Abstract: Methods and systems for capturing carbon dioxide and producing fuels such as alcohol using a solvent including a nanoparticle organic hybrid material and a secondary fluid are disclosed. In some embodiments, the methods include the following: providing a solvent including a nanoparticle organic hybrid material and a secondary fluid, the material being configured to capture carbon dioxide; introducing a gas including carbon dioxide to the solvent until the material is loaded with carbon dioxide; introducing at least one of catalysts for carbon dioxide reduction and a proton source to the solvent; heating the solvent including the material loaded with carbon dioxide until carbon dioxide loaded on the material is electrochemically converted to a fuel.

Title: CAPTURE OF CARBON DIOXIDE AND PRODUCING A FUEL USING A SOLVENT INCLUDING A NANOPARTICLE ORGANIC HYBRID

FIG. 1
(88) Date of publication of the international search report:
4 April 2013
## INTERNATIONAL SEARCH REPORT

**International application No.**

PCT/US 12/49865

### A. CLASSIFICATION OF SUBJECT MATTER

- **IPC(8)**: 12/49865
- **USPC**: 423/437.1, 977/700

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)

- **IPC(8)**: B01J 20/26 (2012.01)
- **USPC**: 423/437.1, 977/700

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)
  - PubWEST (PGPGB, USPT, EPAB, JPAB): Search Term limited - see extra sheet
  - Google Patents: Google Scholian carbon dioxide capture nanoparticle organic hybrid materials (About 2,450 results)

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 7,799,299 B2 (Heldebrant et al.) 21 September 2010 (21.09.2010). Fig: 1; Fig: 2; col. 1, ln. 34-39; col. 2, ln. 57-62; col. 2, ln. 66 to col. 3, ln. 1; col. 4, ln. 3-6, 47-54; 49-54, 49-63, 55-59; col. 5, ln. 6-9, 27-31, 27-36; col. 7, ln. 49-52; col. 7, ln. 62 to col. 8, ln. 2; col. 8, ln. 34-37.</td>
<td>1-19</td>
</tr>
<tr>
<td>Y</td>
<td>US 2011/01 14504 A1 (Sivasankar et al.) 19 May 2011 (19.05.2011 1); para [0019], [0021], [0028],</td>
<td>1-8</td>
</tr>
<tr>
<td>Y</td>
<td>US 7,795,175 B2 (Olah et al.) 14 September 2010 (14.09.2010); col. 4, ln. 29-37; col. 5, ln. 8-12, 17-22, 29-34; col. 6, ln. 10-25, 26,29, 29-33, 29-45; col. 7, ln. 13-18.</td>
<td>2, 7-13</td>
</tr>
<tr>
<td>Y</td>
<td>US 5,928,806 A (Olah et al.) 27 July 1999 (27.07.1999); col. 1, ln. 12-17, 12-16; col. 3, ln. 38-45; col. 4, ln. 48-51, 62-64; col. 5, ln. 17-25; col. 6, ln. 36-46.</td>
<td>14-19</td>
</tr>
<tr>
<td>Y</td>
<td>US 2007/0108056 A1 (Nyberg et al.) 17 May 2007 (17.05.2007); para [0002], [0003], [0059], [0060], [0078], [0079].</td>
<td>14-19</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

- "A" Specified categories of cited documents:
  - "E" earlier application or patent but published on or 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
  - "L" document defining the general state of the art which is not considered to be of particular relevance
  - "O" document referring to an oral disclosure, use, exhibition or other special reason as specified
  - "P" document containing a published international filing date or priority date in conflict with the application
  - "S" document containing a published priority date in conflict with the application
- "T" 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
- "U" document of particular relevance; the claimed invention cannot be considered novel or 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
- "Y" document member of the same paten, family

**Date of the actual completion of the international search**

19 September 2012 (19.09.2012)

**Date of mailing of the international search report**

05 QCT 2012

**Name and mailing address of the ISA/US**

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents

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Form PCT/ISA/2 10 (second sheet) (July 2009)
Search Terms: carbon dioxide, C02, greenhouse gas, flue gas, gas stream, emission, sequester, sequestration, capture, sorbent, solid, liquid, solvent, ionic liquid, nanoparticle organic hybrid, NOHMS, core, polymer, tether, link, inorganic, titanium oxide, silica, polysilsesquioxane, polyethylene imine, polyetheramine, PEI, polyethylene glycol, carbon nanotube, SWNT, CNT, amidine, guanidine, conversion, convert, fuel, methanol, reactor, cell, unit, apparatus, electrochemical, electrocatalytic, proton, hydrogen, water, acid, catalyst, control module, controller, control, sorbent, energy.