US 20250265501A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2025/0265501 A1**

Jeon et al. (43) **Pub. Date: Aug. 21, 2025**

(54) **METHOD FOR PREDICTING CHARACTERISTIC OF POLYMER COMPOSITE MATERIALS BASED ON MATERIAL AND DEVICE THEREOF**

(71) Applicants: **SK Geo Centric Co., Ltd.**, Seoul (KR); **SK Innovation Co., Ltd.**, Seoul (KR)

(72) Inventors: **Chan Woong Jeon**, Seoul (KR); **June Haan Kwon**, Seoul (KR); **Duk Hee Kim**, Seoul (KR); **Seok Jun Kim**, Seoul (KR); **Sun Ryong Kim**, Seoul (KR); **Jeong Hwan Kim**, Daejeon (KR); **Chan Woo Kim**, Seoul (KR); **Joo Pyung Lee**, Seoul (KR); **Hee Eun Lee**, Daejeon (KR); **Hyun Jung Jung**, Daejeon (KR)

(73) Assignee: **SK Geo Centric Co., Ltd.**, Seoul (KR)

(21) Appl. No.: **19/053,590**

(22) Filed: **Feb. 14, 2025**

(30) **Foreign Application Priority Data**

Feb. 15, 2024 (KR) 10-2024-0022079

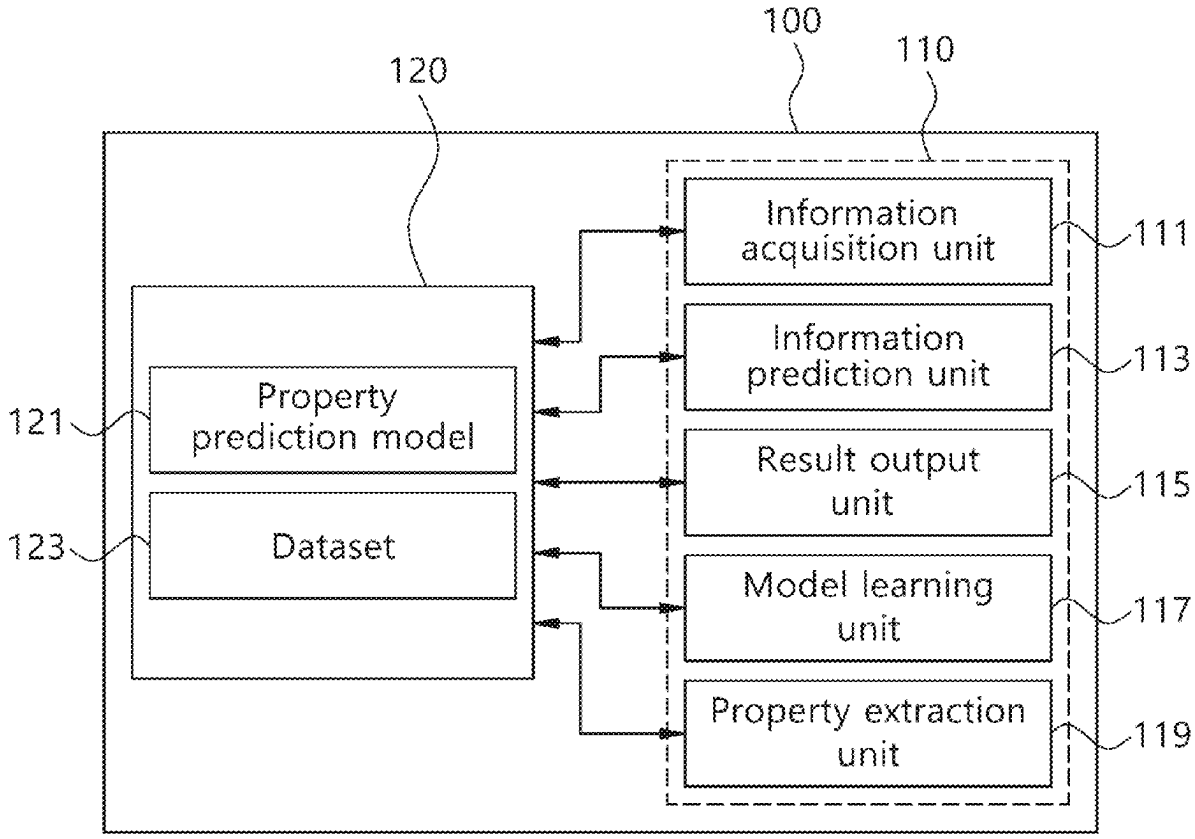
Publication Classification

(51) **Int. Cl.**
G06N 20/00 (2019.01)

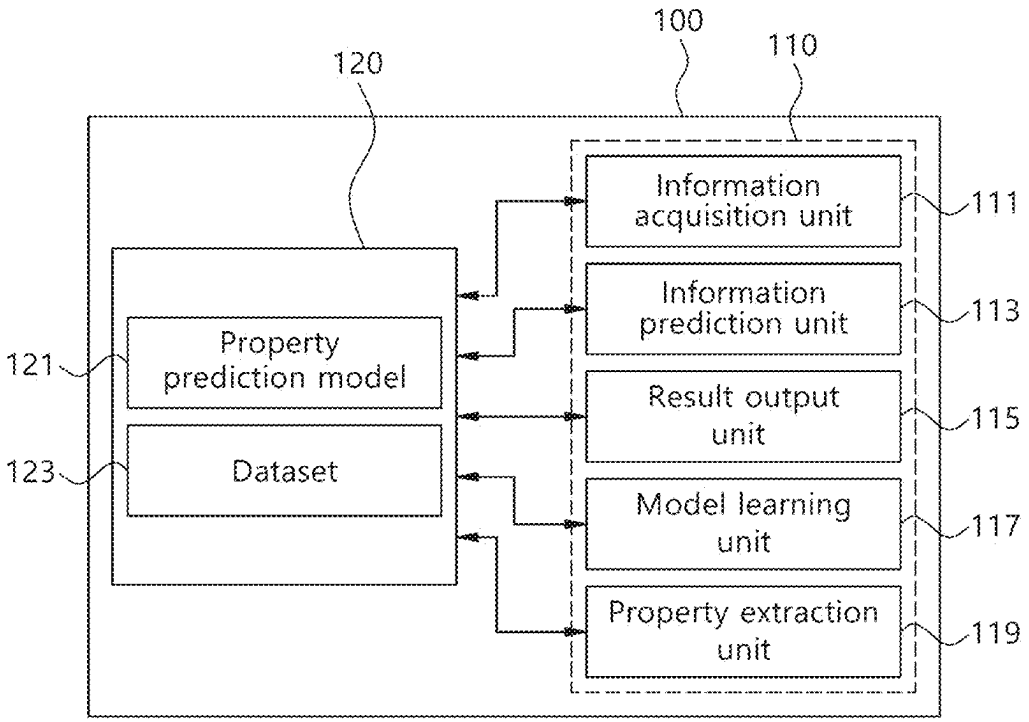
(52) **U.S. Cl.**
CPC ***G06N 20/00*** (2019.01)

(57) **ABSTRACT**

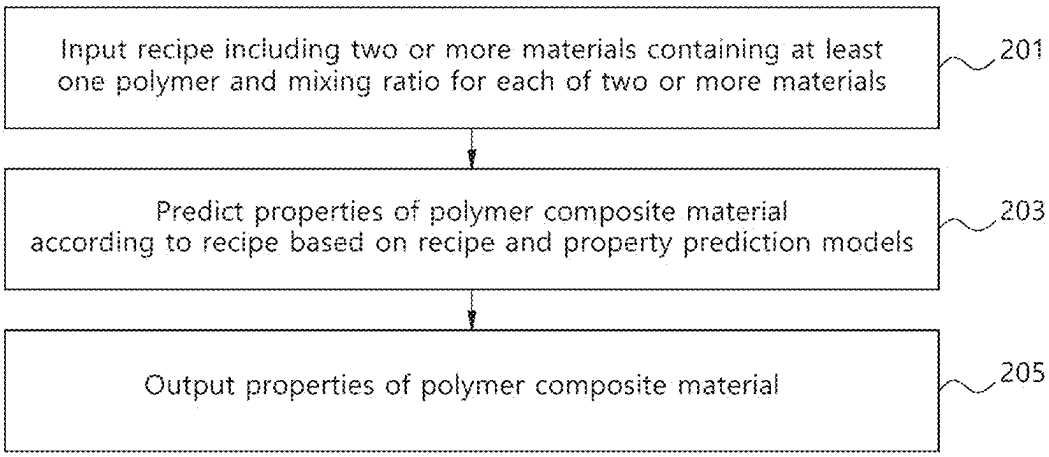
A method for predicting characteristics of a polymer composite material and a device thereof may be provided, wherein the method includes inputting a recipe including two or more materials containing at least one polymer and a mixing ratio for each of the two or more materials; predicting properties of the polymer composite material according to the recipe based on a recipe and property prediction model; and outputting the properties of the polymer composite material.



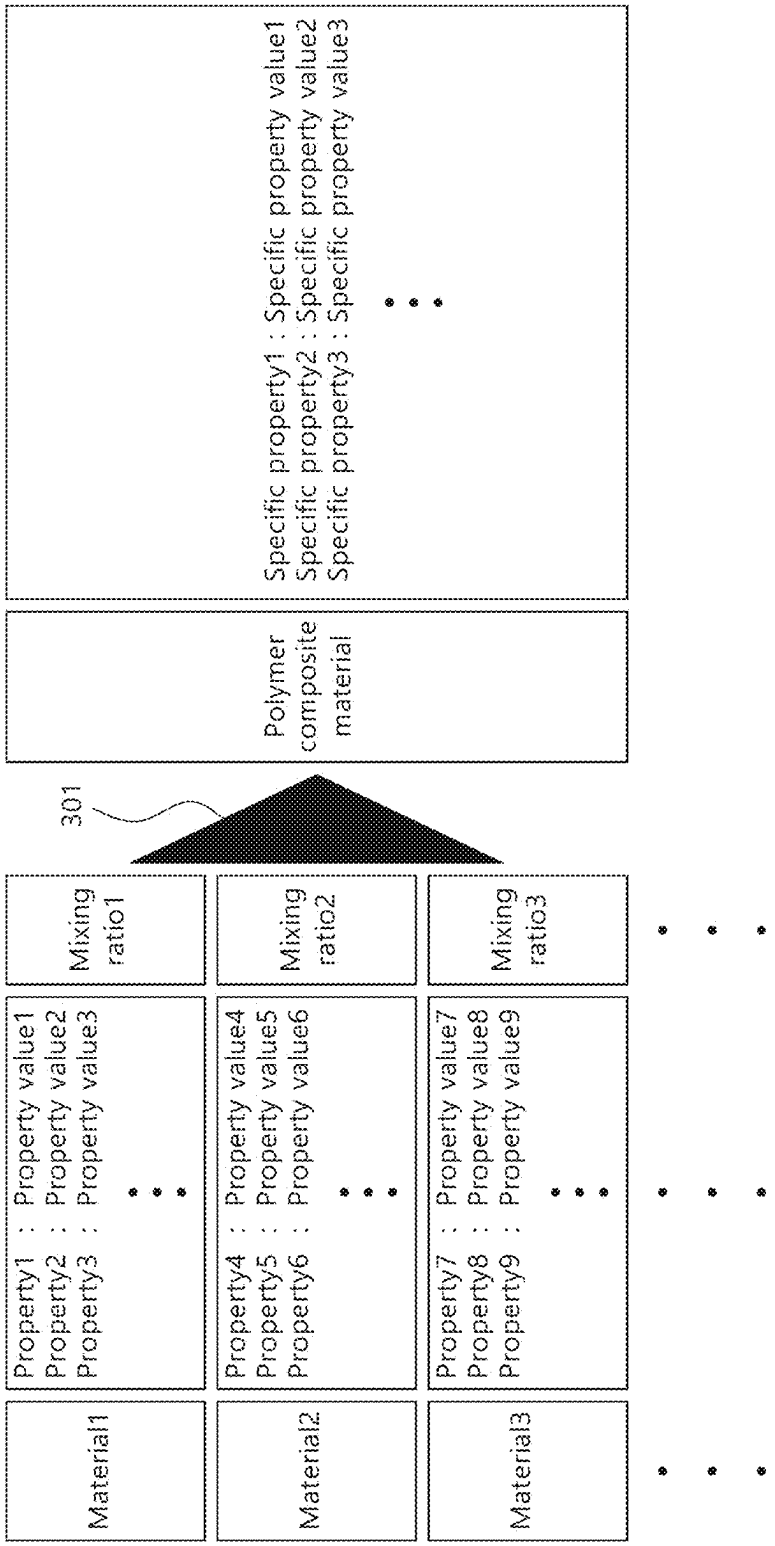
[FIG. 1]


