

2-AMINOPYRIMIDINE DERIVATIVES FOR THE TREATMENT OF VIRAL INFECTIONS

5 This invention relates to 2-aminopyrimidine derivatives, processes for their preparation, pharmaceutical compositions, and their use in treating viral infections.

10 The present invention relates to the use of 2-aminopyrimidine derivatives in the treatment of viral infections, immune or inflammatory disorders, whereby the modulation, or agonism, of toll-like-receptors (TLRs) is involved. Toll-Like Receptors are primary transmembrane proteins characterized by an extracellular leucine rich domain and a cytoplasmic extension that contains a conserved region. The innate immune system can recognize pathogen-associated molecular patterns via these TLRs expressed on the cell surface of certain types of immune cells. Recognition of foreign pathogens activates the
15 production of cytokines and upregulation of co-stimulatory molecules on phagocytes. This leads to the modulation of T cell behaviour.

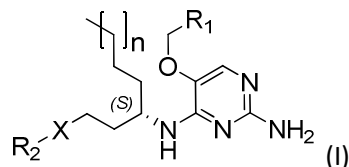
It has been estimated that most mammalian species have between ten and fifteen types of Toll-like receptors. Thirteen TLRs (named TLR1 to TLR13) have been identified in humans and mice together, and equivalent forms of many of
20 these have been found in other mammalian species. However, equivalents of certain TLR found in humans are not present in all mammals. For example, a gene coding for a protein analogous to TLR10 in humans is present in mice, but appears to have been damaged at some point in the past by a retrovirus. On the other hand, mice express TLRs 11, 12, and 13, none of which are
25 represented in humans. Other mammals may express TLRs which are not found in humans. Other non-mammalian species may have TLRs distinct from mammals, as demonstrated by TLR14, which is found in the Takifugu pufferfish. This may complicate the process of using experimental animals as models of human innate immunity.

30 For reviews on TLRs see the following journal articles. Hoffmann, J.A., Nature, **426**, p33-38, 2003; Akira, S., Takeda, K., and Kaisho, T., Annual Rev. Immunology, **21**, p335-376, 2003; Ulevitch, R. J., Nature Reviews: Immunology, **4**, p512-520, 2004.

Compounds indicating activity on Toll-Like receptors have been previously described such as purine derivatives in WO 2006/117670, adenine derivatives in WO 98/01448 and WO 99/28321, and pyrimidines in WO 2009/067081.

However, there exists a strong need for novel Toll-Like receptor modulators having preferred selectivity, higher potency, higher metabolic stability, and an improved safety profile compared to the compounds of the prior art.

The present disclosure provides a compound of formula (I)



or a pharmaceutically acceptable salt, tautomer(s), stereo-isomeric forms, solvate or polymorph thereof, wherein

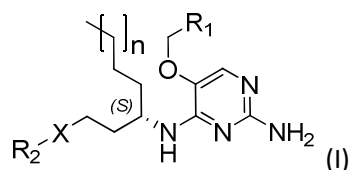
X represents S, S=O or O=S=O,

R_1 is hydrogen, (C_{1-6}) -alkyl, (C_{1-6}) -alkoxy or aryl,

R_2 is (C_{1-3}) -alkyl or (C_{3-6}) -cycloalkyl and

$n = 1$ or 2 .

In one aspect, there is provided a compound of compound of formula (I)



or a pharmaceutically acceptable salt, tautomer(s), or solvate thereof, wherein

X represents S, S=O or O=S=O,

R_1 is hydrogen, (C_{1-6}) -alkyl, (C_{1-6}) -alkoxy or aryl,

R_2 is (C_{1-3}) -alkyl or (C_{3-6}) -cycloalkyl and

$n = 1$ or 2 .

The compounds of formula (I) and their pharmaceutically acceptable salts, tautomer(s), stereo-isomeric forms, solvate or polymorph thereof have activity as pharmaceuticals, in particular as modulators of Toll-Like Receptors (especially TLR7 and/or TLR8 activity).

