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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.

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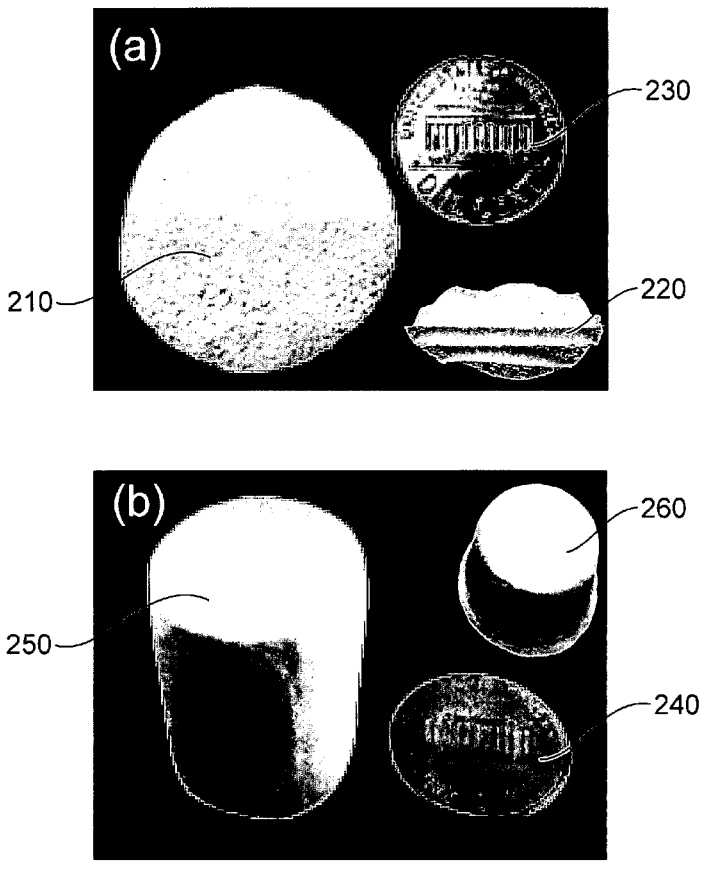
[Continued on next page]

(54) Title: TiO_2 NANOSTRUCTURES, MEMBRANES AND FILMS, AND APPLICATIONS OF SAME



(57) Abstract: The present invention relates to applications of TiO_2-containing, macro-sized nanostructures in the fields including photocatalysis, information writing-erasing- rewriting, microfiltration, controlled drug release, and tire making. In one aspect, the present invention relates to a method of photocatalytically decomposing organic pollutants. In one embodiment, the method includes the steps of mixing a solution containing organic pollutants and a plurality of TiO_2containing, macro-sized nanostructures to form a mixture and exposing the mixture to UV irradiation to decompose the organic pollutants.

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9 April 2009

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H01L 21/20; C02F 1/32 (2008.04)
USPC - 438/584; 210/748
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 - 438/584; 210/748

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)
WEST(Searched US Pre-grant Publications, US Patent Full-Text, EPO Abstract, JPO Abstract), Google Scholar Internet and Google Patent Databases for for membrane, "magnesium nitrate", diethyl phenylthiomethylphosphonate, immers$4 or coat$4 or spray$4

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 6,902,653 B2 (Carmignani et al.) 07 Jun 2005 (07.06.2005); abstract, col 1, ln 40-65	1-6, 11 --- 7-10
Y	US 2003/0183576 A1 (Ohara et al.) 02 Oct 2003 (02.10.2003); para [0040]-[0043] and [0084]	7, 8
Y	US 2003/0215355 A1 (Lanz et al.) 20 Nov 2003 (20.11.2003); para [0005] and [0039]	9, 10

☐ 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	Date of mailing of the international search report
04 July 2008 (04.07.2008)	21 AUG 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	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 07/00885

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:

********** See below on supplemental sheet (page 8) **********

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.:

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.:
Group 1: claims 1-11

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 07/00885

********** SUPPLEMENTAL BOX **********

In continuation of Box III:

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 1, claims 1-11, drawn to a method of photocatalytically decomposing organic pollutants, comprising the steps of:
a. mixing a solution containing organic pollutants and a plurality of TiO2 containing, macro-sized nanostructures to form a mixture; and
b. exposing the mixture to UV irradiation to decompose the organic pollutants.