100
110
120
Information acquisition unit
111
Information prediction unit
113
Result output unit
115
Model learning unit
117
Property extraction unit
119
Property prediction model
121
Dataset
123

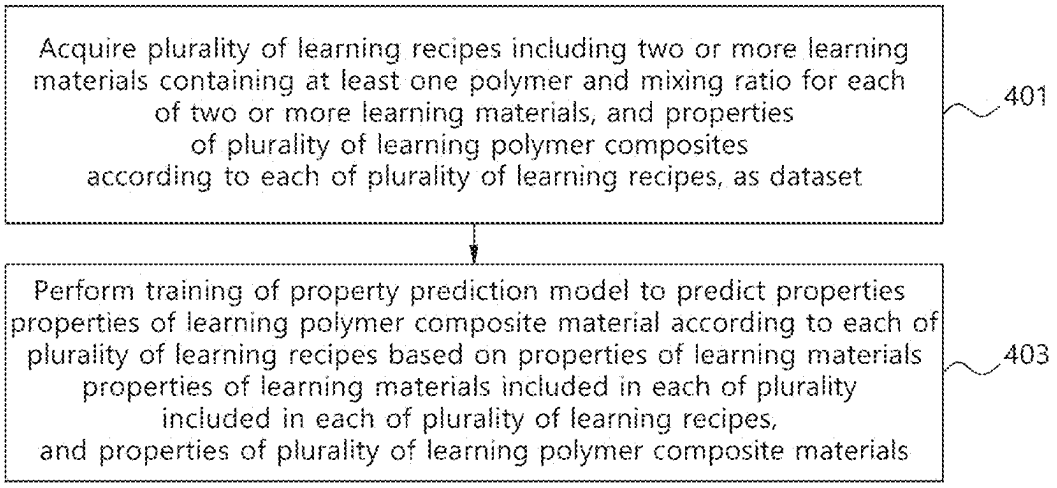
[FIG. 2]


Input recipe including two or more materials containing at least one polymer and mixing ratio for each of two or more materials
201
Predict properties of polymer composite material according to recipe based on recipe and property prediction models
203
Output properties of polymer composite material
205

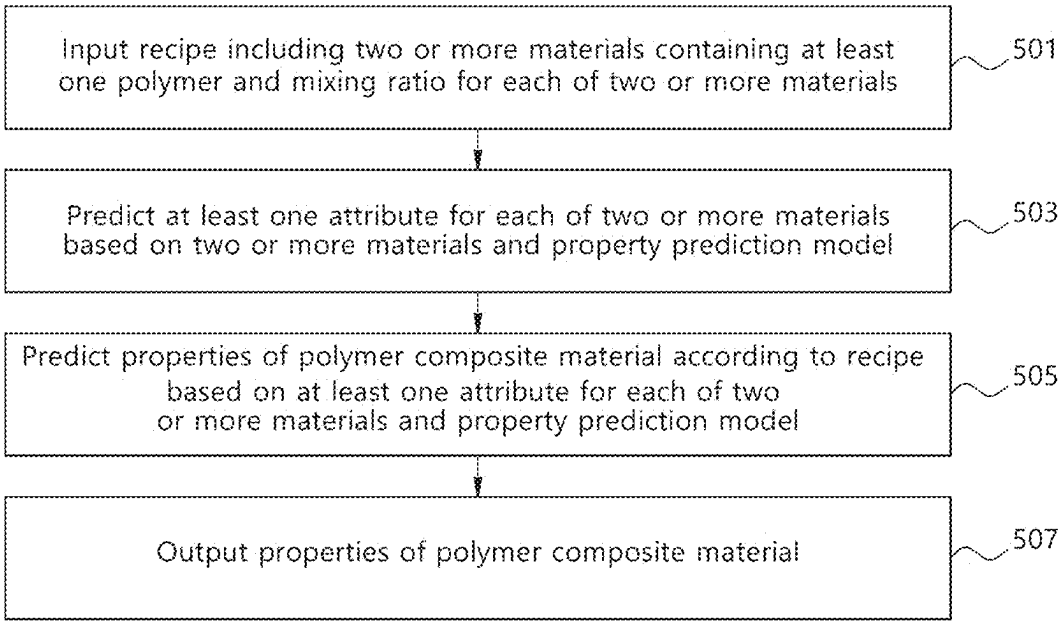
[FIG. 3]


Material1
Property1 : Property value1
Property2 : Property value2
Property3 : Property value3
Mixing ratio1
Material2
Property4 : Property value4
Property5 : Property value5
Property6 : Property value6
Mixing ratio2
Material3
Property7 : Property value7
Property8 : Property value8
Property9 : Property value9
Mixing ratio3
301
Polymer composite material
Specific property1 : Specific property value1
Specific property2 : Specific property value2
Specific property3 : Specific property value3

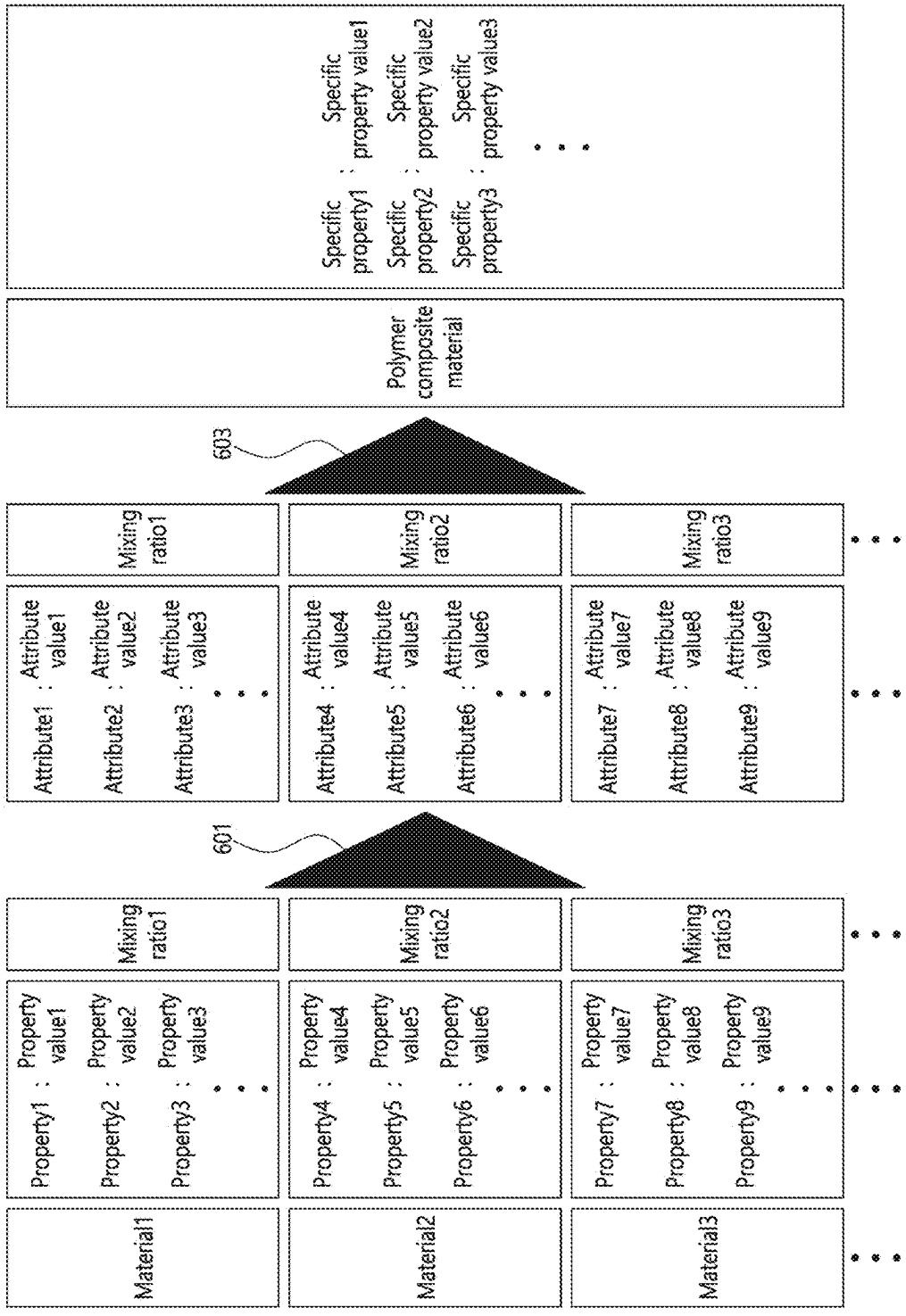
[FIG. 4]


Acquire plurality of learning recipes including two or more learning materials containing at least one polymer and mixing ratio for each of two or more learning materials, and properties of plurality of learning polymer composites according to each of plurality of learning recipes, as dataset
401
Perform training of property prediction model to predict properties properties of learning polymer composite material according to each of plurality of learning recipes based on properties of learning materials properties of learning materials included in each of plurality included in each of plurality of learning recipes, and properties of plurality of learning polymer composite materials
403

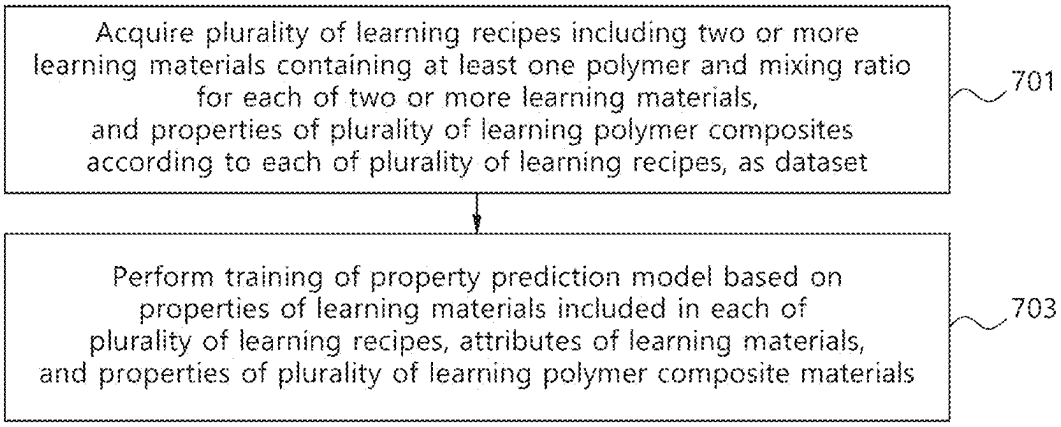
[FIG. 5]


