(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 594 343 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
11.09.2013 Bulletin 2013/37

(43) Date of publication A2:
22.05.2013 Bulletin 2013/21

(21) Application number: **12192414.6**

(22) Date of filing: **13.11.2012**

(51) Int Cl.:
B05D 5/08 *(2006.01)* ***B05D 3/10*** *(2006.01)*

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

(30) Priority: **14.11.2011 JP 2011249135**

(71) Applicant: **Kabushiki Kaisha Toyota Chuo Kenkyusho**
Nagakute-shi, Aichi 480-1192 (JP)

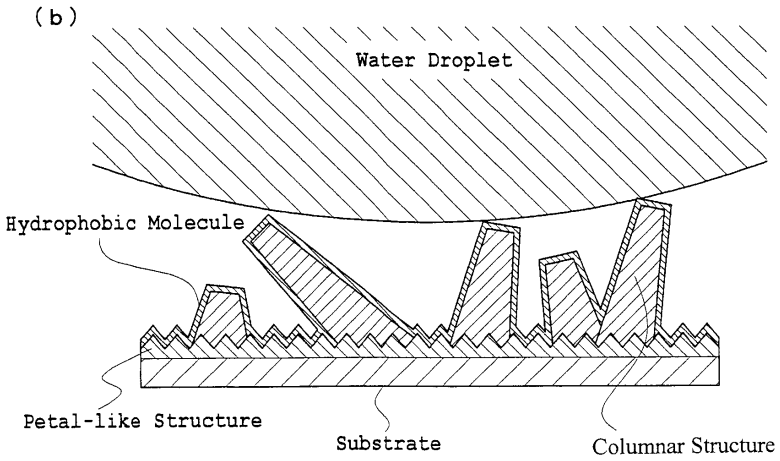
(72) Inventors:
- **Ohta, Riichiro**
  Nagakute-shi, Aichi 480-1192 (JP)
- **Koga, Tomoyuki**
  Nagakute-shi, Aichi 480-1192 (JP)
- **Ohwaki, Takeshi**
  Nagakute-shi, Aichi 480-1192 (JP)
- **Okamoto, Atsuto**
  Nagakute-shi, Aichi 480-1192 (JP)

(74) Representative: **Kramer - Barske - Schmidtchen**
Landsberger Strasse 300
80687 München (DE)

(54) Hydrophobic material and production process thereof

(57) A hydrophobic material includes a substrate, a fine uneven structure formed on a surface of the substrate, and a hydrophobic molecule covering a surface of the fine uneven structure. The fine uneven structure includes a petal-like structure formed of an aggregate of a plurality of plate-like particles and a columnar structure formed of columnar particles, in which a length from a surface of the substrate to the tip of the columnar structure is longer than a length from the surface of the substrate to the tip of the petal-like structure. The hydrophobic material is obtained by forming a fine uneven structure including a petal-like structure formed of an aggregate of a plurality of plate-like particles and a columnar structure formed of columnar particles on a surface of a substrate, in which a length from a surface of the substrate to a tip of the columnar structure is longer than a length from the surface of the substrate to a tip of the petal-like structure, and covering a surface of the fine uneven structure with a hydrophobic molecule.

[Fig. 1]



EP 2 594 343 A3

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 12 19 2414

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2007/031639 A1 (HSU MING F [US] ET AL) 8 February 2007 (2007-02-08) * figure 6 * * paragraphs [0030], [0031], [0039] * * claims 20,21,31,35,36 * -----	1,2,5,6, 9	INV. B05D5/08 B05D3/10

TECHNICAL FIELDS SEARCHED (IPC)

B05D

~~The present search report has been drawn up for all claims~~

1

Place of search	Date of completion of the search	Examiner
The Hague	9 April 2013	Slembrouck, Igor

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

Application Number
EP 12 19 2414

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

2, 5, 9(completely); 1, 6(partially)

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

Europäisches Patentamt
European Patent Office
Office européen des brevets

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 12 19 2414

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 2, 5, 9(completely); 1, 6(partially)

A hydrophobic material comprising the following constitutions:
(1) the hydrophobic material including: a substrate,a fine uneven structure formed on a surface of the substrate; and a hydrophobic molecule covering a surface of the fine uneven structure, and
(2) the fine uneven structure including: a petal-like structure formed of an aggregate of a plurality of plate-like particles; and a columnar structure formed of columnar particles,
wherein a length from the surface of the substrate to a tip of the columnar structure is longer than a length from the surface of the substrate to a tip of the petal-like structure,
and a process of producing said hydrophobic material;