Group 2, claims 12-25, drawn to a device of photocatalytically decomposing organic pollutants, comprising:
a. at least one membrane or sheet formed with TiOz-containing, macrosized nanostructures;
b. a container for receiving a solution containing organic pollutants and the membrane or sheet; and
c. a UV irradiation source positioned at a distance from the container for emitting UV irradiation onto the solution.

Group 3, claims 26-29, drawn to a device usable for filtering micrometer-sized particles, comprising one or more filters made with a plurality of Ti02-containing nanostructures.

Group 4, claims 30-32, drawn to a three-dimensional (3D) scaffold usable for directing the growth of stem cells, comprising a body portion formed with Ti02-containing, macro-sized nanostructures, wherein the body portion is at least partially coated with a plurality of biomolecules.

Group 5, claims 33-47, drawn to a method of writing-erasing-rewriting information, comprising the steps of:
a. providing a writing medium formed with Ti02-containing, macro-sized nanostructures;
b. writing information on the writing medium;
c. exposing the writing medium with the written information to UV irradiation for a period of time so as to erase the written information on the writing medium; and
d. repeating steps (b) and (c) for a desired number of time (claims 33-36); a writing medium for information storage, comprising a paper-like film formed with Ti02-containing, macro-sized nanostructures (claims 37-41); a paper formed with Ti02-containing, macro-sized nanostructures (claims 42-47).

Group 6, claims 48-50, drawn to a composite usable for making tires, comprising an effective amount of Ti02-containing, macro-sized nanostructures and an effective amount of rubber polymers.

Group 7, claims 51-56, drawn to a multi-functional vest/coat, comprising a plurality of Ti02-containing, macro-sized nanofibers.

The inventions listed as Groups 1-7 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:

Groups 1, 3, 4, 6 and 7 do not include the inventive concept of a membrane or sheet formed with TiOz-containing, macrosized nanostructures, as required by Groups 2 and 5.

Groups 1, 2 and 4-7 do not include the inventive concept of a device usable for filtering micrometer-sized particles, comprising one or more filters made with a plurality of Ti02-containing nanostructures, as required by Group 3.

Groups 1 and 3-7 do not include the inventive concept of a container for receiving a solution containing organic pollutants and the membrane or sheet, as required by Group 2.

Groups 1-3 and 5-7 do not include the inventive concept of a three-dimensional (3D) scaffold usable for directing the growth of stem cells, comprising a body portion formed with Ti02-containing, macro-sized nanostructures, wherein the body portion is at least partially coated with a plurality of biomolecules, as required by Group 4.

Groups 1-4, 6 and 7 do not include the inventive concept of a writing medium for information storage, comprising a paper-like film formed with Ti02-containing, macro-sized nanostructures, as required by Group 5.

Groups 1-5 and 7 do not include the inventive concept of a composite usable for making tires, comprising an effective amount of Ti02-containing, macro-sized nanostructures and an effective amount of rubber polymers, as required by Group 6.

Groups 1-6 do not include the inventive concept of a multi-functional vest/coat, comprising a plurality of Ti02-containing, macro-sized nanofibers, as required by Group 7.

Groups 1-7 do share the technical feature of a Ti02-containing, macro-sized nanostructures. However, this shared technical feature does not represent a contribution over the prior art because US 2004/0050773 A1 to Neumann, et al. teaches a filter comprising a metal oxide material (claim 1), wherein the metal oxide is TiO2 (claim 4). As the above Ti02-containing, macro-sized nanostructures were known at the time of the invention, as evidenced by the teaching of Neumann, this cannot be considered a special technical feature that would otherwise unify the groups. Thus, groups 1-7 lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.