Input recipe including two or more materials containing at least one polymer and mixing ratio for each of two or more materials
501
Predict at least one attribute for each of two or more materials based on two or more materials and property prediction model
503
Predict properties of polymer composite material according to recipe based on at least one attribute for each of two or more materials and property prediction model
505
Output properties of polymer composite material
507

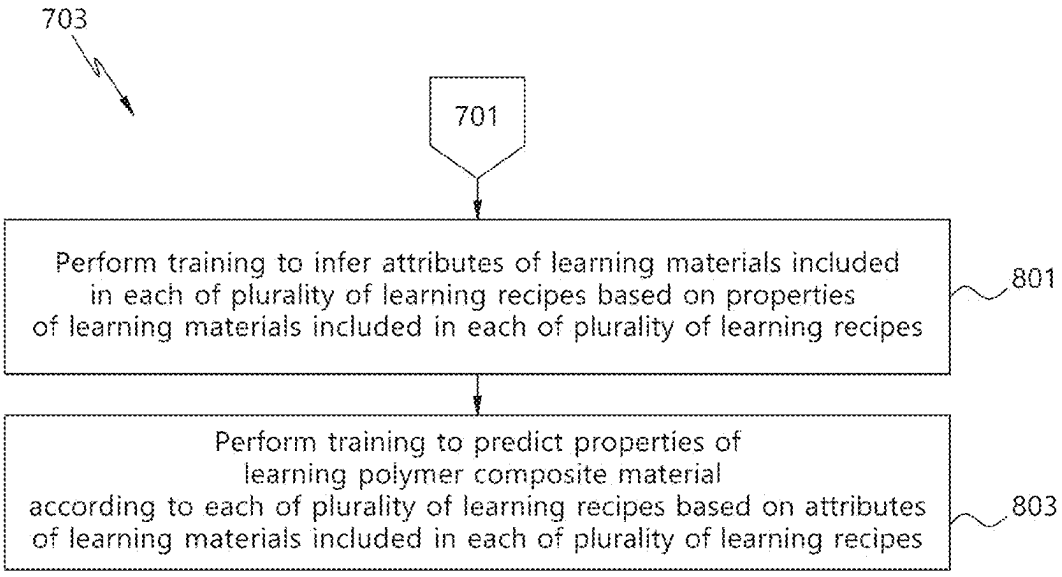
[FIG. 6]


Material1
Property1 : Property value1
Property2 : Property value2
Property3 : Property value3
Mixing ratio1
Material2
Property4 : Property value4
Property5 : Property value5
Property6 : Property value6
Mixing ratio2
Material3
Property7 : Property value7
Property8 : Property value8
Property9 : Property value9
Mixing ratio3
601
Attribute1 : Attribute value1
Attribute2 : Attribute value2
Attribute3 : Attribute value3
Mixing ratio1
Attribute4 : Attribute value4
Attribute5 : Attribute value5
Attribute6 : Attribute value6
Mixing ratio2
Attribute7 : Attribute value7
Attribute8 : Attribute value8
Attribute9 : Attribute value9
Mixing ratio3
603
Polymer composite material
Specific property1 : Specific property value1
Specific property2 : Specific property value2
Specific property3 : Specific property value3

[FIG. 7]


Acquire plurality of learning recipes including two or more learning materials containing at least one polymer and mixing ratio for each of two or more learning materials, and properties of plurality of learning polymer composites according to each of plurality of learning recipes, as dataset
701
Perform training of property prediction model based on properties of learning materials included in each of plurality of learning recipes, attributes of learning materials, and properties of plurality of learning polymer composite materials
703

[FIG. 8]


703
701
Perform training to infer attributes of learning materials included in each of plurality of learning recipes based on properties of learning materials included in each of plurality of learning recipes
801
Perform training to predict properties of learning polymer composite material according to each of plurality of learning recipes based on attributes of learning materials included in each of plurality of learning recipes
803

METHOD FOR PREDICTING CHARACTERISTIC OF POLYMER COMPOSITE MATERIALS BASED ON MATERIAL AND DEVICE THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Korean Patent Application No. 10-2024-0022079 filed Feb. 15, 2024, the disclosure of which is hereby incorporated by reference in its entirety.

BACKGROUND

Technical Field

[0002] The present disclosure relates to a method for predicting characteristics of polymer composite materials and a device thereof.

Technical Considerations

[0003] A polymer composite material is used in various industrial fields, and in order to predict properties according to recipes during the development and synthesis thereof, experiments, simulations, and data-based approaches are comprehensively utilized.

[0004] The current techniques use methods which are still trial and error methods in order to predict the properties of the produced polymer composite material according to the recipes, for example, a method of collecting property data by trying the prediction while changing various composition ratios and process conditions in a laboratory, then inferring and improving the properties of the material based on the collected property data is used.

[0005] Accordingly, attempts are being made to predict the properties of the polymer composite material according to the recipes using a model trained based on the artificial intelligence currently developed, but it takes a lot of costs and time to perform training of the commercially available artificial intelligence model, and there are limitations due to a reason that it is difficult to consider numerous variables of the materials forming the recipes and interactions therebetween.

SUMMARY

[0006] It is an object of the present disclosure to provide a method for predicting characteristics of a polymer composite material and a device thereof.

[0007] Problems to be solved through various embodiments are not limited to the above-described problem, and other problems not described above will be clearly understood by those skilled in the art from the following description.

[0008] To achieve the above object, according to some non-limiting embodiments or aspects of the present disclosure, there is provided a method for predicting characteristics of a polymer composite material, which comprises: inputting a recipe comprising two or more materials comprising at least one polymer and a mixing ratio for each of the two or more materials; predicting properties of the polymer composite material according to the recipe based on a recipe and property prediction model; and outputting the properties of the polymer composite material.

[0009] In some non-limiting embodiments or aspects, the training of the property prediction model may be performed through the steps of: acquiring a plurality of learning recipes comprising two or more learning materials comprising at least one polymer and a mixing ratio for each of the two or more learning materials, and properties of a plurality of learning polymer composite materials according to each of the plurality of learning recipes, as a dataset; and performing training of the property prediction model to predict properties of the learning polymer composite material according to each of the plurality of learning recipes based on the properties of the learning materials comprised in each of the plurality of learning recipes, and the properties of the plurality of learning polymer composite materials.

[0010] In some non-limiting embodiments or aspects, the step of performing training of the property prediction model may comprise: extracting, from each of the plurality of learning recipes, a first preset learning specific property among properties possessed by each of at least one learning specific material, and a second preset learning specific property among the properties of the learning polymer composite material; and performing training of the property prediction model for each of the plurality of learning recipes based on the plurality of learning recipes comprising the plurality of first learning specific properties and the second learning specific properties, wherein the specific material comprises at least one material of a polymer, talc, and/or a polyolefin elastomer.

[0011] In some non-limiting embodiments or aspects, the step of predicting properties of the polymer composite material may comprise: extracting at least one specific property among a plurality of properties possessed by each of at least one specific material among the two or more materials; and predicting properties of the polymer composite material using the two or more materials and the at least one specific property of the at least one specific material as inputs to the property prediction model.

[0012] In some non-limiting embodiments or aspects, there is provided a method for predicting characteristics of a polymer composite material, which comprises: inputting a recipe comprising two or more materials comprising at least one polymer and a mixing ratio for each of the two or more materials; predicting at least one attribute for each of the two or more materials based on the two or more materials and a property prediction model; predicting properties of the polymer composite material according to the recipe based on the at least one attribute for each of the two or more materials and the property prediction model; and outputting the properties of the polymer composite material.

[0013] In some non-limiting embodiments or aspects, the training of the property prediction model may be performed through the steps of: acquiring a plurality of learning recipes comprising two or more learning materials comprising at least one polymer and a mixing ratio for each of the two or more learning materials, and properties of a plurality of learning polymer composite materials according to each of the plurality of learning recipes, as a dataset; and performing training of the property prediction model based on properties of the learning materials comprised in each of the plurality of learning recipes, attributes of the learning materials, and the properties of the plurality of learning polymer composite materials.

[0014] In some non-limiting embodiments or aspects, the step of performing training of the property prediction model

may comprise: training to infer attributes of the learning materials comprised in each of the plurality of learning recipes based on the properties of the learning materials comprised in each of the plurality of learning recipes; and training to predict the properties of the learning polymer composite material according to each of the plurality of learning recipes based on the attributes of the learning materials comprised in each of the plurality of learning recipes.

[0015] In some non-limiting embodiments or aspects, the step of performing training of the property prediction model further may comprise extracting, from each of the plurality of learning recipes, a first preset learning specific property among properties possessed by each of at least one learning specific material, and a second preset learning specific property among the properties of the learning polymer composite material, wherein the step of training to infer attributes of the learning materials performs training to infer attributes of the learning materials comprised in each of the plurality of learning recipes based on the first learning specific property comprised in each of the plurality of learning recipes, the step of training to predict properties of the learning polymer composite material performs training to predict the second specific property of the learning polymer composite material according to each of the plurality of learning recipes based on the attributes of the learning materials comprised in each of the plurality of learning recipes, and the specific material comprises at least one material of a polymer, talc, and/or a polyolefin elastomer.

[0016] In some non-limiting embodiments or aspects, the step of predicting properties of the polymer composite material may comprise: extracting at least one specific property among a plurality of properties possessed by each of at least one specific material among the two or more materials; and predicting properties of the polymer composite material using the two or more materials and the at least one specific property of the at least one specific material as inputs to the property prediction model.

[0017] Further, according to some non-limiting embodiments or aspects of the present disclosure, there is provided a device for predicting characteristics of a polymer composite material, which comprises: an information input unit configured to input a recipe comprising two or more materials comprising at least one polymer and a mixing ratio for each of the two or more materials; an information prediction unit configured to predict properties of the polymer composite material according to the recipe based on a recipe and property prediction model; and a result output unit configured to output the properties of the polymer composite material.

[0018] In some non-limiting embodiments or aspects, the device may further comprise a model learning unit configured to: acquire a plurality of learning recipes comprising two or more learning materials comprising at least one polymer and a mixing ratio for each of the two or more learning materials, and properties of a plurality of learning polymer composite materials according to each of the plurality of learning recipes, as a dataset; and perform training of the property prediction model to predict the properties of the learning polymer composite material according to each of the plurality of learning recipes based on the properties of the learning materials comprised in each of the plurality of learning recipes, and the properties of the plurality of learning polymer composite materials, wherein the property prediction model is trained through the model learning unit.

[0019] In some non-limiting embodiments or aspects, the model learning unit may be configured to: extract, from each of the plurality of learning recipes, a first preset learning specific property among properties possessed by each of at least one learning specific material, and a second preset learning specific property among the properties of the learning polymer composite material; and perform training of the property prediction model for each of the plurality of learning recipes based on the plurality of learning recipes comprising the plurality of first learning specific properties and the second learning specific properties, wherein the specific material comprises at least one material of a polymer, talc, and a polyolefin elastomer.

