

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY (PCT Rule 43bis.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference see form PCT/ISA/220		FOR FURTHER ACTION See paragraph 2 below
International application No. PCT/US2017/041391	International filing date (day/month/year) 10.07.2017	Priority date (day/month/year) 12.07.2016
International Patent Classification (IPC) or both national classification and IPC INV. C09K8/584 C09K8/592 C09K8/594		
Applicant DOW GLOBAL TECHNOLOGIES LLC		

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Fax: +49 89 2399 - 4465	Date of completion of this opinion see form PCT/ISA/210	Authorized Officer Zimpfer, Emmanuel Telephone No. +49 89 2399-0	
--	--	--	---

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established 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)).
2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))
3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
 - a. ☐ forming part of the international application as filed:
 - ☐ in the form of an Annex C/ST.25 text file.
 - ☐ on paper or in the form of an image file.
 - b. ☐ furnished together with the international application under PCT Rule 13ter.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
 - c. ☐ furnished subsequent to the international filing date for the purposes of international search only:
 - ☐ in the form of an Annex C/ST.25 text file (Rule 13ter.1(a)).
 - ☐ on paper or in the form of an image file (Rule 13ter.1(b) and Administrative Instructions, Section 713).
4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>1-10</u>
	No: Claims	
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-10</u>
Industrial applicability (IA)	Yes: Claims	<u>1-10</u>
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

- D1 US 6 743 764 B1 (WALLICK DAVID E [US] ET AL) 1 June 2004
(2004-06-01)
- D2 WO 01/08793 A1 (DOW CHEM CO) 8 February 2001 (2001-02-08)
- D3 US 5 203 411 A (DAWE ROBERT D [US] ET AL) 20 April 1993
(1993-04-20)
- D4 WO 97/10320 A1 (CLOROX CO [US]) 20 March 1997 (1997-03-20)
- D5 US 2009/078414 A1 (HORVATH SZABO GEZA [CA] ET AL) 26 March
2009 (2009-03-26)cited in the application

1 Novelty :

- 1.1 Since none of the documents cited in the search report disclose all the features of independent claim 1, it is considered that said claim as well as dependent claims 2-3 and claims 4-10 are novel over said prior art documents.

2 Inventive step :

- 2.1 **Document D1** considered as being the closest prior art document for present claim 1, discloses concentrated compositions comprising a blend of (di)alkyl diphenyloxide (di)sulfonic acids used as surfactants blend (see claims). In particular, the mixture DADS and MADS is predominant in the blend (see col.4 l.1-10), since present at more than 85%.
The specific ratio of DADS alone, in the blend, is not disclosed.
The pH is also not indicated for the aqueous solution.
Said composition are then used to be mixed with water (see col. 7 l.37-41)
Document D2 seems also relevant as closest prior art, since disclosing the same kind of compositions,

Hence, present **claim 1** seem to differ by :

- an amount of DADS equal or greater than 50 wt%, based on the weight of the (di)alkyl diphenyloxide (di)sulfonate blend.
- the value of the pH equal or greater than 7

At this stage of the proceedings it is not clear which specific technical effect, or technical problem, is solved by the amount of DADS of at least 50wt% in the surfactant blend and/or of having a pH of at least 7.

It appears that no comparative examples are present with lower amounts of DADS, showing any negative impact on the composition.

Hence, the objective technical problem to be solved, is considered to provide an alternative composition.

The choice of the amounts of the components is considered as a straightforward possibilities of the skilled person, in particular with the teaching given in D1, that DADS and MADS are predominantly present in the blend.

For the same reason, the choice of a suitable pH is considered as obvious for the skilled person.

Therefore, present **claim 1**, considered as an obvious alternative, is not considered as being inventive over the cited documents.

- 2.2 Present independent **claim 4** is directed to a method for recovering oil from a reservoir using said foam forming composition.

Document D3 discloses a method of enhanced oil recovery based on the injection of a foam forming aqueous composition, comprising (see claims ; col.4 l.60-65) one or more alkylated diphenyl sulfonates combined to amphoteric surfactant to improve the mobility reduction factor, with a gas or gas/aqueous fluid mixture.

The alkylated diphenyl sulfonates can in particular be (see formula on col. 5 / claims) (di)alkyl diphenyloxide (di)sulfonates.

Hence, the use of mixture of (di)alkyl diphenyloxide (di)sulfonates in foaming composition for use in EOR is already known to the skilled person.

Present **claim 4** differs from the disclosure of D3 by :

- an amount of DADS equal or greater than 50 wt%, based on the weight of the (di)alkyl diphenyloxide (di)sulfonate blend.
- the value of the pH equal or greater than 7

Again, no technical effect seems to be linked to this specific amount of DADS present or to this specific pH range.

Hence, the objective technical problem to be solved, is considered to provide an alternative method for recovering oil, based on an alternative foaming composition.

The choice of the amounts of the components is considered as a straightforward possibilities of the skilled person.

For the same reason, the choice of a suitable pH is considered as obvious for the skilled person.

Therefore, present **claim 4**, considered as an obvious alternative, is not considered as being inventive over the cited documents.

- 2.3 Dependent **claims 2-3 and 5-10** do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT with respect to inventive step. In particular cyclic steam stimulation (CSS) or steam assisted gravity drainage (SAGD) are well-known enhanced oil recovery methods.

Re Item VII

Certain defects in the international application

- 1 The units "psi" on page 11 are not additionally expressed in terms of the units stipulated by Rule 10.1/(a)/and/(b) PCT. This should be corrected.
- 2 The used expression "incorporation by reference", as mentioned on page 9 in the present description, is not recognised in the PCT and should be deleted.

Re Item VIII

Certain observations on the international application

- 3 The compounds represented by the formulas in present independent claim 1 are (di)alkyl diphenyloxide (di)sulfonates and not (di)sulfates. Hence, the wording used in **claim 1**, stating that the mixture comprising the "*dialkyl diphenyloxide disulfate (DADS) in an amount equal to or grater than 50 wt%... the monoalkyl diphenyloxide disulfate (MADS)....*" appears to lack clarity under Art. 6 PCT.
- 4 The same objection is raised, mutatis mutandis, for present independent **claim 4** since the same wording is used.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44bis)

Applicant's or agent's file reference 79339-WO-PCT	FOR FURTHER ACTION	See item 4 below
International application No. PCT/US2017/041391	International filing date (<i>day/month/year</i>) 10 July 2017 (10.07.2017)	Priority date (<i>day/month/year</i>) 12 July 2016 (12.07.2016)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant DOW GLOBAL TECHNOLOGIES LLC		

