

COMPOSITIONS AND METHODS FOR THE ATTRACTION AND REPULSION OF INSECTS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 61/684,242 filed August 17, 2012, entitled Compositions and Methods for the Attraction and Repulsion of Insects, U.S. Provisional Patent Application No. 61/805,172 filed March, 26, 2013, entitled Compositions and Methods for the Attraction and Repulsion of Insects and U.S. Provisional Patent Application No. 61/858,931 filed July 26, 2013, entitled Compositions and Methods for the Attraction and Repulsion of Insects, the contents of each of which are herein incorporated by reference in their entireties.

FIELD OF THE INVENTION

[0002] The present invention relates to the field of insect attractants and repellents as well as methods of trapping and/or altering the behavioral patterns of vector pests such as mosquitoes and other hematophagous pests, and the like.

BACKGROUND OF THE INVENTION

[0003] Mosquito-borne illnesses are responsible for the deaths of more than one million people annually. Malaria is one such illness posing a major health problem in tropical and subtropical regions. Another global killer is the Dengue virus, transmitted by *Aedes aegypti* which infects 100 million people annually primarily in Latin America and Asia. Mosquito-borne illnesses are also on the rise in the United States. Since the first reported human infections in New York State in 1999, the West Nile Virus has steadily moved south and west with detection currently recorded in all of the States of the continental United States. Eastern Equine Encephalitis (EEE) is another arbovirus transmitted by mosquitoes that is also causing illness in individuals in the United States as well as in Central and South America. Serious infections of EEE are characterized by seizures and coma leading to death in about half of these patients. Therefore, there exists a worldwide need for safe, effective and affordable agents to protect humans from mosquitoes and other vector pests.

[0004] Many previous methods as well as methods in current practice for controlling mosquito populations rely on chemicals that are harmful to human health as well as to plant and

animal species in the environment. One such chemical is N,N-diethyl-meta-toluamide (DEET). DEET was registered as an insect repellent in 1957 after first being used by the military in 1946. There are over 225 DEET containing products registered for use on skin and/or clothing making it the most widely utilized insect repellent in the market. Unfortunately, DEET poses a health hazard in mammals, having been shown to inhibit acetylcholinesterase, an enzyme affecting muscle control. Since the introduction of DEET, very few novel compounds have made it into the market.

[0005] One compound that has been introduced since DEET is permethrin. Permethrin is an insecticidal neurotoxin that destabilizes the cell membrane of neurons eventually leading to insect death. Mammalian toxicity for permethrin is low, but it can cause harm when coming in contact with the eyes or lungs. Also, the toxicity of permethrin to aquatic animals and aquatic ecosystems is high. With increasing awareness of the harmful effects of these chemicals and their control methods, there remains a need in the field to develop methods, compounds and compositions for controlling insect populations and insect behavior with minimal risk to humans and the environment.

[0006] It is known that female mosquitoes track vertebrate blood-meals primarily through carbon dioxide (CO₂) emissions in exhaled breath (Gillies M.T., *The role of carbon dioxide in host-finding by mosquitoes (Diptera: Culicidae): a review*. Bull. Entomology Res. 1980. 70:525-532). CO₂ is sensed in specialized neurons in the mosquito maxillary palp that express heteromeric CO₂-receptor proteins, highly conserved across the order Diptera. Recent studies utilizing electrophysiology and behavior assays have demonstrated that certain small molecules can stimulate or inhibit the CO₂ receptor (Turner, S.L. et al., *Ultra-prolonged activation of CO₂-sensing neurons disorients mosquitoes*. Nature. 2011 Jun 2;474(7349):87-91). Such molecules that inhibit the CO₂ receptor are currently being explored in the field as mosquito deterrents (or repellents), while molecules that stimulate mosquito CO₂ receptor activity are attractive targets for use in insect traps. It is also the case that strong and prolonged activators of CO₂ receptor activity can have a “masking” effect, with concomitant repellent outcomes, because prolonged activation would saturate the CO₂ receptor signaling, thereby rendering the mosquito unable to track CO₂ plumes. In this situation, even CO₂ receptor activators would be considered repellents for purposes of reducing their contact with subjects (e.g. humans and other animals, including but not limited to cattle, horses, cats, dogs, and pigs) and their areas of habitation.

[0007] The present invention provides compounds and compositions that directly interact with the CO₂-responsive machinery. These compositions are desirable for use in mosquito control due to their specificity and low toxicity. The compounds described herein include a number of natural products as well as structurally similar synthetic molecules, potentially making these compounds less harmful to the environment and to human health.

[0008] Thus, the methods and compositions described herein which activate and/or inhibit CO₂ receptor activity in vector pests represent a solution to address the long felt need for improved vector pest control with minimal risk to humans and the environment.

SUMMARY OF THE INVENTION

[0009] In some embodiments, the present invention provides compounds and/or compositions that alter or modify the behavior of vector pests. Some such compositions may comprise at least one of compounds OLI0001-OLI0121. Such compositions may comprise a compound selected from the group consisting of compounds OLI0001-OLI0013. Such compounds may be present at a concentration of from about 0.01% to about 5%.

[0010] In some embodiments, compositions of the present invention may comprise a combination of two compounds, wherein at least one compound is selected from the group consisting of OLI0001-OLI0004, OLI0006-OLI0008, OLI0010, OLI0011, OLI0013-OLI0015, OLI0017, OLI0018, OLI0020-OLI0022, OLI0024, OLI0025, OLI0027, OLI0096, OLI0097 and OLI0099. Compounds within such compositions may be present at a concentration of from about 0.01% to about 5%. In some cases, at least one compound is a beta activator selected from the group consisting of OLI0027, OLI0096, OLI0097 and OLI0099. Some compositions may comprise a combination of two compounds, wherein each compound is independently selected from the group consisting of OLI0006, OLI0008, OLI0013-OLI0022, OLI0024-OLI0029, OLI0063, OLI0091, OLI0092, OLI0096-OLI0100. Compounds within such compositions may be present at a concentration of from about 0.01% to about 5%. Some such compositions may comprise at least one beta activator selected from the group consisting of OLI0027 and OLI0096-OLI0100.

