

COMPOSITIONS AND METHODS

FIELD OF INVENTION

The present invention relates to a composition for repelling an arthropod, for example an insect such as a mosquito. Also disclosed herein is a method of repelling an arthropod using the composition disclosed herein.

BACKGROUND

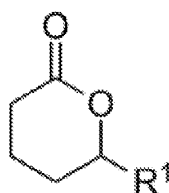
The spreading of vector-borne diseases caused by pathogen-transmitting insects is a widespread issue globally (WHO, 2020, <https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases>, accessed on 18 January 2024). Vector-Borne diseases account for more than 17% of all infectious diseases. *Aedes* mosquitoes transmit diseases such as dengue fever, Zika, yellow fever, and chikungunya, affecting regions worldwide. Dengue incidences alone have surged from approximately 500,000 cases in 2000 to 5.2 million cases in 2019, with more than 390 million people estimated to be at risk for contracting dengue, due to rapid urbanization and global warming in recent decades. As the *Aedes* mosquitoes require blood nutrients for egg production, they often prey on humans for blood meals. When feeding on hosts infected with a virus, mosquitoes become the carriers and can infect their next target during subsequent blood meals. Given the widespread nature of vector-borne diseases, the World Health Organization (WHO) has been supporting and providing training for many affected countries, focusing on strategies such as dengue outbreak management, surveillance, prevention, and vector control, and evaluation of new insecticide products and applications technology.

One effective method to prevent the spread of vector-borne diseases is using arthropod repellents, in particular insect repellents. Currently, various commercial repellents, containing active compounds such as *N,N*-diethyl-*meta*-toluamide (DEET), picaridin, permethrin, and natural essential oils, are available. DEET, developed in the 1940s, has been the gold standard ingredient but it poses health risks, acting as a skin irritant and causing breathing difficulties, burning eyes, and headaches (Toxicological Profile for DEET (N,N-DIETHYL-META-TOLUAMIDE). Atlanta (GA): Agency for Toxic Substances and Disease Registry (US); 2017 Aug; Legeay *et al.*, Eur J Pharmacol, 2018, 825, 92-98). Additionally, DEET can be toxic to aquatic animals and widespread use of DEET may result in environmental damage. Furthermore, instances of insects, including mosquitoes, developing resistance to DEET and other repellents have been observed, due to the prolonged and widespread use of DEET.

There is therefore a need for improved and/or alternative arthropod repellents, in particular insect repellents, which is not only effective against arthropods but also gentle on the skin, being non-irritating and non-sensitizing, while demonstrating long-lasting potential.

5 SUMMARY

The present invention provides a composition for repelling an arthropod, the composition consisting essentially of one or more compounds according to formula (I), one or more carriers, and optionally one or more excipients:



(I)

wherein,

R¹ is C₅ alkenyl.

15 The present inventors have found that compounds of formula (I) are potent repellents towards arthropods, in particular mosquitoes, ticks, and bed bugs. Specifically, the present inventors have found that compositions containing 0.1% (v/v) to 5% (v/v) jasmolactone (i.e. (E)-8-decen-5-olide) displayed equivalent or greater repelling activity towards mosquitoes, bed bugs and ticks as compositions containing 0.1% (v/v) to 5% (v/v) DEET. The
20 compositions containing jasmolactone were also found to display good duration of repelling activity, and were found to maintain repelling activity at lower concentrations than possible with DEET. A composition containing jasmine lactone (i.e. (Z)-7-decen-5-olide) was found to display comparable insect repelling activity as compositions containing jasmolactone.

Thus, the present invention also provides a method of repelling an arthropod, the method
25 comprising exposing the arthropod to the composition of the present invention.

Preferred but optional features are set out in the dependent claims. Additional aspects and embodiments of the composition and method of the present invention will be apparent from the following description, figures and claims. As can be appreciated from the foregoing and following description, each and every feature described herein, and each and every
30 combination of two or more such features, is included within the scope of the present disclosure provided that the features included in such a combination are not mutually

inconsistent. In addition, any feature or combination of features may be specifically excluded from any embodiment.

BRIEF DESCRIPTION OF THE FIGURES

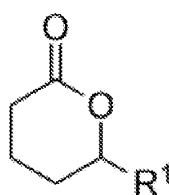
- 5 FIG. 1 shows a schematic diagram of a modified cage used for the hand assay.
- FIG. 2 shows a schematic diagram of the setup for the 2-port assay.
- FIG. 3 shows a schematic diagram of the cage used for the blood feeding assay.
- FIG. 4 shows a schematic diagram of the petri dish assay set up.
- FIG. 5 is a bar graph showing the repelling activity of jasmolactone and DEET towards
10 *Aedes aegypti* in the hand assay.
- FIG. 6 is a box and whisker plot showing the repelling activity of jasmolactone and DEET towards *Aedes aegypti* in the 2-port assay.
- FIG. 7 is a bar graph illustrating the duration of the repelling activity of jasmolactone against *Aedes aegypti* in the hand assay. The solvent is indicated in parentheses. "Mix" refers to a
15 combination of ethanol, propylene glycol, and water as described in Example 1.
- FIG. 8 is a bar graph showing the repelling activity of jasmolactone, jasmine lactone, and DEET towards *Aedes aegypti* in the hand assay.
- FIG. 9 is a bar graph showing the repelling activity of jasmolactone towards *Culex quinquefasciatus* females in the blood-feeding assay. The control used in the experiment
20 was 100% ethanol.
- FIG. 10 is a bar graph showing the repelling activity of jasmolactone and DEET towards bed bugs (*Cimex hemipterus*) in the petri dish assay (TLL-P2 2% = 2% (v/v) jasmolactone; and TLL-P2 5% = 5% (v/v) jasmolactone).
- FIG. 11 is a bar graph showing the repelling activity of jasmolactone and DEET towards bed
25 bugs (*Cimex hemipterus*) in the arena assay at three time points (1H = 1 hour, 2H = 2 hours; and 3H = 3 hours). The negative control sample was 100% ethanol. TLL-P2 = jasmolactone.
- FIG. 12 is a box and whisker plot showing the repelling activity of jasmolactone and DEET towards Ticks in the petri dish assay. The control sample was 100% ethanol.

30

DETAILED DESCRIPTION

The listing or discussion of a prior-published document in this specification should not necessarily be taken as an acknowledgement that the document is part of the state of the art or is common general knowledge.