1.	This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 bis.1(a).																								
2.	This REPORT consists of a total of 8 sheets, including this cover sheet.																								
In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.																									
3.	This report contains indications relating to the following items: <table style="width: 100%;"> <tr> <td style="width: 5%; text-align: center;">☒</td> <td style="width: 25%;">Box No. I</td> <td style="width: 70%;">Basis of the report</td> </tr> <tr> <td style="text-align: center;">☐</td> <td>Box No. II</td> <td>Priority</td> </tr> <tr> <td style="text-align: center;">☐</td> <td>Box No. III</td> <td>Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</td> </tr> <tr> <td style="text-align: center;">☐</td> <td>Box No. IV</td> <td>Lack of unity of invention</td> </tr> <tr> <td style="text-align: center;">☒</td> <td>Box No. V</td> <td>Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</td> </tr> <tr> <td style="text-align: center;">☐</td> <td>Box No. VI</td> <td>Certain documents cited</td> </tr> <tr> <td style="text-align: center;">☒</td> <td>Box No. VII</td> <td>Certain defects in the international application</td> </tr> <tr> <td style="text-align: center;">☒</td> <td>Box No. VIII</td> <td>Certain observations on the international application</td> </tr> </table>	☒	Box No. I	Basis of the report	☐	Box No. II	Priority	☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability	☐	Box No. IV	Lack of unity of invention	☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement	☐	Box No. VI	Certain documents cited	☒	Box No. VII	Certain defects in the international application	☒	Box No. VIII	Certain observations on the international application
☒	Box No. I	Basis of the report																							
☐	Box No. II	Priority																							
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability																							
☐	Box No. IV	Lack of unity of invention																							
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement																							
☐	Box No. VI	Certain documents cited																							
☒	Box No. VII	Certain defects in the international application																							
☒	Box No. VIII	Certain observations on the international application																							
4.	The International Bureau will communicate this report to designated Offices in accordance with Rules 44bis.3(c) and 93bis.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44bis .2).																								

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Date of issuance of this report 15 January 2019 (15.01.2019) Authorized officer Athina Nickitas-Etienne e-mail: pct.team4@wipo.int
--	--

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY (PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.
PCT/US2017/041391

International filing date (day/month/year)
10.07.2017

Priority date (day/month/year)
12.07.2016

International Patent Classification (IPC) or both national classification and IPC
INV. C09K8/584 C09K8/592 C09K8/594

Applicant
DOW GLOBAL TECHNOLOGIES LLC

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:



European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0
Fax: +49 89 2399 - 4465

Date of completion of
this opinion

see form
PCT/ISA/210

Authorized Officer

Zimpfer, Emmanuel

Telephone No. +49 89 2399-0



Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established 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)).
2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))
3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
 - a. ☐ forming part of the international application as filed:
 - ☐ in the form of an Annex C/ST.25 text file.
 - ☐ on paper or in the form of an image file.
 - b. ☐ furnished together with the international application under PCT Rule 13ter.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
 - c. ☐ furnished subsequent to the international filing date for the purposes of international search only:
 - ☐ in the form of an Annex C/ST.25 text file (Rule 13ter.1(a)).
 - ☐ on paper or in the form of an image file (Rule 13ter.1(b) and Administrative Instructions, Section 713).
4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>1-10</u>
	No: Claims	
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-10</u>
Industrial applicability (IA)	Yes: Claims	<u>1-10</u>
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

- D1 US 6 743 764 B1 (WALLICK DAVID E [US] ET AL) 1 June 2004
(2004-06-01)
- D2 WO 01/08793 A1 (DOW CHEM CO) 8 February 2001 (2001-02-08)
- D3 US 5 203 411 A (DAWE ROBERT D [US] ET AL) 20 April 1993
(1993-04-20)
- D4 WO 97/10320 A1 (CLOROX CO [US]) 20 March 1997 (1997-03-20)
- D5 US 2009/078414 A1 (HORVATH SZABO GEZA [CA] ET AL) 26 March
2009 (2009-03-26)cited in the application

1 Novelty :

- 1.1 Since none of the documents cited in the search report disclose all the features of independent claim 1, it is considered that said claim as well as dependent claims 2-3 and claims 4-10 are novel over said prior art documents.

2 Inventive step :

- 2.1 **Document D1** considered as being the closest prior art document for present claim 1, discloses concentrated compositions comprising a blend of (di)alkyl diphenyloxide (di)sulfonic acids used as surfactants blend (see claims). In particular, the mixture DADS and MADS is predominant in the blend (see col.4 l.1-10), since present at more than 85%.
The specific ratio of DADS alone, in the blend, is not disclosed.
The pH is also not indicated for the aqueous solution.
Said composition are then used to be mixed with water (see col. 7 l.37-41)
Document D2 seems also relevant as closest prior art, since disclosing the same kind of compositions,

Hence, present **claim 1** seem to differ by :

- an amount of DADS equal or greater than 50 wt%, based on the weight of the (di)alkyl diphenyloxide (di)sulfonate blend.
- the value of the pH equal or greater than 7

At this stage of the proceedings it is not clear which specific technical effect, or technical problem, is solved by the amount of DADS of at least 50wt% in the surfactant blend and/or of having a pH of at least 7.

It appears that no comparative examples are present with lower amounts of DADS, showing any negative impact on the composition.

Hence, the objective technical problem to be solved, is considered to provide an alternative composition.

The choice of the amounts of the components is considered as a straightforward possibilities of the skilled person, in particular with the teaching given in D1, that DADS and MADS are predominantly present in the blend.

For the same reason, the choice of a suitable pH is considered as obvious for the skilled person.

Therefore, present **claim 1**, considered as an obvious alternative, is not considered as being inventive over the cited documents.

- 2.2 Present independent **claim 4** is directed to a method for recovering oil from a reservoir using said foam forming composition.

Document D3 discloses a method of enhanced oil recovery based on the injection of a foam forming aqueous composition, comprising (see claims ; col.4 l.60-65) one or more alkylated diphenyl sulfonates combined to amphoteric surfactant to improve the mobility reduction factor, with a gas or gas/aqueous fluid mixture.

The alkylated diphenyl sulfonates can in particular be (see formula on col. 5 / claims) (di)alkyl diphenyloxide (di)sulfonates.

Hence, the use of mixture of (di)alkyl diphenyloxide (di)sulfonates in foaming composition for use in EOR is already known to the skilled person.

Present **claim 4** differs from the disclosure of D3 by :

- an amount of DADS equal or greater than 50 wt%, based on the weight of the (di)alkyl diphenyloxide (di)sulfonate blend.
- the value of the pH equal or greater than 7

Again, no technical effect seems to be linked to this specific amount of DADS present or to this specific pH range.

Hence, the objective technical problem to be solved, is considered to provide an alternative method for recovering oil, based on an alternative foaming composition.

The choice of the amounts of the components is considered as a straightforward possibilities of the skilled person.

For the same reason, the choice of a suitable pH is considered as obvious for the skilled person.

Therefore, present **claim 4**, considered as an obvious alternative, is not considered as being inventive over the cited documents.

- 2.3 Dependent **claims 2-3 and 5-10** do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT with respect to inventive step. In particular cyclic steam stimulation (CSS) or steam assisted gravity drainage (SAGD) are well-known enhanced oil recovery methods.

Re Item VII

Certain defects in the international application

- 1 The units "psi" on page 11 are not additionally expressed in terms of the units stipulated by Rule 10.1/(a)/and/(b) PCT. This should be corrected.
- 2 The used expression "incorporation by reference", as mentioned on page 9 in the present description, is not recognised in the PCT and should be deleted.

