 2015, Vol. 119, pages 23221-23230 abstract; table 2	1-6
A	US 9868875 B2 (RUDHARDT, D. et al.) 16 January 2018 (2018-01-16) claims 1-3, 8	1-6

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 February 2021	**17 February 2021**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/MY2020/050120

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2960205 A1 (SOLVAY SA) 30 December 2015 (2015-12-30) paragraphs [0054], [0055]; claims 1-5, 8	1-6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/MY2020/050120

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☑ Claims Nos.: **7, 8**
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/MY2020/050120

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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		EP 3033406 B1	26 February 2020
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EP 2960205 A1	30 December 2015	None	