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(54) Title: AN ELECTROSTATICALLY ATOMIZING EQUIPMENT AND A METHOD FOR CHARACTERIZING ATOMIZATION OF A DIRECT CHARGING ATOMIZER

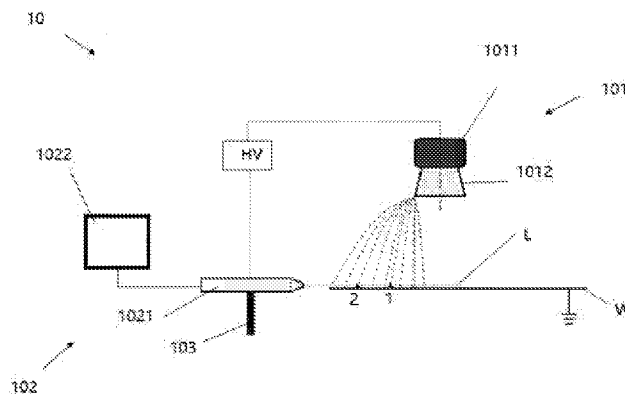


Figure 1

(57) Abstract: The present invention provides an electrostatically atomizing equipment comprising parts of: (A) a direct charging atomizer for atomizing and dispensing a coating composition; and (B) a device for quantitatively characterizing atomization of the atomizer, comprising an optical measurement part for optically capturing droplets of a spray of electrostatically charged atomized coating composition, and said optical measurement part is connected to a high voltage power and kept substantially equipotential to the atomizer. The present invention also provides a method for characterizing atomization of the invented electrostatically atomizing equipment, comprising steps of: (i) spraying a coating composition atomized by the electrostatically atomizing equipment, (ii) detecting the atomized coating composition by an optical measurement part that is connected to a high voltage power and kept substantially equipotential to the atomizer, and (iii) determining characteristic parameters of atomization based on data obtained through the optical measurement part.



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AN ELECTROSTATICALLY ATOMIZING EQUIPMENT AND A METHOD FOR
CHARACTERIZNG ATOMIZATION OF A DIRECT CHARGING ATOMIZER

TECHNOLOGY FIELD

5 The invention relates to an electrostatically atomizing equipment and a method for characterizing atomization of a direct charging atomizer.

BACKGROUND

10 Nowadays in automotive industry there are various coating compositions, such as coating composition for clearcoat that is often applied onto substrates through atomization, for example by using electrostatically atomizing equipment. Painting in automotive OEM (original equipment manufacturer) production lines always uses high voltage to atomize coating materials through charging static electricity in order to increase the efficiency of applying (i.e. increasing the amount of coating droplet that are finally deposited on the
15 substrate) and decrease overspray which may cause contamination and surface defects such as pinholes after curing or baking of the coating composition.

Characteristic parameters of atomization, such as size and quantity of atomized coating droplets as well as droplet size distribution and homogeneity of spraying formed by
20 atomization are used to characterize and evaluate atomization of coating composition. For example, smaller droplet size and larger quantity of droplets indicate a higher degree of atomization and homogeneity of spraying.

In automotive OEM production lines, or painting laboratories, atomization is accomplished
25 by electrostatically atomizing equipment, particularly an indirect charging atomizer with a rotary bell cup and is subject to many influencing factors such as the rotation speed of the bell cup, shaping air, flowrate of the liquid paint, and the high voltage applied to the atomizer. Thus, the atomization of the electrostatically atomizing equipment could be managed by adjusting the influencing factors.

30 However, there is no deep dive into the correlation between the high voltage applied to the atomizer through electrostatically charging and the characteristic parameters of the atomization for example, the droplet size distribution of the spraying. Thus, the qualities of coating layers after curing or baking could be only controlled based on empiric and
35 repetitive experiments are required to pick out best conditions.

It is typical to use a measure part in conventional atomization to detect the spraying of coating compositions from a non-electrostatic atomizer. However, such method is not
40 applicable for electrostatically-aided atomizers operating with a voltage as high as tens of kilovolts since it may cause dangers like electric sparks, electric arcs and even machine burns. To adapt to electrostatically atomizing, the distance between the atomizer and the measurement part should be as large as possible while the larger distance inevitably results in lower accuracy of measurement results.

