



- (51) **International Patent Classification:**
B01F 3/08 (2006.01)
- (21) **International Application Number:**
PCT/US2014/040358
- (22) **International Filing Date:**
30 May 2014 (30.05.2014)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
61/829,586 31 May 2013 (31.05.2013) US
- (71) **Applicant:** UNIVERSITY OF WASHINGTON through its CENTER FOR COMMERCIALIZATION [US/US]; 4311-11th Avenue N.E., Suite 500, Seattle, WA 98105-4608 (US).
- (72) **Inventors:** CHIU, Daniel, T.; 4311-11th Avenue N.E., Suite 500, Seattle, WA 98105-4608 (US). HAKIMI, Bejan; 4311-11th Avenue N.E., Suite 500, Seattle, WA 98105-4608 (US). LIU, Dingsheng; 4311-11th Avenue N.E., Suite 500, Seattle, WA 98105-4608 (US). TURECEK, Frantisek; 4311-11th Avenue N.E., Suite 500, Seattle, WA 98105-4608 (US). VOLNY, Michael; 4311-11th Avenue N.E., Suite 500, Seattle, WA 98105-4608 (US). ROLFS, Joelle; 4311-11th Avenue N.E., Suite 500, Seattle, WA 98105-4608 (US).
- (74) **Agents:** HARWOOD, Melissa, M. et al.; Wilson Sonsini Goodrich & Rosati, 650 Page Mill Road, Palo Alto, CA 94304-1050 (US).
- (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, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, 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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, 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, 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))

[Continued on next page]

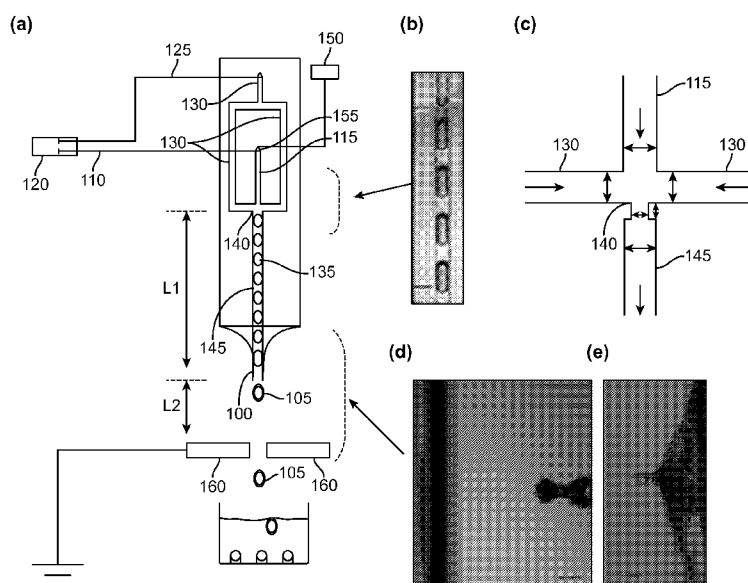
(54) **Title:** DROPLET-MASS SPECTROMETER INTERFACE

FIG. 1

(57) **Abstract:** The present disclosure describes devices and methods capable of generating multi-phase emulsions, including double emulsion droplets in a gas phase. The present disclosure also describes interfaces for coupling a multi-phase emulsion droplet source to an analytical instrument such as a mass spectrometer. The present disclosure further describes methods, systems, and apparatuses for using the devices and interfaces described to perform analysis, including mass spectrometry. The present disclosure also describes methods, systems, and apparatuses for generating and using multi-phase emulsions to perform analysis.



— *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:**
12 March 2015

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2014/040358

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B01F 3/08 (2014.01)

CPC - B01F 3/0807 (2014.11)

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) - B01F 3/00, 08 (2014.01)

USPC - 436/52, 53, 180

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - B01F 3/00, 08, 0803, 0807, 0815 (2013.01) Keyword delimited

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

PatBase, Google Patents, Google Scholar

Search Terms used: droplet produce, double emulsion, multi-phase emulsion, immiscible, electrode, voltage

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/023405 A1 (BARRERO RIPOLL et al) 03 March 2011 (03.03.2011) entire document	1, 26
---		-----
Y		2, 3, 27
Y	US 2012/0309002 A1 (LINK) 06 December 2012 (06.12.2012) entire document	2, 27
Y	US 2009/0012187 A1 (CHU et al) 08 January 2009 (08.01.2009) entire document	3
A	WO 2010/148106 A1 (BOSE et al) 23 December 2010 (23.12.2010) entire document	1-3, 26, 27

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"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

30 December 2014

Date of mailing of the international search report

13 JAN 2015

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. 571-273-3201

Authorized officer:

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2014/040358

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:

see extra 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 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, 26, 27

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/US2014/040358

Continuation of Box III: Lack of Unity

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, claims 1-3,26-27, drawn to a method and device for producing a droplet.

Group II, claims 8-10, drawn to an interface for coupling a droplet source to an analytical instrument.

Group III, claims 20,28-29,38, drawn to a method and system for performing mass spectrometry.

The inventions listed as Groups I, II and III 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 the Group I invention: flowing a first liquid through the first fluidic channel; flowing a second liquid through a second fluidic channel, wherein the second liquid is immiscible with the first liquid, and wherein the second fluidic channel is in fluidic communication with the first fluidic channel as claimed therein is not present in the invention of Groups II and III. The special technical feature of the Group II invention: an outer surface, having a proximal end and a distal end, providing a substantially enclosed inner space; an inlet to the substantially enclosed inner space, the inlet disposed on the proximal end of the outer surface; an electrostatic lens disposed within the substantially enclosed inner space and between the proximal end and distal end of the outer surface as claimed therein is not present in the invention of Groups I or III. The special technical feature of the Group III invention: evaporating the first liquid of the droplet, the second liquid of the droplet, or a combination thereof; ionizing the analyte; transporting the analyte to a mass spectrometer; and obtaining the mass spectrum of the analyte, the ion mobility spectrum of the analyte as claimed therein is not present in the invention of Groups I or II.

Groups I, II and III lack unity of invention because even though the inventions of these groups require the technical feature of an interface configured to allow the passage of a droplet comprising an analyte; flowing a first liquid through a fluidic channel; wherein the second liquid is immiscible with the first liquid; double emulsion, this technical feature is not a special technical feature as it does not make a contribution over the prior art.

Specifically, WO 2010/148106 A1 (BOSE et al) 23 December 2010 (23.12.2010) teaches an interface configured to allow the passage of a droplet comprising an analyte (the parts of the precipitates that had been bound by the oil- water interface were freely suspended in the inner aqueous phase, page 29, lines 15-25); flowing a first liquid through a fluidic channel (the system may be a microfluidic system. "Microfluidic," as used herein, refers to a device, apparatus or system including at least one fluid channel, page 14, lines 27-32); wherein the second liquid is immiscible with the first liquid (Second fluid 14 may be immiscible with first fluid 12, page 7, lines 24-27); double emulsion (double emulsion droplets, page 24, lines 13-15).

Since none of the special technical features of the Group I, II or III inventions are found in more than one of the inventions, unity of invention is lacking.