[0011] In some embodiments, compositions may comprise a synergistic combination of compounds. Some compositions may comprise at least one compound selected from the group consisting of OLI0014-OLI0018, OLI0022, OLI0024, OLI0025, OLI0027 and OLI0029. Some such compositions may comprise at least one other compound selected from the group consisting

of OLI0019-OLI0021, OLI0025, OLI0026, OLI0028, OLI0063, OLI0091, OLI0092 and OLI0100.

[0012] In some embodiments, compositions of the present invention may comprise a compound selected from the group consisting of OLI0067-OLI0070. Some such compositions may comprise a combination of two compounds, wherein at least one compound is selected from the group consisting of OLI0015, OLI0067-OLI0078, OLI0080, OLI0082-OLI0084, OLI0089, OLI0093, OLI0095, OLI0100 and OLI0102. Some compounds within such compositions may be present at a concentration of from about 0.01% to about 5%. Some such compositions may comprise at least one beta activator selected from the group consisting of OLI0074, OLI0084 and OLI0100. In some cases, such compositions may comprise a synergistic combination. In some cases, such compositions may comprise at least one environmentally friendly compound selected from the group consisting OLI0076, OLI0093 and OLI0102.

[0013] In some embodiments, compositions of the present invention may comprise a combination of three compounds, wherein each compound is individually selected from the group consisting of OLI0068, OLI0071, OLI0072, OLI0074, OLI0078, OLI0080, OLI0100 and OLI0102. Such compositions may comprise at least one environmentally friendly compound, selected from the group consisting of OLI0076, OLI0093 and OLI0102. Such compositions may comprise at least one beta activator selected from the group consisting of OLI0074 and OLI0100. Some compositions may comprise a synergistic combination comprising at least one compound selected from the group consisting of OLI0071, OLI0093 and OLI0102. Such compositions may comprise at least one other compound selected from the group consisting of OLI0015, OLI0072-OLI0078, OLI0080, OLI0082-OLI0084, OLI0089, OLI0095 and OLI0100.

[0014] In some embodiments, the present invention provides methods of modifying the behavior of a vector pest comprising exposing said vector pest to a composition of the present invention. Some such methods may comprise increased CO₂ responsive neuronal activity and/or CO₂ receptor activity in said vector pest. In some such methods, the vector pest is a flying dipteran, mosquito, sand fly, black fly, tsetse fly, biting midge, bed bug, assassin bug, flea, louse, mite and/or tick. Compositions of some such methods comprise a compound selected from the group consisting of compounds OLI0001-OLI0013. Compositions of other methods comprise a combination of two compounds, wherein at least one compound is selected from the group consisting of OLI0001-OLI0004, OLI0006-OLI0008, OLI0010, OLI0011, OLI0013-OLI0015,

OLI0017, OLI0018, OLI0020-OLI0022, OLI0024, OLI0025, OLI0027, OLI0096, OLI0097 and OLI0099. The concentration of some such compounds may be from about 0.5% to about 5%.

[0015] According to some methods, flying dipterans selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettidia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more members of the genus *Galindomyia*, one or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*, one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus *Orthopodomyia*, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the genus *Tripteroides*, one or more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*,

Glossina nigrofusca nigrofusca, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and one or more members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium metallicum*, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)) may be affected.

[0016] In some embodiments, methods of the present invention may comprise the use of compositions comprising a combination of two compounds, wherein each compound is independently selected from the group consisting of OLI0006, OLI0008, OLI0013-OLI0022, OLI0024-OLI0029, OLI0063, OLI0091, OLI0092, OLI0096-OLI0100. Some such methods may be used to in the control of vector pests that may include flying dipterans, mosquitoes, sand flies, black flies, tsetse flies, biting midges, bed bugs, assassin bugs, fleas, lice, mites or ticks. Flying dipterans may be selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettidia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more

members of the genus *Galindomyia*, one or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*, one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus *Orthopodomyia*, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the genus *Tripteroides*, one or more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and one or more members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium metallicum*, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticatum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

According to some such methods, compounds may be present as concentrations from about 0.5% to about 5%. According to some methods, composition may comprise synergistic combinations of compounds. Such synergistic combinations may be selected from the group consisting of OLI0014-OLI0018, OLI0022, OLI0024, OLI0025, OLI0027 and OLI0029. According to other synergistic methods, at least one other compound may be selected from the group consisting of OLI0019-OLI0021, OLI0025, OLI0026, OLI0028, OLI0063, OLI0091, OLI0092 and OLI0100.

[0017] In some embodiments, methods of the present invention may comprise vector pest behavioral modification comprising reduced CO₂ responsive neuronal activity and/or CO₂ receptor activity in said vector pest. Some such methods may comprise the use of composition wherein compounds are selected from the group consisting of OLI0067-OLI0070. According to some such methods, vector pests may be selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettidia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more members of the genus *Galindomyia*, one or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*, one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus *Orthopodomyia*, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the

genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the genus *Tripteroidea*, one or more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and one or more members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium metallicum*, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticatum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

[0018] Some methods may comprise the use of a composition wherein the composition comprises a combination of two compounds, wherein at least one compound is selected from the group consisting of OLI0015, OLI0067-OLI0078, OLI0080, OLI0082-OLI0084, OLI0089, OLI0093, OLI0095, OLI0100 and OLI0102. In some cases the concentration of at least one compound may be from about 0.01% to about 5%. In some cases, the vector pest is a flying dipteran selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and

Anopheles annulipes), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more members of the genus *Galindomyia*, one or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*, one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus *Orthopodomyia*, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the genus *Tripteroides*, one or more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and

Leptoconops torrens) and one or more members of the genus *Forcipomyia*), black flies of the family Simuliidae (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium metallicum*, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticatum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

[0019] In some embodiments, methods of the present invention may comprise compositions comprising a combination of three compounds, wherein each compound is individually selected from the group consisting of OLI0068, OLI0071, OLI0072, OLI0074, OLI0078, OLI0080, OLI0100 and OLI0102. Compounds within such compositions may be present at concentrations of from about 0.01% to about 5%. In some embodiments, such methods may be used to modify the behavior of a flying dipteran, wherein the flying dipteran is selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettidia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more members of the genus *Galindomyia*, one or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*, one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus

Orthopodomyia, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the genus *Tripteroides*, one or more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and one or more members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium metallicum*, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticatum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

[0020] In some embodiments, methods of the present invention may be used to modify the behavior of a bed bug. Such methods may comprise the use of at least one compound selected from the group consisting of OLI0001-OLI0012, OLI0014-OLI0022, OLI0024-OLI0029, OLI0052, OLI0059, OLI0063, OLI0065-OLI0072, OLI0074, OLI0076-OLI0079, OLI0084, OLI0091-OLI0093, OLI0095-OLI0097, OLI0099-OLI0102, OLI0104-OLI0107, OLI0109-OLI0115 and OLI0118-OLI0121. In some cases, bed bugs are repelled by such compositions. In some embodiments, bed bug repellent compositions may comprise at least one compound

selected from the group consisting of OLI0014-OLI0017, OLI0020, OLI0024, OLI0029 and OLI0102. According to other methods, compositions may be used to attract bed bugs. Attractant compositions according to such methods may comprise a combination of at least two compounds, wherein at least one compound is selected from the group consisting of OLI0007, OLI0008 and OLI0010.

[0021] In some embodiments, methods of the present invention may be biocidal toward one or more vector pests and may comprise the use of one or more compositions of the present invention. Such methods may comprise the use of compositions comprising one or more biocidal agents selected from the group consisting of OLI0001-OLI0003, OLI0005, OLI0006, OLI0009, OLI0011-OLI0014, OLI0016, OLI0017, OLI0019, OLI0020, OLI0021, OLI0024-OLI0029, OLI0052, OLI0059, OLI0065-OLI0077, OLI0079, OLI0084, OLI0091, OLI0092, OLI0096, OLI0097 and OLI0100-OLI0119. Such compositions may comprise biocidal agents at a concentration of from about 0.2 mg/ml to about 2 mg/ml. Such biocidal agents may affect one or more of a flying dipteran, mosquito, sand fly, black fly, tsetse fly, biting midge, bed bug, assassin bug, flea, louse, mite and/or tick. In some embodiments, biocidal agents are present at a concentration of from about 50 ppm to about 150 ppm. In other compositions, biocidal agents may be present at a concentration of from about 0.1% to about 0.5%. In other embodiments, such methods comprise compositions comprising one or more larvicidal agents selected from the group consisting of OLI0001-OLI0003, OLI0005, OLI0006, OLI0008, OLI0009, OLI0011-OLI0014, OLI0016, OLI0017, OLI0019, OLI0020, OLI0024-OLI0029, OLI0052, OLI0059, OLI0065-OLI0077, OLI0079, OLI0084, OLI0091, OLI0092, OLI0096, OLI0097, OLI0100-OLI0102, OLI0104-OLI0107 and OLI0109-OLI0119. Such larvicidal agents may comprise larvicidal activity toward larvae from one or more of a flying dipteran, mosquito, sand fly, black fly, tsetse fly or biting midge.

[0022] In some embodiments, the present invention provides devices comprising at least one of compounds OLI0001-OLI0102. Some such devices may comprise a patch. Such patches may comprise one or more materials selected from the group consisting of paper, plastic, metal, fabric, wax, polymeric materials, polyethylene, polypropylene, rubber, cellulose, silicon rubber and cellulose-based materials. In some cases, patches may comprise an area from about 1 cm² to about 5 cm². Some patches may comprise a shape selected from the group consisting of a circle, a square, a rectangle, a triangle and a polygon. In some cases, patches may comprise an adhesive.

Some patches may comprise a film or paper layer to protect said adhesive prior to application of said patch. Some patches may be square in shape with side lengths comprising 1.5 cm each.

Some patches may be applied to a subject's skin, clothing or apparel.

[0023] In some embodiments, devices of the present invention may be placed inside or attached to a holder selected from the group consisting of a pocket, a compartment, a cassette, a box or a clip. Such holders may be attached to a subject using an accessory device selected from the group consisting of a bracelet, a necklace, a wrist band, a collar, an arm band, an article of clothing or a clip-on device. In some embodiments, accessory devices may comprise an air diffuser.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The foregoing and other objects, features and advantages will be apparent from the following description of particular embodiments of the invention, as illustrated in the accompanying drawings. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of various embodiments of the invention.

[0025] Figure 1 is an electrophysiology trace illustrating a comparison between an activator, and inhibitor and control. The response is quantified as spikes/second in the adjacent histogram. The figure illustrates the basal activity of the carbon dioxide receptor with paraffin oil, the solvent for the chemicals tested using electrophysiology (top panel), compared to 1% concentrations of an inhibitor, 2-methoxy-3-methylpyridine (middle panel), and an activator, 2,4-lutidine (bottom panel). 2-methoxy-3-methylpyridine is approved for fragrance use and has a "nutty" odor. 2,4-lutidine has a "green" odor, is approved for cosmetic fragrance use and is listed by the Flavor and Extract Manufacturers Association (FEMA) as a GRAS compound (Generally Recognized As Safe).

[0026] Figure 2 is a histogram of data obtained from a landing assay. The landing assay is designed to identify lures for *Aedes aegypti*. The data of the histogram indicate that compounds cyclopentanone and 2-pentanone act as lures as compared to control. 2-ethylpyrazine is an activator of CO₂ receptors that can act as a repellent in this assay.

[0027] Figure 3 is a histogram of data obtained from a netsphere assay. The "netsphere assay" as used herein is a semi-field trail assay used to identify compounds that can serve as lures or repellents in a large area. The histogram depicts a sampling using compounds cyclopentanone

and 2-pentanone, which have been previously shown to be lures, and can act over large areas to attract mosquitoes. The controls included a carbon dioxide positive control and a repellent compound, 2,4-lutidine. This experiment was performed with *Aedes aegypti* mosquitoes.

DETAILED DESCRIPTION OF THE INVENTION

[0028] Given the tremendous impact vector pests have on the human condition, it is of great interest and imperative that compositions and methods be developed to minimize the deleterious effects these species have on the transmission of disease in animal species, especially humans and domesticated animals.

