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

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(54) Title: IMPROVED LACTAM SOLUBILITY

(57) Abstract: Compositions comprising lactams and non-ionic surfactants, suitable for use as antimicrobial, anti-biofilm and bacteriostatic compositions.

IMPROVED LACTAM SOLUBILITY

This application claims priority from EP 15181858.0 filed 20 August 2015 which is herein incorporated by reference for all purposes.

The present invention relates to compositions comprising lactams and non-ionic surfactants. The compositions are suitable for use as, for example, antimicrobial anti-biofilm and bacteriostatic compositions.

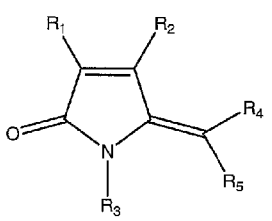
WO 2007/085042 and WO 2004/016588 disclose lactams for antimicrobial benefit and steps towards their synthesis. WO2014/118240 discloses antimicrobial compositions comprising a lactam and a hydrotope.

However, use of these lactams is limited by compatibility with certain formulations and, in particular, solubility in certain aqueous solutions.

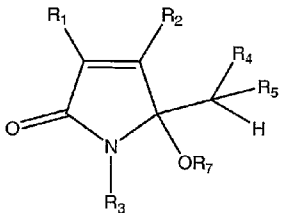
The present invention relates to compositions comprising lactams and non-ionic surfactants. The inventor(s) have found that, surprisingly, the presence of a non-ionic surfactant advantageously improves lactam solubility.

More specifically, the present invention relates to compositions comprising lactams as described in WO 2007/085042 and WO 2004/016588, the contents of which, and in particular the lactam structures explicitly drawn out therein, are incorporated by reference. The compositions further comprise a non-ionic surfactant.

For example, in a first aspect, the present invention relates to a compositions comprising a lactam and a non-ionic surfactant, wherein the lactam is a lactam of formula (I) or (II):



(I)



or (II)

wherein:

R_1 and R_2 are each independently selected from hydrogen, halogen, alkyl, cycloalkyl, alkoxy, oxoalkyl, alkenyl, heterocyclyl, heteroaryl, aryl and aralalkyl; and

R_3 is selected from hydrogen, hydroxyl, alkyl, cycloalkyl, alkoxy, oxoalkyl, alkenyl, heterocyclyl, heteroaryl, cycloalkyl, aryl, aralalkyl and $–C(O)CR_6=CH2$;
R_4 and R_5 are independently selected from hydrogen, aryl, heterocyclyl, heteroaryl, and arylalkyl; and

R_6 is selected from hydrogen and methyl; and

R_7 is selected from hydrogen and $–C(O)CR_6=CH_2$; and

Preferably, at least one of R_4 and R_5 is hydrogen.

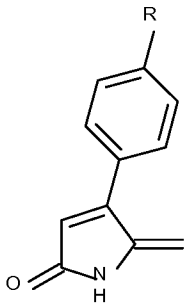
It will be appreciated that, where appropriate groups may be optionally substituted. Optional substituents may include halogens, C_{1-4}alkyl, C_{1-4}haloalkyl (for example, CF_3) and C_{1-4}alkoxy.

Alkyls may, for example, be C_{1-12}alkyls, such as C_{1-6}alkyls. Aryls may, for example, be C_{6-10}aryls, for example, phenyls.

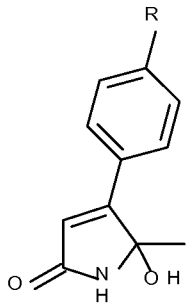
Preferably, at least one of R_1 and R_2 is selected from heterocyclyl, heteroaryl, aryl and arylalkyl.

Preferably, R_1 is hydrogen. Preferably, R_3 is hydrogen. Preferably, R_4 is hydrogen. Preferably, R_5 is hydrogen. Preferably, R_6 is hydrogen. Preferably, R_7 is hydrogen. Preferably, R_2 is aryl or aralalkyl. More preferably, R_2 is a phenyl group or a substituted phenyl group, for example, a mono-substituted phenyl group. Substitution may be *ortho*, *meta*, or *para*. Preferably, it is *para.* Preferred substituents include halogen and methyl. For example, and without limitation, R_2 may be selected from phenyl, 4-fluorophenyl, 4-chlorophenyl, 4-bromophenyl and 4-methylphenyl.