Therefore, it is still required to provide a method for characterizing atomization through which the coating spraying could be accurately controlled and an electrostatically atomizing equipment thereof.

5

SUMMARY OF THE INVENTION

In one aspect, the present invention provides an electrostatically atomizing equipment comprising parts of:

- 10 (A) a direct charging atomizer for atomizing and dispensing a coating composition; and
(B) a device for quantitatively characterizing atomization of the atomizer, comprising an optical measurement part for optically capturing droplets of a spray of electrostatically charged atomized coating composition,
wherein said optical measurement part is connected to a high voltage power and kept substantially equipotential to the atomizer.

15

In another aspect, the present invention provides a method for characterizing atomization of the invented electrostatically atomizing equipment, comprising steps of:

- 20 (i) spraying a coating composition atomized by the electrostatically atomizing equipment,
(ii) detecting the atomized coating composition by an optical measurement part that is connected to a high voltage power and kept substantially equipotential to the atomizer,
and
(iii) determining characteristic parameters of atomization based on data obtained through the optical measurement part.

25 DETAILED DESCRIPTION OF THE INVENTION

The undefined article “a”, “an”, “the” means one or more of the species designated by the term following said article.

30 In the context of the present disclosure, any specific values mentioned for a feature (comprising the specific values mentioned in a range as the end point) can be recombined to form a new range.

35 In the context of the present disclosure, each aspect so defined may be combined with any other aspect or aspects unless clearly indicated to the contrary. In particular, any feature indicated as being preferred or advantageous may be combined with any other feature or features indicated as being preferred or advantageous.

40 In the context of the present disclosure, “coating” and “paint” is used alternatively to express the same meaning, i.e. a substance composed of solid matters suspended in a liquid medium and applied as a protective or decorative coating to surfaces of various substrates.

In the automotive OEM industry, the liquid coating materials, including primer, basecoat,

and clearcoat, are sprayed to car body surfaces via atomizers. To maximize transfer efficiency and minimize overspray, atomizers working electrostatically usually by application of high voltage (i.e. electrostatically aided atomizers), have been the majority in the paint shops of car production factories. Among the atomizers working electrostatically, direct/internal charging atomizers, for example, Duerr ecobell DC, are widely used in automotive OEM production lines worldwide, which involve high voltage up to 100,000 volts.

The present invention provides an electrostatically atomizing equipment comprising parts of:

(A) a direct charging atomizer for atomizing and dispensing a coating composition; and
(B) a device for quantitatively characterizing atomization of the atomizer, comprising an optical measurement part for optically capturing droplets of a spray of electrostatically charged atomized coating composition, wherein said optical measurement part is connected to a high voltage power and kept substantially equipotential to the atomizer.

The present invention also provides a method for characterizing atomization of the invented electrostatically atomizing equipment, comprising steps of:

(i) spraying a coating composition atomized by the electrostatically atomizing equipment,
(ii) detecting the atomized coating composition by an optical measurement part that is connected to a high voltage power and kept substantially equipotential to the atomizer, and
(iii) determining characteristic parameters of atomization based on data obtained through the optical measurement part.

By implementing the method of the present invention, it is possible to improve properties of coating layers by electrostatically charging atomization, especially to overcome surface defects such as pinholes and clouding. Moreover, it is helpful to figure out whether the coating composition is homogeneous to avoid surface defects of coating layers such as streaks. All in all, the invented method provides a simple, efficient and cost-saving approach to screen coating formulations.

EMBODIMENT

Below embodiments further illustrate how this invention could be carried out.

Embodiment 1

An electrostatically atomizing equipment comprising parts of:

(A) a direct charging atomizer for atomizing and dispensing a coating composition; and
(B) a device for quantitatively characterizing atomization of the atomizer, comprising an optical measurement part for optically capturing droplets of a spray of electrostatically charged atomized coating composition, wherein said optical measurement part is connected to a high voltage power and kept substantially equipotential to the atomizer.

Embodiment 2

The electrostatically atomizing equipment according to embodiment 1, wherein the device for characterizing atomization of the atomizer comprises a data collecting and processing unit that collects optical data from the optical measurement part and determines characteristic parameters of atomization based on collected data.