- 5 As discussed in more detail below, the present inventors have found that compounds according to formula (I) are surprisingly effective at repelling arthropods, in particular insects. It is also gentle on the skin, being non-irritating and non-sensitizing, and demonstrates long-lasting potential. Thus, the present invention provides a composition for repelling an arthropod, the composition consisting essentially of one or more compounds according to
 10 formula (I), one or more carriers, and optionally one or more excipients:

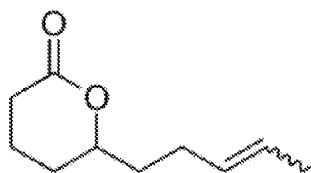


(I)

wherein,

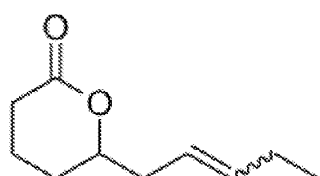
R¹ is C₅ alkenyl.

- 15 In certain embodiments, the one or more compounds of formula (I) are each independently selected from the group consisting of a compound according to formula (Ia) and a compound according to formula (Ib):



(Ia)

; or

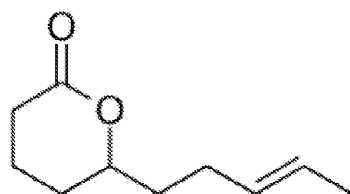


(Ib)

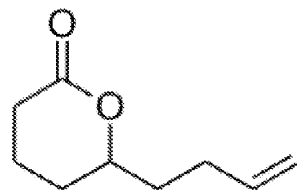
In certain embodiments, the composition consists essentially of two or more compounds according to formula (I), one or more carriers, and optionally one or more excipients.

- 20 Typically, the two or more compounds according to formula (I) are a compound according to formula (Ia) and a compound according to formula (Ib).

For the avoidance of doubt, in this document, it is intended that formulas (I), (Ia) and (Ib) each encompass the E and Z isomers of the compounds within the scope of the formulas. For example, formula (Ia) encompasses compounds according to formulas (Ic) and (Id):

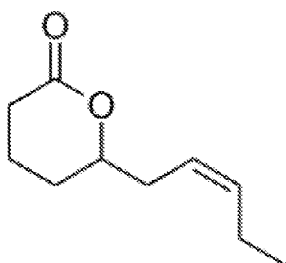


(Ic)

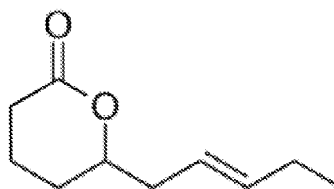


(Id)

Similarly, formula (Ib) encompasses compounds according to formulas (Ie) and (If):



(Ie)



(If)

5

Thus, when the one or more compounds of formula (I) are compounds of formula (Ia), the one or more compounds are (E)-7-decen-5-olide, (Z)-7-decen-5-olide, or a mixture thereof. When the compound of formula (Ia) is (Z)-7-decen-5-olide, the compound may be referred to as jasmine lactone.

- 10 When the one or more compounds of formula (I) are compounds of formula (Ib), the one or more compounds are (Z)-8-decen-5-olide, (E)-8-decen-5-olide, or a mixture thereof. When the compound of formula (Ib) is (E)-8-decen-5-olide, the compound may be referred to as jasmolactone.

- 15 Also for the avoidance of doubt, it is intended that the compounds of formula (I) (including the compounds of formula (Ia), (Ib), (Ic), (Id), (Ie), and (If)) include all enantiomers thereof, unless stated otherwise. Typically, the composition of the invention may contain a racemic mixture of the compound(s) of formula (I). However, compositions that contain only one of the enantiomers of the compound of formula (I), or different ratios of each enantiomer, are also encompassed by the present invention.

Compounds of formula (I) may be synthesised using methods known to those skilled in the art of organic chemistry. The compounds of formula (I) may also be extracted from plants, for example, from plants or parts(s) thereof of the genus Jasmine, and plant species such as *Prunus persica* L., *Passiflora* species, and *Mangifera* species. Jasmine lactone and jasmolactone are also readily available in isolated form from commercial suppliers.

- The composition of the invention contains one or more carriers. The term "carrier" as used herein refers to a material in which the one or more compounds of formula (I) may be dissolved or suspended. When the composition of the invention is to be applied to the skin or hair of a subject, the carrier is preferably a dermatologically acceptable carrier.
- Typically, the carrier is an aqueous solvent, an organic solvent or a mixture thereof. Suitable carriers for use in the composition of the invention, include but are not limited to, water; hydrocarbons such as liquid paraffin, paraffin; silicones such as dimethylsiloxane, colloidal silica and bentonite; monohydric alcohols such as ethanol, propanol, isopropanol, stearyl alcohol, lauryl alcohol and cetyl alcohol; polyhydric alcohols such as polyethylene glycol, ethylene glycol, propylene glycol and glycerine; carboxylic acids such as lauric acid and stearic acid; and esters such as beeswax and lanoline. The composition of the present invention may contain a mixture of two or more carriers disclosed hereinabove. In certain exemplary embodiments, the carrier is a monohydric alcohol such as ethanol, propanol, or isopropanol. For example, the carrier may be ethanol.
- The composition of the invention may also contain one or more excipients. As used herein, the term "excipient" refers to any inactive ingredient (e.g. an ingredient without arthropod repelling activity) in the composition that may not be considered a carrier. For example, the composition may contain an excipient such as an emulsifying or dispersing agent, spreading agent, wetting agent, suspending agent, preservative, propellant, fragrance, and film-forming agent. Examples of emulsifying or dispersing agents suitable for use in the present invention include soaps, polyoxyethylene fatty acid; alcohol ethers such as polyoxyethylene oleyl ether, polyoxyethylene alkylaryl ethers such as polyoxyethylene nonylphenyl ether, polyoxyethylene fatty acid esters, fatty acid glyceride, sorbitan fatty acid esters, sulfuric esters of higher alcohols, and alkylaryl sulfonates such as sodium dodecylbenzenesulfonate; examples of the spreading and wetting agents include glycerine and polyethylene glycol; examples of the suspending agents include casein, gelatin, alginic acid, carboxymethyl cellulose, gum arabic, hydroxypropyl cellulose and bentonite; examples of preservatives include methyl p-hydroxybenzoate, ethyl p-hydroxybenzoate, propyl p-hydroxybenzoate, and butyl p-hydroxybenzoate; examples of propellants include dimethyl ether, chlorofluorocarbons and carbon dioxide; and examples of film forming agents include

nitrocellulose, acetyl cellulose, acetylbutyl cellulose, methyl cellulose derivatives, vinyl resins such as vinyl acetate resin, and polyvinyl alcohol. When the composition of the invention is to be applied to the skin or hair of a subject, the excipient, when present, is preferably a dermatologically acceptable excipient.

- 5 As used herein, the term “dermatologically acceptable” refers to a compound or component which may be approved for skin or hair use on humans or domesticated animals and/or known in the art as being suitable for use in dermatological compositions.