Accordingly, in a first aspect, the present invention may provide a composition comprising a lactam and a non-ionic surfactant, wherein the lactam is a lactam of Formula Ia or Formula IIa:



Ia

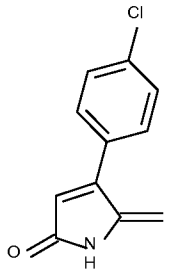


IIa

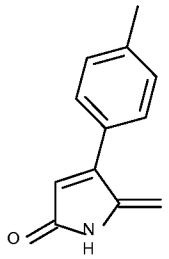
wherein R is H, halogen (preferably, F, Cl, or Br), or C_{1-4}alkyl (preferably methyl).

In some embodiments, the lactam is a lactam of formula Ia. In some embodiments, the lactam is a lactam of formula IIa.

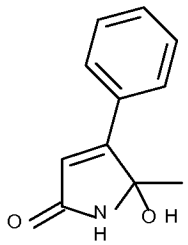
Preferred lactams may include:



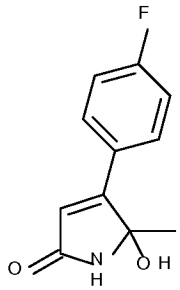
; 4-(4-chlorophenyl)-5-methylene-pyrrol-2-one (Ref. 488);



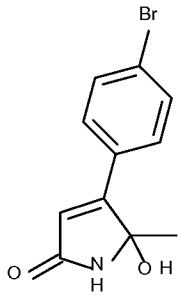
; 5-methylene-4-(p-tolyl)pyrrol-2-one (Ref. 491)



; 4-phenyl-5-hydroxy-5-methyl-1H-pyrrol-2-one (Ref. 131)



; 4-(4-fluorophenyl)-5-hydroxy-5-methyl-1H-pyrrol-2-one (Ref. 258)



; 4-(4-bromophenyl)-5-hydroxy-5-methyl-1H-pyrrol-2-one (Ref. 316).

The composition may be, without limitation, any of a personal care composition, a homecare composition, a pharmaceutical composition, or an industrial composition such as an anti-biofilm coating or paint, for example, for use in maritime environments. The composition may also be an agricultural chemical. The compositions may be suitable for use as antimicrobial, anti-biofilm and bacteriostatic compositions. Non-limiting examples

of such compositions are provided herein. The compositions may also be used as additive compositions; in other words, the composition may be combined with further ingredients such as excipients to form a composition as described above.

Suitably, the composition is an aqueous composition. It may be a non-aqueous composition.

Preferably the composition contains 0.000001 to 50% wt. lactam, more preferably 0.001 to 50% wt. even more preferably 0.01 to 5% wt, most preferably 0.01 to 2%.

In some cases, the non-ionic surfactant may be a polysorbate (in other words, a PEG-ylalated sorbitan esterified with a fatty acid. Polysorbates are commercially available and often called polysorbate XX or Tween® XX, wherein XX denotes the total number of PEG units.

Suitable polysorbates may include polysorbate 20 (polyoxyethylene (20) sorbitan monolaurate), polysorbate 40 (polyoxyethylene (20) sorbitan monopalmitate), polysorbate 60 (polyoxyethylene (20) sorbitan monostearate), polysorbate 80 (polyoxyethylene (20) sorbitan monooleate). Preferred non-ionic surfactants may include Tween® 20.