[0020] In some non-limiting embodiments or aspects, the information prediction unit may be configured to: extract at least one specific property among a plurality of properties possessed by each of at least one specific material among the two or more materials; and predict the properties of the polymer composite material using the two or more materials and the at least one specific property of the at least one specific material as inputs to the property prediction model.

[0021] Furthermore, according to some non-limiting embodiments or aspects of the present disclosure, there is provided a device for predicting characteristics of a polymer composite material, which comprises: an information input unit configured to input a recipe comprising two or more materials comprising at least one polymer and a mixing ratio for each of the two or more materials; an information prediction unit configured to predict at least one attribute for each of the two or more materials based on the two or more materials and a property prediction model, and predict properties of the polymer composite material according to the recipe based on the at least one attribute for each of the two or more materials and the property prediction model; and a result output unit configured to output the properties of the polymer composite material.

[0022] In some non-limiting embodiments or aspects, the property prediction model may comprise: a property-attribute prediction model configured to predict the at least one attribute; and an attribute-property prediction model configured to predict the properties of the polymer composite material.

[0023] In some non-limiting embodiments or aspects, the device may further comprise a model learning unit configured to: acquire a plurality of learning recipes comprising two or more learning materials comprising at least one polymer and a mixing ratio for each of the two or more learning materials, and properties of a plurality of learning polymer composite materials according to each of the plurality of learning recipes, as a dataset; and perform training of the property prediction model based on properties of the learning materials comprised in each of the plurality of learning recipes, attributes of the learning materials, and the properties of the plurality of learning polymer composite materials, wherein the property prediction model is trained through the model learning unit.

[0024] In some non-limiting embodiments or aspects, the model learning unit may perform training of: the property-attribute prediction model to infer attributes of the learning materials comprised in each of the plurality of learning recipes based on the properties of the learning materials comprised in each of the plurality of learning recipes, and

the attribute-property prediction model to predict properties of the learning polymer composite material according to each of the plurality of learning recipes based on the attributes of the learning materials comprised in each of the plurality of learning recipes.

[0025] In some non-limiting embodiments or aspects, the model learning unit may be configured to: extract, from each of the plurality of learning recipes, a first preset learning specific property among properties possessed by each of at least one learning specific material, and a second preset learning specific property among the properties of the learning polymer composite material; perform training of the property-attribute prediction model to infer attributes of the learning materials comprised in each of the plurality of learning recipes based on the first learning specific property comprised in each of the plurality of learning recipes; and perform training of the attribute-property prediction model to predict the second specific property of the learning polymer composite material according to each of the plurality of learning recipes based on the attributes of the learning materials comprised in each of the plurality of learning recipes, wherein the specific material comprises at least one material of a polymer, talc, and/or a polyolefin elastomer.

[0026] In some non-limiting embodiments or aspects, the information prediction unit may be configured to: extract at least one specific property among a plurality of properties possessed by each of at least one specific material among the two or more materials; and predict the properties of the polymer composite material using the two or more materials and the at least one specific property of the at least one specific material as inputs to the property prediction model.

[0027] According to some non-limiting embodiments or aspects, the method for predicting characteristics of a polymer composite material and the device thereof may provide an environment capable of quickly checking changes in the properties of the polymer composite material prepared during synthesis only by changing the materials and the mixing ratio of the materials.

[0028] According to some non-limiting embodiments or aspects, the method for predicting characteristics of a polymer composite material and the device thereof allow users to predict the characteristics of the polymer composite material prepared during synthesis according to the mixing ratio of the materials comprised in the recipes without performing the material synthesis and property measurement processes for the polymer composite material, thereby significantly reducing the time and costs required for development of materials.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The above and other objects, features and other advantages of the present disclosure will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

[0030] FIG. **1** is a block diagram schematically illustrating the configuration of a device according to a non-limiting embodiment according to the principles of the present disclosure;

[0031] FIG. **2** is a flowchart illustrating the flow of an operation of predicting characteristics of a polymer composite material in the device according to a non-limiting embodiment according to the principles of the present disclosure;

[0032] FIG. **3** is a view schematically illustrating a property prediction model to output properties of the polymer composite material using properties of the materials comprised in a recipe as an input in the device according to a non-limiting embodiment according to the principles of the present disclosure;

[0033] FIG. **4** is a flowchart illustrating the flow of an operation of training the property prediction model based on a deep learning algorithm in the device according to a non-limiting embodiment according to the principles of the present disclosure;

[0034] FIG. **5** is a flowchart illustrating the flow of an operation of predicting characteristics of the polymer composite material in the device according to a non-limiting embodiment according to the principles of the present disclosure;

[0035] FIG. **6** is a view schematically illustrating an operation of the property prediction model to predict attributes of the materials using the properties of the materials comprised in the recipe as an input, and output properties of the polymer composite material using the attributes of the materials as an input in the device according to a non-limiting embodiment according to the principles of the present disclosure;

[0036] FIG. **7** is a flowchart illustrating the flow of an operation of training the property prediction model based on the deep learning algorithm in the device according to a non-limiting embodiment according to the principles of the present disclosure; and

[0037] FIG. **8** is a flowchart illustrating the flow of the detailed operation of training the property prediction model based on the deep learning algorithm in the device according to a non-limiting embodiment according to the principles of the present disclosure.

DETAILED DESCRIPTION

[0038] Hereinafter, embodiments will be described in detail with reference to the accompanying drawings. However, since various changes may be made in the embodiments, the scope of the patent disclosure is not limited or restricted by these embodiments. It should be understood that all modifications, equivalents, and alternatives for the embodiments are comprised in the scope of the present disclosure.

[0039] It will be understood that when a component is described as being "connected," "combined" or "coupled" to another component, the component may be directly connected or coupled to the other component, or indirectly connected or coupled to the other component, such as through or combined with an intervening component.

[0040] Further, in describing the components of the embodiment, the meaning of "or" may mean each of the components, may mean two or more of the components, or may mean all of the components. For example, it should be understood that the expressions "a, b or c" represent any one of "a," "b," "c," "a and b," "a and c," "b and c," and "a, b and c."

[0041] Components comprised in one embodiment and components comprising common functions will be described using the same names in other embodiments. The description given in one embodiment may be applied to other embodiments, and therefore will not be described in detail within the overlapping range, unless there is a description opposite thereto.

[0042] The device and/or 'data' processed by the device may be expressed in terms of 'information'. Here, the information may be used as a concept comprising the data.

[0043] The present disclosure relates to a method for predicting characteristics of a polymer composite material and a device thereof. To describe in more detail, a method for predicting properties of a polymer composite material prepared (or synthesized) based on materials of input recipes and a device thereof will be described.

[0044] According to some non-limiting embodiments or aspects, the operation of predicting characteristics of a polymer composite material may be performed based on at least one deep learning algorithm. To describe in more detail, the operation of predicting characteristics of a polymer composite material is based on at least one deep learning model, and when inputting recipes, the properties of the polymer composite material predicted to be synthesized according to the input materials may be predicted based on the mixing ratio and properties of the materials.

[0045] According to some non-limiting embodiments or aspects, the deep learning model may comprise a property prediction model trained to predict properties of a polymer composite material prepared for various properties of materials comprising at least one polymer and a mixing ratio of the materials.

[0046] In some non-limiting embodiments or aspects, the polymer composite material may be a material prepared using at least one polymer as at least a portion of various polymer composites, such as polymer blends, polymer copolymer, polymer nanocomposites, polymer interpenetrating network (IPN), and/or polymer metal composites.

[0047] In some non-limiting embodiments or aspects, the polymer which is the material of the polymer composite material may comprise at least one polymer among polypropylene (PP), polyethylene (PE), and/or polyethylene terephthalate (PET).

[0048] In some non-limiting embodiments or aspects, the polymer may comprise at least one of a variety of recycled polymers, such as recycled polypropylene (rPP), recycled polyethylene (rPE), and/or recycled polyethylene terephthalate (rPET), as well as normal or virgin polymer as described above.

[0049] Hereinafter, various non-limiting embodiments of the present disclosure will be described with reference to the accompanying drawings. However, the drawings attached to the present specification serve to further understand the technical idea together with the detailed description, such that the present disclosure should not be construed as being limited only to the illustrations of the drawings.

[0050] FIG. **1** is a block diagram illustrating the configuration of a device according to some non-limiting embodiments or aspects. To describe in more detail, the device may be illustrated as a block diagram by dividing the detailed configuration according to functions thereof as shown in FIG. **1**.

[0051] First, referring to FIG. **1**, a device **100** may comprise: an information acquisition unit **111** configured to acquire recipes for synthesizing a polymer composite material in order to predict properties of the polymer composite material according to the recipes using the input recipes, and acquire a recipe comprising a plurality of materials and properties of each of the materials, and a mixing ratio of the materials from the acquired recipe; an information prediction unit **113** configured to predict the properties of the polymer composite material based on the acquired properties and mixing ratio of the materials; and a result output unit **115** configured to output the predicted properties of the polymer composite material.

[0052] In some non-limiting embodiments or aspects, the information prediction unit **113** may predict the properties of the polymer composite material according to the properties of the materials and the mixing ratio of the materials acquired from the recipe through the pre-trained property prediction model **121**.

[0053] In some non-limiting embodiments or aspects, the device **100** may further comprise a model learning unit **117** configured to perform training of the property prediction model **121**.

[0054] According to some non-limiting embodiments or aspects, the device **100** may comprise a storage unit **120** configured to store the property prediction model **121**. In some non-limiting embodiments or aspects, at least one dataset **123** used to perform training of the property prediction model **121** may be stored in the storage unit **120**.

[0055] Hereinafter, as an operation of the device **100** based on FIG. **1**, operations of predicting the characteristics of a polymer composite material by the device **100** will be described with reference to FIGS. **2** to **8**. According to some non-limiting embodiments or aspects, an operation of predicting the properties of the polymer composite material from the properties of materials comprised in the recipe using the property prediction model and an operation of training the property prediction model will be described with reference to FIGS. **2** to **4**.

[0056] To this end, FIG. **2** is a flowchart illustrating the flow of an operation of predicting characteristics of a polymer composite material in the device according to some non-limiting embodiments or aspects. FIG. **3** is a view schematically illustrating a property prediction model to output properties of the polymer composite material using properties of the materials comprised in the recipe as an input in the device according to some non-limiting embodiments or aspects. In addition, FIG. **4** is a flowchart illustrating the flow of an operation of training the property prediction model based on a deep learning algorithm in the device according to some non-limiting embodiments or aspects.

[0057] First, referring to FIG. **2**, in step **201**, the information acquisition unit **111** may input (or acquire) a recipe comprising two or more materials comprising at least one polymer and a mixing ratio for each of the two or more materials.

[0058] According to some non-limiting embodiments or aspects, the information acquisition unit **111** may acquire a specific recipe through at least one input unit (not shown) and/or communication unit (not shown) comprised in the device **100**.

[0059] In some non-limiting embodiments or aspects, the recipe may comprise materials capable of producing a specific polymer composite material or identification information corresponding to each of the materials among various materials for producing a polymer composite material, such as at least one polymer, a reinforcing agent (e.g., talc), and/or an additive (e.g., polyolefin ether).

