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(71) Applicant (for all designated States except US): MEDIS TECHNOLOGIES LTD. [IL/IL]; 14 Shabaz St., 56101 Yahud (IL).

Inventors: Filanovsky, Boris [IL/IL]; Dahomei 4, 96587 Jerusalem (IL).

Agent: FRIEDMAN, Mark; 7 Jabotinsky St., 52520 Ramat Gan (IL).


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(51) International Patent Classification:
G01N 27/30, 27/413

(54) Title: ELECTROCHEMICAL METHOD AND SENSOR FOR THE DETECTION OF TRACE EXPLOSIVES

(57) Abstract: A system for highly sensitive electrochemical detection of trace nitro- aromatic compounds in air, uses a carbon or carbon/gold working electrode (103) with a surface that is modified to increase the electron transfer kinetics of nitro-aromatic compounds. Chemical modifiers of the working electrode (103) would include amino-aromatic compounds such as aniline and its derivatives. The detection method involves dissolving trace nitro-aromatic compounds in an electrolyte (109) including aprotic solvents, or dipolar solvents, in the electrochemical cell including a working electrode (103), a reference electrode (105) and an auxiliary electrode (106). Voltage is varied across the working electrode (103) and the reference electrode (105), and an electrical current is measured between the working electrode (103) and the auxiliary electrode (106). The measured electrical peak current is a sensitive indication of the concentration of the trace compounds. This invention is appropriate for portable, field-testing of trace explosive compounds in air.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G01N 27/00, 413
US CL : 204/400, 402, 409; 205/780.5
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.: 204/400, 402, 409, 411; 205/780.5

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)

Please See Continuation Sheet

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>
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<tbody>
<tr>
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<tr>
<td>Y</td>
<td>NAAL et al, Analytical Chemistry, 2002, 74, pp. 140-148, see abstract, p. 142 and fig. 4.</td>
<td>7, 8, 9, 11-14</td>
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<td>Y</td>
<td>XU et al, Analyst, 2000, 125, pp. 1453-1457, see &quot;Electrode preparation&quot; on p. 1454.</td>
<td>6-9, 11</td>
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<td>Y</td>
<td>US 6356433 B1 (SHI et al) 12 March 2002 (12.03.2002), col. 3, l. 66 through col. 4, l. 15.</td>
<td>7-9, 11</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

See patent family annex.

Date of the actual completion of the international search: 22 December 2005 (22.12.2005)

Date of mailing of the international search report: 05 JAN 2006

Authorized officer:

Kaj K. Olsen
Telephone No. 571-272-1300

Form PCT/ISA/210 (second sheet) (April 2005)
### INTERNATIONAL SEARCH REPORT

**C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
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<th>Relevant to claim No.</th>
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<tr>
<td>Y</td>
<td>US 4,895,620 A (KO et al) 23 January 1990 (23.01.1990), col. 8, ll. 31-56.</td>
<td>6, 7, 9</td>
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<td>Y</td>
<td>US 4,970,145 A (BENNETTO et al) 13 November 1990 (13.11.1990), col. 6, ll. 6-14.</td>
<td>7, 9</td>
</tr>
<tr>
<td>Y</td>
<td>US 5,296,125 A (GLASS et al) 22 March 1994 (22.03.1994), col. 9, ll. 56-58 and col. 14, ll. 52-62.</td>
<td>8</td>
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<td>Y</td>
<td>US 4,696,184 A (FUKUMOTO et al) 29 September 1987 (29.11.1987), fig. 1 and 3 and col. 1, ll. 25-45.</td>
<td>11</td>
</tr>
<tr>
<td>Y</td>
<td>WANG et al, Analytical Chemistry, 2002, 74, pp. 1187-1191, see &quot;Chemicals&quot; on p. 1188.</td>
<td>12, 13</td>
</tr>
<tr>
<td>Y</td>
<td>US 5,762,808 A (PEYTON) 9 June 1998 (09.06.1998), col. 10, ll. 32-38.</td>
<td>14</td>
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</tbody>
</table>

Form PCT/ISA/210 (continuation of second sheet) (April 2005)
# INTERNATIONAL SEARCH REPORT

## 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.: 1-14

**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.

Form PCT/ISA/210 (continuation of first sheet(2)) (April 2005)
BOX III. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

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(s) 1-14, drawn to an assay having a chemically modified working electrode.

Group II, claim(s) 15-25, drawn to an assay using aprotic or organic dipolar solvents.

The inventions listed as Groups I and 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: The special technical feature of group I is a chemical modification of an electrode, which is not required for group II. The special technical feature of group II is the use of particular solvents, which is not required for group I.

Continuation of B. FIELDS SEARCHED Item 3: