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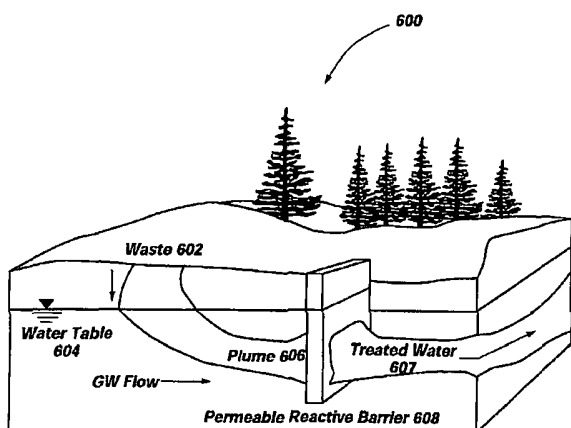
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(54) Title: ORGANIC/INORGANIC NANOCOMPOSITES, METHODS OF MAKING, AND USE AS A PERMEABLE REACTIVE BARRIER



(57) Abstract: Nanocomposite materials having a composition including an inorganic constituent, a preformed organic polymer constituent, and a metal ion sequestration constituent are disclosed. The nanocomposites are characterized by being single phase, substantially homogeneous materials wherein the preformed polymer constituent and the inorganic constituent form an interpenetrating network with each other. The inorganic constituent may be an inorganic oxide, such as silicon dioxide, formed by the *in situ* catalyzed condensation of an inorganic precursor in the presence of the solvated polymer and metal ion sequestration constituent. The polymer constituent may be any hydrophilic polymer capable of forming a type I nanocomposite such as, polyacrylonitrile (PAN), polyethyleneoxide (PEO), polyethylene glycol (PEG), polyvinyl acetate (PVAc), polyvinyl alcohol (PVA),

and combinations thereof. Nanocomposite materials of the present invention may be used as permeable reactive barriers (PRBs) to remediate contaminated groundwater. Methods for making nanocomposite materials, PRB systems, and methods of treating groundwater are also disclosed.

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/41680

A. CLASSIFICATION OF SUBJECT MATTER		
IPC(7) : C08 K 3/18, 3/34		
US CL : 524/492, 430, 414, 783, 786; 210/170, 679, 681, 682, 688, 747		
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) U.S. : 524/492, 430, 414, 783, 786; 210/679, 681, 682, 688, 747, 170		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched ACS Journals, CRCnetBase		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) USPAT, US-PGPUB, USOCR, EPO, JPO, DERWENT		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	POLSON, LINDA, et al. Synthesis, Characterization, and Ion Sequestration of Novel Nanocomposite Materials. April 2002 (04.2002), whole document.	1-3,5,7,9-11,16-18,20,22,31-34,36,38,49,52-53,55,57-58.
Y	NOVAK, B.M., et al. Simultaneous Interpenetrating Networks of Inorganic Glasses and Organic Polymers, New Routes into Nonshrinking Sol-Gel Composites. Depart. of Chem, Univ. of California at Berkeley. Aug 1990 (08.1990), pg 698-699.	1-3,5,7,9-11,16-18,20,22,31-34,36,38,49,52-53,55,57-58
Y	SEBESTA, F., et al. Composite Ion Exchanger with Ammonium Molybdophosphate and its Properties, Journal of Radioanalytical and Nuclear Chem. Vol 140, No. 1, 1990, pg 15-21.	4,6,8,13-15,19,21,30,35,37,39,54,56,59
Y	WEN, JIANYE, et al. Organic/Inorganic Hybrid Network Materials by the Sol-Gel Approach. Chem. Mater. Vol 8, No. 8, 1996, pg 1667-1681.	12
Y	POWELL, ROBERT M., et al. Permeable Reactive Barrier Technologies for Containment Remediation. Environmental Protection Agency, EPA/600/R-98/125, September 1998, pg 1-94, especially pg 1, 36-39.	24-28,44-48,51
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> 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	"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
"E"	earlier application or patent published on or after the international filing date	"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
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed	
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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 Sandra K. Poulos Telephone No. 571-272-1700 <i>J. Whitehead</i> <i>for</i>

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International application No.  
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**C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,728,302 (CONNER et al) 17 March 1998 (17.03.1998), abstract; col 2, lines 39-67; col 3; lines 28-35; col 7, lines 14-22; col 5, lines 27-35.	41-43
Y	US PGPub 2001/0033772 A1 (GILMORE et al) 25 October 2001 (25.10.2001), pg 1-2.	23,40,50
Y	US 5,857,810 (CANTRELL et al) 12 January 1999 (12.01.1999), abstract; col 2, 4.	29
A	ONODERA, YOSHIO. A New Granular Composite with High Selectivity for Cesium Ion Prepared from Phosphomolybdic Acid Hydrate and Inorganic Porous Material. Separation Science and Technology, Vol 34, No. 12, 1999, pg 2347-2354.	
A	GAUR, SUSHMA. Determination of Cs-137 in Environmental Water by Ion-Exchange Chromatography. Journal of Chromatography A, Vol 733, Issues 1-2, 1996, pg 57-71.	

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/41680

## 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:  
Please See Continuation Sheet

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 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.:
- 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**

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**BOX III. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING**

Group 1, claims(s) 1-15, drawn to a nanocomposite.

Group 2, claim(s) 16-59, drawn to a permeable reactive barrier system and a method of making, and a method of treating groundwater.

The inventions listed as Groups 1 and 2 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 1 is drawn to a nanocomposite that does not necessarily have any relationship to permeable reactive barriers or treating groundwaters.