- 5 The present disclosure provides a pharmaceutical composition comprising a compound of formula (I) or a pharmaceutically acceptable salt, tautomer, stereo-isomeric form, solvate or polymorph thereof together with one or more pharmaceutically acceptable excipients, diluents or carriers. In a further aspect, the present disclosure provides a pharmaceutical composition comprising a compound
10 of formula (I) or a pharmaceutically acceptable salt, tautomer(s), or solvate thereof according to the current disclosure together with one or more pharmaceutically acceptable excipients, diluents or carriers.

- The present disclosure provides a compound of formula (I) or a pharmaceutically acceptable salt, solvate, tautomer, stereo-isomeric form or polymorph thereof
15 according to the current disclosure, or a pharmaceutical composition comprising said compound of formula (I) or a pharmaceutically acceptable salt, solvate, tautomer, stereo-isomeric form or polymorph thereof for use as a medicament. In a further aspect, the present disclosure provides a compound of formula (I) or a pharmaceutically acceptable salt, tautomer(s), or solvate thereof according to the
20 current disclosure or a pharmaceutical composition according to the current disclosure for use as a medicament.

The disclosure also provides a compound of formula (I) or its pharmaceutically acceptable salt, solvate, tautomer, stereo-isomeric form or polymorph thereof, or a pharmaceutical composition comprising said compound of formula (I) or a pharmaceutically acceptable salt, solvate, tautomer, stereo-isomeric form or polymorph thereof for use in the treatment of a disorder where the modulation of TLR's, more specifically TLR7 and /or TLR8, is involved.

The term "(C₁₋₆)-alkyl" or "(C₁₋₃)-alkyl refers to a straight-chain, branched-chain or cyclic saturated aliphatic hydrocarbon containing the specified number of carbon atoms.

10 The term "aryl" means an aromatic ring structure optionally comprising one or two heteroatoms selected from N, O and S, in particular from N and O. Said aromatic ring structure may have 4, 5, 6 or 7 ring atoms. In particular, said aromatic ring structure may have 5 or 6 ring atoms.

15 The term "(C₁₋₆)-alkoxy refers to an alkyl (carbon and hydrogen chain) group singular bonded to oxygen like for instance a methoxy group or ethoxy group.

The term "(C₃₋₆)-cycloalkyl" means refers to a carbocyclic ring containing the specified number of carbon atoms.

20 As used herein, any chemical formula with bonds shown only as solid lines and not as solid wedged or hashed wedged bonds, or otherwise indicated as having a particular configuration (e.g. *R*, *S*) around one or more atoms, contemplates each possible stereoisomer, or mixture of two or more stereoisomers.

The terms "stereoisomers", "stereoisomeric forms" or "stereochemically isomeric forms" hereinbefore or hereinafter are used interchangeably.

25 The invention includes all stereoisomers of the compounds of the invention either as a pure stereoisomer or as a mixture of two or more stereoisomers.

Enantiomers are stereoisomers that are non-superimposable mirror images of each other. A 1:1 mixture of a pair of enantiomers is a racemate or racemic mixture.

30 Diastereomers (or diastereoisomers) are stereoisomers that are not enantiomers, i.e. they are not related as mirror images. If a compound contains a double bond, the substituents may be in the *E* or the *Z* configuration. If a compound contains an at least disubstituted non-aromatic cyclic group, the substituents may be in the *cis* or *trans* configuration.

Therefore, the invention includes enantiomers, diastereomers, racemates, E isomers, Z isomers, cis isomers, trans isomers and mixtures thereof, whenever chemically possible.

The meaning of all those terms, i.e. enantiomers, diastereomers, racemates, E isomers, Z isomers, cis isomers, trans isomers and mixtures thereof are known to the skilled person.

The absolute configuration is specified according to the Cahn-Ingold-Prelog system. The configuration at an asymmetric atom is specified by either R or S. Resolved stereoisomers whose absolute configuration is not known can be designated by (+) or (-) depending on the direction in which they rotate plane polarized light. For instance, resolved enantiomers whose absolute configuration is not known can be designated by (+) or (-) depending on the direction in which they rotate plane polarized light.