The composition of the invention may be employed in any physical form that is suitable for exposing an arthropod to the composition. For example, the composition of the invention
10 may be a foam, a gel, a cream, a lotion, an oil, a liquid suitable for an aerosol spray or surface spray, a suspension, an emulsion, an emulsifiable concentrate, or other appropriate physical form.

The phrase “consists essentially of”, as used herein, means that the component(s) recited after the phrase forms the main components of the composition. In particular, the phrase
15 is used to mean that the composition contains the recited components at greater than 90 wt%, greater than 95 wt%, greater than 96 wt%, greater than 97 wt%, greater than 98 wt%, greater than 99 wt%, greater than 99.9 wt%, greater than 99.99 wt%, or 100 wt% of the total weight of the composition.

In certain embodiments, the one or more compounds according to formula (I) are present in
20 the composition of the invention at a concentration of from about 0.001 wt% to about 15 wt%, for example, from about 0.1 wt% to about 5 wt%. In certain exemplary embodiments, the one or more compounds according to formula (I) are present in the composition of the invention at a concentration of from about 0.1 wt% to about 4 wt%, for example, about 0.5 wt%, about 1 wt%, about 2 wt%, and about 3 wt%.

25 The term “wt%” as used herein refers to the percentage mass of a particular substance in the composition of the invention with respect to the total mass of the composition of the invention, unless indicated otherwise. For example, a composition of the invention containing 5 wt% of one or more compounds according to formula (I) is to be understood as containing 5 g of the one or more compounds according to formula (I) in every 100 g of the composition
30 of the invention.

In certain embodiments, when the carrier is an aqueous solvent, an organic solvent or a mixture thereof, the concentration of the one or more compounds according to formula (I) in the composition of the invention may be expressed as the percentage volume of the one or more compounds according to formula (I) with respect to the total volume of the composition.

In such instances, the units used herein are "% (v/v)". By way of example, a composition of the invention containing 5% (v/v) of one or more compounds according to formula (I) is to be understood as containing 5 mL of the one or more compounds according to formula (I) in every 100 mL of the composition of the invention.

- 5 Thus, in certain embodiments, when the carrier is an aqueous solvent, an organic solvent or a mixture thereof, the concentration of the one or more compounds according to formula (I) in the composition of the invention may from about 0.001% (v/v) to about 15% (v/v), for example, from about 0.1% (v/v) to about 5% (v/v). In certain exemplary embodiments, when the carrier is an aqueous solvent, an organic solvent or a mixture thereof, the one or more
10 compounds according to formula (I) are present in the composition of the invention at a concentration of from about 0.1% (v/v) to about 4% (v/v), for example, about 0.5% (v/v), about 1% (v/v), about 2% (v/v), and 3% (v/v).

- For the avoidance of doubt, it is explicitly contemplated that where a number of numerical ranges related to the same feature are cited herein, that the end points for each range are
15 intended to be combined in any order to provide further contemplated (and implicitly disclosed) ranges. The term "about" as used herein can allow for a degree of variability in a value or range, for example, within 10%, within 5%, within 1%, within 0.5%, within 0.1%, within 0.05%, within 0.01%, within 0.005%, or within 0.001% of a stated value or of a stated limit of a range, and includes the exact stated value or range.

- 20 In certain exemplary embodiments, the composition of the invention consists essentially of (Z)-7-decen-5-olide, one or more carriers, and optionally one or more excipients. For example, the composition of the invention may consist essentially of (Z)-7-decen-5-olide and a monohydric alcohol (e.g. ethanol). For example, the composition of the invention may consist essentially of (Z)-7-decen-5-olide and a monohydric alcohol (e.g. ethanol), wherein
25 the (Z)-7-decen-5-olide is present in the composition at a concentration of from about 0.1 wt% to about 5 wt% (e.g. from about 0.1 wt% to about 4 wt%, for example, about 0.5 wt%, about 1 wt%, about 2 wt%, or about 3 wt%). Or, for example, the composition of the invention may consist essentially of (Z)-7-decen-5-olide and a monohydric alcohol (e.g. ethanol), wherein the (Z)-7-decen-5-olide is present in the composition at concentration of
30 from about 0.1% (v/v) to about 5% (v/v) (e.g. from about 0.1% (v/v) to about 4%, for example, about 0.5% (v/v), about 1% (v/v), about 2% (v/v), or about 3% (v/v)).

In certain other exemplary embodiments, the composition of the invention consists essentially of (E)-8-decen-5-olide, one or more carriers, and optionally one or more excipients. For example, the composition of the invention may consist essentially of (E)-8-

- decen-5-olide and a monohydric alcohol (e.g. ethanol). For example, the composition of the invention may consist essentially of (E)-8-decen-5-olide and a monohydric alcohol (e.g. ethanol), wherein the (E)-8-decen-5-olide is present in the composition at a concentration of from about 0.1 wt% to about 5 wt% (e.g. from about 0.1 wt% to about 4 wt%, for example, about 0.5 wt%, about 1 wt%, about 2 wt%, or about 3 wt%). Or, for example, the composition of the invention may consist essentially of (E)-8-decen-5-olide and a monohydric alcohol (e.g. ethanol), wherein the (E)-8-decen-5-olide is present in the composition at a concentration of from about 0.1% (v/v) to about 5% (v/v) (e.g. from about 0.1% (v/v) to about 4%, for example, about 0.5% (v/v), about 1% (v/v), about 2% (v/v), or about 3% (v/v)).
- 10 In certain other embodiments, the composition of the invention consists essentially of (Z)-7-decen-5-olide, (E)-8-decen-5-olide, one or more carriers, and optionally one or more excipients. For example, the composition of the invention may consist essentially of (Z)-7-decen-5-olide, (E)-8-decen-5-olide, and a monohydric alcohol (e.g. ethanol). For example, the composition of the invention may consist essentially of (Z)-7-decen-5-olide, (E)-8-decen-5-olide and a monohydric alcohol (e.g. ethanol), wherein (Z)-7-decen-5-olide and (E)-8-decen-5-olide are together present in the composition at a concentration of from about 0.1 wt% to about 5 wt% (e.g. from about 0.1 wt% to about 4 wt%, for example, about 0.5 wt%, about 1 wt%, about 2 wt%, or about 3 wt%). Or, for example, the composition of the invention may consist essentially of (Z)-7-decen-5-olide, (E)-8-decen-5-olide and a monohydric alcohol (e.g. ethanol), wherein (Z)-7-decen-5-olide and (E)-8-decen-5-olide are together present in the composition at a concentration of from about 0.1% (v/v) to about 5% (v/v) (e.g. from about 0.1% (v/v) to about 4%, for example, about 0.5% (v/v), about 1% (v/v), about 2% (v/v), or about 3% (v/v)).

25 Optionally, the composition of the invention may consist essentially of one or more compounds according to formula (I), one or more carriers, optionally one or more excipients, and optionally one or more further compounds with arthropod repelling activity.

As explained in the examples herein, the present inventors have found that compounds of formula (I) are potent repellents towards arthropods, in particular mosquitoes, ticks, and bed bugs. Thus, the present invention also provides a method of repelling an arthropod, in particular an insect, the method comprising exposing the arthropod to a composition of the present invention.

In embodiments herein, the word "comprising" may be interpreted as requiring the features mentioned, but not limiting the presence of other features. Alternatively, the word "comprising" may also relate to the situation where only the components/features listed are intended to be present (e.g. the word "comprising" may be replaced by the phrases "consists

of” or “consists essentially of”). It is explicitly contemplated that both the broader and narrower interpretations can be applied to all aspects and embodiments of the present invention. In other words, the word “comprising” and synonyms thereof may be replaced by the phrase “consisting of” or the phrase “consists essentially of” or synonyms thereof and
5 *vice versa*.

Arthropods include invertebrate animals, such as insects, arachnids, and crustaceans that have a segmented body and jointed appendages. Arthropods usually have a chitinous exoskeleton molted at intervals, and a dorsal anterior brain connected to a ventral chain of ganglia. The present inventors have demonstrated that the composition of the present
10 invention is particularly effective at repelling insects, for example mosquitoes, ticks, and bed bugs. Thus, in certain embodiments, the arthropod is an insect.

In certain embodiments, the arthropod is of the order Hemiptera, Hymenoptera, Siphonaptera, Diptera, Araneae, Ixodida, or Blattodea. For example, the arthropod may be a mosquito, a bed bug, a tick, an ant, a cockroach, a flea, a mite, a spider, a termite, a biting
15 midge or a wasp.

In certain exemplary embodiments, the arthropod is a mosquito, bed bug, or tick. When the arthropod is a mosquito, the mosquito may be of the genus *Aedes*, *Culex* or *Anopheles*. For example, the mosquito may be of the species *Aedes aegypti*, *Culex quinquefasciatus*, *Anopheles sinensis*, or *Anopheles gambiae*. When the arthropod is a bed bug, the bed bug
20 may be of the species *Cimex hemipterus*. When the arthropod is a tick, the tick may be of the species *Haemaphysalis longicornis*. The present inventors have found that the compositions of the invention are especially effective against mosquitos, bed bugs and ticks, displaying equivalent or superior repelling activity towards the arthropod compared to DEET.

As used herein, the term “arthropod repellent”, “insect repellent”, “repellent composition”,
25 “repelling an arthropod”, “arthropod repelling activity” or similar terms, refer to the ability of the composition or compound to minimize, reduce, discourage or prevent approach or the presence of an arthropod at the arthropod repellent source, such as in the air, on a surface of an article or on a surface (e.g. body part(s)) of a subject.

In certain embodiments, exposing the arthropod to the composition of the invention
30 comprises contacting a subject or an article with the composition. The term “subject” as used herein refers to animal subjects and part(s) thereof. Examples of animal subjects includes humans and domesticated animal, for example a domesticated animal such as a household pet or a livestock animal. Typically, subjects are considered to be arthropod food sources or arthropod habitats. For example, human subjects may be bitten by mosquitos and be
35 vulnerable to, for example, mosquito-borne disease such as malaria, Dengue virus and Zika virus. Animal subjects include but are not limited to mammals, including domesticated animals such as household pets, and livestock animals that are vulnerable to insect-borne

diseases and/or infestations. Thus, the composition of the invention may be particularly useful in reducing the spread of diseases and/or arthropod infestations.

The composition of the invention may be applied topically to a subject, for example applied to the skin or hair of a subject.

5 Rather than direct contact of the composition with a subject, the composition of the invention may be applied to a surface of, or impregnated in, an article. The term "article" as used herein refers to an object such as a man-made product comprised of fabric or solid substrate that an arthropod may contact or come in close proximity to. The article may include items of furniture, clothing, candle, air diffuser, tablet, cosmetic, netting, building material, and
10 incense.

The invention has been described broadly and generically herein. Those of ordinary skill in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for
15 which the teachings of the present invention is/are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, the invention may be
20 practiced otherwise than as specifically described herein. The present invention is directed to each individual feature, system, article, material, kit, and/or method described herein. In addition, any combination of two or more such features, systems, articles, materials, kits, and/or methods, if such features, systems, articles, materials, kits, and/or methods are not mutually inconsistent, is included within the scope of the present invention. Further, each of
25 the narrower species and subgeneric groupings falling within the generic disclosure also form part of the invention. This includes the generic description of the invention with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein.

30 The following Examples illustrate the invention.

EXAMPLES

Materials and methods:

Jasmolactone (CAS Number: 32764-98-0) was purchased from Lluch Essence. DEET (97%, SKU: D100951) was purchased from Sigma-Aldrich. Jasmine Lactone (97%, CAS Number:
35 25524-95-2) was purchased from Precision Technologies, Singapore. The compounds were dissolved in 100% ethanol, according to the concentration stated in the corresponding experiment.

For the hand assay (for *Aedes aegypti*), compounds were dissolved in 100% ethanol to make up 1 mL of solution according to the concentration stated in the corresponding experiment. The solution was added dropwise onto a cut out of a piece of fabric with a diameter of 10 cm. The fabric was left to dry in a fume hood for 5 minutes before usage or
5 longer in the case of duration experiments. The dried fabric was placed in between the donut lid and onto the cage.

For the blood-feeding assay (for *Culex quinquefasciatus*), compounds were dissolved in 100% ethanol to make up 200 μ L of solution. The solution was added dropwise onto mice skins that were wrapped around the blood reservoir and left to dry in a fume hood for 5
10 minutes before usage.

Mosquito experiments:

The *Aedes aegypti* (Singapore Strain) and *Culex quinquefasciatus* (Singapore Strain) used in the experiments were reared in environmental chambers at $28\pm1^{\circ}\text{C}$ and 75-80% relative humidity on a 12:12 hour photoperiod. The larvae were fed with a mixture of grounded fish
15 food flakes (Tetramin) and dry yeast granules (2:1) and adult mosquitoes were provided with 10% sugar solution. The blood feedings were carried out using a membrane feeding system (Orinno Technology) with rabbit blood and mouse skins as the membrane.

Hand Assay for *Aedes aegypti*:

For each experimental set of at least 3 repeats, 20 female mosquitoes aged 5 – 7 days were
20 used. The mosquitoes were starved for 12 hours (h) with access only to water before being placed in a rearing cage (30 cm x 30 cm x 30 cm) and they were allowed to acclimatize for 10 minutes before the start of the experiment. Only female *Aedes aegypti* which exhibit host-seeking behaviour were used. The cage was purchased from Bug Dorm and contained an opening with a sleeve for transferring mosquitoes and two screen ports (wired screen with
25 donut lid) on the left and right side of the cage that has a diameter of 9 cm (FIG. 1). For the experiment, the wired screen of one screen port was replaced with cling wrap for a better view, and the wired screen of the other screen port was replaced with a cut out of a fabric (diameter: 10 cm) that is soaked with the tested compounds.