Embodiment 3

The electrostatically atomizing equipment according to any one of embodiments 1 to 2, wherein the atomizer and the optical measurement part are connected to the same high voltage power.

Embodiment 4

The electrostatically atomizing equipment according to any one of embodiments 1 to 3, wherein the light source of the optical measurement part is laser.

Embodiment 5

The electrostatically atomizing equipment according to any one of embodiments 1 to 4, wherein it further comprises a supporting stand made of electrically insulative materials.

Embodiment 6

The electrostatically atomizing equipment according to any one of embodiments 1 to 5, wherein the atomizer and the optical measurement part have a distance of at least 20cm away from the grounded objects.

Embodiment 7

A method for characterizing atomization of the electrostatically atomizing equipment according to any one of embodiments 1 to 6, comprising steps of:

- (i) spraying a coating composition atomized by the electrostatically atomizing equipment,
- (ii) detecting the atomized coating composition by an optical measurement part that is connected to a high voltage power and kept substantially equipotential to the atomizer, and
- (iii) determining characteristic parameters of atomization based on data obtained through the optical measurement part.

Embodiment 8

The method according to embodiment 7, wherein the characteristic parameters of atomization comprise average size, size distribution of droplets of atomized coating composition after spraying and homogeneity of spraying.

Embodiment 9

The method according to any one of embodiments 7 to 8, wherein the atomizer and the optical measurement part are connected to the same high voltage power.

Embodiment 10

The method according to any one of embodiments 7 to 9, wherein the light source of the optical measurement part is laser.

Embodiment 11

- 5 The method according to any one of embodiments 7 to 10, wherein the optical measurement part is electrically insulated from the supporting stand.

Embodiment 12

- 10 The method according to any one of embodiments 7 to 11, wherein the atomizer and the optical measurement part have a distance of at least 20cm away from the grounded objects.

DESCRIPTION OF FIGURES

- 15 FIG. 1 shows a schematic view of an electrostatically atomizing equipment according to the present invention.

FIG.2 shows a schematic structural diagram of a direct charging atomizer of the electrostatically atomizing equipment according to the present invention.

- 20 FIG.3 shows indicative curves of droplet size distribution of the atomized coating composition formed under different voltages applied to the atomizer and the optical measurement part.

FIG.4 shows comparison between characteristic parameters of the spraying of different coating compositions formed by atomization under different voltages.

EXAMPLE

- 25 The present invention will be better understood in view of the following non-limiting examples. The examples do not limit the scope of the invention as described and claimed.

- 30 FIG.1 shows an electrostatically atomizing equipment 10 according to the present invention in which an electrostatically aided rotary atomizer 101 is used to atomize, charge and dispense the atomized coating compositions onto the target W such as substrates or workpieces.

- 35 Specifically referring to FIG.2, the electrostatically aided atomizer 101 comprising an atomizer header 1011 and a fast-rotating bell cup 1012 (for example, with a rotation speed of from 10 to 70kRPM), is supplied with liquid paint P (for example, a coating composition) from a paint supply system. The liquid paint is atomized by the electrostatically aided atomizer with applying centrifugal force and sprayed in the form of droplets.

- 40 In the atomizer shown in FIG.2, the liquid paint P is charged directly by an electrode in the atomizer head 1011 when it flows to the bell cup 1012, followed by spraying into numerous droplets by centrifugal force at the edge of the bell cup. The substrate to be sprayed is usually grounded, which creates an electrostatic field E between the substrate and the charged droplets of liquid paint. The atomizer in present invention is a direct or

internal charging atomizer in which liquid paint is charged by direct applying a voltage (such as a high voltage). Besides rotary atomizer, a pneumatic atomizer can be used as well that directly atomizes the liquid paint in the form of droplets.

- 5 For the direct charging atomizer, the liquid paint is usually selected from solvent-borne clearcoats or basecoats having a low electrical conductivity.

10 The electrostatically atomizing equipment 10 in FIG. 1 further comprises a device 102 for characterizing atomization of the atomizer. The device 102 comprises an optical measurement part 1021 configured for optically capturing droplets of the spray produced by the atomizer. The optical measurement part 1021 is connected to a high voltage power to keep substantially equipotential to the atomizer.