[0060] At this time, if the recipe comprises the identification information corresponding to each of the materials, the information acquisition unit **111** may acquire informa-

tion on the materials corresponding to each of the identification information from the storage unit **120**.

[0061] To this end, the storage unit **120** may store information on materials of the polymer composite material, identification information corresponding to the materials, and properties of each of the materials as a data table.

[0062] According to some non-limiting embodiments, the properties of each of the materials stored in the storage unit **120** or the recipe may comprise at least one property of tensile strength, tensile failure, tearing strength, yield strength, flexural modulus, impact strength, elongation at break, heat distortion temperature, air permeability and/or shrinkage, and property values corresponding thereto.

[0063] To describe in more detail, the impact strength may comprise properties of dart impact strength and/or Izod impact strength. In addition, at least some of the tearing strength, yield strength, tensile failure, and/or elongation at break may comprise properties in a machine direction and/or properties in a transverse direction.

[0064] In describing embodiments of the present disclosure, when expressing the 'properties (or at least one property) of a specific material', it may be expressed comprising properties (or property items) and property values of the specific material such as property items (e.g., tensile strength) and/or property values (tensile strength value possessed by a specific polypropylene) of the specific material (e.g., specific polypropylene).

[0065] In some non-limiting embodiments or aspects, the mixing ratio is a relative weight (or mass) ratio for each of the materials (e.g., a weight ratio sum (WRS)), and a content for each material may be represented as a percent (%).

[0066] In some non-limiting embodiments or aspects, the recipe may comprise information on the properties of each of the comprised materials. However, the properties for each of the materials may be stored in the storage unit **120**, and in this state, the information acquisition unit **111** may acquire the properties for each of the materials from the storage unit **120**.

[0067] To describe the materials acquired from a specific recipe, properties of the materials, and a mixing ratio thereof in more detail with reference to FIG. **3**, the information acquisition unit **111** may acquire various materials for forming a polymer composite material, comprising material 1, material 2, and material 3, from the acquired specific recipe.

[0068] At this time, the information acquisition unit **111** may acquire identification codes corresponding to materials from the recipe, and also acquire information on materials corresponding to each identification code from the storage unit **120**.

[0069] Referring to FIG. **3**, it illustrates that the materials comprised in the recipe are three materials, such as material 1, material 2, and material 3, but it is not limited thereto, and the recipe may also comprise at least one more or less material than three, for example two materials, three materials, four materials, five materials, or more.

[0070] In addition, the information acquisition unit **111** may acquire the properties for each of the materials comprised in the recipe.

[0071] For example, the information acquisition unit **111** may acquire properties comprising property value **1** for property **1**, property value **2** for property **2**, and property value **3** for property **3** in material **1**, properties comprising property value **4** for property **4**, property value **5** for property **5**, and property value **6** for property **6** in material **2**, and properties comprising property value **7** for property **7**, property value **8** for property **8**, and property value **9** for property **9** in material **3**.

[0072] In some non-limiting embodiments or aspects, referring to FIG. **3**, it illustrates that, for the properties comprised in each of the materials comprised in the recipe, three properties are comprised therein, but it is not limited thereto, and the properties for each of the materials may also comprise at least one more or less property than three.

[0073] In some non-limiting embodiments or aspects, the expressions of properties **1** to **9** are expressions for describing the properties possessed by the materials, and two or more properties among properties **1** to **9** may represent the same property. Similarly, two or more among mixing ratios **1** to **3** may represent the same mixing ratio.

[0074] In some non-limiting embodiments or aspects, the information acquisition unit **111** may acquire the mixing ratio for each of the materials comprised in the recipe.

[0075] For example, the information acquisition unit **111** may acquire a mixing ratio **1** for material **1**, a mixing ratio **2** for material **2**, and a mixing ratio **3** for material **3**. To describe in more detail, the mixing ratios of the materials comprised in the recipe may be comprised as a ratio possessed by each of the materials based on 100% of total materials, such as a mixing ratio of 20% for material **1**, a mixing ratio of 30% for material **2**, and a mixing ratio of 50% for material **3**.

[0076] In step **203**, the information prediction unit **113** may predict the properties of the polymer composite material according to the recipe based on the recipe and the property prediction models.

[0077] According to some non-limiting embodiments or aspects, the information prediction unit **113** may process a plurality of properties for each of two or more materials acquired based on the recipe as an input to the property prediction model **121**, and acquire properties of the polymer composite material according to the recipe as an output from the property prediction model **121**.

[0078] To describe in more detail with reference to FIG. **3**, the property prediction model according to some non-limiting embodiments or aspects of FIGS. **2** to **4** may comprise a property-property prediction model (hereinafter, a property prediction model **301**) trained to predict the properties of the polymer composite material according to the recipe based on the properties of the materials comprised in the recipe.

[0079] The information prediction unit **113** may process the materials comprised in the recipe (e.g., material **1**, material **2**, and material **3**), the properties of the materials (e.g., properties comprising property value **1** for property **1**, property value **2** for property **2**, and property value **3** for property **3** in material **1**, properties comprising property value **4** for property **4**, property value **5** for property **5**, and property value **6** for property **6** in material **2**, and properties comprising property value **7** for property **7**, property value **8** for property **8**, and property value **9** for property **9** in material **3**), and the mixing ratios for the materials (e.g., mixing ratio **1** for material **1**, mixing ratio **2** for material **2**, and mixing ratio **3** for material **3**) as inputs to the property prediction model **301**, and acquire specific properties of the polymer composite material according to the recipe (e.g., specific property value **1** for specific property **1**, specific property value **2** for specific property **2**, and specific property value **3** for a specific property **3**).

[0080] In some non-limiting embodiments or aspects, the specific property may comprise at least one property of melt index, tensile strength, tensile failure, tearing strength, yield strength, flexural modulus, impact strength, elongation at break, heat distortion temperature, air permeability and/or shrinkage.

[0081] In some non-limiting embodiments or aspects, referring to FIG. **3**, it is described that, for the properties of the polymer composite material output by the property prediction model **301**, three specific properties are output, but it is not limited thereto, and the properties of the polymer composite material output by the property prediction model **301** may further comprise at least one more or less specific property than three.

[0082] When performing the embodiment according to FIGS. **2** and **3**, the pre-trained property prediction model **301** of step **203** may be a deep learning model trained to output specific properties of the polymer composite material according to the recipe based on the properties of the materials comprised in the recipe.

[0083] In this regard, the training of the property prediction model **301** will be described in detail through FIG. **4**.

[0084] First, the property prediction model **301** may be configured to perform training based on at least some of various deep learning algorithms which process structured data, such as TabNet, XGBoost, LightGBM, CatBoost, and/or deep neural network (DNN).

[0085] The property prediction model **301** may comprise a deep learning model configured to receive as an input, recipes comprising a plurality of materials, properties for each of the materials, and a mixing ratio for the plurality of materials, and output properties of the polymer composite material corresponding to the recipes.

[0086] In step **401**, the model learning unit **117** may acquire a plurality of learning recipes comprising two or more learning materials comprising at least one polymer and a mixing ratio for each of the two or more learning materials, and properties of a plurality of learning polymer composite materials according to each of the plurality of learning recipes, as a dataset.

[0087] To describe in more detail, the dataset may comprise the plurality of learning recipes and the properties of the learning polymer composite materials according to each of the plurality of learning recipes. In some non-limiting embodiments or aspects, each of the plurality of recipes may comprise information on two or more materials, properties of each of the two or more materials, and a mixing ratio of each of the two or more materials.

[0088] For example, to describe the dataset comprising information on a specific learning recipe and properties of the specific learning polymer composite material according to the specific learning recipe, it may comprise learning materials comprised in the specific learning recipe (e.g., material **4**, material **5**, and material **6**), properties for the learning materials (e.g., properties comprising property value **10** for property **10**, property value **11** for property **11**, and property value **12** for property **12** in material **4**, properties comprising property value **13** for property **13**, property value **14** for property **14**, and property value **15** for property **15** in material **5**, and properties comprising property value **16** for property **16**, property value **17** for property **17**, and property value **18** for property **18** in material **6**), and mixing ratios for the learning materials (e.g., mixing ratio **4** for material **4**, mixing ratio **5** for material **5**, and mixing ratio **6** for material **6**).

[0089] The specific learning polymer composite material according to the specific learning recipe is a polymer composite material which is confirmed to be capable of being synthesized using the specific learning recipe, and may comprise properties possessed by the specific learning polymer composite material (e.g., properties comprising property value **19** for property **19**, property value **20** for property **20**, and property value **21** for property **21**).

[0090] In some non-limiting embodiments or aspects, it is described that the number of materials comprised in the learning recipe, the number of properties comprised in each of the materials, and the number of properties of the learning polymer composite material are three, respectively, but they are not limited thereto, and may be changed depending on the setting.

[0091] In some non-limiting embodiments or aspects, the expressions of properties **10** to **18** are expressions for describing the properties possessed by the materials, and two or more properties among properties **10** to **18** may represent the same property, and at least one property among properties **10** to **18** may represent the same property as at least one property among properties **1** to **9** and property **19** to property **21**.

[0092] Similarly, two or more of the mixing ratios **4** to **6** may have the same mixing ratio, and at least one of the mixing ratios **4** to **6** may have the same value as at least one of the mixing ratios **1** to **3**.

[0093] In some non-limiting embodiments or aspects, a dataset **123** and/or data comprised in the dataset (e.g., recipes and properties of the polymer composite material corresponding to the recipes) may be received by the information acquisition unit **111** through an input unit or the communication unit.

[0094] In some non-limiting embodiments or aspects, the properties of the polymer composite material may comprise at least some of melt index, tensile strength, tensile failure, tearing strength, yield strength, flexural modulus, impact strength, elongation at break, heat distortion temperature, air permeability and/or shrinkage.

[0095] In step **403**, the model learning unit **117** may perform training of the property prediction model to predict the properties of the learning polymer composite material according to each of the plurality of learning recipes based on the properties of the learning materials comprised in each of the plurality of learning recipes, and the properties of the plurality of learning polymer composite materials.

[0096] To describe in more detail, the model learning unit **117** may perform training of the property prediction model **301** so as to, when inputting any one recipe, output the properties of the polymer composite material according to the corresponding recipe, based on the learning materials comprised in each of the plurality of learning recipes, properties of the learning materials, and properties of the plurality of learning polymer composite materials.

[0097] When performing training of the property prediction model **301**, the model learning unit **117** may train the property prediction model **301** based on the specific properties of at least some specific materials comprised in the learning recipe, and specific properties of the learning polymer composite material.

[0098] To describe in more detail, the model learning unit **117** may extract, from each of the plurality of learning recipes, a first preset learning specific property among properties possessed by each of at least one learning specific material, and a second preset learning specific property among the properties of the learning polymer composite material.

[0099] To this end, the device **100** may further comprise a property extraction unit **119** for extracting the properties of the materials comprised in the recipes and/or specific properties from the properties of the polymer composite material.

[0100] In some non-limiting embodiments or aspects, the specific material may comprise a polymer, talc, or a polyolefin elastomer.

[0101] In some non-limiting embodiments or aspects, the model learning unit **117** and/or the property extraction unit **119** may extract a first learning specific property or a second learning specific property comprising at least some of melt index, tensile strength, tensile failure, tearing strength, yield strength, flexural modulus, impact strength, elongation at break, heat distortion temperature, air permeability and/or shrinkage.