[0029] Described herein are compositions (including pharmaceutical compositions) and methods for the design, preparation and manufacture of compounds which alter the behavior of vector pests in a manner that is beneficial to animals, particularly humans. Such altered behavior may be the result of exposing a vector pest to compounds or compositions of the present invention in multiple forms. As used herein, the term “exposing” refers to applying a compound or composition to an object, surface, area, or region in such a manner and in sufficient proximity to a vector pest as to allow the sensing of the compound or composition by the vector pest. The resulting behavioral alteration may be induced by a compound or composition in the form of an attractant to a site distant from humans or human habitation or it may be induced by a compound or composition in the form of a repellent resulting in the pests being deterred from coming to or toward human beings or their habitats. It may also be induced by the use of a receptor activator in concentrations that saturate the response with the ultimate outcome resulting in a masking of the receptor sense. Consequently an activating compound may also become a vector pest repellent. As used herein, an “attractant” is any compound, composition or combination capable of attracting one or more pests, whereas a “repellent” is any compound, composition or combination capable of repelling or deterring one or more pests. Attractants may be used as a bait or lure in a trap. As used herein, a “bait” or “lure” is any compound, composition combination, object or chemically treated object capable of attracting one or more pests to a trap. Regardless of directionality, the objective of the present invention is the provision of compounds, compositions and methods which ameliorate, reduce, or eliminate the deleterious effects on human (or animal) health caused by pests, especially vector pests. As such, the compounds, compositions and/or combinations of the present invention are useful for the prevention of vector-borne illnesses in individuals, groups of individuals or large populations as

well as the spread of said illnesses. Said illnesses include, but are not limited to malaria, dengue, yellow fever, sleeping sickness, West Nile virus, Eastern equine encephalitis, river blindness, lymphatic filariasis, leishmaniasis, epidemic polyarthritis, Australian encephalitis and the like.

[0030] As used herein, a “pest” refers to any one of a number of species that cause harm, irritation, discomfort or general annoyance to humans or other animals. “Vector pests” are those organisms that are capable of carrying and/or transmitting a viral, bacterial, protozoan or other pathogen from reservoir to host.

[0031] Most vector pests are arthropod insects and may be hematophagous. Pests or vector pests may also include biting insects. Vector pests which are of the order *Hemiptera* may include, but are not limited to assassin bugs of the subfamily *Triatominae* (including, but not limited to members of the genus *Melanolestes*, *Platyeris*, *Pselliopus*, *Rasahus*, *Reduvius*, *Sinea*, *Triatoma* and *Zelus*) and bed bugs of the genus *Cimex* (including, but not limited to *Cimex lectularius*). Vector pests which are fleas of the order *Siphonaptera* may include, but are not limited to members of the genus *Ctenocephalides* (including, but not limited to *Ctenocephalides felis* and *Ctenocephalides canis*), *Pulex* (including, but not limited to *Pulex irritans*), *Dasypsyllus*, *Nosopsyllus* and *Xenopsylla*. Vector pests which are of the order *Ixodida* may include, but are not limited to ticks of the family *Nuttalliellidae* (including *Nuttalliella namaqua*), *Ixodidae* (including, but not limited to *Ixodes scapularis*, *Ixodes holocyclus*, *Ixodes hexagonus*, *Ixodes pacificus*, *Ixodes ricinus* and *Ixodes uriae*) and *Argasidae*. Vector pests which are lice of the order *Phthiraptera* may include, but are not limited to members of the genus *Pediculus* (including, but not limited to *Pediculus humanus capitis* and *Pediculus humanus humanus*) and members of the genus *Pthirus* (including, but not limited to *Pthirus pubis*). Vector pests which are of the order *Diptera*, including flying dipterans (the term “flying dipterans” as used herein refers to any members of the order *Diptera* that are capable of flight) may include, but are not limited to, members of the mosquito family *Culicidae* (including, but not limited to members of the genus *Aedeomyia*, members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), members of the genus *Armigeres*, members of the genus *Ayurakitia*, members of the genus *Bironella*, members of the genus *Borichinda*, members of the genus *Chagasia*, members of the genus *Coquillettidia*, members of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex*

australicus), members of the genus *Culiseta*, members of the genus *Deinocerites*, members of the genus *Eretmapodites*, members of the genus *Ficalbia*, members of the genus *Galindomyia*, members of the genus *Haemagogus*, members of the genus *Heizmannia*, members of the genus *Hodgesia*, members of the genus *Isostomyia*, members of the genus *Johnbelkinia*, members of the genus *Kimia*, members of the genus *Limatus*, members of the genus *Lutzia*, members of the genus *Malaya*, members of the genus *Mansonia*, members of the genus *Maorigoeldia*, members of the genus *Mimomyia*, members of the genus *Onirion*, members of the genus *Opifex*, members of the genus *Orthopodomyia*, members of the genus *Psorophora*, members of the genus *Runchomyia*, members of the genus *Sabethes*, members of the genus *Shannoniana*, members of the genus *Topomyia*, members of the genus *Toxorhynchites*, members of the genus *Trichoprosopon*, members of the genus *Tripteroides*, members of the genus *Udaya*, members of the genus *Uranotaenia*, members of the genus *Verrallina*, members of the genus *Wyeomyia* and members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium metallicum*, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticatum*) and sand flies (including but not limited to members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

Carbon Dioxide (CO₂) Response or Activity Targeting

[0032] The present invention provides compounds and compositions useful to activate, saturate and/or inhibit the activity of CO₂-responsive neurons, the receptors of which are conserved across different species of vector pests and are expressed by neurons in the antennae or maxillary palp. As used herein, a “CO₂ receptor” is a receptor or other cellular protein capable of sensing, binding or otherwise responding to CO₂ or to changes in CO₂ levels. A “CO₂-responsive neuron” is a neuron capable of directly sensing CO₂ or responds to changes in CO₂ levels and in which activity correlates with those levels.

[0033] As used herein, “neuronal activity” refers to cellular impulses that can be detected using electrophysiological methods.