In some cases, the no-ionic surfactant may be a fatty acid alkoxylates, for example an ethoxylate. The fatty acid alkoxylate may have a C_{8-35} alkyl or alkenyl chain, preferably a C_{10-18} alkyl or alkenyl chain, most preferably a C_{10-18} alkyl chain such as a C_{10-12} alkyl chain or a C_{12-15} alkyl chain. It will be appreciated that alkyl and alkenyl chains may be branched or straight chain. The fatty acid ethoxylate may have, for example, from 3 to 25, more preferably 5 to 15 ethylene oxide groups, for example, Neodol® surfactants. A preferred surfactant is a C_{12-15} alcohol ethoxylate having 7 ethylene oxide groups. This may be referred to as Neodol® 25-7.

In other words, the non-ionic surfactant may be a fatty acid ethoxylate of formula (II):

$$Alk\text{-}(OCH_2)_pOH \quad (II)$$

wherein p is 3 to 25, preferably 5 to 15, more preferably 5 to 10, most preferably 7; and Alk is a C_{8-35} alkyl or alkenyl chain, preferably a C_{10-15} alkyl chain, for example a C_{10-15} alkyl chain, for example a C_{12-15} alkyl chain.

The composition may comprise up to 20% wt. non-ionic surfactant, for example up to 15 % wt. Suitably, the amount of non-ionic surfactant is up to 10% wt. of the composition. For example, the composition may comprise 0.01 to 10% wt. surfactant, such as 0.1 to 10% wt, optionally 1 to 10%wt. In some cases, the amount of non-ionic surfactant may be up to 9 % wt., 8% wt., 7 % wt., 6 % wt., 5 % wt, 4 % wt., 3% wt. or even up to 2 % wt. As demonstrated herein, very small amount of surfactant may be used and still provide enhanced solubility. For example, the amount may be less than 2 % wt, for example less than 1.5 % wt., less than 1 % wt. and in some cases as low as 0.5 % wt.

The ratio of lactam to non-ionic surfactant may, for example, be from 1 : 0.5 to 1 : 20, preferably from 1 : 0.5 to 1 : 10, such as from 1 : 0.5 to 1 : 5.

DESCRIPTION

Lactams may be obtained using methods as described in WO 2007/085042 and WO 2004/016588, which are herein incorporated by reference in their entirety.

Non-ionic surfactant

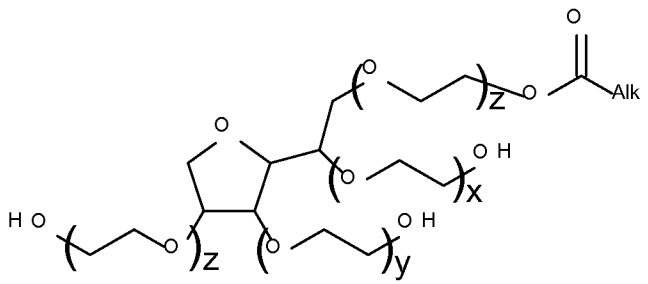
For the purposes of this disclosure, 'non-ionic surfactant' shall be defined as amphiphilic molecules with a molecular weight of less than about 10,000, unless otherwise noted, which are substantially free of any functional groups that exhibit a net charge at the normal wash pH of 6-11.

Any type of non-ionic surfactant may be used, although preferred materials are further discussed below. Highly preferred are fatty acid alkoxylates, especially ethoxylates, having a C_{8-35} alkyl or alkenyl chain, preferably a C_{8-30} alkyl or alkenyl chain, more preferably a C_{10-24} alkyl or alkenyl chain chain, especially a C_{10-18} alkyl or alkenyl chain, alkyl groups may be preferred, and having preferably 3 to 25, more preferred 5 to 15 ethylene oxide groups, for example, Neodol® surfactants, available from Shell® (The Hague, The Netherlands); ethylene oxide/propylene oxide block polymers which may

have molecular weight from 1,000 to 30,000, for example, Pluronic® from BASF (Ludwigshafen, Germany); and alkylphenol ethoxylates, for example Triton X-100®, available from Dow Chemical® (Midland, Mich., USA).