To induce a host-seeking response, 10% CO_2 and 90% air mixture were introduced at 3
30 NL/min (normal liters per minute) into the cage via a fly pad placed at the top of the cage (FIG. 1). Mosquitoes were allowed to acclimatize for 10 minutes before the start of the experiment. A timer of 5 minutes started once the hand was placed onto a 90 mm petri dish cover that was placed over the screen port to create a gap between the fabric and the hand. A photograph was taken every minute for 5 minutes for quantification purposes. The control

experiment was usually conducted with fabric soaked with the diluent (100% ethanol). Each experiment consisted of 3 repeats of control and 3 repeats of treatment using the same cages of mosquitoes. For different compounds or the same compound at different concentrations, fresh cages and mosquitoes were used.

- 5 A schematic drawing of the cage used in this experiment is show in FIG. 1. The figure shows:
 1. Wiring mesh for viewing of mosquito and air exchange. 2. 10% CO₂ and 90% air mixture
 are introduced at 3 NL/min (normal liters per minute) into the cage *via* a fly pad placed at the
 top of the cage. 3. Wire mesh from the screen port replaced with cling wrap for a better view
 of the opposite screen port. 4. The posterior end of the cage containing an opening covered
 10 by sleeves that had been removed for illustration purposes. 5. The wire mesh of the screen
 port replaced with a cut out of a cloth that is soaked with the tested compound. 6. A 90 mm
 petri dish cover with a cut out of 70 mm placed over the screen port to create a gap between
 the cloth and the hand. 7. Filter paper covering the side of the cage facing the subject's hand
 to minimize air exchange and block vision.

15 Two-Port Assay for *Aedes aegypti*:

- The 2-port assay set-up was modified from the Y-tube olfactometer (FIG. 2). The cylinder
 traps and the holding cage are separated by sliding doors which are lifted at the start of the
 experiment. At the other end of the holding cage, a square opening that has a 20 cm box fan
 fitted is used to create the airflow. The opening is covered using nylon mesh and the rate of
 20 the airflow when the box fan is switched on is 81 - 84 feet/min. At the other end of the
 cylinder traps, donut lids with testing fabrics that are either impregnated with active
 compounds or solvent were used to act as a barrier between the human attractant (hand)
 and the mosquitos that enter the traps.

- Before the start of the experiment, 50 female *Ae. aegypti* mosquitoes aged 5 – 7 days were
 25 placed in the holding cage and were allowed to acclimatize for 20 minutes. During the
 acclimatization period, fabrics soaked with either the solvent or active compounds were
 prepared, allowed to dry, and placed at the end of the cylinder traps (6 in FIG. 2). The
 cylinder traps with the compound-impregnated fabrics were secured onto the holding cage.
 Two tubes supplying 10% CO₂ and 90% air mixture at 3 NL/min were inserted into a
 30 diaphragm on the top of the cylinder traps (7 in FIG. 2) and turned on at the end of the
 acclimatization period. Next, the box fan (2 in FIG. 2) was turned on to a level that induced
 an airflow of 81 - 84 feet/min before the shutter doors (3 in FIG. 2) were lifted. Hands were
 placed at the end of each cylinder trap to act as attractants for the female mosquitoes. The
 mosquitoes were allowed to enter freely into either of the traps for 8 minutes and after the
 35 given time, the shutter doors were closed and the box fan and CO₂ were switched off. The

numbers of mosquitoes that were trapped in each of the cylinder traps were accounted. The mosquitoes that did not enter either of the traps and remained in the holding cage were removed. The box fan was turned on with the shutter lifted to air the holding cage for 15 minutes before the start of the next set of experiments.

- 5 A schematic drawing of the cage used in this experiment is shown in FIG. 2. The figure shows: 1. The main holding cage to house mosquitoes. One side of the cage can be opened for removal of unattracted mosquitoes and cleaning. 2. Box fan that is filtered by a mesh. A 200 mm diameter box fan is used to induce air flow at a rate of 81 - 84 feet/min. 3. The shutter door covers the opening that is connected to the cylinder traps. Doors that can be
10 lifted to the start of the experiment. 4. Cylinder traps to trap the mosquitoes during the process of the mosquitoes. 5. The funnel-shaped design at the connector between the holding cage and the cylinder traps allowed for ease of entry and reduced the mosquito's ability to escape the trap during the experiment. 6. Compound-impregnated fabrics that are secured by donut lids at the end of the cylinder traps. 7. Gas tubes that supply 10% CO₂ and
15 90% air mixture at 3 NL/min through diaphragms situated on the top of the cylinder traps.

Blood Feeding Assay for *Culex quinquefasciatus*:

The cage for this assay was custom-made and has dimensions of 10 cm x 10 cm x 10 cm. The cage contains an opening with a sleeve for transferring mosquitoes and another opening with mesh for blood feeding with a diameter of 8 cm (FIG. 3).

- 20 20 females *Culex quinquefasciatus* mosquitoes aged 4 – 6 days that exhibits host-seeking behavior were transferred from the rearing cage to the testing cage (10 cm x 10 cm x 10 cm) (FIG. 3). They were allowed to acclimatize for 10 minutes in the dark before the start of the experiment. Blood reservoirs (feeding probes) from Orinno Technology membrane feeding system were wrapped with mice skins with skin hair removed. 1 mL of fresh rabbit blood was
25 added to the reservoir. Testing compounds were dissolved in 100% ethanol to make up 200 µl of solution and were added dropwise onto mice skins. The reservoirs were left to dry in a fume hood for 5 minutes before usage. For each repeat, the 20 mosquitoes were allowed to feed on the blood ad libitum for 15 minutes. After 15 minutes, the mosquitoes were removed and quantified for the number of blood-fed mosquitoes.

30 Quantification:

Hand Assay (push-pull): The number of mosquitoes landing and probing on the fabric for the 5 minutes was added up and divided by 5 to get an average landing number. The repellency = $(C-T)/C \times 100\%$, where C is the average landing number for the control and T is the average landing number for the tested compound.

Two-Port Assay: The number of mosquitoes trapped in the cylinder traps at the end of the 8 minutes was recorded. The preference of the mosquitoes was calculated by dividing the number of mosquitoes in each trap by the total number of mosquitoes released in the test chamber. The percentage of mosquitoes in the treatment was directly compared to that in the control traps.

