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(54) Title: MAGNETIC PARTICLE SPECTROSCOPY

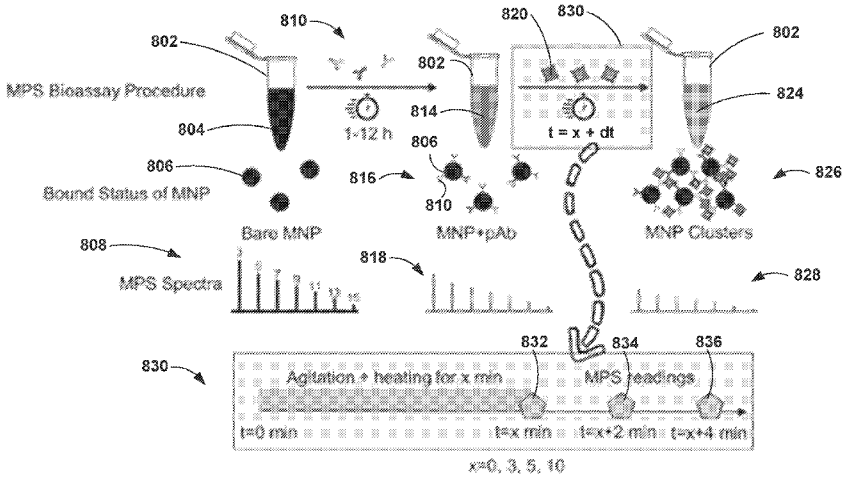


FIG. 8

(57) Abstract: An example method includes receiving a sample in a fluid, the fluid comprising a. plurality of surface functionalized magnetic nanoparticles (MNPs), the surface functionalized MNPs comprising a probe configured to capture an analyte. Hie method also includes increasing a rate of capture by which the probe is configured to capture the analyte within the fluid. The method also includes, subsequent to increasing the rate of capture, sensing, via volumetric-based magnetic particle spectroscopy (MPS), a magnetic response of the plurality of surface functionalized MNPs, the magnetic response being indicative of whether the sample comprises the analyte.

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[Continued on next page]

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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) **Date of publication of the international search report:**
18 January 2024 (18.01.2024)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 23/68433

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. G01N 27/74, G01N 33/543, G01N 33/553, G01N 33/569 (2023.01)
ADD. G01R 33/24, G01R 33/465 (2023.01)

CPC - INV. G01N 27/745, G01N 33/54326, G01N 33/54333, G01N 33/553, G01N 33/56983, G01R 33/1269
ADD. G01R 33/24, G01R 33/465

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)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2021/212144 A1 (REGENTS OF THE UNIVERSITY OF MINNESOTA) 21 October 2021 (21.10.2021); especially para [0005]-[0006], [0055], [0060], [0083]-[0085], [0126]-[0127], [0133]	1-4, 6-7
A	US 2020/0284787 A1 (FUNDACION IMDEA NANOCIENCIA) 10 September 2020 (10.09.2020); entire document	1-4, 6-7
A	WO 2012/044387 A2 (T2 BIOSYSTEMS, INC. et al.) 5 April 2012 (05.04.2012); entire document	1-4, 6-7

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

☐ 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
"D" document cited by the applicant in the international application
"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
14 November 2023	DEC 12 2023
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. 571-273-8300	Authorized officer Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 23/68433

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.: 5, 8-11, 15-21
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:
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 searched, the appropriate additional search fees must be paid.

Group I: Claims 1-4 and 6-7, directed to a method of sensing an analyte.

Group II: Claims 12-14 and 22-23, directed to a bioassay system comprising a volumetric-based magnetic particle spectroscopy (MPS) device, or a MPS device.

Continued on Supplemental Page

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.:
1-4, 6-7

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 23/68433

Continued from Box No. III Observations where unity of invention is lacking

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:

Special Technical Features

Group I requires a method comprising: receiving a sample in a fluid comprising a plurality of surface functionalized magnetic nanoparticles (MNPs), wherein the MNPs comprise a probe configured to capture an analyte; increasing a rate of capture by the probe; and sensing, via volumetric-based magnetic particle spectroscopy (MPS), a magnetic response of the plurality of surface functionalized MNPs, wherein the magnetic response is indicative of whether the sample comprises the analyte, not required by Group II.

Group II requires a MPS device comprising a fluid comprising a plurality of surface-functionalized MNPs, wherein the MNPs comprise a probe configured to capture an analyte; an incubator configured to increase a rate of capture by which the probe is configured to capture the analyte; at least one sensing conductive coil configured to determine a magnetic response of the fluid positioned within the sample mount to the alternating magnetic field subsequent to increasing the rate of capture; processing circuitry configured to determine whether the sample comprises the analyte based on the magnetic response, not required by Group I.

Common Technical Features

The feature shared by Groups I-II is a sample in a fluid comprising a plurality of surface functionalized MNPs, wherein the surface functionalized MNPs comprise a probe configured to capture an analyte; increasing a rate of capture by which the probe is configured to capture the analyte within the fluid; a volumetric-based MPS configured to sense a magnetic response of the plurality of surface functionalized MNPs.

However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is taught by WO 2021/212144 A1 to Regents of the University of Minnesota (hereinafter 'Univ Minnesota').

Univ Minnesota discloses a sample in a fluid comprising a plurality of surface functionalized MNPs, wherein the surface functionalized MNPs comprise a probe configured to capture an analyte; increasing a rate of capture by which the probe is configured to capture the analyte within the fluid; a volumetric-based MPS configured to sense a magnetic response of the plurality of surface functionalized MNPs (para [0005]-[0006] - "a handheld MPS device is described The handheld MPS device may be configured to generate an alternating magnetic field including a plurality of frequencies via conductive excitation coils. The handheld MPS device may be configured to position a sample including surface functionalized magnetic nanoparticles (MNPs) within the conductive excitation coils and within the alternating magnetic field. The handheld MPS device may be further configured to determine a magnetic response of the surface functionalized MNPs to the alternative magnetic field via a conductive sensing coil... In some examples, a biological sample may be added to the sample including the surface functionalized MNPs, and analytes within the biological sample may bind with the surface functionalized MNPs thereby changing the hydrodynamic size of the surface functionalized MNPs and, consequently, the magnetic response of the surface functionalized MNPs to the alternating magnetic field... The microfluidic MPS device may be configured to be in fluid communication with a microfluidic filtering device configured to filter a fluid, e g., blood, mix a fluid including analytes from the filtered fluid with a fluid including surface functionalized MNPs via microfluidic mixing channels, and provide the mixed fluid to a plurality of microfluidic channels."; para [0055] - "MPS may be a volumetric-based bioassay method that analyzes the response signal from the whole nanoparticle suspension, and may allow for one step, wash-free immunoassay with reduced technical requirements").

As the technical features were known in the art at the time of the invention, they cannot be considered special technical features that would otherwise unify the groups.

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

Item 4 (continued)
Claims 5, 8-11, and 15-21 are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).