

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference UIX-04525		FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/US2024/042436	International filing date (<i>day/month/year</i>) 15 August 2024 (15.08.2024)	(Earliest) Priority Date (<i>day/month/year</i>) 18 August 2023 (18.08.2023)	
Applicant THE BOARD OF TRUSTEES OF THE UNIVERSITY OF ILLINOIS			

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of:

- ☒ the international application in the language in which it was filed.
☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6bis(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☒ **Certain claims were found unsearchable** (see Box No. II).

3. ☒ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

- ☒ the text is approved as submitted by the applicant.
☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

- ☒ the text is approved as submitted by the applicant.
☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

- a. the figure of the **drawings** to be published with the abstract is Figure No. _____
☐ as suggested by the applicant.
☐ as selected by this Authority, because the applicant failed to suggest a figure.
☐ as selected by this Authority, because this figure better characterizes the invention.
- b. ☒ none of the figures is to be published with the abstract.

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.: **4-43, 47-78**
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.

Group I: Claims 1-3 directed toward the method for iterative carbon-carbon bond formation, comprising a cycle comprising the following steps: (a) combining a first boronic ester, a first silanolate, a palladium (Pd) precatalyst, and a halogenated reagent under conditions sufficient to produce a cross-coupling product; (b) purifying the cross-coupling product, thereby generating a purified product; (c) combining the purified product, a second silanolate, and a diol under conditions sufficient to produce a second boronic ester, wherein the halogenated reagent is represented by structural formula (I): the first boronic ester is a compound of formula $R_5-B(OR_6)(OR_7)$, and the palladium precatalyst is represented by structural formula (II), (III), (IV), or (V): wherein Hal is F, Cl, Br, or I; A is selected from the group consisting of alkylene, alkenylene, alkynylene, cycl^oalkylene, cycl^oalkenylene, cycl^oalkynylene, heteroalkylene, heteroalkenylene, heteroalkynylene, heterocyclylene, arylene, and heteroarylene; R^* , RH , R_{21} , R_{31} , and R_{41} are each independently alkyl; R_5 is selected from the group consisting of alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkenyl, cycloalkynyl, heteroalkyl, heteroalkenyl, heteroalkynyl, heterocyclyl, aryl, and heteroaryl; R_6 and R_7 are each independently alkyl, or R_6 and R_7 together with oxygen atoms to which they are attached and the boron atom form heterocyclyl; and X is a non-coordinating anion; each R_{1-} is independently H, alkyl, haloalkyl, hydroxy, alkoxy, aryloxy, aryl, or halogen; L is a trialkylphosphine, triarylphosphine, dialkylarylphosphine, alkylarylphosphine, bis(phosphine), phosphoramidate, amine, bis(amine), or N-heterocyclic carbene; and each R_2 is independently alkyl, haloalkyl, or aryl; and each R_Y is independently H, alkyl, haloalkyl, or aryl.

Group II: Claims 44-46 directed toward a method for producing an activated boronate reagent, the method comprising the following step: (a) combining a first boronate reagent and a fourth silanolate under conditions sufficient to produce an activated boronate reagent; wherein the first boronate reagent is represented by structural formula (I): A' is selected from the group consisting of optionally substituted alkyl, alkenyl, alkynyl, cycloalkyl, cycloalkenyl, cycloalkynyl, heteroalkyl, heteroalkenyl, heteroalkynyl, heterocyclyl, aryl, and heteroaryl; and R^* , R'' , R_{21} , R_{31} , and R_{41} are each independently alkyl.

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 the special technical feature of a method for iterative carbon-carbon bond formation, comprising a cycle comprising the following steps: (a) combining a first boronic ester, a first silanolate, a

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

palladium (Pd) precatalyst, and a halogenated reagent under conditions sufficient to produce a cross-coupling product; (b) purifying the cross-coupling product, not required by Group II.

Group II requires the special technical feature of a method for producing an activated boronate reagent, the method comprising the following step: (a) combining a first boronate reagent and a fourth silanolate under conditions sufficient to produce an activated boronate reagent, not required by Group I.

Common Technical Features:

Groups I-II share the common technical feature of a boronate reagent is represented by structural formula (I).

However, these shared technical features do not represent a contribution over prior art, because the shared technical feature is being anticipated by US 2018/0230170 A1 to The Board of the University of Illinois (hereinafter "Illinois") which discloses the compound of formula (I) 9para [0014]).

As the shared technical features were known in the art, they cannot be considered common technical features that would otherwise unify the groups. Therefore, Groups I-II lack unity under PCT Rule 13.

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.: **1-3**

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/US2024/042436

A. CLASSIFICATION OF SUBJECT MATTERIPC: **C07F 5/02** (2024.01); **C07F 5/04** (2024.01); **C07B 37/02** (2024.01); **C07B 37/04** (2024.01); **C07B 37/10** (2024.01); **C07C 69/003** (2024.01); **C07C 213/10** (2024.01)CPC: **C07F 5/02**; **C07F 5/04**; **C07B 37/02**; **C07B 37/04**; **C07B 37/10**; **C07C 69/003**; **C07C 69/02**; **C07C 2531/22**; **C07C 2531/24**; **C07C 213/10**

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.
A	US 2018/0230170 A1 (The Board of Trustees of the University of Illinois) 16 August 2018 (16.08.2018) abstract; para [0427]	1-3
A	US 2013/0243670 A1 (Burke et al.) 19 September 2013 (19.09.2013) abstract; figure 2; para [0073]	1-3
A	US 2011/0201806 A1 (Burke et al.) 18 August 2011 (18.08.2011) abstract; para [0057]; [[0099]	1-3
A	US 2021/0009508 A1 (The Board of Trustees of the University of Illinois) 14 January 2021 (14.01.2021) entire document	1-3



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

02 October 2024 (02.10.2024)

Date of mailing of the international search report

30 January 2025 (30.01.2025)

Name and mailing address of the ISA/US

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