



(51) International Patent Classification:

C07F 5/02 (2006.01) G01N 33/551 (2006.01)
H01L 51/00 (2006.01) G01N 33/569 (2006.01)

(21) International Application Number:

PCT/US2017/018755

(22) International Filing Date:

21 February 2017 (21.02.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/296,961 18 February 2016 (18.02.2016) US
62/316,367 31 March 2016 (31.03.2016) US

(71) Applicant: THE REGENTS OF THE UNIVERSITY
OF CALIFORNIA [US/US]; 1111 Franklin Street,
Twelfth Floor, Oakland, CA 94607-5200 (US).

(72) Inventors: SPOKOYNY, Alexander; 1111 Franklin
Street, 12th Floor, Oakland, CA 94607-5200 (US).
MAYNARD, Heather, D.; 1111 Franklin Street, 12th
Floor, Oakland, CA 94607-5200 (US). QIAN, Elaine, A.;
1111 Franklin Street, 12th Floor, Oakland, CA 94607-
5200 (US). MESSINA, Marco, S.; 1111 Franklin Street,
12th Floor, Oakland, CA 94607-5200 (US). WIXTROM,
Alex; 1111 Franklin Street, 12th Floor, Oakland, CA
94607-5200 (US). AXTELL, Jonathan; 1111 Franklin
Street, 12th Floor, Oakland, CA 94607-5200 (US). KIR-
LIKOVALI, Kent; 1111 Franklin Street, 12th Floor, Oak-
land, CA 94607-5200 (US). GONZALEZ, Alejandra;
1111 Franklin Street, 12th Floor, Oakland, CA 94607-
5200 (US).

(74) Agent: PECK, John, W.; KPPB LLP, 2400 E. Katella,
Suite 1050, Anaheim, CA 92806 (US).

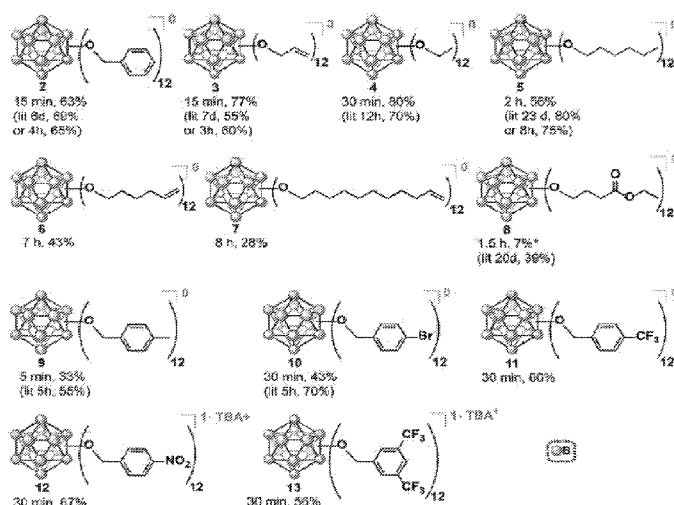
(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN,
KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA,
MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG,
NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS,
RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY,
TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN,
ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,

[Continued on next page]

(54) Title: NOVEL THREE-DIMENSIONAL BORON-RICH CLUSTERS

FIG. 10



(57) Abstract: Novel three-dimensional molecular clusters and methods of their synthesis are provided. The three-dimensional molecular clusters may be perfunctionalized polyhedral boranes and carboranes. The three-dimensional clusters may be configured to manipulate the photophysical properties of other materials, including, for example, for use as photooxidants or as components in organic light-emitting diode materials. Methods are also provided for synthesizing and perfunctionalizing such three-dimensional clusters. The three-dimensional clusters may also be configured for use as organomimetic materials.



TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:

12 October 2017

Published:

— *with international search report (Art. 21(3))*

A. CLASSIFICATION OF SUBJECT MATTER**C07F 5/02(2006.01)i, H01L 51/00(2006.01)i, G01N 33/551(2006.01)i, G01N 33/569(2006.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C07F 5/02; H01L 51/00; G01N 33/551; G01N 33/569

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: photooxidant, icosahedral dodecaborate, photo-mediated (co)polymerization, nanomolecules**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LEE, M. W., et al. "Alkoxy derivatives of dodecaborate: Discrete nanomolecular ions with tunable pseudometallic properties", Angew. Chem. Int. Ed., 2007, Vol. 46, No. 17, pp. 3018-3022 See pages 3019, 3020; scheme 1; and figures 1, 3.	1,2
A		3-6,15-28
A	PEYMANN, T. et al., "Dodeca (benzyloxy) dodecaborane, B12 (OCH2Ph) 12: A Stable Derivative of hypercloso-B12H12", Angewandte Chemie International Edition, 2001, Vol. 40, No. 9, pp. 1664-1667 See page 1665, left column; scheme 1; and figure 1.	1-6,15-28
A	SPOKOYNY, A. M., "New ligand platforms featuring boron-rich clusters as organomimetic substituents", Pure and Applied Chemistry, 2013, Vol. 85, No. 5, pp. 903-919 See abstract; page 905; and figure 2.	1-6,15-28
A	MUKHERJEE, S. et al., "Boron clusters in luminescent materials", Chemical Communications, [Epub.] 26 October 2015, Vol. 52, No. 6, pp. 1070-1093 See abstract; page 1071; and figure 1.	1-6,15-28



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

Date of the actual completion of the international search

29 August 2017 (29.08.2017)

Date of mailing of the international search report

29 August 2017 (29.08.2017)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

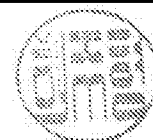
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

HEO, Joo Hyung

Telephone No. +82-42-481-8150



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2017/018755

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	MESSINA, M. S. et al., "Visible-light-induced olefin activation using 3D aromatic boron-rich cluster photooxidants", Journal of the American Chemical Society, 17 May 2016, Vol. 138, No. 22, pp. 6952-6955 See abstract; page 6952, right column - page 6953, left column; and figure 2.	1-6
PX	QIAN, E. A. et al., "Atomically precise organomimetic cluster nanomolecules assembled via perfluoroaryl-thiol SNAr chemistry", Nature chemistry, [Epub.] 19 December 2016, Vol. 9, No. 4, pp. 333-340 See abstract; page 334, right column; page 337, left column; page 338, right column; and figures 2-4.	15-28

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

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

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

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

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

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

- I. claims 1-6 and 15-28, directed to a metal-free photooxidant, a method for photo-mediated (co)polymerization, a molecular scaffold for forming atomically precise nanomolecules or a method for forming atomically precise nanomolecules, all of them related to an icosahedral dodecaborate.
- II. claims 7-12, directed to a transition metal complex ligand comprising unsubstituted or substituted 1,1'-bis(o-carborane).
- III. claims 13-14, directed to a transition metal complex carboranyl-aryl ligand.
- IV. claims 29-33, directed to a covalent organic framework or a method of forming a covalent organic framework.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-6, 15-28

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/018755Patent document
cited in search reportPublication
datePatent family
member(s)Publication
date

None