15 The term “substantially equipotential” in the context means that the optical measurement part and the atomizer are at substantially the same potential, and their potential difference is reduced to zero or at least kept as minimum to avoid operation risks such as electric arc.

20 The distance between the atomizer 101 and the optical measurement part 1021 can be reduced to the largest extent, with precondition that they do not interfere with each other. To maximally capture the spraying of liquid paint, the distance between the atomizer and the optical measurement part can be set as close as 2 mm.

25 The atomizer 101 and the optical measurement part 1021 are connected to the same high voltage power HV to keep substantially equipotential, i.e., zero potential difference or a negligible potential difference between the optical measurement part and the atomizer. The optical measurement part and the high voltage generator are connected via a Schmier high voltage cable in a length of less than 5 meters having an electric resistance of below 1000k Ω .

30 The term “high voltage” in the context used refers to a voltage having a magnitude above zero and, in most cases, lower than 100kV. It may vary according to the specific application of the electrostatically aided atomizers.

35 The optical measurement part 1021 is a laser measuring means, for example, an AOM SpraySpy sensor unit. The electrostatically atomizing equipment 10 comprises a supporting stand 103 configured for supporting the optical measurement part 1021 and made of electrically insulative material. Thus, the optical measurement part is sufficiently insulated from the ground or any grounded objects. Preferably, the optical measurement part 1021 and the atomizer 101 are spaced from any grounded objects (for example, substrates W or wall) by at least 200 mm. In practice the optical measurement part 1021 and the supporting stand 103 may be well cleaned to avoid charge accumulation and therefore electric issues such as electro sparks.

40

The device 102 for characterizing paint atomization of the atomizer comprises a data collecting and processing unit 1022 for collecting optical data obtained from the optical measurement part 1021 and determining characteristic parameters of atomization (for example, at least one characteristic parameter of droplet size distribution and

5 homogeneity of spraying) based on collected optical data.

With the electrostatically atomizing equipment 10 of the present invention, a method for characterizing atomization can be implemented by following steps:

Step S01: producing a spray of electrostatically charged atomized coating composition by means of the direct charging atomizer 101;

10 Step S02: optically capturing droplets of a spray of the atomized coating composition by means of the optical measurement part 1021 that is connected to the high voltage power HV to keep substantially equipotential to the direct charging atomizer; and

Step S03: based on optical data obtained from the optical measurement part, determining characteristic parameters of atomization by the data collecting and processing unit 1022

15 (for example, at least one characteristic parameter of droplet size distribution and homogeneity of spraying).

It is noted that “characteristic parameters of atomization” here refers to all the characteristic parameters that can be indicative of atomization behavior, including but not

20 limited to characteristic parameters of droplet size distribution and of homogeneity of spraying arising from the atomization.

The droplets of the spraying formed by atomization in step S01 are captured optically by a traversing optical measurement L through the spraying. The traversing optical

25 measurement L may pass through the spraying in an imaginary plane parallel to the substrate to be applied. It may go along a radial direction or a chord direction of the projection area of the spraying in the form of a cone. The implementation of this traversing measurement allows the entire spray and hence all droplets forming the spray, to be captured without missing any information. Thus, the spraying can be measured as a

30 whole, instead of only partial spraying. The traversing measurement enables point-specific optical measurement at numerous locations of the droplets in the atomized spraying, and therefore in step S03 the determination is achieved with higher precision. The optical capture is carried out by a fixed optical measurement inside the spraying.

35 In step S02 of the invented method, the optical capture is accomplished by an optical measurement that is based on scattered light investigations on the droplets of liquid paint in spraying. And preferably at least one laser is used as light source in such measurement. The optical capture in step S02 takes place preferably by means of PDA (Phase Doppler anemometry) and/or the time-shift technique (TS). From the optical data obtained when

40 carrying out step S02 by means of PDA, it is possible in step S03 to determine at least one characteristic parameter of the droplet size distribution. From the optical data obtained in step S02 by means of TS, it is possible in step S03 to determine both of the droplet size distribution and the homogeneity of spraying.