Other non-ionic surfactants may be preferred. These include condensates of alkanolamines with fatty acids, such as cocamide DEA, polyol-fatty acid esters, such as the Span series available from Uniqema® (Gouda, The Netherlands), ethoxylated polyol-fatty acid esters, such as the Tween® series available from Uniqema (Gouda, The Netherlands), alkylpolyglucosides, such as the APG line available from Cognis® (Düsseldorf, Germany) and n-alkylpyrrolidones, such as the Surfadone® series of products marketed by ISP (Wayne, N.J., USA).

For example, the non-ionic surfactant may be a non-ionic surfactant of comprising an esterified sorbitan, such as a non-ionic surfactant of formula (III):



(III)

wherein w + x + y + z is 0 to 20, and n is alkyl or alkenyl. For example w + x + y + z may be 0, as in the Span series available from Uniqema®; and Alk may be C_{8-35}, for example, C_{10-24}, especially C_{10-18}. For example, in Span monopalmitate, Alk is C_{15} alkyl, while in Span 20, Alk is C_{11} alkyl.

For example, w + x + y + z may be 20, as in the Tween® series, also referred to polysorbates. Suitable polysorbates may include polysorbate 20 (polyoxyethylene (20) sorbitan monolaurate), polysorbate 40 (polyoxyethylene (20) sorbitan monopalmitate), polysorbate 60 (polyoxyethylene (20) sorbitan monostearate), polysorbate 80 (polyoxyethylene (20) sorbitan monooleate).

The non-ionic surfactant may be an alkyl polysaccharide, for example of formula IV:

$RO(C_nH_{2n}O)_t$ (glycosyl)$_x$ (IV)

wherein R is selected from the group consisting of alkyl, alkylphenyl, hydroxyalkyl, hydroxyalkylphenyl, and mixtures thereof in which alkyl groups contain from about 10 to about 18, preferably from about 12 to about 14, carbon atoms; n is 0 to 3, preferably 2; t is from 0 to about 10, preferably 0; and x is from 1.3 to about 10, preferably from 1.3 to about 2.7. The glycosyl is preferably derived from glucose. To prepare these compounds, the alcohol or alkylpolyethoxy alcohol is formed first and then reacted with glucose, or a source of glucose, to form the glucoside (attachment at the 1-position). The additional glycosyl units can then be attached between their 1-position and the preceding glycosyl unit's 2-, 3-, 4- and/or 6-position, preferably predominantly the 2-position.

Furthermore, non-ionic surfactants not specifically mentioned above, but within the definition, may also be used.

Of course, it will be appreciated that more than one non-ionic surfactant may be used; in other words, the compositions may comprise more than one non-ionic surfactant as described herein. In this case, the amounts of non-ionic surfactant disclosed herein refer to the total amount of non-ionic surfactant.

Compositions

The compositions described herein may be compositions having anti-microbial activity. In some cases, the compositions are anti-bacterial. They may have bactericidal and / or bacteriostatic activity. The inventor(s) have observed desirable bacteriostatic activity. Accordingly, in some cases, the composition is a bacteriostatic composition.

The compositions may also prevent and / or inhibit biofilm formation. Biofilms are formed when microorganisms stick to a surface. Biofilm extracellular polymeric substances may be formed. Biofilms (also referred to as slime) present problems in industrial environments; for example, they may form in pipes in apparatus, or industrial and agricultural structures, on solar panels, and on boat hulls and other marine structures. Biofilms may also pose a problem in domestic environments. For example, biofilms may

form in domestic appliances such as washing machines. Biofilms are also present in personal care, for example, they may form on tooth surfaces.

Compositions suitable for any and all of these applications are within the scope of the invention. In some cases, the composition is a paint or other coating. In such cases, the composition may further comprise a binder, optionally a pigment and optionally one or more conventional additives (for example, to modify surface tension, improve flow properties, improve the finished appearance, increase wet edge, improve pigment stability, etc – such additives are known in the art). The composition may comprise an aqueous solvent or an organic solvent to suit purpose.

The composition may also be used in medical applications, for example to coat equipment including medical devices.