Blood Feeding Assay: The number of blood-fed mosquitoes was divided by the total number of mosquitoes in the cage (20) to get a percentage of the blood-fed mosquitoes. The percentage of blood-fed mosquitoes in the treatment was directly compared with that in the control (ethanol) groups.

10 ***Bed bug experiments:***

The bed bugs (*Cimex hemipterus*) used in experiments were maintained in incubators with 26 ± 1 °C and $40\pm10\%$ relative humidity on a 12:12 hour photoperiod as reported (Zhang *et al.*, Pest Manag Sci. 2023, 10.1002/ps.7829). Only adult males were used in the experiments to prevent oviposition in the experimental arenas.

15 *Petri Dish Assay set up:*

This experiment was set up according to the methods described in Zhang *et al.*, 2023. Briefly, a glass Petri dish (Diameter: 15 cm x Height: 2 cm) without the cap was used as the arena for the experiment (FIG. 4). To prevent bed bugs from escaping, the inner wall of the Petri dish was treated with polytetrafluoroethylene (PTFE). A filter paper (Diameter: 15 cm) was cut into two halves; 1 half was treated with approximately 1.4 mL of 100% ethanol; and the other half was treated with approximately 1.4 mL of either DEET or Jasmolactone (2% (v/v) or 5% (v/v)) solution. The filter papers were allowed to dry under laboratory conditions for 30 minutes and fixed onto the base of the Petri dish thereafter. 10 bed male bugs were introduced to the center of the Petri dish and the numbers of bed bugs on either of the filter paper were recorded at 2 h and 6 h with 6 repeats for each treatment.

25 *Arena Assay set up:*

This experiment was set up according to the methods described in Zhang *et al.*, 2023. Briefly, the arena consisted of a piece of tan kraft paper was used to line the bottom of a blue plastic tray (Length: 95 cm x Width: 75 cm x Height: 10 cm) and PTFE was coated on the wall of the inner side of the tray to prevent the bed bugs from escaping. 100 male bed bugs were placed at the center of the arena for acclimation 12 to 14 H before the test. The bed bugs were confined within a plastic ring (Diameter: 6 cm x Height: 5 cm) that has PTFE coating on the inner wall to prevent escapees. Before the start of the experiment, each leg of a 3-legged wooden stool (Diameter: 25 cm x Height: 32 cm) was placed in a white ClimbUp insect

interceptor (Diameter: 15.2 cm x Height: 2.3 cm; Susan McKnight, Inc., Memphis, TN, USA). To prevent the bed bugs from climbing up the legs, PTFE was used to coat the inner wall of the interceptor. The outer wall of the interceptor was covered by fabric surgical tape (Type: 1530C-1; 3M Medical Devices and Materials Manufacturing Co., Ltd. Shanghai, China) that
5 was treated with either 100% ethanol, Jasmolactone solution, or DEET solution. The compounds were allowed to dry for 30 minutes before being placed in the arena and under the legs of the stool about 1 H into the dark cycle. At the top of the stool, CO₂ was released at a rate of 220 mL/min into a glass bottle and the plastic ring that contained the bed bugs was removed. The number of bed bugs trapped in the interceptors was recorded at 1 h, 2 h,
10 and 4 h after the start of the experiment and was repeated 4 times.

Quantification:

Petri Dish Assay: The repellency was calculated according to the methods described in Zhang *et al.*, 2023 as follows: Repellency = $(C - T) / C \times 100\%$, where C is the mean
15 number of bed bugs staying on the treated half of the filter paper in all control Petri dishes and T is the number of bed bugs staying on the treated half of the filter paper in one test Petri dish.

Arena Assay: In the arena assay, the percentage of bed bugs captured by the interceptors that were treated with different compounds were summarized and calculated according to the formula $T = P / S \times 100\%$ described in Zhang *et al.*, 2023, where T is the percentage of
20 bed bugs trapped in the interceptor, P is the number of bed bugs trapped in interceptor and S is the total number of bed bugs trapped in all interceptors.

Tick experiments:

The Ticks (*H. longicornis*) used in experiments were maintained under laboratory conditions at 22-25°C with a 12:12 hour photoperiod and 85% relative humidity, according to the
25 previously published method (Zhong *et al.*, 2021).

Petri Dish Assay Set Up:

This experiment was set up according to the published method by Zhong *et al.*, 2021 and similar to that of FIG. 4. Briefly, a Petri dish (Diameter: 6 cm x Height: 2 cm) was used as the arena for the experiment. A filter paper (Diameter: 6 cm) was cut into two halves; 1 half was
30 treated with approximately 1 mL of 100% ethanol; the other half was treated with approximately 1 mL of either DEET or Jasmolactone (2% (v/v) DEET, 2% (v/v) and 0.2% (v/v) Jasmolactone) in ethanol solution. The filter papers were allowed to dry under laboratory conditions for 30 minutes and fixed onto the base of the Petri dish thereafter. 40-60 ticks were introduced to the center of the Petri dish and the numbers of ticks moving towards or

away from the treatment filter paper were recorded for 30 minutes and the experiment was repeated 3 times.

Quantification:

- 5 The method for measuring the repellency is the same as described for the Petri Dish Assay for Bed bugs in previous section.

Biting midge experiment:

Biting midges prefer humid and warm environments, and only females feed on blood. The biting midge experiment herein was conducted outdoors.

Site selection:

- 10 Expose the calves and closely observe the landing behaviour of midges. Drive them away before their mouthparts penetrate the skin. A test site is deemed suitable if more than 10 midge landings are recorded within 15 min.

Repellency Test:

- 15 Two human subjects were selected for testing each repellent sample, who should abstain from consuming alcohol, tea or coffee before and during the test and avoid using scented products. Spray one exposed calf evenly with the sample and leave the other exposed calf untreated as a control. Observe 15 min and record the number of midge landings. After 3 hours, perform the observation and record the same again.

Quantification:

- 20 Repellency (%) = $C-T/C \times 100\%$, where C is the number of landings on the untreated calf, T is the number of landings on the treated calf.

Human Repeat Insult Patch Test (HRIPT):

- 25 The Human Repeat Insult Patch Test (HRIPT) is a clinical method used to assess whether a product causes irritation or sensitization to human skin. The test involves exposing participants to the chemical substance nine times over a period of three weeks, with each exposure lasting 24 or 48 hours. Following a two-week rest period, a challenge test is conducted on both exposed and non-exposed areas. This challenge test involves a 24- or 48-hour patch application, with clinical responses scored accordingly. HRIPT is commonly employed to verify the safety of cosmetics, skincare products, and other personal care items.
- 30 In this study, the test was conducted by a third-party testing agency.