Re Item VIII

Certain observations on the international application

- 3 The compounds represented by the formulas in present independent claim 1 are (di)alkyl diphenyloxide (di)sulfonates and not (di)sulfates. Hence, the wording used in **claim 1**, stating that the mixture comprising the "*dialkyl diphenyloxide disulfate (DADS) in an amount equal to or grater than 50 wt%... the monoalkyl diphenyloxide disulfate (MADS)....*" appears to lack clarity under Art. 6 PCT.
- 4 The same objection is raised, mutatis mutandis, for present independent **claim 4** since the same wording is used.



(51) International Patent Classification:

C09K 8/584 (2006.01) *C09K 8/594* (2006.01)
C09K 8/592 (2006.01)

(21) International Application Number:

PCT/US2017/041391

(22) International Filing Date:

10 July 2017 (10.07.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/361,225 12 July 2016 (12.07.2016) US

(71) Applicant: DOW GLOBAL TECHNOLOGIES LLC
[US/US]; 2040 Dow Center, Midland, MI 48674 (US).

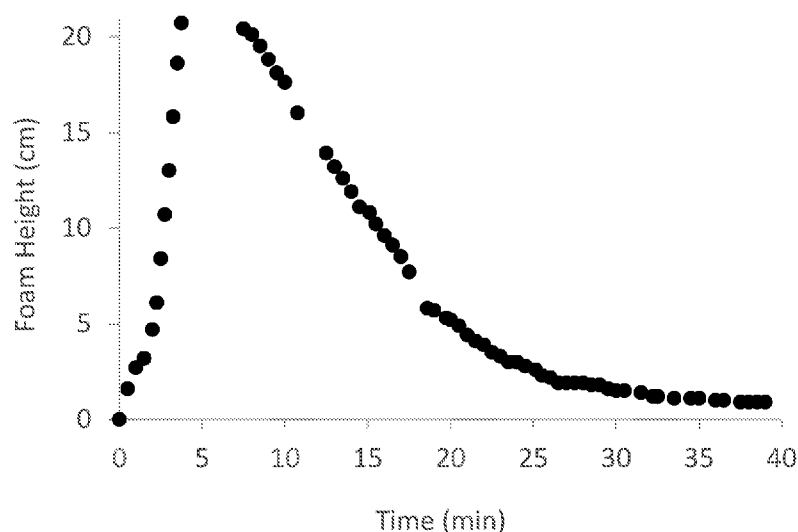
(72) Inventors: MUKHERJEE, Biplob; 2301 N. Brazosport Blvd., Freeport, TX 77541 (US). CROSLEY, Matthew E.; 2301 N. Brazosport Blvd, B-1603/8, Freeport, TX 77541 (US). KIDA, Yuko; 2301 N. Brazosport Blvd, Freeport, TX 77541 (US). SHI, Zhi; 2301 N. Brazosport Blvd, Freeport, TX 77541 (US). SINGH, Harpreet; 2301 N. Brazosport Blvd., Freeport, TX 77541 (US). ZHOU, Zhe; 2301 N. Brazosport Blvd., Freeport, TX 77541 (US).

(74) Agent: CHRISTY, Robert M.; The Dow Chemical Company, Intellectual Property, PO Box 1967, Midland, Michigan 48641-1967 (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, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, 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, 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, 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).

(54) Title: FOAM-FORMING COMPOSITION FOR STEAM ASSISTED OIL RECOVERY

FIG. 2



(57) **Abstract:** The present invention includes a foam-forming composition for use in enhanced heavy oil recovery, and a method of using said foam-forming composition for recovering heavy oil and/or bitumen. The foam-forming composition of the present invention comprises a mixture of (di)alkyl diphenyloxide (di)sulfonate compounds and the process of heavy oil recovery is performed at elevated temperatures using steam.

Published:

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

FOAM-FORMING COMPOSITION FOR STEAM ASSISTED OIL RECOVERY

FIELD OF THE INVENTION

5 This invention relates to a foam-forming composition and method of use thereof for foam steam assisted oil recovery process. Specifically, the foam-forming composition comprises primarily a dialkyl diphenyloxide disulfonate.

BACKGROUND OF THE INVENTION

10

The present invention relates to a composition and method for enhancing the recovery of crude oil and/or bitumen.

A common way of categorizing petroleum deposits is by density. Light oil, also known as "conventional oil", has an API gravity of greater than 22° and a viscosity less than 100 centipoise (cP). Heavy oil, by contrast, is an asphaltic, dense (low API gravity), and
15 viscous hydrocarbon that is chemically characterized by its content of asphaltenes. Although definitions vary, the upper limit for heavy oils is usually an API gravity of 22° and a viscosity of more than 100 cP. Extra-heavy crude oil or bitumen has an API gravity of less than 10°.

20 In the recovery of conventional oil from reservoirs, the use of primary production techniques (i.e., the use of only the initial reservoir pressure to recover the crude oil) followed by the secondary recovery technique of waterflooding, recovers only a portion of the original oil present in the formation. Moreover, the use of certain enhanced oil recovery (EOR) techniques is also known in the art. These enhanced oil recovery techniques involve
25 injection of any suitably tailored composition of fluids for example, water with tailored salinity, re-injection of hydrocarbon gases produced from the formation, in cases of heavy oil thermal methods can be used by increasing the enthalpy of injected fluid e.g., utilizing steam, and injection of chemicals like surfactants and polymers to enhance performance of any of these recovery techniques.

30 Usually heavy oil from an oil-bearing formation and/or bitumen from oil sands are produced by reducing the viscosity of the oil enough to make it flow. Viscosity reduction can be achieved by applying heat, often in the form of steam, and/or adding solvents to partially dilute the oil. There are several different EOR steam utilization techniques for

extracting heavy oil and/or bitumen, for example: cyclic steam simulation (CSS), steam flood, steam assisted gravity drainage (SAGD), foam-assisted SAGD, and vapor extraction process (VAPEX). These methods employ injecting high temperature steam in the formation to reduce the oil viscosity followed by driving of the mobilized oil to the producer well either using a negative pressure, for example CSS, or positive pressure, for example steam flood.

In CSS, the same well acts as the injector and the producer and is also known as a huff and puff method. Steam is injected into a well at a temperature of 300-340°C for a period of weeks to months. The well is allowed to sit for days to weeks to allow heat to soak into the formation, and, later, the hot oil is pumped out of the well for weeks or months. Once the production rate falls off, the well is put through another cycle of steam injection, soak and production. This process is repeated until the cost of injecting steam becomes higher than the money made from producing oil. Recovery factors are around 20 to 25%, but the cost to inject steam is high.

In steam flood, also known as steam drive, steam is injected into the formation through one vertical well; the heat of the steam helps lower the viscosity of the oil, and forces the mobilized oil to flow towards vertical producer wells located at certain distance from the producer. Although a promising technology, in steam floods after the initial injection breakthrough, the probability of steam bypassing the oil increases. With time, the active steam zone in the reservoir tends to bypass, or channel, the oil-bearing regions and limits the total amount of the formation that is effectively swept by the steam.