[0034] In one embodiment, the compounds and compositions disclosed are activators of CO₂-responsive neurons. As used herein, an “activator” is any compound, composition or combination capable of stimulating neuronal activity in CO₂-responsive neurons. Activators may alter vector pest behavior in varying ways and as such may act as attractants or inhibitors depending on the application.

[0035] Activation, measured in spikes per second (spk/sec), may be reflected in an activity of by about 20-300 spikes per second (spk/sec), by about 20-200 spk/sec, by about 20-100 spk/sec, by about 20-80 spk/sec, by about 20-60 spk/sec, by about 20-40 spk/sec, by about 40-300 spk/sec, by about 40-200 spk/sec, by about 40-100 spk/sec, by about 40-80 spk/sec, by about 40-60 spk/sec, by about 60-300 spk/sec, by about 60-200 spk/sec, by about 60-100 spk/sec, by about 60-80 spk/sec, by about 100-300 spk/sec or by about 100-200 spk/sec. A “spike” refers to an impulse of neuronal activity as recorded through extracellular single-sensillum electrophysiology.

[0036] Activators of the present invention are divided into mild, moderate, strong and very strong. A “mild activator” is a compound, composition or combination that is able to directly activate CO₂-responsive neurons resulting in a spike rate of 20-40 spk/sec over the baseline activity of the neuron. A “moderate activator” is a compound, composition or combination that is able to directly activate CO₂-responsive neurons resulting in a spike rate of 40-60 spk/sec over the baseline activity of the neuron. A “strong activator” is a compound, composition or combination that is able to directly activate CO₂-responsive neurons resulting in a spike rate of 60-100 spk/sec over the baseline activity of the neuron. A “very strong activator” is a

compound, composition or combination that is able to directly activate CO₂-responsive neurons resulting in a spike rate of over 100 spk/sec over the baseline activity of the neuron.

Where activators are delivered in saturating concentrations to the effect of producing a repellent response, these compounds, compositions or combinations are referred to as “masking” agents.

Masking agents, therefore may also be termed repellents or deterrents.

[0037] In some embodiments, activator compounds of the present invention may comprise any of those listed in Table 1.

Table 1. Activator compounds

Compound No.	Compound
OLI0001	2,4-lutidine
OLI0002	2-ethylpyrazine
OLI0003	2-methoxypyrazine
OLI0004	2-methyltetrahydrofuran-3-one
OLI0005	4-ethylphenol
OLI0006	5-methyl furfural
OLI0007	butyl formate
OLI0008	cyclopentanone
OLI0009	ethyl 2-furoate
OLI0010	ethyl lactate
OLI0011	ethylvinylcarbinol
OLI0012	guaiacol
OLI0013	trans-2-methyl-2-butenal
OLI0014	2,3,5-trimethylpyrazine
OLI0015	2,3-dimethylpyrazine
OLI0016	2-acetyl-5-methyl furan
OLI0017	2-furyl methyl ketone
OLI0018	2-pentanone
OLI0019	allyl butyrate
OLI0020	cinnamyl nitrile
OLI0021	ethyl 3-hydroxyhexanoate
OLI0022	ethylacetoacetate
OLI0023	ethylvinylketone
OLI0024	gamma-heptalactone
OLI0025	methanethiol acetate
OLI0026	methyl crotonate
OLI0027	methyl levulinate
OLI0028	phenylacetaldehyde
OLI0029	phenylpropylaldehyde
OLI0030	2,4-dimethyl benzaldehyde

OLI0031	2,4-dimethyl-3-cyclohexene-carboxaldehyde (mixture of cis/trans forms)
OLI0032	2-ethyl-5(6)-methylpyrazine
OLI0033	2-methoxy-4-methylphenol
OLI0034	2-phenylpropionaldehyde
OLI0035	3-hexanone
OLI0036	4-ethylbenzaldehyde
OLI0037	4-oxoisophorone
OLI0038	acetyl-2-pyrazine
OLI0039	butan-3-one-2-yl butanoate
OLI0040	dimethyl succinate
OLI0041	dipropylenglykol-monomethyl ether
OLI0042	ethyl 3-hydroxybutyrate
OLI0043	ethyl-2,3,5(6)-dimethyl pyrazine
OLI0044	ethylformate
OLI0045	ethylisobutyrate
OLI0046	ethylisovalerate
OLI0047	ethyllevulinate
OLI0048	furfurylethylether
OLI0049	heptaldehyde
OLI0050	heptanone-4
OLI0051	hexanal
OLI0052	indole
OLI0053	isobutyl acetate
OLI0054	isobutyl propionate
OLI0055	isobutyl trans-2-butenate
OLI0056	isopropyl butyrate
OLI0057	isopropyl tiglate
OLI0058	methyl isovalerate
OLI0059	methylheptadienone
OLI0060	m-tolualdehyde
OLI0061	o-anisaldehyde
OLI0062	prenylacetate
OLI0063	propyl formate
OLI0064	R-+ pulegone
OLI0065	trans-cinnamaldehyde
OLI0066	valeraldehyde

[0038] In one embodiment the compounds and compositions disclosed are inhibitors of CO₂-responsive neurons. As used herein, an “inhibitor” is any compound, composition or combination capable of reducing neuronal activity in CO₂-responsive neurons. Inhibitors may

alter pest behavior in varying ways and as such may act as pest attractants or repellents depending on the application.

[0039] Inhibition, measured as relative reduction of activity, may be reflected in reduced activity of about 20-100%, by about 20-80%, by about 20-60%, by about 20-40%, by about 40-100%, by about 40-80%, by about 40-60%, by about 60-100% or by about 60-80%.

[0040] Inhibitors of the present invention are divided into mild, moderate and strong inhibitors. A “mild inhibitor” is a compound, composition or combination that is able to directly inhibit CO₂-responsive neuronal activity resulting in a 20-40% reduction in neuronal activity as compared to baseline activity of the neuron. A “moderate inhibitor” is a compound, composition or combination that is able to directly inhibit CO₂-responsive neuronal activity resulting in a 40-60% reduction in neuronal activity as compared to baseline activity of the neuron. A “strong inhibitor” is a compound, composition or combination that is able to directly inhibit CO₂-responsive neuronal activity resulting in a greater than 60% reduction in neuronal activity as compared to baseline activity of the neuron.