1.1. claims: 2, 9(completely); 1, 6(partially)

A hydrophobic material comprising the following constitutions:
(1) the hydrophobic material including: a substrate,a fine uneven structure formed on a surface of the substrate; and a hydrophobic molecule covering a surface of the fine uneven structure, and
(2) the fine uneven structure including: a petal-like structure formed of an aggregate of a plurality of plate-like particles; and a columnar structure formed of columnar particles,
wherein a length from the surface of the substrate to a tip of the columnar structure is longer than a length from the surface of the substrate to a tip of the petal-like structure,
wherein the fine uneven structure is formed of a metal oxide or a material including a polar functional group (A) at least on the surface thereof,
the hydrophobic molecule includes a polar functional group (B) capable of forming a chemical bond with the surface of the fine uneven structure, and the hydrophobic material is obtained by covering the surface of the fine uneven structure with the hydrophobic molecule and forming a chemical bond of the surface of the fine uneven structure with the polar functional group (B);
and a process of producing said hydrophobic material;

1.2. claims: 5(completely); 1, 6(partially)

A hydrophobic material comprising the following constitutions:
(1) the hydrophobic material including: a substrate,a fine

Europäisches Patentamt
European Patent Office
Office européen des brevets

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 12 19 2414

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

uneven structure formed on a surface of the substrate; and a hydrophobic molecule covering a surface of the fine uneven structure, and
(2) the fine uneven structure including: a petal-like structure formed of an aggregate of a plurality of plate-like particles; and a columnar structure formed of columnar particles,
wherein a length from the surface of the substrate to a tip of the columnar structure is longer than a length from the surface of the substrate to a tip of the petal-like structure,
wherein the substrate is formed of an aluminum-containing and a process of producing said hydrophobic material;

---

2. claims: 3(completely); 1, 6(partially)

A hydrophobic material comprising the following constitutions:
(1) the hydrophobic material including: a substrate,a fine uneven structure formed on a surface of the substrate; and a hydrophobic molecule covering a surface of the fine uneven structure, and
(2) the fine uneven structure including: a petal-like structure formed of an aggregate of a plurality of plate-like particles; and a columnar structure formed of columnar particles,
wherein a length from the surface of the substrate to a tip of the columnar structure is longer than a length from the surface of the substrate to a tip of the petal-like structure,
wherein the petal-like structure is formed of boehmite and the columnar structure is formed of bayerite,
and a process of producing said hydrophobic material;

---

3. claims: 4, 10(completely); 1, 6(partially)

A hydrophobic material comprising the following constitutions:
(1) the hydrophobic material including: a substrate,a fine uneven structure formed on a surface of the substrate; and a hydrophobic molecule covering a surface of the fine uneven structure, and
(2) the fine uneven structure including: a petal-like structure formed of an aggregate of a plurality of plate-like particles; and a columnar structure formed of columnar particles,
wherein a length from the surface of the substrate to a tip of the columnar structure is longer than a length from the surface of the substrate to a tip of the petal-like

Europäisches Patentamt
European Patent Office
Office européen des brevets

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 12 19 2414

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

structure,
wherein the hydrophobic molecule is further specified according to claim 4,
and a process of producing said hydrophobic material;
---

4. claims: 7, 8(completely); 6(partially)

A process of producing a hydrophobic material comprising:
(1) an unevenness step of forming a fine uneven structure including a petal-like structure formed of an aggregate of a plurality of plate-like particles and a columnar structure formed of columnar particles on a surface of a substrate, wherein a length from the surface of the substrate to a tip of the columnar structure is longer than a length from the surface of the substrate to a tip of the petal-like structure to obtain a fine uneven substrate, and
(2) a covering step of covering a surface of the fine uneven structure with a hydrophobic molecule to obtain a hydrophobic molecule-covered fine uneven substrate,
wherein the substrate is formed of an aluminum-containing material and the unevenness step is a hot-water treatment step of forming the fine uneven structure on the surface of the substrate by immersing the substrate in a solution including water and an amine-based molecule at a temperature from 60°C to 300°C to obtain the fine uneven substrate;

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 19 2414

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-04-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007031639 A1	08-02-2007	EP 1951518 A2	06-08-2008
		JP 2009509794 A	12-03-2009
		US 2007031639 A1	08-02-2007
		WO 2008036074 A2	27-03-2008

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82