SAGD uses at least two horizontal wells--one at the bottom of the formation and another about 5 meters above it. Steam is injected into the upper well, the heat reduces the viscosity of the heavy oil, which allows it to drain by gravity into the lower well, where it is pumped to the surface. SAGD is cheaper than CSS, allows very high oil production rates, and recovers up to 60% of the oil in place.

VAPEX is similar to SAGD, but instead of steam, hydrocarbon solvents are injected into an upper well to dilute heavy oil which enables the diluted heavy oil to flow into a lower well.

Surfactants have been proposed as a means for generating foam in reservoir formations to reduce channeling. See, for example, USP 4,380,266; 4,540,049; 4,739,831; 4,860,828; 5,052,478; 5,005,644; 5,502,538; US Patent Application Nos. 2009/0078414, 2009/0218099, and 2014/0216739; WO 2014/160563, WO 2014/099466; and PCT/US

15/021253. The purpose of this foam is to block channeling and divert the flow of the steam into that portion of the formation containing high oil saturation.

Aqueous anionic surfactant systems are known to be particularly efficient as foaming agents. Such an anionic surfactant system is a substantially homogeneous aqueous liquid composition that may comprise a solution, a microemulsion, or a micellar dispersion of anionic surfactant molecules and/or micelles. The water-solubilities and oil-solubilities of the surfactants in such a system are such that those materials tend to remain along an oil/water interface, rather than being completely dissolved or dispersed within either the water-phase or oil-phase of the system. The anionic surfactants comprise surface active salts or soaps of organic acids.

In a process for displacing oil, the surfactants in an aqueous anionic surfactant system can be pre-formed or formed within permeable material such as a subterranean reservoir. USP 3,174,542 describes oil displacing processes in which acidic materials are injected ahead of basic materials so that surfactant systems are formed in situ.

Although aqueous anionic surfactant systems are generally efficient oil-displacing fluids, they have relatively low tolerances to multivalent cations. Such cations are commonly encountered in waters or brines in subterranean reservoirs that contain solutions of calcium or magnesium salts, or the like. The multivalent cations tend to react with the anionic surfactants or the components of anionic surfactants or the components of anionic surfactant systems to form precipitates, to cause phase separations, or the like.

Multivalent cation tolerance problems typical of aqueous anionic surfactant systems are discussed in patents such as USP 3,508,612 and 3,675,716. Those patents suggested improving the multivalent cation tolerance by dissolving co-surfactant such as alkoxy-alcohol sulfates in the systems. USP 3,799,264 suggests using surfactant systems that contain sulfated aliphatic anionic surfactants, nonionic surfactants, and a water-soluble guanidine salt, in order to provide an improved tolerance to multivalent cations.

It is taught that improved aqueous anionic surfactant systems can be employed in displacing oil within remotely located permeable subterranean reservoirs in USP 3,945,437; 4,013,569; and 4,393,937. For example, it is taught in USP 4,393,937 that a steam foam drive process can be employed in displacing oil within a subterranean reservoir.

In view of the fact that high foaming, thermally stable, brine and divalent ion tolerant surfactants are desirable for use in displacing oil from subterranean reservoirs, it would be highly desirable to provide such surfactants.

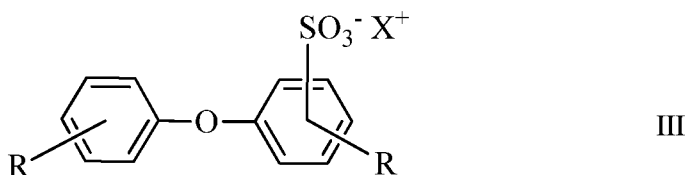
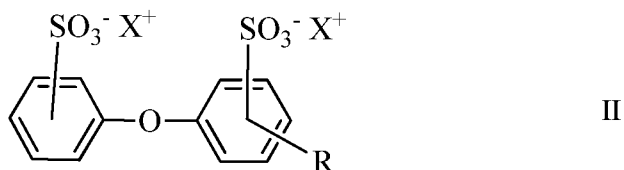
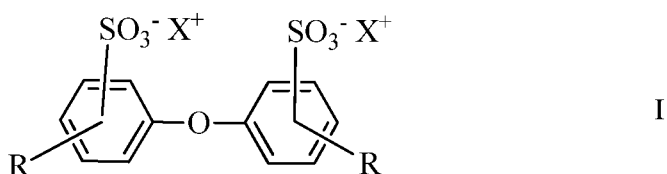
There is a continued need for an enhanced oil recovery technique that can be performed at elevated temperatures typically used in steam applications to further increase or maintain the recovery yields by chemical means, but not reduce the energy spent on recovery of heavy oils.

5

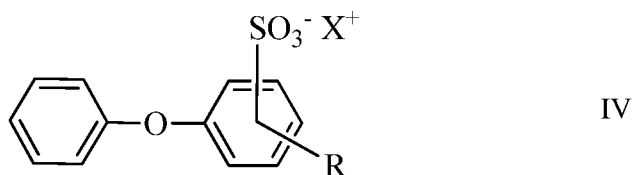
SUMMARY OF THE INVENTION

The present invention is a foam-forming composition and method of use in a steam assisted oil recovery process wherein the composition comprises an anionic surfactant wherein the anionic surfactant is a mixture of (di)alkyl diphenyloxide (di)sulfonate compounds having the formula:

10



15



where R is a C₃ to C₂₄ alkyl group, preferably a C₁₆ group and X is H, an alkali metal, divalent metal e.g., calcium, magnesium, and the like, alkaline earth metal, or ammonium, wherein the aqueous mixture of (di)alkyl diphenyloxide (di)sulfonate compounds has a pH equal to or greater than 7 and contains I, the dialkyl diphenyloxide disulfate (DADS), in an

20

amount equal to or greater than 50 weight percent with the remaining 50 weight percent or less comprising one or more of II, the monoalkyl diphenyloxide disulfate (MADS), III, the dialkyl diphenyloxide monosulfate (DAMS), and/or IV, the monoalkyl diphenyloxide monosulfate (MAMS), weight percent based on the combined weight of mixture of (di)alkyl
5 diphenyloxide (di) sulfonate compounds.

Another embodiment of the present invention is a method for recovering oil from a reservoir formation that is penetrated by at least one injection well and one production well, comprising: (a) selecting a foam-forming composition comprising an aqueous mixture comprising two or more (di)alkyl diphenyloxide (di)sulfonate disclosed herein above, (b)
10 injecting the foam-forming composition with steam into the injection well and forming a stable foam in the reservoir; (c) lowering a viscosity of oil in the reservoir formation; and (d) producing oil having the lowered viscosity from the reservoir formation.

In one embodiment of the present invention, in the foam-forming composition disclosed herein above R is a C₁₆ alkyl group and X is sodium.

15 In another embodiment of the present invention the foam-forming composition disclosed herein above further comprises one or more additive selected from a nonionic surfactant, an ionic surfactant, a corrosion inhibitor, a scale inhibitor, an antioxidant, a nonionic surfactant, an alcohol, another anionic surfactant, different from (i), a cationic surfactant, a foaming agent, and mixtures thereof.