[0041] In some embodiments, inhibitor compounds of the present invention may include, but are not limited to any of those listed in Table 2.

Table 2. Inhibitor compounds

Compound No.	Compound
OLI0067	2,3-diethyl-5-methylpyrazine
OLI0068	2,3-diethylpyrazine
OLI0069	2-ethyl-3-methylpyrazine
OLI0070	2-methoxy-3-methylpyrazine
OLI0071	2-ethyl-3-methoxypyrazine
OLI0072	2-methoxy-3(5or6) isopropylpyrazine
OLI0073	cis-3-hexenyl acetate
OLI0074	furfurylpentanoate
OLI0075	octanone-3
OLI0076	Phenethyl propionate
OLI0077	trans-2-decenal
OLI0078	(Z)-hept-3-enylacetate
OLI0079	1-ethylhexyl tiglate
OLI0080	1-octanol
OLI0081	2,5-dimethyl-4-methoxy-3(2H) furanone
OLI0082	alpha,alpha-dimethyl phenethyl butyrate
OLI0083	cis-3-hexenyl butyrate

OLI0084	cis-5-octen-1-ol
OLI0085	ethyl nicotinate
OLI0086	Ethylheptanoate
OLI0087	Eucalyptol
OLI0088	furfurylpentenoate
OLI0089	Geranylacetone
OLI0090	Geranylbutyrate
OLI0091	methyl heptanoate
OLI0092	methyldamylketone
OLI0093	rosemary oil
OLI0094	whiskey lactone
OLI0095	Veratraldehyde

Beta activators

[0042] Three types of CO₂-responsive neurons reside in the maxillary palp of mosquitoes. These include cpA, cpB and cpC neurons. While activity from cpA neurons produces the largest amplitude spike during electrophysiological analysis, cpB and cpC neurons present in this region are responsive to skin odors (Lu, T. et al., *Odor coding in the maxillary palp of the malaria vector mosquito Anopheles gambiae*. Curr Biol. 2007 Sep 18;17(18):1533-44. Epub 2007 Aug 30). These neurons produce spikes with much lower amplitude than those produced by cpA neurons. Although the activity from cpB and cpC neurons cannot easily be distinguished from one another, their collective activity can be distinguished from cpA neurons due to their characteristic spikes. This is useful in the identification of compounds and compositions that only activate or inhibit cpB and cpC neurons or compounds and compositions that activate or inhibit both. As used herein, the term “beta activator” refers to any compound or composition that can stimulate cpB and cpC neuronal activity.

[0043] In some embodiments, beta activator compounds of the present invention may include, but are not limited to any of those listed in Table 3.

Table 3. Beta activator compounds

Compound No.	Compound
OLI0096	cis-3-hexenyl formate
OLI0097	hexyl formate
OLI0098	isoamyl formate
OLI0099	isoamyl propionate

OLI0100	methyl (E)-hex-3-enoate
OLI0101	peppermint oil
OLI0074	furfurylpentanoate
OLI0084	cis-5-octen-1-ol
OLI0079	1-ethylhexyl tiglate
OLI0027	methyl levulinate

Synergistic compositions

[0044] It has been unexpectedly found that certain compounds of the inventions, when combined produce synergistic outcomes with regard to their effect on neuronal activity. For example, some combinations were found to be strong activators although comprising only mild or moderate activator compounds. Likewise, other combinations were found to be synergistic inhibitors although comprising only mild or moderate inhibitor compounds. In addition, synergistic combinations were identified which act as either activators or inhibitors despite comprising a compound that individually displayed the opposite function when applied as a single compound.

Biocidal and/or lethal compounds

[0045] Some compositions of the present invention may comprise biocidal agents, also referred to herein as “biocides.” As used herein, the term “biocidal agent” or “biocide” refers to any agent capable of controlling (e.g. retarding growth, retarding reproduction, repelling, neutralizing harmful effects, sterilizing, immobilizing and/or killing) a biological organism. In some embodiments, such organisms are pests. In some embodiments, such pests are vector pests (e.g. a flying dipteran, mosquito, sand fly, black fly, tsetse fly, biting midge, bed bug, assassin bug, flea, louse, mite or tick.) As used herein, the term “biocidal activity” refers to the controlling capability of a given biocide. In some embodiments, biocides may be larvicides. As used herein, the term “larvicide” refers to an agent that exhibits biocidal activity toward one or more larvae. Such larvae may be pest larvae. In some cases, pest larvae comprise vector pest larvae (e.g. dipteran larvae, mosquito larvae or larvae from a sand fly, black fly, tsetse fly or biting midge.)

[0046] In some embodiments, biocides of the present invention are lethal. As used herein the term “lethal” is used to refer to any agent capable of causing death in one or more organisms that are exposed to such an agent. In some embodiments, such organisms are pests. In some

embodiments, such pests are vector pests. As used herein, the term “lethality” refers to the capability of a given agent to cause death in one or more organisms exposed to such an agent.

[0047] In some embodiments, biocidal compounds and/or compositions of the present invention may comprise one or more of the compounds listed in Table 4.

Table 4. Biocidal compounds

Compound No.	Compound
OLI0005	4-ethylphenol
OLI0020	cinnamyl nitrile
OLI0021	ethyl 3-hydroxyhexanoate
OLI0029	phenylpropylaldehyde
OLI0052	Indole
OLI0076	phenethylpropionate
OLI0077	trans-2-decenal
OLI0079	1-ethylhexyl tiglate
OLI0084	cis-5-octen-1-ol
OLI0102	Eugenol
OLI0103	phenethyl cinnamate
OLI0104	allyl cinnamate
OLI0105	trans-cinnamyl propionate
OLI0106	cinnamic aldehyde dimethyl acetal
OLI0107	cinnamyl formate
OLI0108	cinnamyl isobutyrate
OLI0109	cinnamyl propionate
OLI0110	ethyl cinnamate
OLI0111	Menthallactone
OLI0112	methoxy cinnamic aldehyde
OLI0113	methyl cinnamate
OLI0114	methyl trans-cinnamate