[0102] In some non-limiting embodiments or aspects, the second learning specific property may comprise at least one property among the specific properties of the polymer composite material to be predicted through the pre-trained property prediction model **121**.

[0103] In some non-limiting embodiments or aspects, the model learning unit **117** and/or the property extraction unit **119** may extract the first learning specific property in different manners based on types of the learning specific material.

[0104] For example, when the learning specific material is polypropylene (PP), the model learning unit **117** and/or the property extraction unit **119** may extract at least one property among the melt index, flexural modulus, tensile strength, impact strength, shrinkage, and/or heat distortion temperature as a first feature.

[0105] When the learning specific material is polyethylene (PE), the model learning unit **117** and/or the property extraction unit **119** may extract at least one property among the impact strength, tearing strength, yield strength, tensile failure, and/or elongation at break as a second feature.

[0106] In some non-limiting embodiments or aspects, when the learning specific material is polyethylene terephthalate (PET), the model learning unit **117** and/or the property extraction unit **119** may extract at least one property among the air permeability, tensile strength, tearing strength, and/or elongation at break as a third feature.

[0107] Thereafter, the model learning unit **117** may perform training of the property prediction model for each of the plurality of learning recipes based on the plurality of learning recipes comprising the plurality of first learning specific properties and the second learning specific properties.

[0108] To describe in more detail, the model learning unit **117** may perform training of the property prediction model **301** to output properties comprising the second learning specific properties of the specific polymer composite material corresponding to the specific learning recipe by setting the first learning specific properties and/or the second learning specific properties as a region of interest, and using the specific learning recipe and the first learning specific properties of the specific learning recipe as inputs.

[0109] The information prediction unit **113** may perform an operation of predicting the properties of a polymer composite material for a recipe using the trained property prediction model **301** as described above.

[0110] Returning to FIG. **2** again, the operation of predicting the properties of the polymer composite material according to the input recipe using the trained property prediction model **301** will be described in more detail.

[0111] For example, in step **203**, the information prediction unit **113** may process two or more materials comprised in the recipe, properties for each of the materials, and a mixing ratio of each of the materials as inputs to the property prediction model **301**, and acquire properties of the polymer composite material from the property prediction model **301**.

[0112] According to some non-limiting embodiments or aspects, the information prediction unit **113** may extract at least one specific property among the plurality of properties possessed by each of at least one specific material among two or more materials comprised in the input recipe, and process it as an input to the property prediction model **301**.

[0113] At this time, the information prediction unit **113** may predict the properties of the polymer composite material using the two or more materials and the at least one specific property of the at least one specific material as inputs to the property prediction model **301**.

[0114] In step **205**, the result output unit **115** may output the properties of the polymer composite material. To describe in more detail, the result output unit **115** may generate result information by comprising the recipe acquired in step **201** and the specific properties of the polymer composite material acquired from the property prediction model **301** corresponding to the acquired recipe, and output the result information.

[0115] According to some non-limiting embodiments or aspects, the result output unit **115** may comprise at least some chemical formulas and/or at least some chemical structures of the polymer composite material predicted by the pre-trained property prediction model **121** corresponding to the recipe in the result information.

[0116] In some non-limiting embodiments or aspects, the result output unit **115** may display a portion corresponding to the specific properties of the predicted polymer composite material through at least some chemical formulas and/or at least some chemical structures. In this case, the result output unit **115** may display the portion corresponding to the specific property of the polymer composite material through highlighting or color change.

[0117] According to various some non-limiting embodiments or aspects, the result output unit **115** may transmit the result information to other preset devices through the communication unit **130**.

[0118] When the operation of step **205** is completed, the result output unit **115** may terminate the procedures of embodiment in FIG. **2**.

[0119] According to some non-limiting embodiments or aspects, it is not limited to predicting the properties of the polymer composite material from the properties of the materials comprised in the recipe as described above, and the properties of the polymer composite material may also be predicted based on attributes of the materials.

[0120] In this regard, an operation of predicting the properties of the polymer composite material from the properties of the materials and the attributes of the materials comprised in the recipe using the property prediction model and an

operation of training the property prediction model will be described with reference to FIGS. **5** to **8**.

[0121] To this end, FIG. **5** is a flowchart illustrating the flow of an operation of predicting characteristics of the polymer composite material in the device according to some non-limiting embodiments or aspects. FIG. **6** is a view schematically illustrating an operation of the property prediction model to predict attributes of the materials using the properties of the materials comprised in the recipe as an input, and output properties of the polymer composite material using the attributes of the materials as an input in the device according to some non-limiting embodiments or aspects. FIG. **7** is a flowchart illustrating the flow of an operation of training the property prediction model based on the deep learning algorithm in the device according to some non-limiting embodiments or aspects of the present disclosure. In addition, FIG. **8** is a flowchart illustrating the flow of the detailed operation of training the property prediction model based on the deep learning algorithm in the device according to some non-limiting embodiments or aspects of the present disclosure.

[0122] First, referring to FIG. **5**, in step **501**, the information acquisition unit **111** may input (or acquire) a recipe comprising two or more materials comprising at least one polymer and a mixing ratio for each of the two or more materials.

[0123] Step **501** may be performed identically or similarly to at least some procedures of step **201** in FIG. **2**, unless specifically mentioned, and therefore will not be described in detail.

[0124] The materials acquired from the specific recipe, the properties of the materials, and the mixing ratio thereof have been described in detail with reference to FIG. **3**, and therefore the operation of acquiring various materials, the properties of the materials, and the mixing ratio of the materials for forming the polymer composite material comprising material **1**, material **2**, and material **3** from the specific recipe by the information acquisition unit **111** will not be described.

[0125] Thereafter, the information prediction unit **113** may predict the attributes of the materials based on the properties of the materials acquired from the recipe, and may predict the properties of the polymer composite material based on the attributes of the materials.

[0126] For this purpose, to describe in more detail with reference to FIG. **6**, the property prediction model **121** may comprise a property-attribute prediction model (hereinafter, a first prediction model **601**) configured to predict attributes of the materials using the properties of materials as an input, and an attribute-property prediction model (hereinafter, a second prediction model **603**) configured to predict specific properties of the polymer composite material using the attributes of the materials.

[0127] In step **503**, the information prediction unit **113** may predict at least one attribute for each of the two or more materials based on the two or more materials and the first prediction model **601**.

[0128] According to some non-limiting embodiments or aspects, the information prediction unit **113** may process a plurality of properties for each of two or more materials acquired based on the recipe as an input to the first prediction model **601**, and acquire a plurality of attributes for each of the two or more materials from the first prediction model **601** as an output.

[0129] The information prediction unit **113** may process materials comprised in the recipe (e.g., material **1**, material **2**, and material **3**), properties of the materials (e.g., properties comprising property value **1** for property **1**, property value **2** for property **2**, and property value **3** for property **3** in material **1**, properties comprising property value **4** for property **4**, property value **5** for property **5**, and property value **6** for property **6** in material **2**, and properties comprising property value **7** for property **7**, property value **8** for property **8**, and property value **9** for property **9** in material **3**), and mixing ratios for the materials (e.g., mixing ratio **1** for material **1**, mixing ratio **2** for material **2**, and mixing ratio **3** for material **3**) as inputs to the first prediction model **601**, and acquire attributes of the materials (e.g., attributes comprising attribute value **1** for attribute **1**, attribute value **2** for attribute **2**, and attribute value **3** for attribute **3** in material **1**, attributes comprising attribute value **4** for attribute **4**, attribute value **5** for attribute **5**, and attribute value **6** for attribute **6** in material **2**, and attributes comprising attribute value **7** for attribute **7**, attribute value **8** for attribute **8**, and attribute value **9** for attribute **9** in material **3**).

[0130] In some non-limiting embodiments or aspects, the attributes of the materials may comprise at least one attribute of syndiotactic PP content or molecular weight, atactic PP content or molecular weight, rubber content or molecular weight, type or content of reinforcing agent, PE content or molecular weight, type or content of copolymer, long-chain branch content, acid content, density, and degree of crystallization.

[0131] In some non-limiting embodiments or aspects, referring to FIG. **6**, it is described that, for each of the attributes of the materials output by the first prediction model **601**, three attributes are output, but it is not limited thereto, and each of the attributes of the materials output by the first prediction model **601** may comprise at least one more or less attribute than three.

[0132] In step **505**, the information prediction unit **113** may predict the properties of the polymer composite material according to the recipe based on the at least one attribute for each of the two or more materials and the property prediction model.

[0133] According to some non-limiting embodiments or aspects, the information prediction unit **113** may process the attributes of the materials and the mixing ratio of the materials acquired from the first prediction model **601** as inputs to the second prediction model **603**, and acquire the properties of the polymer composite material according to the recipe from the second prediction model **603** as an output.

[0134] The information prediction unit **113** may process the attributes for materials (e.g., attributes comprising attribute value **1** for attribute **1**, attribute value **2** for attribute **2**, and attribute value **3** for attribute **3** in material **1**, attributes comprising attribute value **4** for attribute **4**, attribute value **5** for attribute **5**, and attribute value **6** for attribute **6** in material **2**, and attributes comprising attribute value **7** for attribute **7**, attribute value **8** for attribute **8**, and attribute value **9** for attribute **9** in material **3**) as an input to the second prediction model **603**, and acquire specific properties of the polymer composite material according to the recipe (e.g., properties comprising specific property value **1** for specific property **1**, specific property value **2** for specific property **2**, and specific property value **3** for specific property **3**).

[0135] In some non-limiting embodiments or aspects, the specific property may comprise at least one property of melt index, tensile strength, tensile failure, tearing strength, yield strength, flexural modulus, impact strength, elongation at break, heat distortion temperature, air permeability and shrinkage.

[0136] In some non-limiting embodiments or aspects, referring to FIG. **6**, it is described that, for the properties of the polymer composite material output by the second prediction model **603**, three specific properties are output, but it is not limited thereto, and the properties of the polymer composite material output by the second prediction model **603** may further comprise at least one more or less specific property than three.

[0137] When performing the embodiment according to FIGS. **5** and **6**, the pre-trained first prediction model **601** of step **503** may be a deep learning model trained to output attributes of the materials based on the properties of the materials comprised in the recipe, and the pre-trained second prediction model **603** of step **505** may be a deep learning model trained to output specific properties of the polymer composite material according to the recipe based on the attributes of the materials.

[0138] In this regard, the training of the first prediction model **601** and the second prediction model **603** will be described in detail through FIGS. **7** and **8**.

[0139] First, the first prediction model **601** and the second prediction model **603** may be configured to perform training based on at least some of various deep learning algorithms which process structured data, such as TabNet, XGBoost, LightGBM, CatBoost, and/or deep neural network (DNN).

[0140] In step **701**, the model learning unit **117** may acquire a plurality of learning recipes comprising two or more learning materials comprising at least one polymer and a mixing ratio for each of the two or more learning materials, and properties of a plurality of learning polymer composite materials according to each of the plurality of learning recipes, as a dataset.

[0141] To describe in more detail, the dataset may comprise the plurality of learning recipes and the properties of the learning polymer composite materials according to each of the plurality of learning recipes. In some non-limiting embodiments or aspects, each of the plurality of recipes may comprise information on two or more materials, properties of each of the two or more materials, attributes of each of the two or more materials, and a mixing ratio of each of the two or more materials.