20 In one embodiment of the method of the present invention described herein above, the injection well and the production well are the same well, preferably the method is cyclic steam stimulation (CSS).

In one embodiment of the method of the present invention described herein above, the injection well and the production well are not the same well, preferably the method is
25 steam assisted gravity drainage (SAGD).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic of the experimental apparatus used to determine foam
30 stability.

FIG. 2 is a plot showing foam height for Example 1 versus time.

DETAILED DESCRIPTION OF THE INVENTION

Described herein are methods for removal of heavy oils from underground reservoirs. The term "heavier crudes" is any source or form of viscous oil. For example, a source of heavier crudes includes tar sand. Tar sand, also referred to as oil sand or bituminous sand, is a combination of clay, sand, water, and bitumen. The thermal recovery of heavier crudes is based on the viscosity decrease of fluids with increasing temperature. Once the viscosity is reduced, the mobilization of fluids by steam, hot water flooding, or gravity is possible. The reduced viscosity makes the drainage quicker and therefore directly contributes to the recovery rate.

In one aspect, the method comprises recovering oil from a reservoir formation that is penetrated by at least one injection well and one production well comprising the steps of injecting into the reservoir (i) a foam-forming composition which comprises, consists essentially of, or consists of a mixture of (di)alkyl diphenyloxide (di)sulfonate compounds and steam, (ii) lowering a viscosity of oil in the reservoir formation, and (iii) removing the oil from the reservoir.

In one embodiment of the method of the present invention the injection well and the production well are the same well.

In another embodiment of the method of the present invention the injection well and the production well are not the same well, but are two different wells.

Steam techniques known in the art for removing heavier crudes can be used herein, including, but not limited to CSS, steam flood, SAGD, FA-SAGD, and VAPEX. In general, steam is injected into the underground reservoir thereby heating the oil, reducing its viscosity making it more mobile, and recovering at least a fraction of reservoir hydrocarbons. After the initial injection steam breakthrough, the probability of steam bypassing the oil increases, which limits the total amount of the formation that is effectively swept by the steam. Next, surfactants, with or without a non-condensable gas (e.g., nitrogen), and steam are introduced into the injection well either periodically or continuously. The oil may be recovered in a production well separate from the injection well.

The SAGD process, invented by Butler in the early 80's (e.g., USP 4,344,485) has been the most popular thermal recovery process used to date in the production of heavy oil and bitumen. In the SAGD process, at least two horizontal wells are drilled, one over the

other, and steam is injected into the upper well. The hot steam creates an expanding steam chamber, where the heat is transferred from the condensation of the steam mobilizes the oil, which then gravity drains around the edge of the steam chamber into the lower well along with any condensed water. The heat is transferred, by both conduction and convection, first
5 to the condensate that flows along the edge of the steam chamber, and then the adjacent oil. As the oil is removed and more steam is injected, the boundary of the steam chamber expands upwards and sideways, and new oil is mobilized. The advantage of the SAGD process is its high oil production rate, recovering as much as 60-70% of the oil in place.

In one embodiment of the present invention is a method of producing oil by SAGD,
10 said method comprising the steps of providing in an oil formation a horizontal injection well and a horizontal production well beneath said horizontal injection well, wherein said injection well and said production well are in fluid communication with each other; injecting steam and a foaming agent comprising an anionic surfactant, described herein below, into said injection well for a first period of time; collecting a production fluid from
15 said production well.

The method of the present invention is not limited to SAGD and other such gravity drainage methods. The method of the present invention can be used in any known or invented steam-based enhanced oil production methods. Thus, the method can be used with toe to heel steam production methods, steam flooding techniques using vertical wells, cyclic
20 steam stimulation (CSS), steam and gas push (SAGP), steam flooding, and the like, as well as in any of the hybrid methodologies, such as expanding solvent-SAGD (ES-SAGD), solvent aided process (SAP), and the like. Furthermore, the method can be used after any of the existing EOR methods.

The choice of water for use in the method of the present invention is typically the
25 produced water, e.g., from the reservoir, but the source may be different, based upon the requirements of the reservoir to be treated, economics, and compatibility of the composition upon dilution, for example fresh water, aquifer water, or reservoir brine produced from the well. This invention will find particular applicability with brines having a total dissolved solids (TDS) content of from 0 up to 18 weight percent, preferably with 0 up to 15, and
30 more preferably 0 up to 12 weight percent.

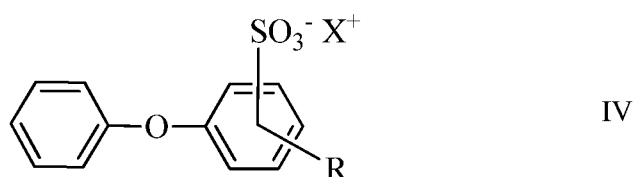
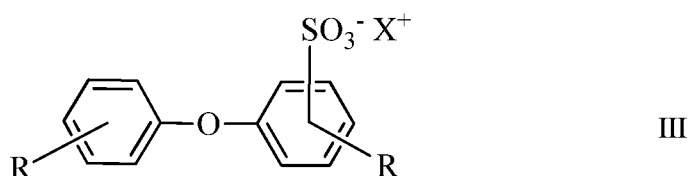
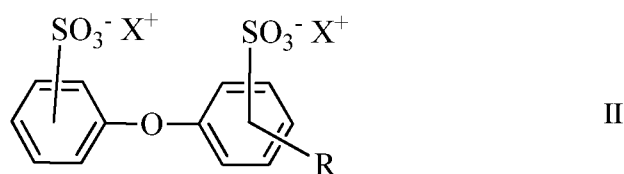
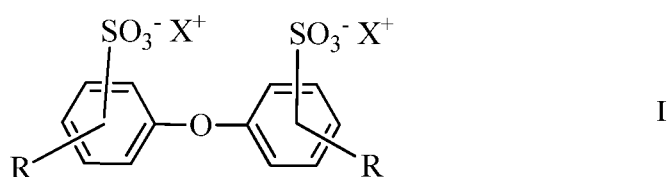
In another embodiment of the present invention, gases can be co-injected with the steam and surfactant. Suitable gases include, but are not limited to air, oxygen, hydrogen, nitrogen, methane, carbon dioxide, carbon monoxide, hydrogen sulfide, propane, butane,

natural gas, and flue gas. Gases may come in the form of a gas/liquid mixture; including natural gas liquids containing propane, butane, pentane, and hexane.

The foam-forming composition employed in the present invention comprises one or more anionic surfactant, preferably comprising a mixture of alkyl aryl-sulfonate

- 5 compounds. Suitable alkyl aryl-sulfonate compounds are products based on mono- and di-alkylated diphenyl oxide mono- and di-sulfonates (mono- and di-alkylates herein after referred to as (di)alkylates and mono- and di-sulfonates herein after referred to as (di)sulfonates). Preferred (di)alkyl diphenyloxide (di)sulfonate compounds are described by one or more of the following formulas:

10



15

where R is a C₃ to C₂₄ alkyl group, preferably a C₁₆ group and

X is H, an alkali metal, alkaline earth metal, divalent metal, preferably calcium or magnesium, or ammonium.

