(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 October 2012 (11.10.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/138803 A3

(51) International Patent Classification:
C01B 31/02 (2006.01) *B82B 3/00* (2006.01)
B01J 2/08 (2006.01) *B82Y 40/00* (2011.01)

(21) International Application Number:
PCT/US2012/032229

(22) International Filing Date:
4 April 2012 (04.04.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/516,458 4 April 2011 (04.04.2011) US
61/575,941 31 August 2011 (31.08.2011) US

(71) Applicant *(for all designated States except US)*: **CARNEGIE MELLON UNIVERSITY** [US/US]; 5000 Forbes Avenue, Pittsburgh, Pennsylvania 15213 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **ISLAM, Mohammad F.** [BD/US]; 1226 Inverness Avenue, Pittsburgh, Pennsylvania 15217 (US). **KIM, Kyu Hun** [KR/US]; 5435 Claybourne Street, Apt. 405, Pittsburgh, Pennsylvania 15232 (US). **OH, Youngseok** [KR/US]; 5700 Centre Ave., Apt. 816, Pittsburgh, Pennsylvania 15206 (US). **LEE, Ilha** [KR/US]; 222 Melwood Ave., Apt. 402, Pittsburgh, Pennsylvania 15213 (US).

(74) Agents: **FLANAGAN, Heather L.** et al.; Fish & Richardson P.C., P. O. Box 1022, Minneapolis, Minnesota 55440-1022 (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, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, 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.

[Continued on next page]

(54) Title: CARBON NANOTUBE AEROGELS, COMPOSITES INCLUDING THE SAME, AND DEVICES FORMED THEREFROM

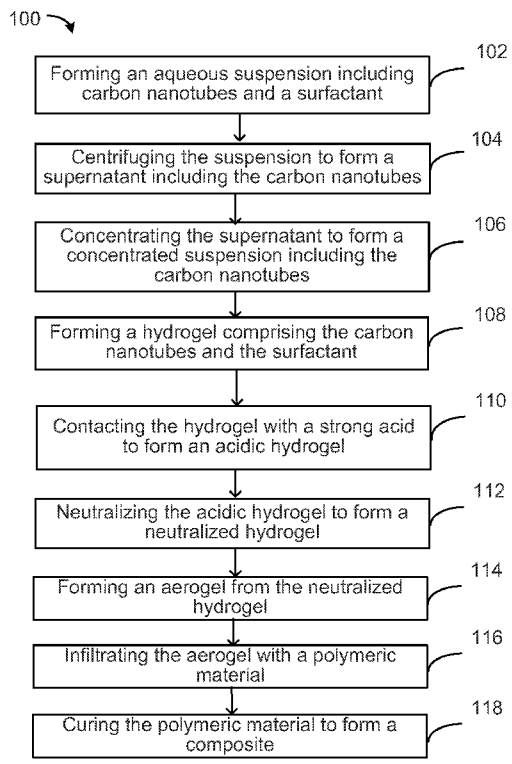


FIG. 1

(57) Abstract: An aerogel fabricated by forming an aqueous suspension including carbon nanotubes and a surfactant, agitating the aqueous suspension, and centrifuging the agitated suspension to form a supernatant including the carbon nanotubes. The supernatant is concentrated to form a concentrated suspension including the carbon nanotubes, and a hydrogel is formed from the concentrated suspension. The hydrogel is contacted with a strong acid to form an acidic hydrogel and to remove surfactant from the hydrogel, and then neutralized. An aerogel is formed from the hydrogel. The aerogel may consist essentially of carbon nanotubes. A composite may be formed from the hydrogel or the aerogel by infiltrating the hydrogel or the aerogel with a polymeric material and curing or pyrolyzing the polymeric material. The composite may be electrically conductive, transparent, flexible, superelastic, or any combination thereof. A device, such as a flexible conductor, sensor, or electrode may include the aerogel or the composite.

WO 2012/138803 A3

(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, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

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

— *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:
31 January 2013

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/032229

A. CLASSIFICATION OF SUBJECT MATTER

C01B 31/02(2006.01)i, B01J 2/08(2006.01)i, B82B 3/00(2006.01)i, B82Y 40/00(2011.01)n

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)

C01B 31/02; C09C 1/44; H01B 1/12; H01B 1/24; H01B 1/04

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: hydrogel, aerogel, carbon nanotube, single-wall, surfactant, acid, polymer, density, specific surface area, conductive

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	ADV. MATER. 2007, 19, 661-664 (MATEUSZ B. BRYNING et al.) 01 February 2007 See p. 661-662; figure 1	26 1-25,27-45
A	US 2010-0187484 A1 (MARCUS A. WORSLEY et al.) 29 July 2010 See abstract; examples; claims 1, 6-7, 11-18	1-45
A	US 2011-0024698 A1 (MARCUS A. WORSLEY et al.) 03 February 2011 See abstract; examples 1-2; claims 10-13	1-45
A	US 2010-0092371 A1 (RENAL BACKOV et al.) 15 April 2010 See abstract; example; claims 24-25, 29	1-45

☐ 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 citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 NOVEMBER 2012 (30.11.2012)	**03 DECEMBER 2012 (03.12.2012)**

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

LEE, Young Wan

Telephone No. 82-42-481-5560

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2012/032229

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010-0187484 A1	29.07.2010	None	
US 2011-0024698 A1	03.02.2011	US 2012-037854 A1	16.02.2012
US 2010-0092371 A1	15.04.2010	AT 484336 T	15.10.2010
		DE 602007009875 D1	25.11.2010
		EP 2111292 A1	28.10.2009
		EP 2111292 B1	13.10.2010
		FR 2910458 A1	27.06.2008
		FR 2910458 B1	03.04.2009
		JP 2010-513202 A	30.04.2010
		JP 2010-513202 T	30.04.2010
		WO 2008-096065 A1	14.08.2008