When a specific stereoisomer is identified, this means that said stereoisomer is substantially free, i.e. associated with less than 50%, preferably less than 20%, more preferably less than 10%, even more preferably less than 5%, in particular less than 2% and most preferably less than 1%, of the other stereoisomers. Thus, when a compound of Formula (I) is for instance specified as (R), this means that the compound is substantially free of the (S) isomer; when a compound of Formula (I) is for instance specified as E, this means that the compound is substantially free of the Z isomer; when a compound of Formula (I) is for instance specified as cis, this means that the compound is substantially free of the trans isomer.

Pharmaceutically acceptable salts of the compounds of formula (I) include the acid addition and base salts thereof. Suitable acid addition salts are formed from acids which form non-toxic salts. Suitable base salts are formed from bases which form non-toxic salts.

The compounds of the invention may also exist in unsolvated and solvated forms. The term "solvate" is used herein to describe a molecular complex comprising the compound of the invention and one or more pharmaceutically acceptable solvent molecules, for example, ethanol.

The term "polymorph" refers to the ability of the compound of the invention to exist in more than one form or crystal structure.

The compounds of the present invention may be administered as crystalline or amorphous products. They may be obtained for example as solid plugs,

powders, or films by methods such as precipitation, crystallization, freeze drying, spray drying, or evaporative drying. They may be administered alone or in combination with one or more other compounds of the invention or in combination with one or more other drugs. Generally, they will be administered
5 as a formulation in association with one or more pharmaceutically acceptable excipients. The term "excipient" is used herein to describe any ingredient other than the compound(s) of the invention. The choice of excipient depends largely on factors such as the particular mode of administration, the effect of the excipient on solubility and stability, and the nature of the dosage form.

10 The compounds of the present invention or any subgroup thereof may be formulated into various pharmaceutical forms for administration purposes. As appropriate compositions there may be cited all compositions usually employed for systemically administering drugs. To prepare the pharmaceutical compositions of this invention, an effective amount of the particular compound,
15 optionally in addition salt form, as the active ingredient is combined in intimate admixture with a pharmaceutically acceptable carrier, which carrier may take a wide variety of forms depending on the form of preparation desired for administration. These pharmaceutical compositions are desirably in unitary dosage form suitable, for example, for oral, rectal, or percutaneous
20 administration. For example, in preparing the compositions in oral dosage form, any of the usual pharmaceutical media may be employed such as, for example, water, glycols, oils, alcohols and the like in the case of oral liquid preparations such as suspensions, syrups, elixirs, emulsions, and solutions; or solid carriers such as starches, sugars, kaolin, diluents, lubricants, binders, disintegrating
25 agents and the like in the case of powders, pills, capsules, and tablets. Because of their ease in administration, tablets and capsules represent the most advantageous oral dosage unit forms, in which case solid pharmaceutical carriers are obviously employed. Also included are solid form preparations that can be converted, shortly before use, to liquid forms. In the compositions
30 suitable for percutaneous administration, the carrier optionally comprises a penetration enhancing agent and/or a suitable wetting agent, optionally combined with suitable additives of any nature in minor proportions, which additives do not introduce a significant deleterious effect on the skin. Said additives may facilitate the administration to the skin and/or may be helpful for
35 preparing the desired compositions. These compositions may be administered in various ways, e.g., as a transdermal patch, as a spot-on, as an ointment. The compounds of the present invention may also be administered via

inhalation or insufflation by means of methods and formulations employed in the art for administration via this way. Thus, in general the compounds of the present invention may be administered to the lungs in the form of a solution, a suspension or a dry powder.