- 20 Structure I represents a dialkyl diphenyloxide disulfonate (DADS), Structure II represents a monoalkyl diphenyloxide disulfonate (MADS), Structure III represents a dialkyl diphenyloxide monosulfate (DAMS); and Structure IV represents a monoalkyl

diphenyloxide monosulfate (MAMS). Preferably the mixture of (di)alkyl diphenyloxide (di)sulfonate compounds contains DADS in an amount equal to or greater than 50 weight percent of DADS with the remaining 50 weight percent or less comprising one or more of MADS, DAMS, and/or MAMS, weight percent based on the combined weight of the mixture of (di)alkyl diphenyloxide (di)sulfonate compounds. More preferably the mixture of (di)alkyl diphenyloxide (di)sulfonate compounds contains DADS in an amount equal to or greater than 70 weight percent of DADS with the remaining 30 weight percent or less comprising one or more of MADS, DAMS, and/or MAMS, weight percent based on the combined weight of the mixture of (di)alkyl diphenyloxide (di)sulfonate compounds. Most preferably the mixture of (di)alkyl diphenyloxide (di)sulfonate compounds contains DADS in an amount equal to or greater than 85 weight percent of DADS with the remaining 15 weight percent or less comprising one or more of MADS, DAMS, and/or MAMS, weight percent based on the combined weight of the mixture of (di)alkyl diphenyloxide (di)sulfonate compounds.

In one embodiment, the mixture of (di)alkyl diphenyloxide (di)sulfonate compounds comprise MADS in an amount of 0.05 to 15 weight percent, DAMS in an amount of 0 to 10 weight percent, MAMS in an amount of 0 to 5 weight percent, and DADS in an amount of equal to or greater than 50 to 90 weight percent, wherein higher alkylates of mono- and di-sulfonates makes up the balance of the mixture.

In another embodiment, the mixture of (di)alkyl diphenyloxide (di)sulfonate compounds comprise MADS in an amount of 0.05 to 15 weight percent, DAMS in an amount of 0 to 7.5 weight percent, and MAMS in an amount of 0 to 2 weight percent, wherein DADS makes up the balance of the mixture with the proviso that it is present in an amount equal to or greater than 50 weight percent, weight percent based on the combined weight of the mixture of (di)alkyl diphenyloxide (di)sulfonate compounds.

Suitable (di)alkyl diphenyloxide (di)sulfonates of the present invention can be prepared by methods recognized in the art. For example, attention is directed towards USP 4,860,828 to Oswald et al. which is incorporated herein by reference.

The mixture of (di)alkyl diphenyloxide (di)sulfonate compounds may be added neat or preferably in solution, preferably an aqueous solution having a pH equal to or greater than 7, more preferably equal to or greater than 7.5, more preferably equal to or greater than 8, and more preferably equal to or greater than 8.5.

The (di)alkyl diphenyloxide (di)sulfonate compounds are added down hole and/or to the steam neat and/or diluted with water to form an aqueous solution and then added, such that the amount of the (di)alkyl diphenyloxide (di)sulfonate compounds in the steam present down-hole is from 0.0001 to 0.5 weight percent. Preferably, the amount of anionic
5 surfactant in the down-hole water is equal to or greater than 0.0001 weight percent, more preferably equal to or greater than 0.001 weight percent, more preferably equal to or greater than 0.01 weight percent, more preferably equal to or greater than 0.05 weight percent, and even more preferably equal to or greater than 0.08 weight percent. Generally, the amount of the anionic surfactant is present in the water pumped down-hole in an amount equal to or
10 less than 0.5 weight percent, preferably equal to or less than 0.3 weight percent, preferably equal to or less than 0.2 weight percent.

In some embodiments, foam-forming compositions of the present invention may include other additives. For example, the composition may further include one or more ionic surfactant, one or more nonionic surfactant, one or more alcohol, corrosion inhibitors,
15 scale inhibitors, mixtures thereof, as well as other additives. In some embodiments, the total amount of the additives added to the compositions of the present disclosure is not greater than about 5 weight percent.

EXAMPLES

20

Preparation of (di)alkyl diphenyloxide (di)sulfonate compound.

Example 1 is a (di)alkyl diphenyloxide (di)sulfonate compound prepared in three steps: (a) alkylation of diphenyl oxide (DPO), (b) sulfonation of the alkylated product, and (c) neutralization using caustic solution.

25

Alkylation of DPO with olefin of specific chain length is done in the presence of aluminum chloride catalyst between 50°C to 100°C. The Friedel-Crafts alkylation reaction generates isomeric mixture of mono-, di-, and higher poly-alkylates from competitive reactions of olefins around the aromatic rings. Alkylation is carried out in presence of excess DPO to control relative amounts of monoalkylated DPO, dialkylated DPO, and
30 higher alkylate DPOs.

Sodium hydroxide solution is then added to the reaction mixture to neutralize the aluminum chloride catalyst. This is followed by phase separation of the mixture by using a decanter. The crude product is then subjected to distillation to separate out the unreacted

DPO, the unreacted olefins, and the final alkylated product. The alkylated end product is then distilled further to concentrate dialkylated and higher alkylated DPOs to greater than 50%.

5 The distilled alkylated product is then subjected to sulfonation by sulfur trioxide, which results in primarily the disulfonated products. The level of sulfonation is greater than 80%. While the sulfonation reaction is highly exothermic, the reaction is kept under isothermal conditions at or below room temp. Following sulfonation, water is added to remove any unreacted SO₃. The aqueous acid solution is then neutralized using caustic soda to get a final product with pH of equal to or greater than 7.

10 The resulting active product comprises 1 wt% monoalkyl diphenyloxide monosulfate (MAMS), 10 wt% monoalkyl diphenyloxide disulfate (MADS), 7. wt % dialkyl diphenyloxide monosulfate (DAMS), 75 wt % dialkyl diphenyloxide disulfate (DADS), and the rest being higher alkylates of mono- and di-sulfonates.

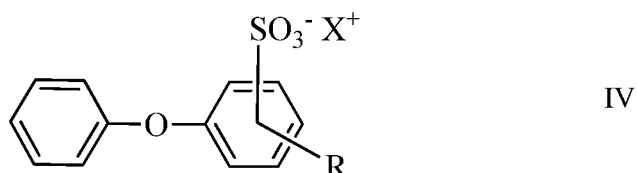
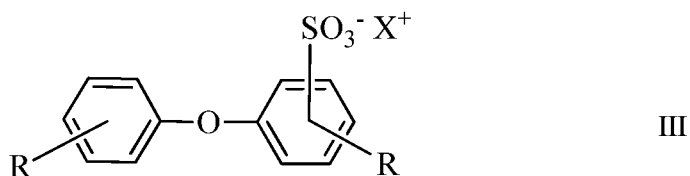
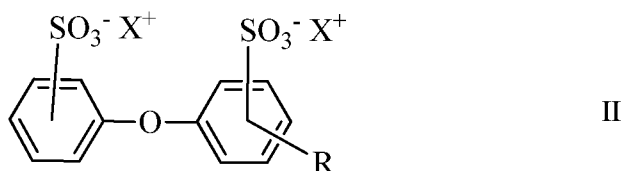
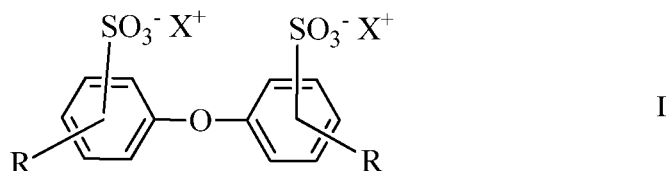
15 **Foam Stability Test.**