Example 1: Jasmolactone effects on *Aedes aegypti* mosquitoes:**Hand Assay for Jasmolactone**

A titration test ranging from 0.1% (v/v) to 2% (v/v) was conducted for Jasmolactone to evaluate its repellency compared to DEET at the same concentrations. Notably, at 2% (v/v), Jasmolactone exhibited 100% protection which is slightly better than DEET (97% protection). Furthermore, as the concentration decreased, DEET exhibited a significant decline in efficacy, dropping to 64% at 1%. In contrast, Jasmolactone maintained substantial protection even at the low concentration of 1% (v/v), registering an efficacy of 90%. Jasmolactone exhibited similar protection at 0.1% (v/v), 0.2% (v/v), and 0.5% (v/v) but protection of DEET continued to drop as the concentration decreased (FIG. 5).

Two-port Assay for Jasmolactone:

Two-ports assays were conducted for Jasmolactone and DEET at various concentrations, including 0.1% (v/v), 1% (v/v), and 2% (v/v). Notably, Jasmolactone at 2% (v/v) demonstrated a high level of repellency, with only 1.3% of the female mosquitoes entering the cylinder traps containing fabrics impregnated with Jasmolactone. In comparison, the 2% (v/v) DEET control saw 12.7% of mosquitoes entering the traps. As the concentration decreased, a higher percentage of mosquitoes entered the treated cylinder traps (2.7% of mosquitoes in 1% (v/v) Jasmolactone-treated traps and 8.0% of mosquitoes in 0.1% (v/v) Jasmolactone-treated traps). In contrast, significantly more mosquitoes entered the DEET-treated cylinder traps, with 25.1% of mosquitoes in 1% (v/v) DEET-treated traps and 35% of mosquitoes in 0.1% (v/v) DEET-treated traps (FIG. 6).

Duration test on the repellency of Jasmolactone:

To evaluate the duration of the repellent activity of Jasmolactone, fabric was soaked in a 5% (v/v) Jasmolactone solution (100% ethanol), and its repellency against *Aedes aegypti* was observed 6 hours and 8 hours post-application. Using the hand assay, the repellency was 99.44% at 6 hours and 98.67% at 8 hours (FIG. 7). These results demonstrate the excellent duration of the repellent effect of the 5% (v/v) Jasmolactone solution.

Those skilled in the art can make appropriate adjustments to the solution composition based on common general knowledge in this field or related fields, such as cosmetics and perfumery, to achieve complete protection for 8 hours (i.e., 100% repellency). For example, increasing the water content or adding humectants such as propylene glycol or glycerol can reduce evaporation and extend the repellent duration. A new 5% (v/v) Jasmolactone solution (mix) can be formulated with a volumetric ratio of Jasmolactone, ethanol, propylene glycol,

and water at 5:60:15:20. Testing with the hand assay method confirmed that the repellency for both 6 hours and 8 hours reached 100% (FIG. 7).

In comparison, to achieve complete protection for up to 8 hours, common mosquito repellents such as DEET, picaridin, or IR3535 require concentrations of at least 20% to 30%.

- 5 However, using these compounds at high concentrations poses disadvantages in terms of safety, odour, greasiness, and solution stability.

Jasmine Lactone has a strong repellency against *Aedes aegypti* mosquitoes:

- As shown in FIG. 8, 2% (v/v) of Jasmine Lactone showed a high efficacy of 100% in repelling *Ae. aegypti*, similar to that of 2% (v/v) Jasmolactone and outperforming 97.36%
10 observed for 2% (v/v) DEET. Similarly, those skilled in the art can anticipate that other compounds falling within the Formula (I) described herein will exhibit effects very similar to those demonstrated in the examples.

Example 2: The effect of Jasmolactone towards *Culex quinquefasciatus*:

- In the blood-feeding assay, 52% of *Culex quinquefasciatus* females successfully engorged
15 on the rabbit blood from the control feeding probe sprayed with solvent (ethanol). However, a notable shift was observed with the application of 2% (v/v) Jasmolactone. In this case, none of the females opted to take blood from the blood reservoir with the application of 2% (v/v) Jasmolactone on the mice's skin (FIG. 9).

Example 3: The effect of Jasmolactone towards bed bugs:

- 20 In FIG. 10, no significant differences were observed between DEET 2% (v/v) and Jasmolactone 2% (v/v) as well as between DEET 5% (v/v) and Jasmolactone 5% (v/v). Additionally, the enduring efficacy of the repellency was evident even after 6 hours, with no significant differences between the repellency between these two different time points. Therefore, Jasmolactone works well as an insect repellent against bed bugs.
25 FIG. 11 illustrates that, like the effect of DEET, Jasmolactone-treated interceptors proved to be highly effective in preventing bed bugs from entering. Notably, the long-lasting efficacy of the compound was evident at 4 h, Jasmolactone remained as effective in deterring the bed bugs as it was at 1 h.

Example 4: the effect of Jasmolactone towards Ticks:

- 30 In FIG. 12, Jasmolactone, it is evident that both 0.2% (v/v) and 2% (v/v) concentration of Jasmolactone were effective in repelling ticks from the treated filter paper, similar to that of 2% (v/v) DEET. This experiment serves as a compelling demonstration of Jasmolactone's efficacy as an insect repellent for ticks.

Example 5: the effect of Jasmolactone towards biting midges

The experiment was conducted in an tropical outdoor environment. The testing site was located in Shiping Village, Heqing Town, Danzhou City, Hainan Province, China (19°35'06.0"N, 109°39'49.0"E), surrounded by lychee trees, longan trees, and landscaped shade trees. The experiment was conducted on 3 Aug 2024, from 10:30 to 14:30 under clear weather conditions. The maximum temperature during the test was 37°C, and the minimum was 31°C. The experimental personnel surveyed the density and aggressiveness of biting midges on-site and confirmed that the conditions met the criteria described earlier in the Materials and Methods section.

Commercial DEET-based repellents typically have a concentration around 10%. In outdoor settings, factors such as high temperatures and air currents usually reduce their protection time against mosquitoes to approximately 2 hours, despite the claims of up to 4 hours under laboratory conditions. Limited information is available regarding their efficacy against biting midges. Therefore, as a matter of experimental design, we referenced the working concentration and protection time of DEET. Two test samples were prepared: a 10% (v/v) DEET solution and a 10% (v/v) Jasmolactone solution. The repellency was tested at two time points: immediately after application (0 H) and 3 hours post-application (3 H). The results are shown in Table 1.

Table 1. Repellency of DEET and Jasmolactone against biting midges

Sample	Repellency (%)	
	0 H	3 H
Jasmolactone 10%	100.00 ±0.00	100.00 ±0.00
DEET 10%	100.00 ±0.00	57.57 ±3.85

As shown in Table 1, when the experiment was conducted immediately after application, both DEET and Jasmolactone at 10% (v/v) achieved 100% repellency against biting midges outdoors. After 3 hours, the repellency of the DEET sample significantly dropped to 57.57%, and it was in fact no longer effective in preventing midge attacks. In contrast, Jasmolactone maintained a 100% repellency even after 3 hours. These results indicate that 10% (v/v) Jasmolactone demonstrates superior outdoor durability against biting midges compared to DEET at the same concentration.