[0048] Compositions with biocidal activity may comprise biocidal compounds at varying concentrations. In some embodiments, concentrations of biocidal compounds in such compositions may be measured in parts per million (ppm.) Some compositions may comprise from about 0.1 ppm to about 2 ppm, from about 1 ppm to about 10 ppm, from about 5 ppm to about 50 ppm, from about 50 ppm to about 150 ppm, from about 100 ppm to about 200 ppm, from about 200 ppm to about 500 ppm, from about 500 ppm to about 1000 ppm or at least 1000 ppm. In other embodiments, compositions may comprise biocidal compounds at concentrations of from about 0.1% to about 0.5%, from about 0.25% to about 1.5%, from about 1% to about

10%, from about 5% to about 20%, from about 10% to about 30%, from about 15% to about 35%, from about 20% to about 40%, from about 30% to about 50%, from about 40% to about 60%, from about 50% to about 75% or at least 75%. In still other embodiments, biocidal compounds may be present in biocidal compositions at concentrations of from about 0.01 mg/ml to about 0.1 mg/ml, from about 0.2 mg/ml to about 2 mg/ml, from about 1 mg/ml to about 4 mg/ml, from about 2 mg/ml to about 5 mg/ml, from about 5 mg/ml to about 10 mg/ml, from about 10 mg/ml to about 20 mg/ml, from about 15 mg/ml to about 30 mg/ml, from about 25 mg/ml to about 50 mg/ml, from about 40 mg/ml to about 60 mg/ml, from about 50 mg/ml to about 75 mg/ml, from about 70 mg/ml to about 100 mg/ml, from about 100 mg/ml to about 500 mg/ml, from about 500 mg/ml to about 1 g/ml or at least 1 g/ml.

[0049] In some embodiments, larvicidal compounds and/or compositions of the present invention may comprise one or more of the compounds listed in Table 5.

Table 5. Larvicidal compounds

Compound No.	Compound
OLI0001	2,4-lutidine
OLI0002	2-ethylpyrazine
OLI0003	2-methoxypyrazine
OLI0005	4-ethylphenol
OLI0006	5-methyl furfural
OLI0008	Cyclopentanone
OLI0009	ethyl 2-furoate
OLI0011	ethyl vinyl carbinol
OLI0012	Guaiacol
OLI0013	trans-2-methyl-2-butenal
OLI0014	2,3,5-trimethylpyrazine
OLI0016	2-acetyl-5-methyl furan
OLI0017	2-furyl methyl ketone
OLI0019	allyl butyrate
OLI0020	cinnamyl nitrile
OLI0024	gamma-heptalactone
OLI0025	methanethiol acetate
OLI0026	methyl crotonate
OLI0027	methyl levulinate
OLI0028	phenylacetaldehyde
OLI0029	phenyl propyl aldehyde

OLI0052	Indole
OLI0059	methyl heptadienone
OLI0065	trans-cinnamaldehyde
OLI0066	Valeraldehyde
OLI0067	2,3-diethyl-5-methylpyrazine
OLI0068	2,3-diethylpyrazine
OLI0069	2-ethyl-3-methylpyrazine
OLI0070	2-methoxy-3-methylpyrazine
OLI0071	2-ethyl-3-methoxypyrazine
OLI0072	2-methoxy-3(5or6) isopropylpyrazine
OLI0073	cis-3-hexenyl acetate
OLI0074	furfuryl pentanoate
OLI0075	octanone-3
OLI0076	phenethyl propionate
OLI0077	trans-2-decenal
OLI0079	1-ethylhexyl tiglate
OLI0084	cis-5-octen-1-ol
OLI0091	methyl heptanoate
OLI0092	methyl amy ketone
OLI0096	cis 3-hexenyl formate
OLI0097	hexyl formate
OLI0100	methyl (E)-hex-3-enoate
OLI0101	peppermint oil
OLI0102	Eugenol
OLI0104	allyl cinnamate
OLI0105	trans-cinnamyl propionate
OLI0106	cinnamic aldehyde dimethyl acetal
OLI0107	cinnamyl formate
OLI0109	cinnamyl propionate
OLI0110	ethyl cinnamate
OLI0111	Menthallactone
OLI0112	methoxy cinnamic aldehyde
OLI0113	methyl cinnamate
OLI0114	methyl trans-cinnamate
OLI0115	Menthol
OLI0116	Salicylaldehyde
OLI0117	cinnamyl isobutyrate
OLI0118	Ultrazur
OLI0119	hexyl butyrate

Bed bug repellent and attractant compounds

[0050] In some embodiments, compounds, combinations and/or compositions of the present invention may be useful in the control of bed bug behavior. Bed bugs of the genus *Cimex* (including, but not limited to *Cimex lectularius*) are pests that bite humans (as well as other animals), feeding on blood. Bed bugs that feed on human blood often live in or around human sleeping areas, especially in warmer dwellings. Bites from bed bugs are associated with a number of adverse effects on health including, but not limited to rash development, allergic reactions and psychological effects. Some compounds and/or combinations of compounds of the present invention may be used to repel bed bugs from a given subject, region or habitat. Other compounds and/or combinations of compounds of the present invention may be used to attract bed bugs from a given subject, region or habitat.

Compounds, compositions and combinations

[0051] According to the present invention, behavior modifying compounds useful as pest attractants and/or repellents have been identified. Many of these compounds can be categorized according to different structural and chemical properties. These categories include, but are not limited to aromatic compounds, pyrazine ring-containing compounds, furan ring-containing compounds, ketones, aldehydes, acetates, essential oils, environmentally safe compounds, flavoring agents and odorants.

[0052] Pyrazine compounds – compounds and compositions are disclosed herein containing components with one or more pyrazine ring structures. Pyrazine rings can be formed through the pyrolysis of natural amino acid precursors including serine and threonine in the presence of sugars such as glucose and fructose (Teranishi, R., *Flavor Chemistry: Thirty Years of Progress*, Springer, 1999). They are found in a variety of food items, especially those processed at elevated temperatures in the absence of water.

[0053] Furan compounds – compounds and compositions are disclosed herein containing components with one or more furan ring structures. Many of these compounds can be found in nature or are synthetic chemicals closely resembling those in nature. Furans themselves are cyclic and contain the formula C_4H_4O . They are often used as the starting point for chemical synthesis of other compounds.