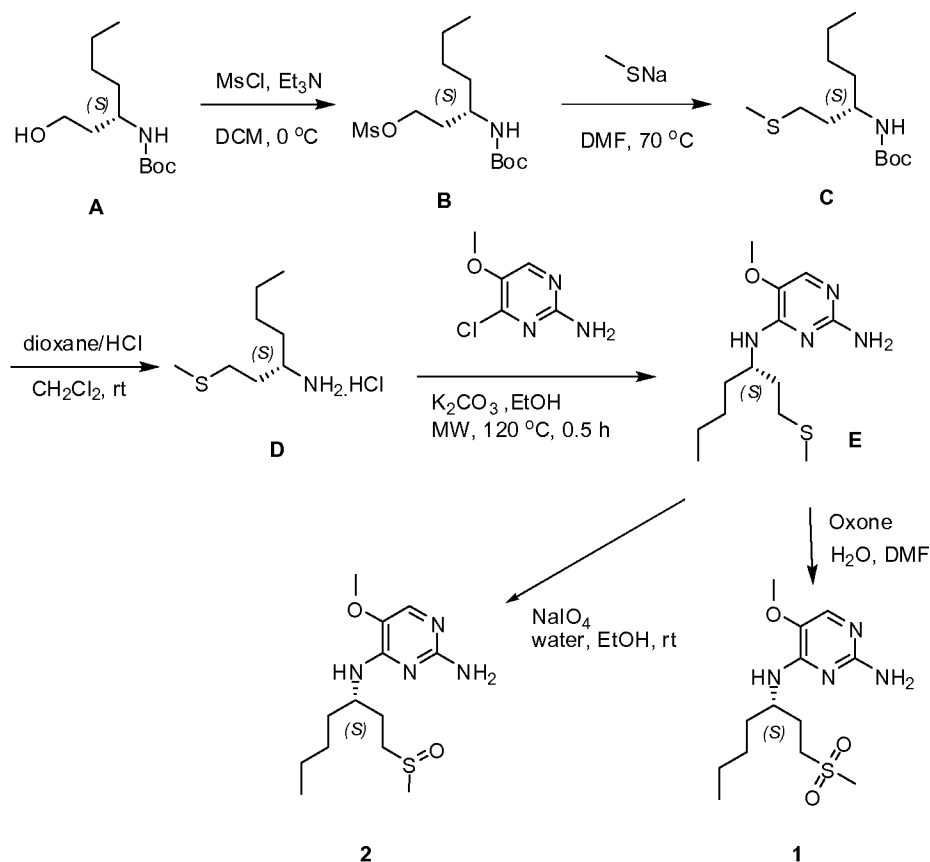
- 5 It is especially advantageous to formulate the aforementioned pharmaceutical compositions in unit dosage form for ease of administration and uniformity of dosage. Unit dosage form as used herein refers to physically discrete units suitable as unitary dosages, each unit containing a predetermined quantity of active ingredient calculated to produce the desired therapeutic effect in
10 association with the required pharmaceutical carrier. Examples of such unit dosage forms are tablets (including scored or coated tablets), capsules, pills, powder packets, wafers, suppositories, injectable solutions or suspensions and the like, and segregated multiples thereof.

- Those of skill in the treatment of infectious diseases will be able to determine
15 the effective amount from the test results presented hereinafter. In general it is contemplated that an effective daily amount would be from 0.01 mg/kg to 50 mg/kg body weight, more preferably from 0.1 mg/kg to 10 mg/kg body weight. It may be appropriate to administer the required dose as two, three, four or more sub-doses at appropriate intervals throughout the day. Said sub-doses may be
20 formulated as unit dosage forms, for example, containing 1 to 1000 mg, and in particular 5 to 200 mg of active ingredient per unit dosage form.

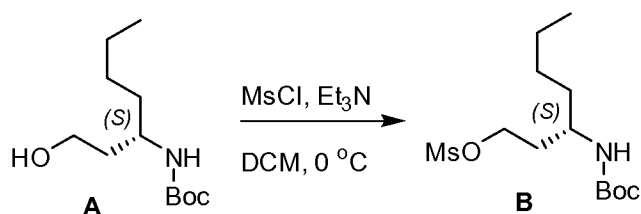
- The exact dosage and frequency of administration depends on the particular compound of formula (I) used, the particular condition being treated, the severity of the condition being treated, the age, weight and general physical
25 condition of the particular patient as well as other medication the individual may be taking, as is well known to those skilled in the art. Furthermore, it is evident that the effective amount may be lowered or increased depending on the response of the treated subject and/or depending on the evaluation of the physician prescribing the compounds of the instant invention. The effective
30 amount ranges mentioned above are therefore only guidelines and are not intended to limit the scope or use of the invention to any extent.