The droplet size distribution in step S03 is determined by method known to persons skilled in the art such as dN,50% (number-based median) and dV,50% (volume-based median). The homogeneity of spraying refers to the ratio between two quotients, i.e. the ratio
5 between T_1/T_{Total1} and T_2/T_{Total2} , wherein T_1 means the number of transparent droplets at the first position P1, T_2 means the number of transparent droplets at the second position P2, T_{Total1} means the number of all the droplets in the spray including transparent and non-transparent ones at the first position P1, and T_{Total2} means the number of all the droplets in the spray including transparent and non-transparent ones at the second position P2, as
10 shown in FIG.1. And preferably both positions are lying on a measuring axis passing through the spraying.

The invented method for characterizing atomization allows investigation on the differences between atomization with and without electrostatically charging for solvent-borne coating
15 composition. As shown in FIG.3, the higher the voltage is applied to the atomizer, the finer droplets are obtained.

The invented method for characterizing atomization allows investigation on atomization of different formulations of solvent-borne coating compositions such as primer, basecoat or clearcoat. It can be seen in FIG.4 that, when non-electrostatic atomization is applied to the
20 three paint samples, paint sample #1 exhibits the largest average particle size and as a contrast, when electrostatically aided atomization is used, surprisingly as paint sample #1 shows the smallest dN,50%, finest atomization and best leveling, compared with samples #2 and #3. Thus, it could be concluded that paint sample #1 is quite sensitive to high
25 voltage applied.

The invented method allows direct measurement of electrostatic atomization of a direct/internal charging atomizer operating under high voltage conditions. Such conditions could be set as the same to that in production lines of automotive OEM so that the data
30 obtained from labs could be used for industry without gaps.

By means of the invented method, it is possible to anticipate optical defects and/or surface defects of coating layers based on droplet size distribution and homogeneity of spraying. Sufficient atomization could reduce the wetness of the obtained coating layers and the
35 wetness tends to cause drawbacks of pinholes, poor shade, flop and clouding etc.

Based on these characteristic parameters such as the droplet size distribution and the homogeneity of spraying, it is possible to predict properties of the coating layers and help to avoid drawbacks of pinholes, clouding and streaking etc.
40

The method of the invention provides a simple and efficient approach for development of coating compositions without steps of curing or baking as well as the following performance tests.

Various modifications and variations conceivable by those skilled in the art can be made without departing from the scope or spirit of the present disclosure. This description and its disclosed examples are to be considered illustrative only, and the protection scope of the present disclosure is to be specified by the appended claims and their equivalents.

5

CLAIM

1. An electrostatically atomizing equipment comprising parts of:
(A) a direct charging atomizer for atomizing and dispensing a coating composition; and
5 (B) a device for quantitatively characterizing atomization of the atomizer, comprising an optical measurement part for optically capturing droplets of a spray of electrostatically charged atomized coating composition,
wherein said optical measurement part is connected to a high voltage power and kept substantially equipotential to the atomizer.
- 10 2. The electrostatically atomizing equipment according to claim 1, wherein the device for characterizing atomization of the atomizer comprises a data collecting and processing unit that collects optical data from the optical measurement part and determines characteristic parameters of atomization based on collected data.
- 15 3. The electrostatically atomizing equipment according to any one of claims 1 to 2, wherein the atomizer and the optical measurement part are connected to the same high voltage power.
- 20 4. The electrostatically atomizing equipment according to any one of claims 1 to 3, wherein the light source of the optical measurement part is laser.
5. The electrostatically atomizing equipment according to any one of claims 1 to 4, wherein it further comprises a supporting stand made of electrically insulative materials.
- 25 6. The electrostatically atomizing equipment according to any one of claims 1 to 5, wherein the atomizer and the optical measurement part have a distance of at least 20cm away from the grounded objects.
- 30 7. A method for characterizing atomization of the electrostatically atomizing equipment according to any one of claims 1 to 6, comprising steps of:
(i) spraying a coating composition atomized by the electrostatically atomizing equipment,
(ii) detecting the atomized coating composition by an optical measurement part that is
35 connected to a high voltage power and kept substantially equipotential to the atomizer,
and
(iii) determining characteristic parameters of atomization based on data obtained through the optical measurement part.
- 40 8. The method according to claim 7, wherein the characteristic parameters of atomization comprise average size, size distribution of droplets of atomized coating composition after spraying and homogeneity of spraying.
9. The method according to any one of claims 7 to 8, wherein the atomizer and the optical

measurement part are connected to the same high voltage power.