[0142] For example, to describe the dataset comprising information on a specific learning recipe and properties of the specific learning polymer composite material according to the specific learning recipe, it may comprise learning materials comprised in the specific learning recipe (e.g., material **4**, material **5**, and material **6**), properties for the learning materials (e.g., properties comprising property value **10** for property **10**, property value **11** for property **11**, and property value **12** for property **12** in material **4**, properties comprising property value **13** for property **13**, property value **14** for property **14**, and property value **15** for property **15** in material **5**, and properties comprising property value **16** for property **16**, property value **17** for property **17**, and property value **18** for property **18** in material **6**), attributes for the learning materials (e.g., attributes comprising attribute value **10** for attribute **10**, attribute value **11** for attribute **11**, and attribute value **12** for attribute **12** in material **4**, attributes comprising attribute value **13** for attribute **13**, attribute value **14** for attribute **14**, and attribute value **15** for attribute **15** in material **5**, and attributes comprising attribute value **16** for attribute **16**, attribute value **17** for attribute **17**, and attribute value **18** for attribute **18** in material **6**), and mixing ratios for the learning materials (e.g., mixing ratio **4** for material **4**, mixing ratio **5** for material **5**, and mixing ratio **6** for material **6**).

[0143] The specific learning polymer composite material according to the specific learning recipe is a polymer composite material which is confirmed to be capable of being synthesized using the specific learning recipe, and may comprise properties possessed by the specific learning polymer composite material (e.g., properties comprising property value **19** for property **19**, property value **20** for property **20**, and property value **21** for property **21**).

[0144] In some non-limiting embodiments or aspects, it is described that the number of materials comprised in the learning recipe, the number of properties comprised in each of the materials, and the number of properties of the learning polymer composite material are three, respectively, but they are not limited thereto, and may be changed depending on the setting.

[0145] In some non-limiting embodiments or aspects, the expressions of properties **10** to **18** are expressions for describing the properties possessed by the materials, and two or more properties among properties **10** to **18** may represent the same property, and at least one property among properties **10** to **18** may represent the same property as at least one property among properties **1** to **9** and property **19** to property **21**.

[0146] Similarly, two or more of the mixing ratios **4** to **6** may have the same mixing ratio, and at least one of the mixing ratios **4** to **6** may have the same value as at least one of the mixing ratios **1** to **3**.

[0147] In some non-limiting embodiments or aspects, the dataset **123** and/or data comprised in the dataset (e.g., recipes and properties of the polymer composite material corresponding to the recipes) may be received by the information acquisition unit **111** through an input unit or the communication unit.

[0148] In step **703**, the model learning unit **117** may perform training of the property prediction model based on properties of the learning materials comprised in each of the plurality of learning recipes, attributes of the learning materials, and the properties of the plurality of learning polymer composite materials.

[0149] In this regard, the operation of training the first prediction model **601** and the second prediction model **603** will be described in more detail with reference to FIG. **8**. At least some procedures of steps **801** and/or **803** in FIG. **8** may be executed in step **703** of FIG. **7**.

[0150] In step **801**, the model learning unit **117** may perform training of the first prediction model **601** to infer attributes of the learning materials comprised in each of the plurality of learning recipes based on the properties of the learning materials comprised in each of the plurality of learning recipes.

[0151] To describe in more detail, when inputting any one recipe based on the learning materials comprised in each of the plurality of learning recipes and the properties of the learning materials, the model learning unit **117** may perform training of the first prediction model **601** to output the attributes of the materials comprised in the recipe.

[0152] When performing training of the first prediction model **601**, the model learning unit **117** may train the first prediction model **601** based on the specific properties of at least some specific materials comprised in the learning recipes.

[0153] To describe in more detail, the model learning unit **117** may extract, from each of the plurality of learning recipes, a first preset learning specific property among properties possessed by each of at least one learning specific material, and a second preset learning specific property among the properties of the learning polymer composite material.

[0154] To this end, the device **100** may further comprise a property extraction unit **119** for extracting the properties of the materials comprised in the recipes and/or specific properties from the properties of the polymer composite material.

[0155] In some non-limiting embodiments or aspects, the specific material may comprise a polymer, talc, and/or a polyolefin elastomer.

[0156] In some non-limiting embodiments or aspects, the model learning unit **117** and/or the property extraction unit **119** may extract a first learning specific property or a second learning specific property comprising at least some of melt index, tensile strength, tensile failure, tearing strength, yield strength, flexural modulus, impact strength, elongation at break, heat distortion temperature, air permeability and/or shrinkage.

[0157] In some non-limiting embodiments or aspects, the second learning specific property may comprise at least one property among the specific properties of the polymer composite material to be predicted through the pre-trained property prediction model **121**.

[0158] In some non-limiting embodiments or aspects, the model learning unit **117** and/or the property extraction unit **119** may extract the first learning specific property in different manners based on types of the learning specific material.

[0159] For example, when the learning specific material is polypropylene (PP), the model learning unit **117** and/or the property extraction unit **119** may extract at least one property among the melt index, flexural modulus, tensile strength, impact strength, shrinkage, and/or heat distortion temperature as a first feature.

[0160] When the learning specific material is polyethylene (PE), the model learning unit **117** and/or the property extraction unit **119** may extract at least one property among the impact strength, tearing strength, yield strength, tensile failure, and elongation at break as a second feature.

[0161] In some non-limiting embodiments or aspects, when the learning specific material is polyethylene terephthalate (PET), the model learning unit **117** and/or the property extraction unit **119** may extract at least one property among the air permeability, tensile strength, tearing strength, and/or elongation at break as a third feature.

[0162] Thereafter, the model learning unit **117** may perform training of the first prediction model **601** to infer attributes of the learning materials comprised in each of the plurality of learning recipes based on the first learning specific properties comprised in each of the plurality of learning recipes.

[0163] To describe in more detail, the model learning unit **117** may perform training of the first prediction model **601** to output attributes for at least some materials comprising specific materials among the materials comprised in the specific learning recipe by setting the first learning specific property as a region of interest, and using the specific learning recipe and the first learning specific property of the specific learning recipe as inputs.

[0164] In step **803**, the model learning unit **117** may perform training of the second prediction model **603** to predict properties of the learning polymer composite material according to each of the plurality of learning recipes based on the attributes of the learning materials comprised in each of the plurality of learning recipes.

[0165] To describe in more detail, when inputting properties of at least some materials comprised in any one recipe based on the learning materials comprised in each of a plurality of learning recipes and attributes of the learning materials, the model learning unit **117** may perform training of the second prediction model **603** to output properties of the polymer composite material according to the recipes.

[0166] When performing training of the second prediction model **603**, the model learning unit **117** may train the second prediction model **603** based on the plurality of materials comprised in the learning recipe and attributes of at least some specific materials.

[0167] Thereafter, the model learning unit **117** may perform training of the second prediction model **603** to predict the second specific property of the learning polymer composite material according to each of the plurality of learning recipes based on the attributes of the learning materials comprised in each of the plurality of learning recipes, and the second preset learning specific property among the properties of the learning polymer composite material.

[0168] To describe in more detail, the model learning unit **117** may perform training of the second prediction model **603** to output properties comprising the second learning specific property of the specific polymer composite material corresponding to the specific learning recipe by setting the second learning specific property as a region of interest, and using the specific learning recipe, the attributes for at least some comprising specific materials among the materials comprised in the specific learning recipe, and the second learning specific property of the specific learning recipe as inputs.

[0169] The information prediction unit **113** may perform an operation of predicting the properties of the polymer composite material for the recipe using the property prediction model **121** comprising the first prediction model **601** and the second prediction model **603**, which are trained as described above.

[0170] Returning to FIG. **5** again, the operation of predicting the properties of the polymer composite material according to the input recipe using the trained first prediction model **601** and/or second prediction model **603** will be described in more detail.

[0171] For example, in step **503**, the information prediction unit **113** may process two or more materials comprised in the recipe, properties for each of the materials, and a mixing ratio of each of the materials as inputs to the first prediction model **601**, and acquire attributes for at least some of the materials comprised in the recipe from the first prediction model **601**.

[0172] In some non-limiting embodiments or aspects, the information prediction unit **113** may extract at least one specific property among the plurality of properties possessed by each of at least one specific material among two or more

materials comprised in the input recipe, and process it as an input to the first prediction model **601**.

[0173] At this time, the information prediction unit **113** may predict attributes for at least some of the materials comprised in the recipe using the two or more materials and the at least one specific property for the at least one specific material as inputs to the first prediction model **601**.

[0174] Thereafter, the information prediction unit **113** may perform the operation of step **505** as described above based on the attributes of the materials acquired from the first prediction model **601** and the input recipe.

[0175] In step **507**, the result output unit **115** may output the properties of the polymer composite material. To describe in more detail, the result output unit **115** may generate result information by comprising the recipe acquired in step **201** and the specific properties of the polymer composite material acquired from the property prediction model **301** corresponding to the acquired recipe, and output the result information. In some non-limiting embodiments or aspects, the result output unit **115** may further comprise the predicted attributes of the materials comprised in the recipe in the result information.

[0176] According to various non-limiting embodiments, the result output unit **115** may comprise at least some chemical formulas and/or at least some chemical structures of the polymer composite material predicted by the pre-trained property prediction model **121** corresponding to the recipe in the result information.

[0177] In some non-limiting embodiments or aspects, the result output unit **115** may display the portion corresponding to the specific property of the predicted polymer composite material through at least some chemical formulas and/or at least some chemical structures. In this case, the result output unit **115** may display the portion corresponding to the specific property of the polymer composite material through highlighting or color change.

[0178] According to some non-limiting embodiments or aspects, the result output unit **115** may transmit the result information to other preset devices through the communication unit **130**.

[0179] When the operation of step **507** is completed, the result output unit **115** may terminate the procedures of embodiment in FIG. **2**.

[0180] According to some non-limiting embodiments or aspects, the method for predicting characteristics of a polymer composite material and the device thereof may provide an environment capable of quickly checking changes in the properties of the polymer composite material prepared during synthesis only by changing the materials and the mixing ratio of the materials.

[0181] According to some non-limiting embodiments or aspects, the method for predicting characteristics of a polymer composite material and the device thereof allow users to predict the characteristics of the polymer composite material prepared during synthesis according to the mixing ratio of the materials comprised in the recipes without performing the material synthesis and property measurement processes for the polymer composite material, thereby significantly reducing the time and costs required for development of materials.

[0182] According to the above description, two or more of the information acquisition unit **111**, the information prediction unit **113**, the result output unit **115**, the model learning unit **117**, and the property extraction unit **119** may be formed as one module, or each unit may be formed as a separate module. In this case, each module may comprise at least one processor.

[0183] According to some non-limiting embodiments or aspects, the functions described as being performed by the device **100** are operations processed through the processing unit **110** of the device **100**, and may be performed by organically being connected to the device **100** and/or components of the device connected to the device **100**.

[0184] To this end, at least some of the information acquisition unit **111**, the information prediction unit **113**, the result output unit **115**, the model learning unit **117**, and the property extraction unit **119** may be formed to be comprised in the processing unit **110** as shown in FIG. **1**.

[0185] The processing unit **110** comprises at least one processor, and may process data received from a battery connected to the device **100** through at least one program (application, tool, plug-in, software, etc., hereinafter referred to as a battery diagnostic program).

[0186] The storage unit **120** may store various data processed by at least one component of the device **100** (e.g., the processing unit **110**, the communication unit or the like). The data may comprise, for example, a program for processing control commands, data processed through the program, or input data and output data related thereto.