Preparation of compounds of formula (I)

Overall scheme. Compound **A** was prepared according to procedures described in WO2008147697 and WO2009067081.



Experimental Section

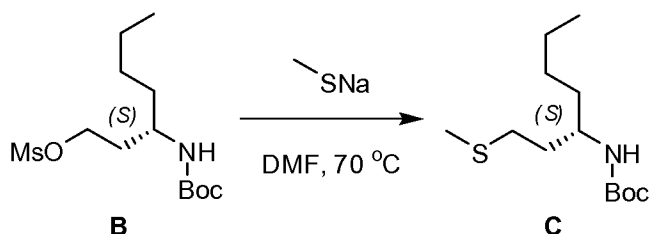


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Triethylamine (10.5 g, 103.75 mmol, 2.4 eq.) was added to the solution of **A** (10 g, 43.23 mmol, 1 eq.) in CH_2Cl_2 (200 mL) at 0°C . Methanesulfonyl chloride (6.4 g, 55.87 mmol, 1.3 eq.) was added dropwise to the solution and stirred 1.5 hours at 0°C . CH_2Cl_2 (500 mL) was added. The solution was washed with aq. NaHCO_3 , brine, and dried over Na_2SO_4 , the solids were removed by filtration and the solvent of the filtrate was removed under reduced pressure to give **B**. Used as such without further purification.

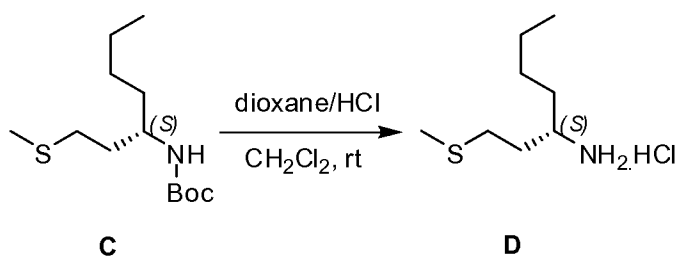
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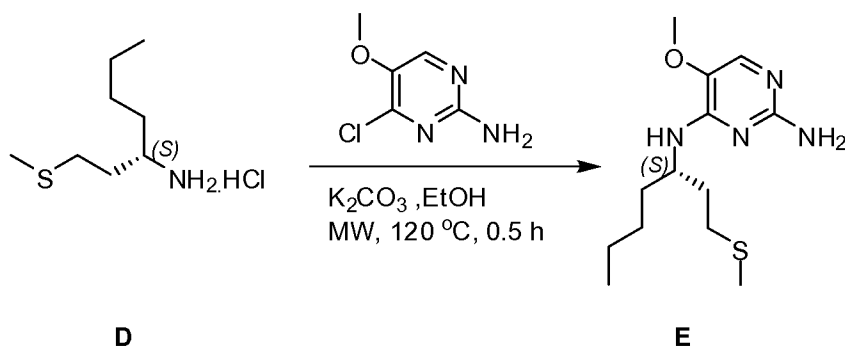


A mixture of **B** (12 g, 38.782 mmol, 1 eq.) and sodium thiomethoxide (4.08 g, 58.17 mmol, 1.5 eq.) in DMF (60 mL) was stirred overnight at 70°C. The solids were removed by filtration and the solvents of the filtrate were removed under reduced pressure. The crude was dissolved in ethyl acetate, washed with water, brine, dried over Na₂SO₄, the solids were removed by filtration and the solvents of the filtrate were removed under reduced pressure. The crude was purified by silica gel column chromatography (eluent: petroleum ether / ethyl acetate from 40/1 to 3/1) to afford **C**.