The experimental set up is shown in **FIG. 1**. Initially, an empty JERGUSON19-T-32 series level gauge **1** is pressurized to 950 psi. The oven **2** is then heated up to 250°C. The pressure is maintained to 950 psi via the back pressure regulator (EQUILIBAR ULF-2) **3** at the exit line of the JERGUSON level gauge. 50 mL of a 0.5 wt% aqueous solution of Example 1 is prepared and its pH adjusted to 9.1 with a sodium hydroxide solution. 50 mL of this solution **4** is loaded into the JERGUSON level gauge via pump **2 5**. The system is allowed to equilibrate to 250°C for an hour. An accumulator (TOBUL 030AT30-1VA19) **6** is used to pump in nitrogen into this solution through a sparger having a 10 micron sintered metal filter element **7**. Water is pumped into the accumulator at 2.7855 mL/min from pump **1 8** to achieve a flow rate of 180 sccm into the JERGUSON level. Pressure is maintained at 950 psi with the back pressure regulator. 0.2 mL/min of water is replenished through pump **2 5** since the system loses water at approximately this rate due to evaporation. As nitrogen flows into the chemical solution, foam **9** starts to rise up inside the glass cylinder **10** in the JERGUSON level gauge. The cylinder is open at top and bottom. Once the foam reaches the top of the level gauge, the nitrogen flow is stopped. The foam slowly decays. The foam height from the foam generation to collapse is recorded and is shown in **FIG. 2**.

What is claimed is:

1. A foam-forming composition for use in an oil recovery process comprising an aqueous mixture comprising

(i) two or more (di)alkyl diphenyloxide (di)sulfonate compounds having the formulas:



where R is a C₃ to C₂₄ alkyl group

and

X is H, an alkali metal, alkaline earth metal, a divalent metal, or ammonium,

wherein the aqueous mixture of (di)alkyl diphenyloxide (di)sulfonate compounds has a pH equal to or greater than 7 and contains I, the dialkyl diphenyloxide disulfate (DADS), in an amount equal to or greater than 50 weight percent with the remaining 50 weight percent or less comprising one or more of II, the monoalkyl diphenyloxide disulfate (MADS), III, the dialkyl diphenyloxide monosulfate (DAMS), and/or IV, the monoalkyl diphenyloxide monosulfate (MAMS), weight

percent based on the combined weight of the mixture of (di) alkyl diphenyloxide
(di)sulfonate compounds.

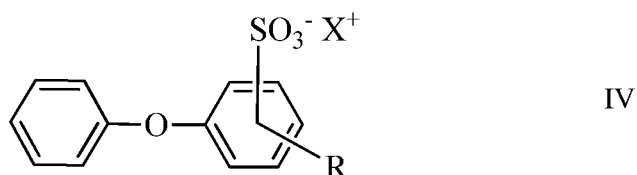
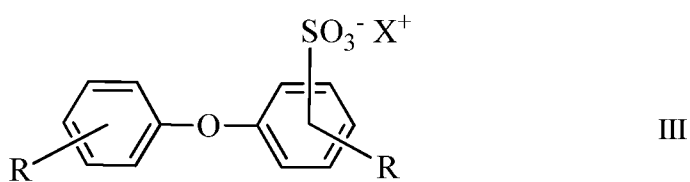
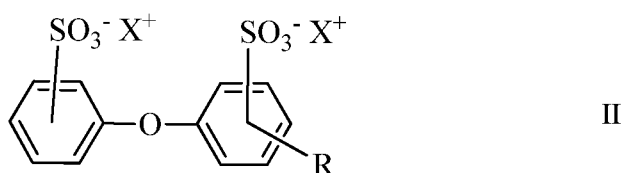
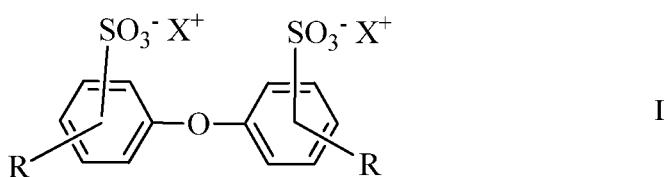
2. The foam-forming composition of Claim 1 wherein R is a C₁₆ alkyl group and X is sodium, calcium, or magnesium.

5 3. The foam-forming composition of Claim 1 further comprises one or more additive selected from a nonionic surfactant, an ionic surfactant, a corrosion inhibitor, a scale inhibitor, an antioxidant, a nonionic surfactant, an alcohol, another anionic surfactant, different from (i), a cationic surfactant, a foaming agent, and mixtures thereof.

10 4. A method for recovering oil from a reservoir formation that is penetrated by at least one injection well and one production well, comprising

(a) selecting a foam-forming composition comprising

(i) an aqueous mixture comprising two or more (di)alkyl diphenyloxide (di)sulfonate compounds having the formulas:



20

where R is a C₃ to C₂₄ alkyl group

and

X is H, an alkali metal, alkaline earth metal, a divalent metal, or ammonium, wherein the aqueous mixture of (di)alkyl diphenyloxide (di)sulfonate compounds has a pH equal to or greater than 7 and contains I, the dialkyl diphenyloxide disulfate (DADS), in an amount equal to or greater than 50 weight percent with the remaining 50 weight percent or less comprising one or more of II, the monoalkyl diphenyloxide disulfate (MADS), III, the dialkyl diphenyloxide monosulfate (DAMS), and/or IV, the monoalkyl diphenyloxide monosulfate (MAMS), weight percent based on the combined weight of the mixture of (di) alkyl diphenyloxide (di)sulfonate compounds;

(b) injecting the foam-forming composition with steam into the injection well and forming a stable foam in the reservoir;

(c) lowering a viscosity of oil in the reservoir formation;

and

(d) producing oil having the lowered viscosity from the reservoir formation.

5. The method of Claim 4 wherein R is a C₁₆ alkyl group and X is sodium, calcium, or magnesium.

6. The method of Claim 4, where the a foam-forming composition further comprises one or more additive selected from a corrosion inhibitor, a scale inhibitor, an antioxidant, a nonionic surfactant, another anionic surfactant, different from (i), a cationic surfactant, a foaming agent, and mixtures thereof.