Example 6. The safety assessment of Jasmolactone

Jasmolactone is commonly used as fragrance and flavours. Many fragrance and flavours compounds have undesirable side effects such as skin irritation and sensitization, as a result, their usage is typically restricted. For example, according to the EU Regulation (EC) No 1223/2009, cosmetics should not contain substances such as citronellol, citral, and linalool, unless specific conditions are met (see Appendix III: "List of Substances Which Cosmetic Products must not Contain except Subject to the Restrictions Laid down"). The above substances require labelling if the concentration exceeds the prescribed limits, with leave-on products requiring $\leq 0.001\%$ and rinse-off products $\leq 0.01\%$. Therefore, it is necessary to conduct a safety assessment for the candidate compound provided herein.

Interestingly, the compounds mentioned in the previous paragraph are common ingredients in mosquito repellent products, especially those marketed as natural or containing plant essential oils. For example, a commercial mosquito repellent lists the ingredients: 9% lemon eucalyptus oil, 3% camphor, and 1% menthol. Based on the composition of lemon eucalyptus oil, the citronellol content in this product is approximately 0.663%. Another product lists 18% lemon eucalyptus oil and 2% lemon citronella oil, with the citronellol content calculated to be approximately 1.32%. As substances and preparations applied to the human skin and outer organs, these mosquito repellents when viewed from a cosmetic perspective, should raise safety concerns. However, the mandatory regulations for skin safety of mosquito repellents are usually less stringent than those for cosmetics, and therefore their irritation and sensitization potential have not been adequately addressed. And sometimes they may even be mistakenly considered safer, simply because they contain natural ingredients.

To evaluate whether the composition provided herein poses any skin safety concerns, the inventors commissioned a third-party testing agency, ALS Global, to conduct a Human Repeat Insult Patch Test (HRIPT) on a 5% (v/v) Jasmolactone solution (mix) as described in Example 1. The test aimed to assess skin irritation and sensitization potential. The testing process was outlined in the Materials and Methods section. The results for the 5% (v/v) Jasmolactone solution showed no significant adverse skin reactions in all volunteers during both the induction and challenge phases, indicating that under the HRIPT testing conditions, this sample did not exhibit skin irritation or sensitization potential, and is therefore considered safe.

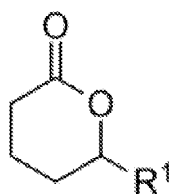
Beyond irritation and sensitization considerations, since repellents are used in large quantities and remain in the environment, their impact on the ecological environment should

also be considered. As mentioned earlier, compounds like citronella oil, picaridin, and nootkatone are known to have aquatic toxicity. However, the exemplary repellent compounds Jasmolactone and Jasmine Lactone, as reported by the Research Institute of Fragrance Materials, do not present such environmental risks (Api AM., et al., RIFM
5 fragrance ingredient safety assessment, tetrahydro-6-(3-pentenyl)-2H-pyran-2-one, CAS Registry Number 32764-98-0. Food Chem Toxicol. 2022 Jan 15;159 Suppl 1:112734; Api AM et al., RIFM fragrance ingredient safety assessment, 5-hydroxy-7-decenoic acid δ -lactone, CAS Registry Number 25524-95-2. Food Chem Toxicol. 2022 Mar;161 Suppl 1:112853).

10

Claims

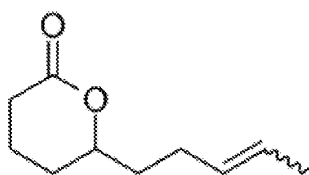
1. A composition for repelling an arthropod, the composition consisting essentially of one or more compounds according to formula (I), one or more carriers, and optionally one or more excipients:



(I)

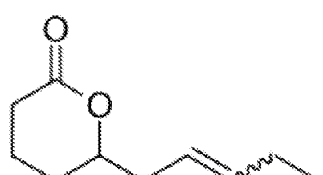
wherein,
R¹ is C₅ alkenyl.

2. The composition of claim 1, wherein the one or more compounds according to formula (I) are each independently selected from the group consisting of a compound according to formula (Ia) and a compound according to formula (Ib):



(Ia)

; or



(Ib)

3. The composition of claim 1 or 2, wherein the composition consists essentially of two or more compounds according to formula (I), one or more carriers, and optionally one or more excipients.
4. The composition of claim 2 or 3, wherein the composition consists essentially of a compound according to formula (Ia), a compound according to formula (Ib), one or more carriers, and optionally one or more excipients.
5. The composition of any one of claims 2-4, wherein the compound according to formula (Ia) is jasmine lactone, and the compound according to formula (Ib) is jasmolactone.

- 5 6. The composition of any one of claims 1 to 5, wherein the one or more carriers is an aqueous solvent, an organic solvent, or a mixture thereof, for example, the one or more carriers may be a monohydric alcohol (e.g. ethanol).
- 10 7. The composition of any one of claim 6, wherein the one or more compounds according to formula (I) are present in the composition at an amount of from about 0.001% (v/v) to about 15% (v/v), for example, from about 0.1% (v/v) to about 5% (v/v).
8. A method of repelling an arthropod, the method comprising exposing the arthropod to the composition of any one of claims 1 to 7.
- 15 9. The method according to claim 8, wherein the arthropod is of the order Hemiptera, Hymenoptera, Siphonaptera, Diptera, Araneae, Ixodida, or Blattodea.
- 20 10. The method according claim 8 or 9, wherein the arthropod is a mosquito, a bed bug, a tick, an ant, a cockroach, a flea, a mite, a spider, a termite, a biting midge or a wasp.
- 25 11. The method according to any one of claims 8 to 10, wherein the arthropod is a mosquito.
12. The method according to claim 11, wherein the mosquito is of the genus *Aedes*, *Culex* or *Anopheles*.
- 30 13. The method according to claim 11 or 12, wherein the mosquito is of the species *Aedes aegypti*, *Culex quinquefasciatus*, *Anopheles sinensis*, or *Anopheles gambiae*.
14. The method to any one of claims 8 to 13, wherein exposing the arthropod to the composition comprises contacting a subject or an article with the composition.
15. The method according to claim 14, wherein the subject is a human.
- 35 16. The method according to claim 14, wherein the subject is a domesticated animal, for example a household pet or a livestock animal.

17. The method according to claim 14, wherein the article is selected from the group consisting of furniture, clothing, candle, air diffuser, tablet, cosmetic, netting, building material, and incense.