¹H NMR (400 MHz, chloroform-*d*) δ ppm 0.70 – 0.85 (m, 5 H), 1.15 – 1.49 (m, 13 H), 1.49 – 1.61 (m, 1 H), 1.61 – 1.80 (m, 1 H), 2.05 (s, 3 H), 2.38 – 2.50 (m, 2 H), 3.51 (br. s., 1 H), 4.25 (br. s., 1 H)

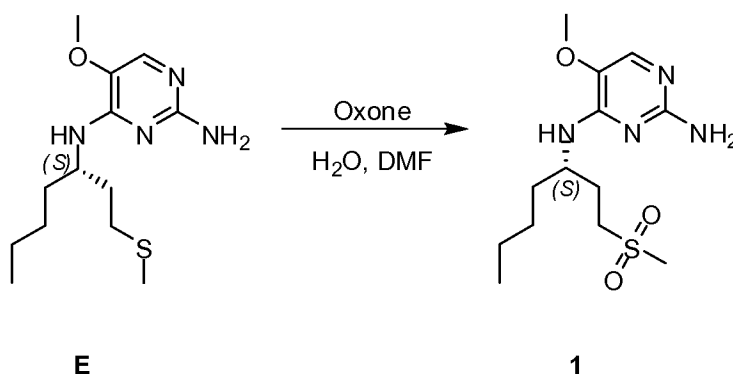


HCl/dioxane (47 mL, 187.43 mmol, 10 eq.) was added drop wise to a stirred solution of **C** (4.9 g, 18.74 mmol, 1 eq.) in CH₂Cl₂ at 0°C, and stirred for 1 hour at 25°C. The solution was concentrated under reduced pressure to give **D**. Used as such in the next step.



D (0.75 g, 3.79 mmol, 1 eq.), 2-amino-4-chloro-5-methoxypyrimidine (0.908 g, 5.69 mmol, 1.5 eq.) and K_2CO_3 (1.57 g 11.38 mmol, 3 eq.) were mixed in ethanol (20 mL). The mixture was stirred at 120°C in the microwave for 30 minutes. The solvent was removed under reduced pressure. The crude was purified by preparative silica thin layer chromatography (eluent: CH_2Cl_2 : CH_3OH = 20:1) to afford **E**.

^1H NMR (400 MHz, chloroform-*d*) δ ppm 1.05 – 1.15 (m, 3 H), 1.40 - 1.60 (m, 4 H), 1.95 (m, 2H), 2.15 (m, 1 H), 2.30 (d, 3 H), 2.70 (t, 1 H), 2.90 (t, 1 H), 3.55 (m, 1 H), 4.50 (m, 1 H), 3.95 (s, 3 H), 6.20 (d, 1H), 6.60 (br. s., 2 H), 7.45 (s, 1 H)

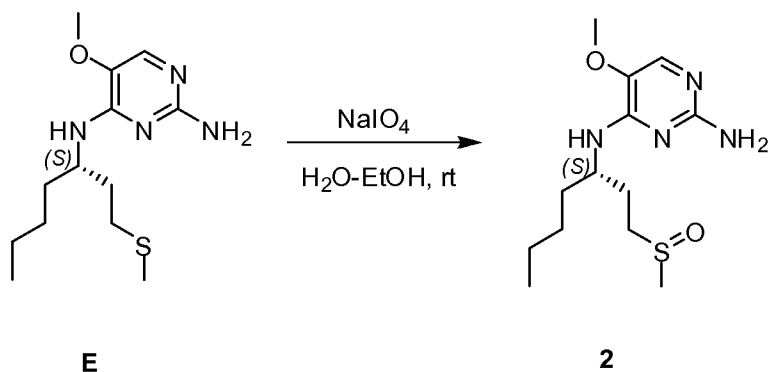


Oxone (6.959 g, 11.32 mmol, 3 eq.) was added to a solution of **E** (1.45 g, 3.773 mmol, 1 eq.) in DMF (100 mL) and water (100 mL). The mixture was stirred for 12 hours at 20°C. The solids were removed by filtration and the filtrate was basified to pH=8 with saturated, aq. Na_2CO_3 solution. The resultant mixture was concentrated under reduced pressure. The residue was purified by preparative high-performance liquid chromatography (column: gemini 150 x 30 mm x 5 μ m, C18, mobile phase: CH_3CN /water (0.05% HCl), Gradient: 2-32% CH_3CN , 0-8min, flow rate: 30mL /min). The best fractions were pooled and concentrated under reduced pressure to afford **1**.