10. The method according to any one of claims 7 to 9, wherein the light source of the optical measurement part is laser.

5 11. The method according to any one of claims 7 to 10, wherein the optical measurement part is electrically insulated from the supporting stand.

10 12. The method according to any one of claims 7 to 11, wherein the atomizer and the optical measurement part have a distance of at least 20cm away from the grounded objects.

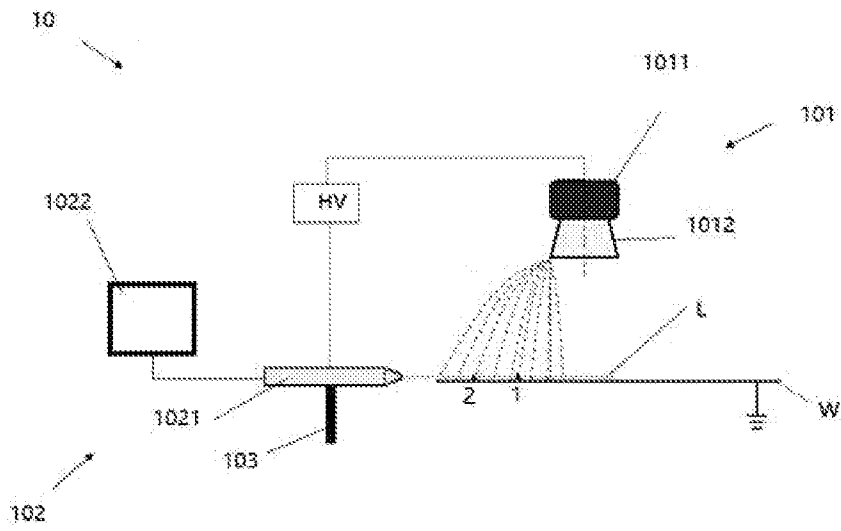


Figure 1

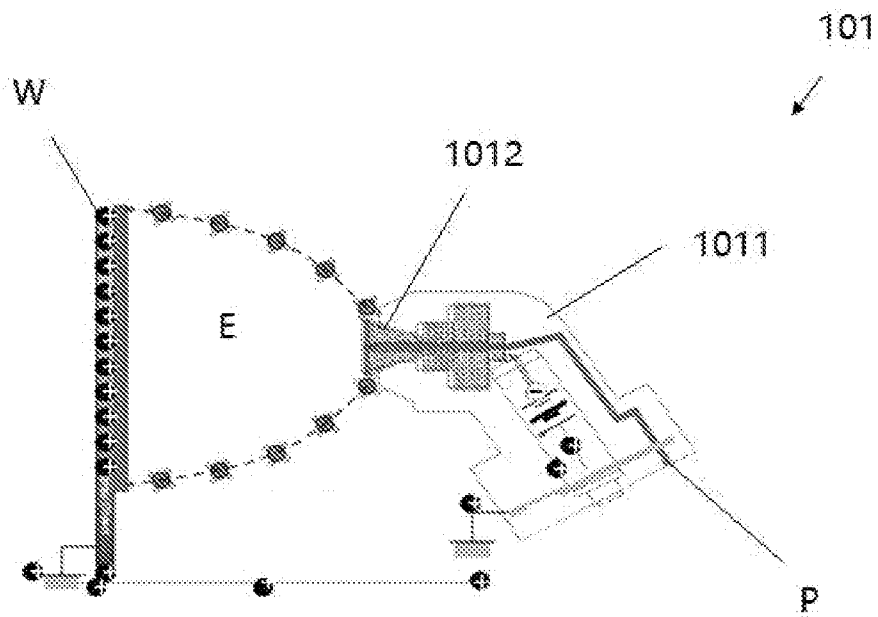


Figure 2

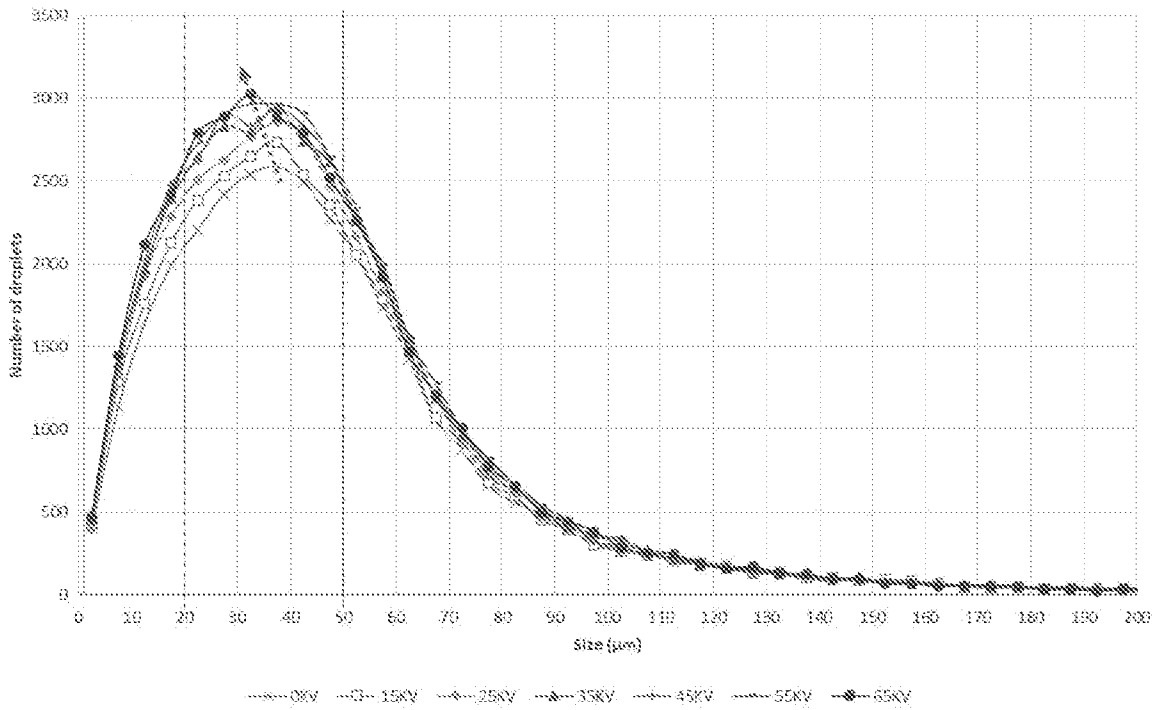


Figure 3

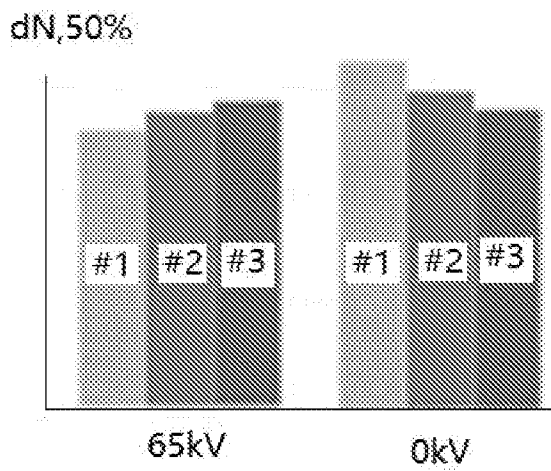


Figure 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/CN2024/116847

A. CLASSIFICATION OF SUBJECT MATTER
 INV. B05B5/043 B05B12/08 B05B5/04
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
 Minimum documentation searched (classification system followed by classification symbols)
B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2020/002245 A1 (BASF COATINGS GMBH [DE]) 2 January 2020 (2020-01-02) abstract; figure 1 page 6, line 29 - page 7, line 31 page 14, line 20 - line 28 page 15, line 16 - line 23 page 16, line 11 - page 23, line 26 -----	1 - 12
Y	WO 2021/032812 A1 (BASF COATINGS GMBH [DE]) 25 February 2021 (2021-02-25) abstract; figures 1-3 page 6, line 29 - page 7, line 31 page 11, line 29 - page 16, line 9 ----- - / - -	1 - 12

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

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family
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Date of the actual completion of the international search	Date of mailing of the international search report
23 November 2024	02/12/2024

Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer <p style="text-align: center;">Frego, Maria Chiara</p>
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INTERNATIONAL SEARCH REPORT

International application No PCT/CN2024/116847

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No

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