In some cases, the composition is a pharmaceutical composition. In other words, the composition may comprise a lactam as described herein and a pharmaceutically acceptable excipient. The composition may be suitable for topical use (for example, it may be a cream or lotion), it may be suitable for ocular use (for example, it may be an used as a pharmaceutical eye drop), it may be suitable for otic use (for example, it may be used as an ear drop), it may be suitable as a mouth wash, or it may be suitable for oral administration.

In some cases, the composition is a composition suitable for use in the home (often referred to as a homecare composition) or institutions. Homecare compositions include, without limitation, cleaning products, laundry detergents, and fabric conditioners. In some cases, the composition is a homecare composition, for example a laundry liquid. The composition may therefore comprise a detergent surfactant and a builder. The composition may be a fabric conditioner (also called a fabric softener) and may comprise an antistatic agent. The composition may also be a domestic cleaning product.

In some cases, the composition is a personal care composition. For example, the composition may be intended for use on the skin (for example, a cream, cleanser or serum). For example, the composition may be useful in the prevention or treatment of

acne. For example, the composition may comprise one or more of dimethicone, petrolatum, a humectant such as hyaluronic acid or glycerin; and ceramide(s). In some cases, the composition is a personal care composition comprising a detergent, for example, the composition may be a face wash or shower gel or hair shampoo. The composition may be a hair treatment composition other than a shampoo. The composition may be a deodorant composition (for example, a deodorant powder, paste or liquid). The composition may be an oral care composition (such as a toothpaste or mouthwash and may include, for example, fluoride and / or flavourings.

In some cases, the composition is a contact lens cleaning fluid.

The composition may be a composition suitable for use in agriculture, for example, as a soil additive (solid or liquid).

The composition may be a composition suitable for use in the treatment of or manufacture of glass or lens for example as an additive / treatment for solar panels.

EXAMPLES

Screening of NIS

The following representative example uses 4-(4-chlorophenyl)-5-methylene-pyrrol-2-one.

Excess solid lactam (~3 mg) was placed in a Whatman® Mini Uniprep sample vial, fitted with a 0.45um nylon filter. Water or water + additive (NIS) (500 µL) was added the mixture shaken and tapped briefly to initially disperse the solid and the mixture then agitated for 48 hours using a plate shaker fitted with a vial holder. After 48 hours, the solid was removed from the system by pressing down the plunger with integral filter on the vial. This removes the solid and provides filtered solution within the inner chamber which is then ready for analysis.

The level of lactam dissolved in solution was quantified using HPLC analysis. Samples were analysed on an Agilent 1200® series HPLC fitted with a Thermo Hypersil Gold® C18 column (15 x 2.1 x 3 µm), isocratic elution with 60/40 methanol/water (+0.1% Formic

Acid), 0.4 mL/min flow rate, using a DAD detector at 285 nm. The lactam tested has a retention time of ~2.8 minutes.

For each additive, the absolute level of lactam in solution was measured and reported as an increase in solubility of lactam relative to water alone.

Each test surfactant solution was tested in triplicate and the mean value of lactam in solution calculated. Values of solubility were quoted as the improvement in aqueous solubility vs water alone (i.e. mean level of lactam dissolved in water + solvent / mean level of lactam dissolved in water) to allow comparison between screens conducted on different days.

Additive	% Additive in Water	Mean Lactam Level in Solution (ppm)	Solubility Increase vs water alone
Neodol 25-7	0	2.4	1.0
	0.5	116.0	48.3
	1	203.2	84.7
	2	390.4	162.7
	5	603.3	251.4
	10	612.5	255.2
	20	455.6	189.8
Tween 20	0	1.7	1.0
	0.5	61.6	36.9
	1	118.3	70.9
	2	226.5	135.8
	5	518.3	310.7
	10	829.6	497.3
	20	1546.3	927.0
Tween 80	0	6.0	1.00
	0.5	41.5	6.92
	1	75.0	12.51
	2	123.3	20.56
	5	208.4	34.74
	10	391.4	65.23
	0.5	50.5	18.9
	1	104.9	39.1
	2	170.7	63.7
	5	432.4	161.3
	10	942.3	351.6

	20	1490.8	556.3
	0.1	15.2	5.7
	0.5	42.6	15.9
	1	77.5	28.9
	2	139.6	52.1

The inventor(s) have demonstrated that non-ionic surfactants are beneficial at increasing lactam solubility in water, in particular at lower concentrations. The best examples are Tween® 20 and Neodol® 25-7.