LC-MS 3.88 min

^1H NMR (400 MHz, methanol-*d*₄) δ ppm 0.92 (t, J =6.9 Hz, 3 H), 1.21 - 1.50 (m, 4 H), 1.69 (q, J =7.1 Hz, 2 H), 1.95 - 2.28 (m, 2 H), 2.98 (s, 3 H), 3.09 - 3.22 (m, 2 H), 3.87 (s, 3 H), 4.37 - 4.55 (m, 1 H), 7.26 (s, 1 H) labile protons not observed.

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A solution of **E** (40 mg, 0.14 mmol, 1 eq.) in ethanol (40 mL) was treated with a solution of NaIO₄ (0.2 g, 1 mmol, 7.5 eq.) in water (10 mL), and then stirred at room temperature overnight. The solution was concentrated under vacuum.

- 5 The residue was diluted with water and extracted with ethyl acetate. The combined organic layers were washed with brine, dried over Na₂SO₄, the solids were removed via filtration, and the solvent of the filtrate was removed under reduced pressure. The crude was purified by preparative high-performance liquid chromatography (C18 column, eluent: CH₃CN, H₂O from 3/97 to 33/67, 10 0.05% HCl). The desired fractions were collected and concentrated under vacuum to afford **2**.

LC-MS 3.78 min

- ¹H NMR (400 MHz, methanol-*d*₄) δ ppm 0.90 (t, *J*=6.8 Hz, 3 H), 1.19 - 1.49 (m, 4 H), 1.67 (d, *J*=6.5 Hz, 2 H), 1.91 - 2.15 (m, 2 H), 2.63 (br. s., 3 H), 2.69 - 2.96 15 (m, 2 H), 3.85 (s, 3 H), 4.46 (br. s., 1 H), 7.25 (s, 1 H) labile protons not observed.

LC-MS Analytical Method.

Column	YMC-PACK ODS-AQ, 50×2.0mm, 5μm		
Mobile Phase	A :H ₂ O (0.1%TFA)		
	B:acetonitrile (0.05%TFA)		
	TIME(min)	A%	B%
	0	100	0
	1	100	0
	5	40	60
	7.5	40	60
	8	100	0
Flow Rate	0.8mL/min		
Wavelength	UV 220nm		
Column Temperature	50°C		
MS polarity	positive		
LCMS	Agilent 1100		

Biological Activity of compounds of formula (I)

5 Description of Biological Assays

Assessment of TLR7 and TLR8 activity

The ability of compounds to activate human TLR7 and/or TLR8 was assessed in a cellular reporter assay using HEK293 cells transiently transfected with a TLR7 or TLR8 expression vector and NFκB-luc reporter construct.

- 10 Briefly, HEK293 cells were grown in culture medium (DMEM supplemented with 10% FCS and 2 mM Glutamine). For transfection of cells in 15 cm dishes, cells were detached with Trypsin-EDTA, transfected with a mix of CMV-TLR7 or TLR8 plasmid (1700 ng), NFκB-luc plasmid (850 ng) and a transfection reagent and incubated for 48 h at 37°C in a humidified 5% CO₂ atmosphere.
- 15 Transfected cells were then washed in PBS, detached with Trypsin-EDTA and resuspended in medium to a density of 1.25 x 10⁵ cells/mL. Forty microliters of cells were then dispensed into each well in 384-well plates, where 200 nL of compound in 100% DMSO was already present. Following 6 hours incubation

at 37°C, 5% CO₂, the luciferase activity was determined by adding 15 µL of Steady Lite Plus substrate (Perkin Elmer) to each well and readout performed on a ViewLux ultraHTS microplate imager (Perkin Elmer). Dose response curves were generated from measurements performed in quadruplicates.

- 5 Lowest effective concentrations (LEC) values, defined as the concentration that induces an effect which is at least two fold above the standard deviation of the assay, were determined for each compound.