7. The method of Claim 4 where in the injection well and the production well are the same well.

8. The method of Claim 7 is cyclic steam stimulation (CSS).

9. The method of Claim 4 where in the injection well and the production well are not the same well.

10. The method of Claim 9 is steam assisted gravity drainage (SAGD).

FIG. 1

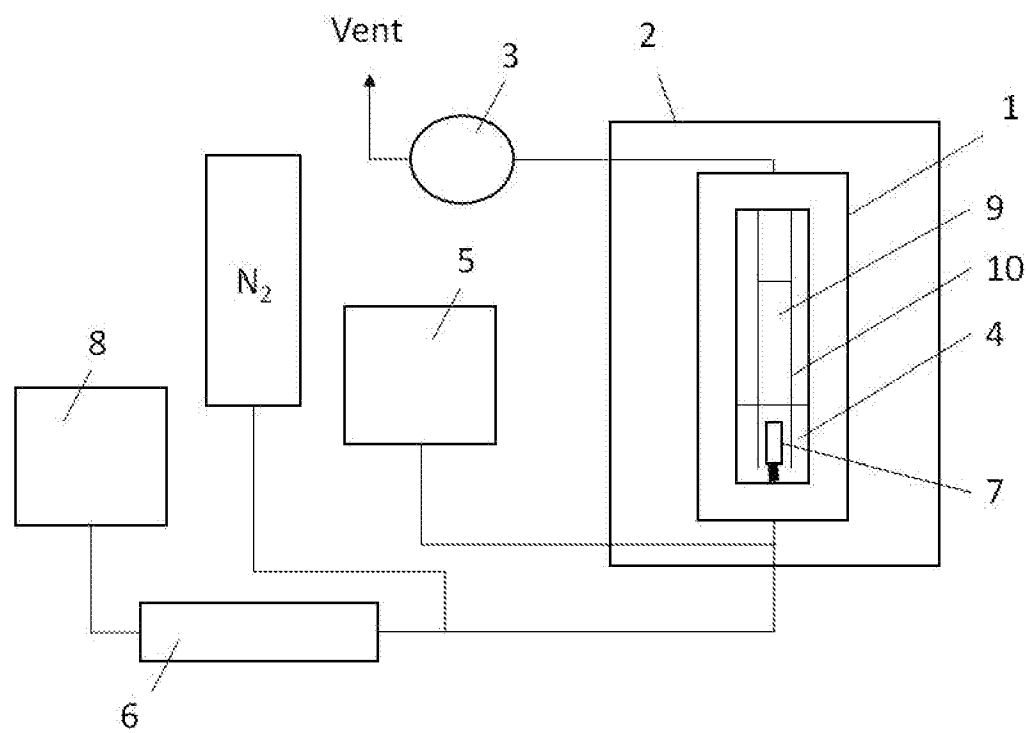
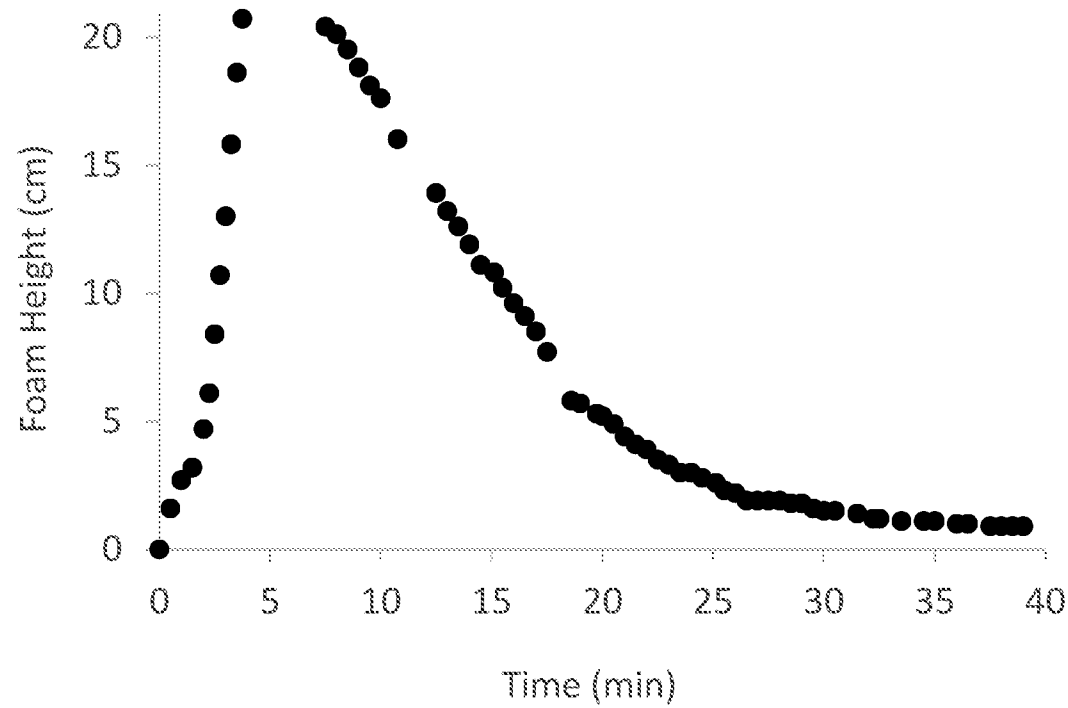


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No

PCT/US2017/041391

A. CLASSIFICATION OF SUBJECT MATTER
 INV. C09K8/584 C09K8/592 C09K8/594
 ADD.

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)
 C09K

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 743 764 B1 (WALLICK DAVID E [US] ET AL) 1 June 2004 (2004-06-01) claims column 3, line 31 - column 4, line 11 -----	1-3
X	WO 01/08793 A1 (DOW CHEM CO) 8 February 2001 (2001-02-08) claims page 6 -----	1-3
X	US 5 203 411 A (DAWE ROBERT D [US] ET AL) 20 April 1993 (1993-04-20) claims -----	4-10
A	WO 97/10320 A1 (CLOROX CO [US]) 20 March 1997 (1997-03-20) page 20 - page 21; table II claims ----- -/-	1-10



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

"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

14 September 2017

Date of mailing of the international search report

22/09/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Zimpfer, Emmanuel

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/041391

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009/078414 A1 (HORVATH SZABO GEZA [CA] ET AL) 26 March 2009 (2009-03-26) cited in the application the whole document -----	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/041391

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6743764	B1	01-06-2004	NONE
WO 0108793	A1	08-02-2001	CA 2379347 A1 08-02-2001 CN 1365299 A 21-08-2002 EP 1204465 A1 15-05-2002 JP 2003505520 A 12-02-2003 MX PA02001105 A 20-08-2002 TW 524716 B 21-03-2003 WO 0108793 A1 08-02-2001
US 5203411	A	20-04-1993	CA 2091417 A1 12-09-1993 US 5203411 A 20-04-1993
WO 9710320	A1	20-03-1997	AR 003545 A1 05-08-1998 BR 9610232 A 29-06-1999 CA 2226519 A1 20-03-1997 CN 1196080 A 14-10-1998 EP 0865479 A1 23-09-1998 PL 325469 A1 20-07-1998 TR 9800434 T1 22-06-1998 US 5728665 A 17-03-1998 WO 9710320 A1 20-03-1997 ZA 9607624 B 10-06-1997
US 2009078414	A1	26-03-2009	US 2009078414 A1 26-03-2009 US 2009159288 A1 25-06-2009 WO 2009042284 A1 02-04-2009