[0187] The communication unit (not shown) may support establishment of a wired communication channel or establishment of a wireless communication channel inside the device **100** and/or between the device **100** and at least one other device (e.g., the user device or a server), and performing communication through the established communication channel.

[0188] The input/output unit may comprise or be connected to at least some of an input unit (not shown) for inputting data, such as a keyboard, mouse, or touch pad, and an output unit (not shown) for outputting data, such as a display unit (e.g., display), speaker, or driving unit.

[0189] According to some non-limiting embodiments or aspects of the present disclosure, the device **100** or user device may comprise at least some of the functions in the range of all information and communication devices, comprising a mobile terminal, a multimedia terminal, a wired terminal, a fixed terminal, and/or an internet protocol (IP) terminal.

[0190] The device **100** is a device for processing the control commands, and may comprise at least some of the functions of a workstation or a large-scale database, or may be connected therewith through communication.

[0191] As described above, although the embodiments have been described with reference to the limited drawings, it will be apparent to those skilled in the art that various modifications and alternations may be applied thereto based on the various non-limiting embodiments.

[0192] For example, adequate effects or results may be achieved even if the foregoing processes and methods are carried out in different order than those described above, and/or the above-described elements, such as systems, structures, devices, or circuits, are combined or coupled in different forms and modes than those described above, or substituted or switched with other components or equivalents.

[0193] In some non-limiting embodiments or aspects, when describing with reference to the flowchart, it is described that a plurality of steps are configured and the

steps are sequentially executed in a designated order, but it is not necessarily limited to the designated order.

[0194] In other words, executing by changing or deleting at least some of the steps described in the flowchart or adding at least one step is applicable as in some non-limiting embodiments or aspects, and executing one or more steps in parallel may also be applicable in some non-limiting embodiments. That is, it is not limited to that the steps are necessarily operated in a time-series order, and should be comprised in various embodiments of the present disclosure.

[0195] The steps shown and described with regard to the flowcharts of FIGS. **2**, **4**, **5**, **7**, and **8** are for example purposes only. It will be appreciated that additional, fewer, different, and/or different order of steps may be used in non-limiting embodiments or aspects. In some non-limiting embodiments or aspects, a step may be automatically performed in response to performance and/or completion of a prior step. In some non-limiting embodiments or aspects, one or more of the steps may be performed (e.g., completely, partially, and/or the like) by a processor (e.g., a processor of at least one computing device of a system). In some non-limiting embodiments or aspects, one or more of the steps may be performed (e.g., completely, partially, and/or the like) by another system, another device, another group of systems, or another group of devices, separate from or including a system, a device, a group of systems, or a group of devices that performed a different step or steps. Non-limiting embodiments or aspects described herein are not limited to any specific combination of hardware circuitry (e.g., a processor) and/or software. The term "configured to," as used herein, may refer to an arrangement of software, device(s), and/or hardware for performing and/or enabling one or more functions (e.g., actions, processes, steps of a process, and/or the like). For example, "a processor configured to" may refer to a processor that executes software instructions (e.g., program code) that cause the processor to perform one or more functions.

[0196] Therefore, other implements, other embodiments, and equivalents to claims are within the scope of the present disclosure.

What is claimed is:

1. A method for predicting characteristics of a polymer composite material, the method comprising:

inputting a recipe comprising two or more materials comprising at least one polymer and a mixing ratio for each of the two or more materials;

predicting properties of the polymer composite material according to the recipe based on a recipe and property prediction model; and

outputting the properties of the polymer composite material.

2. The method according to claim **1**, further comprising training of the property prediction model, wherein the training of the property prediction model comprises:

acquiring a plurality of learning recipes comprising two or more learning materials comprising at least one polymer and a mixing ratio for each of the two or more learning materials, and properties of a plurality of learning polymer composite materials according to each of the plurality of learning recipes, as a dataset; and

performing training of the property prediction model to predict properties of the learning polymer composite material according to each of the plurality of learning recipes based on the properties of the learning materials comprised in each of the plurality of learning recipes, and the properties of the plurality of learning polymer composite materials.

3. The method according to claim **2**, wherein training of the property prediction model further comprises:

extracting, from each of the plurality of learning recipes, a first preset learning specific property among properties possessed by each of at least one learning specific material, and a second preset learning specific property among the properties of the learning polymer composite material; and

performing training of the property prediction model for each of the plurality of learning recipes based on the plurality of learning recipes comprising the plurality of first learning specific properties and the second learning specific properties,

wherein the specific material comprises at least one material of a polymer, talc, and/or a polyolefin elastomer.

4. The method according to claim **1**, wherein predicting the properties of the polymer composite material comprises:

extracting at least one specific property among a plurality of properties possessed by each of at least one specific material among the two or more materials; and

predicting properties of the polymer composite material using the two or more materials and the at least one specific property of the at least one specific material as inputs to the property prediction model.

5. A method for predicting characteristics of a polymer composite material, the method comprising:

inputting a recipe comprising two or more materials comprising at least one polymer and a mixing ratio for each of the two or more materials;

predicting at least one attribute for each of the two or more materials based on the two or more materials and a property prediction model;

predicting properties of the polymer composite material according to the recipe based on the at least one attribute for each of the two or more materials and the property prediction model; and

outputting the properties of the polymer composite material.

6. The method according to claim **5**, further comprising training of the property prediction model, wherein training of the property prediction model comprises:

acquiring a plurality of learning recipes comprising two or more learning materials comprising at least one polymer and a mixing ratio for each of the two or more learning materials, and properties of a plurality of learning polymer composite materials according to each of the plurality of learning recipes, as a dataset; and

performing training of the property prediction model based on properties of the learning materials comprised in each of the plurality of learning recipes, attributes of the learning materials, and the properties of the plurality of learning polymer composite materials.

7. The method according to claim **6**, wherein training of the property prediction model further comprises:

training to infer attributes of the learning materials comprised in each of the plurality of learning recipes based on the properties of the learning materials comprised in each of the plurality of learning recipes; and

training to predict the properties of the learning polymer composite material according to each of the plurality of learning recipes based on the attributes of the learning materials comprised in each of the plurality of learning recipes.

8. The method according to claim **7**, wherein training of the property prediction model further comprises:

extracting, from each of the plurality of learning recipes, a first preset learning specific property among properties possessed by each of at least one learning specific material, and a second preset learning specific property among the properties of the learning polymer composite material,

wherein training to infer attributes of the learning materials performs training to infer attributes of the learning materials comprised in each of the plurality of learning recipes based on the first learning specific property comprised in each of the plurality of learning recipes,

training to predict properties of the learning polymer composite material performs training to predict the second specific property of the learning polymer composite material according to each of the plurality of learning recipes based on the attributes of the learning materials comprised in each of the plurality of learning recipes, and

the specific material comprises at least one material of a polymer, talc, and a polyolefin elastomer.

9. The method according to claim **5**, wherein predicting the properties of the polymer composite material comprises:

extracting at least one specific property among a plurality of properties possessed by each of at least one specific material among the two or more materials; and

predicting properties of the polymer composite material using the two or more materials and the at least one specific property of the at least one specific material as inputs to the property prediction model.

10. A device for predicting characteristics of a polymer composite material, the device comprising:

an information input unit configured to input a recipe comprising two or more materials comprising at least one polymer and a mixing ratio for each of the two or more materials;

an information prediction unit configured to predict properties of the polymer composite material according to the recipe based on a recipe and property prediction model; and

a result output unit configured to output the properties of the polymer composite material.

11. The device according to claim **10**, further comprising a model learning unit configured to:

acquire a plurality of learning recipes comprising two or more learning materials comprising at least one polymer and a mixing ratio for each of the two or more learning materials, and properties of a plurality of learning polymer composite materials according to each of the plurality of learning recipes, as a dataset; and

perform training of the property prediction model to predict the properties of the learning polymer composite material according to each of the plurality of learning recipes based on the properties of the learning materials comprised in each of the plurality of learning recipes, and the properties of the plurality of learning polymer composite materials, wherein the property prediction model is trained through the model learning unit.

12. The device according to claim **11**, wherein the model learning unit is configured to:

extract, from each of the plurality of learning recipes, a first preset learning specific property among properties possessed by each of at least one learning specific material, and a second preset learning specific property among the properties of the learning polymer composite material; and

perform training of the property prediction model for each of the plurality of learning recipes based on the plurality of learning recipes comprising the plurality of first learning specific properties and the second learning specific properties,

wherein the specific material comprises at least one material of a polymer, talc, and a polyolefin elastomer.

13. The device according to claim **10**, wherein the information prediction unit is configured to:

extract at least one specific property among a plurality of properties possessed by each of at least one specific material among the two or more materials; and

predict the properties of the polymer composite material using the two or more materials and the at least one specific property of the at least one specific material as inputs to the property prediction model.

14. A device for predicting characteristics of a polymer composite material, the device comprising:

an information input unit configured to input a recipe comprising two or more materials comprising at least one polymer and a mixing ratio for each of the two or more materials;

an information prediction unit configured to predict at least one attribute for each of the two or more materials based on the two or more materials and a property prediction model, and predict properties of the polymer composite material according to the recipe based on the at least one attribute for each of the two or more materials and the property prediction model; and

a result output unit configured to output the properties of the polymer composite material.

15. The device according to claim **14**, wherein the property prediction model comprises:

a property-attribute prediction model configured to predict the at least one attribute; and

an attribute-property prediction model configured to predict the properties of the polymer composite material.

16. The device according to claim **15**, further comprising a model learning unit configured to:

acquire a plurality of learning recipes comprising two or more learning materials containing at least one polymer and a mixing ratio for each of the two or more learning materials, and properties of a plurality of learning polymer composite materials according to each of the plurality of learning recipes, as a dataset; and

perform training of the property prediction model based on properties of the learning materials comprised in each of the plurality of learning recipes, attributes of the learning materials, and the properties of the plurality of learning polymer composite materials,

wherein the property prediction model is trained through the model learning unit.

17. The device according to claim **16**, wherein the model learning unit is configured to perform training of:

the property-attribute prediction model to infer attributes of the learning materials comprised in each of the plurality of learning recipes based on the properties of the learning materials comprised in each of the plurality of learning recipes, and

the attribute-property prediction model to predict properties of the learning polymer composite material according to each of the plurality of learning recipes based on the attributes of the learning materials comprised in each of the plurality of learning recipes.

18. The device according to claim **17**, wherein the model learning unit is configured to:

extract, from each of the plurality of learning recipes, a first preset learning specific property among properties possessed by each of at least one learning specific material, and a second preset learning specific property among the properties of the learning polymer composite material;

perform training of the property-attribute prediction model to infer attributes of the learning materials comprised in each of the plurality of learning recipes based on the first learning specific property comprised in each of the plurality of learning recipes; and

perform training of the attribute-property prediction model to predict the second specific property of the learning polymer composite material according to each of the plurality of learning recipes based on the attributes of the learning materials comprised in each of the plurality of learning recipes,

wherein the specific material comprises at least one material of a polymer, talc, and a polyolefin elastomer.

19. The device according to claim **14**, wherein the information prediction unit is configured to:

extract at least one specific property among a plurality of properties possessed by each of at least one specific material among the two or more materials; and

predict the properties of the polymer composite material using the two or more materials and the at least one specific property of the at least one specific material as inputs to the property prediction model.

* * * * *