Compound toxicity was determined in parallel using a similar dilution series of compound with 40 µL per well of cells transfected with the CMV-TLR7
10 construct alone (1.25×10^5 cells/mL), in 384-well plates. Cell viability was measured after 6 hours incubation at 37°C, 5% CO₂ by adding 15 µL of ATP lite (Perkin Elmer) per well and reading on a ViewLux ultraHTS microplate imager (Perkin Elmer). Data was reported as CC₅₀.

In parallel, a similar dilution series of compound was used (200 nL of
15 compound in 100% DMSO) with 40 µL per well of cells transfected with NFκB-luc reporter construct alone (1.25×10^5 cells/mL). Six hours after incubation at 37°C, 5% CO₂, the luciferase activity was determined by adding 15 µL of Steady Lite Plus substrate (Perkin Elmer) to each well and readout performed on a ViewLux ultraHTS microplate imager (Perkin Elmer). Counterscreen data is
20 reported as LEC.

Activation of ISRE promoter elements

The potential of compounds to induce IFN-I was also evaluated by measuring the activation of interferon-stimulated responsive elements (ISRE) by
25 conditioned media from PBMC. The ISRE element of sequence GAAACTGAAACT is highly responsive to the STAT1-STAT2-IRF9 transcription factor, activated upon binding of IFN-I to their receptor IFNAR (Clontech, PT3372-5W). The plasmid pISRE-Luc from Clontech (ref. 631913) contains 5 copies of this ISRE element, followed by the firefly luciferase ORF. A HEK293
30 cell line stably transfected with pISRE-Luc (HEK-ISREluc) was established to profile the conditioned PBMC cell culture media.

Briefly, PBMCs were prepared from buffy coats of at least two donors using a standard Ficoll centrifugation protocol. Isolated PBMCs were resuspended in RPMI medium supplemented with 10% human AB serum and 2×10^5 cells/well
35 were dispensed into 384-well plates containing compounds (70 µL total

volume). After overnight incubation, 10 μ L of supernatant was transferred to 384-well plates containing 5×10^3 HEK-ISREluc cells/well in 30 μ L (plated the day before). Following 24 hours of incubation, activation of the ISRE elements was measured by assaying luciferase activity using 40 μ L/well Steady Lite Plus substrate (Perkin Elmer) and measured with ViewLux ultraHTS microplate imager (Perkin Elmer). The stimulating activity of each compound on the HEK-ISREluc cells was reported as LEC value, defined as the compound concentration applied to the PBMCs resulting in a luciferase activity at least two fold above the standard deviation of the assay. The LEC in turn indicates the degree of ISRE activation on transfer of a defined amount of PBMC culture medium. Recombinant interferon α -2a (Roferon-A) was used as a standard control compound.

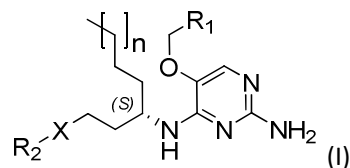
TABLE I: BIOLOGICAL ACTIVITY.

#	Human TLR 7 (LEC) μ M	Human TLR 8 (LEC) μ M	HEK-ISRE luc (LEC) μ M
1	2.0	1.7	0.65
2	1.4	9.2	4.8
E	3.9	10	NA

NA = not available. All compounds showed no toxicity up to the highest tested concentration. All compounds showed no activity (LEC >25 μ M) in the HEK 293 NF-kB counterscreen assay described above.

Claims

1. A compound of formula (I)



or a pharmaceutically acceptable salt, tautomer(s), or solvate thereof, wherein

5 X represents S, S=O or O=S=O,

R_1 is hydrogen, (C_{1-6}) -alkyl, (C_{1-6}) -alkoxy or aryl,

R_2 is (C_{1-3}) -alkyl or (C_{3-6}) -cycloalkyl and

$n = 1$ or 2 .

10 2. A pharmaceutical composition comprising a compound of formula (I) or a pharmaceutically acceptable salt, tautomer(s), or solvate thereof according to claim 1 together with one or more pharmaceutically acceptable excipients, diluents or carriers.

15 3. A compound of formula (I) or a pharmaceutically acceptable salt, tautomer(s), or solvate thereof according to claim 1 or a pharmaceutical composition according to claim 2 for use as a medicament.