



(51) International Patent Classification:

G01N 21/63 (2006.01) C09K 11/06 (2006.01)  
C07F 5/02 (2006.01) G01N 21/64 (2006.01)  
C07F 15/00 (2006.01) H01S 3/00 (2006.01)  
C09B 5/00 (2006.01)

(21) International Application Number:

PCT/US2023/014749

(22) International Filing Date:

07 March 2023 (07.03.2023)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

63/320,063 15 March 2022 (15.03.2022) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available):

AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU,

(54) Title: TRIPLET-TRIPLET ANNIHILATION UPCONVERSION NANOPARTICLES BASED SELF-STANDING BIOLOGICAL SENSORS, AND DEVICES AND METHODS THEREOF

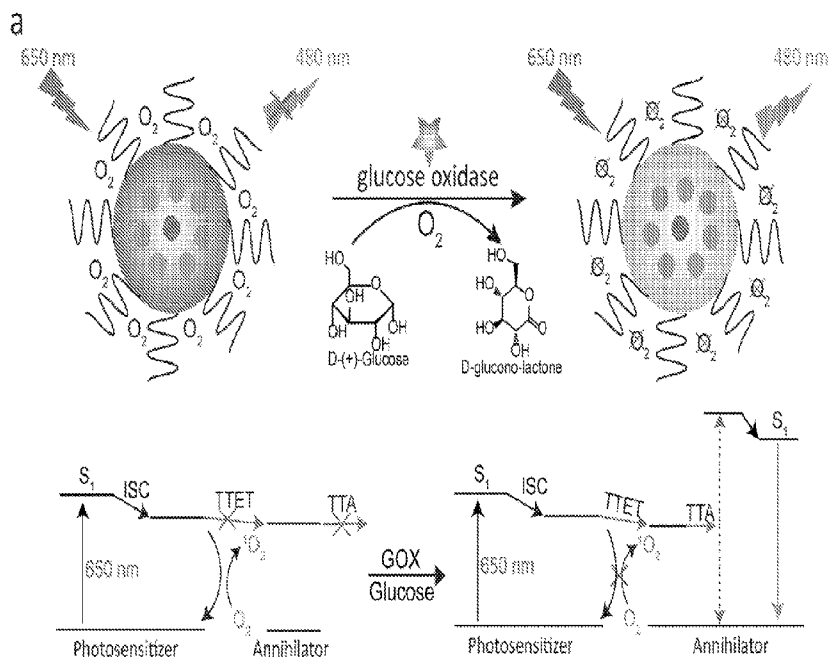


FIG. 1

(57) Abstract: The invention provides novel triplet-triplet annihilation upconversion nanoparticles as background free self-standing biological sensors, and devices and methods thereof. The invention provides novel and simple enzymatic strategy to overcome oxygen-induced triplet-triplet annihilation upconversion quenching. The disclosed invention addresses the long-felt challenges in aqueous TTA-UC due to its sensitivity to oxygen, which has hindered TTAUC's biological applications under ambient atmosphere. This novel strategy stems from glucose oxidase catalyzed glucose oxidation reaction, which enables rapid oxygen depletion to turn on upconversion in the aqueous solution. Furthermore, self-standing upconversion biological sensors of such nanoparticles are developed to detect glucose and measure the activity of enzymes related to glucose metabolism in a highly specific, sensitive, and background-free manner.



LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

- (84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**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:**

16 November 2023 (16.11.2023)

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**INTERNATIONAL SEARCH REPORT**

International application No.  
PCT/US23/14749

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>				
IPC - INV. G01N 21/63; C07F 5/02; C07F 15/00; C09B 5/00; C09K 11/06; G01N 21/64 (2023.01) ADD. H01S 3/00 (2023.01)				
CPC - INV. G01N 21/63; C07F 5/022; C07F 15/0066; C09B 5/00; C09K 11/06; G01N 21/64  ADD. C09K 2211/185; C09K 2211/188; H01S 3/00				
According to International Patent Classification (IPC) or to both national classification and IPC				
<b>B. FIELDS SEARCHED</b>				
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 database consulted during the international search (name of database and, where practicable, search terms used) See Search History document				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>				
<b>Category*</b>	<b>Citation of document, with indication, where appropriate, of the relevant passages</b>	<b>Relevant to claim No.</b>		
X	HUANG. "Enzymatic enhancing of triplet-triplet annihilation upconversion by breaking oxygen quenching for background-free biological sensing" 1-9. Nature Communications. Web. 26 March 2021; Abstract; page 2, first column, first paragraph; page 3, second column, second-third paragraphs; page 6, second column, sixth paragraph; page 7, first column, first paragraph; fig. 1A; DOI: <a href="https://doi.org/10.1038/s41467-021-22282-1">https://doi.org/10.1038/s41467-021-22282-1</a>	1-4		
A	US 2018/0311353 A1 (CHILDREN'S MEDICAL CENTER CORPORATION) 1 November 2018; entire document	1-4		
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.				
<table border="0" style="width:100%;"> <tr> <td style="width:50%; vertical-align: top;"> <p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"D" document cited by the applicant in the international application</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="width:50%; vertical-align: top;"> <p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p> </td> </tr> </table>			<p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"D" document cited by the applicant in the international application</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p>
<p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"D" document cited by the applicant in the international application</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p>			
Date of the actual completion of the international search 26 August 2023 (26.08.2023)		Date of mailing of the international search report <b>SEP 29 2023</b>		
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300		Authorized officer <b>Shane Thomas</b>  Telephone No. PCT Helpdesk: 571-272-4300		

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US23/14749

**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.: 5-28  
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:

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.:

**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.