

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
22 May 2008 (22.05.2008)

PCT

(10) International Publication Number
WO 2008/060639 A3

(51) International Patent Classification:

C01B 31/00 (2006.01) **C01B 31/02** (2006.01)
C04B 35/524 (2006.01) **C04B 35/76** (2006.01)

(21) International Application Number:

PCT/US2007/061185

(22) International Filing Date: 27 January 2007 (27.01.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

60/762,588 27 January 2006 (27.01.2006) US

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(81) Designated States (unless otherwise indicated, for every

kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, 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, LV, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, 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, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

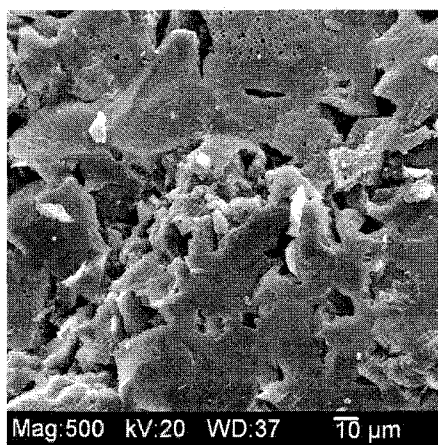
Published:

— with international search report

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

12 March 2009

(54) Title: BIPHASIC NANOPOROUS VITREOUS CARBON MATERIAL AND METHOD OF MAKING THE SAME



(57) Abstract: A biphasic nanoporous vitreous carbon material with a cementitious morphology characterized by presence of non-round porosity, having superior hardness and tribological properties, as useful for high wear-force applications. The biphasic nanoporous vitreous carbon material is produced by firing, under inert atmosphere, of particulate vitrified carbon in a composition containing (i) a precursor resin that is curable and pyrolyzable to form vitreous carbon and, optionally, (ii) addition of one or more of the following: solid lubricant, such as graphite, boron nitride, or molybdenum disulfide; a heat-resistant fiber reinforcement, such as copper, bronze, iron alloy, graphite, alumina, silica, or silicon carbide; or one or more substances to improve electrical conductivity, such as dendritic copper powder, copper "felt" or graphite flake, to produce a superior vitreous carbon that is useful alone or as a continuous phase in reinforced composites, in relation to conventional glassy carbon materials.



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 07/61185

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - C01B 31/00, C04B 35/524, C01B 31/02, C04B 35/76 (2008.04)

USPC - 508/123; 423/445R, 508/113

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)

USPC - 508/123; 423/445R, 508/113

IPC(8) - C01B 31/00, C04B 35/524, C01B 31/02, C04B 35/76 (2008.04)

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

USPC - 508/123, \$; 423/445R, \$; 508/113, \$

(text delimited)

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

PubWEST (USPT, PGPB, EPAB, JPAB); google.com

Search Terms Used: vitreous, carbon, aggregate, porous, porosity, firing, pyrolyzation, pyrolyzing, pore, shape, nanoporosity, nanoporous, round, shaped, biphasic, phases, cement, cementitious, wear, nano

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,506,482 B1 (Burton et al.) 14 January 2003 (14.01.2003), entire document, especially Abstract; col. 2, ln. 16-36; col. 3, ln. 18-25; col. 4, ln. 17-29; col. 6, ln. 53-58; col. 7, ln. 39-67; col. 11, ln. 17-25; col. 12, ln. 57-65	1, 5-21, 25
Y	US 6,620,214 B2 (McArdle et al.) 16 September 2003 (16.09.2003), entire document, especially Abstract; col. 4, ln. 23-32; col. 22, ln. 29-32	22-27
Y	US 4,609,972 A (Edeling et al.) 02 September 1986 (02.09.1986), entire document, especially Abstract; col. 1, ln. 50-68	12, 13, 16-27
Y	US 2005/0079201 A1 (Rathenow et al.) 14 April 2005 (14.04.2005), entire document, especially Abstract; paras [0052]; [0066]; [0080]; [0081]; [0111]	1, 5-11, 14, 15, 25

☐ Further documents are listed in the continuation of Box C.

* 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

27 June 2008 (27.06.2008)

Date of mailing of the international search report

21 JUL 2008

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 07/61185

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:

Five claim groups were found:

Group I: Claim 1, 5-21

Group II: Claim 2

Group III: Claim 3

Group IV: Claim 4

Group V: Claims 22-27

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claim 1, 5-21 are directed to a biphasic nanoporous vitreous carbon material having a cementitious morphology characterized by presence of non-round porosity and a process for making the vitreous carbon composite material, comprising firing, under inert atmosphere, of particulate vitrified carbon in a composition containing (i) a precursor resin curable and pyrolyzable to form vitreous carbon. It is noted that biphasic vitreous carbon materials are known in the art (see US 6,506,482 B1 to Burton et al. - col 1, ln 65-col 2, ln 4). (see extra box)

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 additional fees, this Authority did not invite payment of 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.:
1, 5-27
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.:

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

International application No.

PCT/US 07/61185

Continuation of Box No. III – Observations where unity of invention is lacking

Group II: claim 2 is directed to a biphasic nanoporous vitreous carbon material exhibiting under scanning electronmicroscopy magnification of 500X a micromorphology substantially corresponding to that shown in FIG. 6 hereof.

Group III: Claim 3 is directed to a biphasic nanoporous vitreous carbon material exhibiting under scanning electronmicroscopy magnification of 1000X a micromorphology substantially corresponding to that shown in FIG. 7 hereof.

Group IV: Claim 4 is directed to a biphasic nanoporous vitreous carbon material exhibiting under scanning electronmicroscopy magnification of 1800X a micromorphology substantially corresponding to that shown in FIG. 8 hereof.

Group V: Claims 22-27 are directed to a method of making a vitreous carbon body of a predetermined size, comprising forming a plurality of vitreous carbon precursor articles of smaller size than said predetermined size, wherein each of such precursor articles is formed of a cured precursor resin, bonding said plurality of vitreous carbon precursor articles to one another with a bonding medium comprising said precursor resin to form an aggregate body, and pyrolyzing the aggregate body including the cured bonding medium, to yield the vitreous carbon body of such predetermined size.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Group I does not include the inventive concept of a plurality of vitreous carbon precursor articles to one another with a bonding medium comprising said precursor resin to form an aggregate body as required by Group V or the illustrated morphology of group II, III, or IV.

Group II does not include the inventive concept of a biphasic nanoporous vitreous carbon material characterized by presence of non-round porosity, as required by Group I, a plurality of vitreous carbon precursor articles to one another with a bonding medium comprising said precursor resin to form an aggregate body as required by Group V or the illustrated morphology of group III or IV.

Group III does not include the inventive concept of a biphasic nanoporous vitreous carbon material characterized by presence of non-round porosity, as required by Group I, a plurality of vitreous carbon precursor articles to one another with a bonding medium comprising said precursor resin to form an aggregate body as required by Group V or the illustrated morphology of group II or IV.

Group IV does not include the inventive concept of a biphasic nanoporous vitreous carbon material characterized by presence of non-round porosity, as required by Group I, a plurality of vitreous carbon precursor articles to one another with a bonding medium comprising said precursor resin to form an aggregate body as required by Group V or the illustrated morphology of group II or III.

Group V does not include the inventive concept of a biphasic nanoporous vitreous carbon material characterized by presence of non-round porosity, as required by Group I or the illustrated morphology of group II, III, or IV.

Groups I-V therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.