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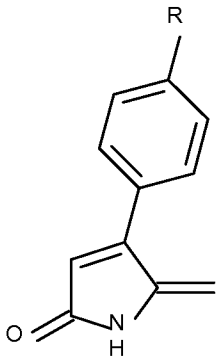
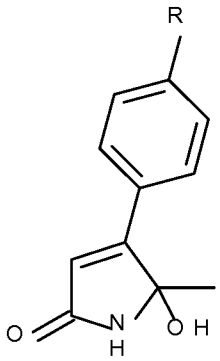
It will be appreciated that, except where expressly provided otherwise, all preferences are combinable.

CLAIMS

1. A composition comprising a lactam and a non-ionic surfactant, wherein the lactam is a lactam of Formula Ia or Formula IIa:



Ia

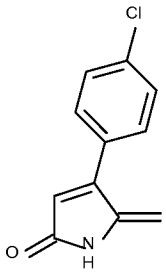


IIa

wherein R is H, halogen, or C_{1-4}alkyl.

2. The composition of claim 1, wherein R is H, F, Cl, Br, or Me.

3. The composition of any preceding claim, wherein the lactam is selected from:



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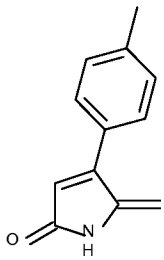
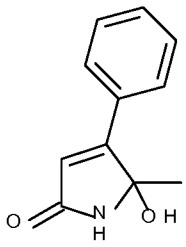
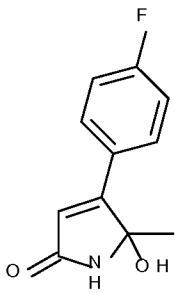


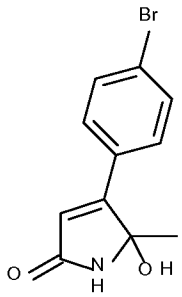
(Ref. 491);



(Ref. 131);



(Ref. 258);



(Ref. 316).

4. The composition of any preceding claim, wherein the non-ionic surfactant is a polysorbate, optionally wherein the polysorbate is Tween® 20.

5. The composition of any one of claims 1 to 3, wherein the non-ionic surfactant is a fatty acid alkoxylate, optionally wherein the non-ionic surfactant has a structure of formula (II):

$$Alk\text{-}(OCH_2)_pOH \quad (II)$$

wherein Alk is a $C_{8\text{-}35}$ alkyl or alkenyl chain and p is 3 to 25.

6. The composition of claim 5, wherein the non-ionic surfactant is a $C_{12\text{-}15}$ alcohol ethoxylate having 7 ethylene oxide groups; optionally wherein the non-ionic surfactant is Neodol®25-7.

7. The composition of any preceding claim, wherein the composition comprises up to 20% wt. non-ionic surfactant, optionally wherein the composition comprises less than 2 % wt. non-ionic surfactant.

8. The composition of any one of claims 1 to 6, wherein the ratio of lactam to non-ionic surfactant is from 1 : 0.5 to 1 : 20.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/068010

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61K8/49 A61Q17/00 A01N33/00
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)
A61K A61Q

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, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/085042 A1 (BIOSIGNAL LTD [AU]; KUMAR NARESH [AU]; ISKANDER GEORGE [AU]) 2 August 2007 (2007-08-02) cited in the application the whole document	1-8
X	WO 2014/118240 A1 (UNILEVER PLC [GB]; UNILEVER NV [NL]; CONOPCO INC DBA UNILEVER [US]) 7 August 2014 (2014-08-07) the whole document	1-8

☐ 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	Date of mailing of the international search report
30 August 2016	12/09/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Mitchell, Gemma

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/068010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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