[0054] Essential oils – compounds and compositions are disclosed herein that contain essential oils and/or compounds derived from essential oils. The term “essential oil” as used herein refers to any volatile aromatic liquid extracted from plants. Typically these compounds

carry a distinctive scent of the plant from which they were extracted. Extraction is typically carried out by distillation allowing for extraction of concentrated compounds. Essential oils of the present invention include, but are not limited to rosemary oil, eucalyptol, peppermint oil and eugenol. Essential oils also include cinnamon oil, clove oil, mint oil, jasmine oil, geraniol, camphor oil, hinoki oil, sage oil, tohi oil, pomegranate oil, rose oil, turpentine oil, bergamot oil, mandarin oil, pine oil, calamus oil, lavender oil, bay oil, hiba oil, lemon oil, thyme oil, menthol, cineole, citral, citronella, linalool, borneol, camphor, thymol, spilanthe, pinene, terpene, limonene and the like. It is known in the art that some essential oils or combinations thereof, have repellent and/or attractant properties with regard to insects.

[0055] Eugenol (OLI0102) is a phenolic essential oil found at high levels in clove oil and is known to have strong antimicrobial and insecticidal activity. Interestingly, it can also act as an attractant for some insects, such as Japanese beetles. Its presence on the list of FIFRA exempt compounds makes it an attractive candidate for use in insecticides, repellents or lures.

[0056] Peppermint oil is extracted from the peppermint plant, a hybrid of watermint and spearmint. It is currently used in natural pesticides due to the presence of menthone, a known repellent agent.

[0057] Rosemary oil is extracted from the rosemary plant. It has a strong aroma and is a natural component of some pesticides.

[0058] Guaiacol is a natural compound and a component of wood-tar creosote. It is aromatic and has been used medicinally as an antipyretic, antiseptic and expectorant. In some embodiments, compounds and/or compositions of the present invention comprise guaiacol.

Formulations

[0059] The compositions may be combined in formulations. As used herein, a “formulation” is a combination of one or more compounds or compositions prepared as per a formula and may include one or more excipients, carriers or delivery agents. Formulations may be dry or wet or may be solid or liquid. Formulations may be designed for one or more particular applications or uses. The formulations of the present invention are also compositions while compositions may be formulated.

[0060] Formulations of the compounds, compositions or combinations of the present invention may be deployed by aerosolization via sublimation, spray, vaporization, candle burning and the like. They may be deployed as solids such as blocks, rods, crystals, granules,

pellets, beads, powders and the like for release of vapors over time. Said formulations may be designed for slow release.

[0061] In another embodiment, the compounds and compositions of the invention may be used in liquid form, either as purified liquids or in aqueous-based or non-aqueous (organic) formulations. As used herein the term “aqueous” means similar to or containing or dissolved in water, e.g., an aqueous solution. A “slurry” according to the present invention is a suspension of predominantly insoluble particles, usually in water. Suitable liquid diluents or carriers include water, petroleum distillates, or other liquid carriers. In one embodiment, said diluents further comprise surface active agents. Non-ionic, anionic, amphoteric, or cationic dispersing and emulsifying agents may be employed. The choice of liquid formulation components is dictated by the intended use of the composition, the desired distribution of the active compounds within the formulation and the ability of the formulation to be effectively spread across the desired treatment area. Said liquid formulations may be in the form of lotions, sprays, aerosols, foams, gels, balms, creams, mousse, patches (comprising such liquid formulations), suspensions, emulsions, microemulsions, emulsifiable concentrates, pump sprays, fragrances, perfumes, colognes, roll ons, solid sticks, gel sticks, towelettes, wipes, wet wipes, ointments, salves, pastes and the like.

[0062] In one embodiment, said odorant or liquid formulations may be used as a repellent to repel vector pests from a given area or from the vicinity of an individual or group of individuals.

[0063] In another embodiment, said odorant or liquid formulations may be activator formulations, employed to activate CO₂-responsive neuronal activity. In further embodiments, said activator formulations are utilized as attractants to draw vector pests to a given site or away from a less desired site. The site of attraction may be a trap or device deployed to capture or otherwise attract the vector pests. Compounds or compositions of the invention may be formulated with attractants known in the art. These attractant formulations may comprise one or more of the following: sugar, honey, molasses, plant oils, animal oils such as fish oil and the like, plant extracts, floral odors, pheromones, proteins, salt, seeds, animal feed, livestock feed, sticky agents, adhesives including substances such as tanglewood and the like. In another embodiment, activator formulations may be utilized as a protectant to prevent vector pest attraction to an individual or group of individuals desired to be protected. These protectant formulations may act

to overwhelm CO₂-responsive neurons in vector pests, rendering them unable to track CO₂ plumes exhaled from individuals or groups of individuals desired to be protected.

[0064] The compounds and compositions of the invention may be formulated for topical use on a given subject. In one embodiment, these topical formulations may be applied to a subject's skin. In a further embodiment the subjects may be non-human animals such as dogs, cats, horses, equines, bovines, pigs and others that exhale carbon dioxide and/or are vulnerable to vector pests. The compounds and compositions may also be formulated for application to materials such as an individual's clothing or apparel. Such materials may also include bedding, netting, bed netting, screens, curtains, walls, gear, equipment, patches, vehicles and the like.

Other components of formulations

[0065] Formulations containing compounds or compositions of the present invention may comprise further components depending upon the desired use of the formulation. These components include, but are not limited to carriers, thickeners, surface-active agents, preservatives, aromatics, deodorizers, sunscreen active and one or more of several types of adjuvant including, but not limited to, wetting agents, spreading agents, sticking agents, foam retardants, buffers and acidifiers. As used herein, "sunscreen active" is an additive capable of absorbing or reflecting a portion of the solar ultraviolet radiation from a surface. In another embodiment, the compounds and compositions of the present invention may be supplied as a concentrate which may be diluted to achieve a desired strength depending on the application. The term "concentrate" as used herein, refers to a compound or composition in condensed form. A concentrate therefore may contain some diluents and not necessarily be purified.

Carriers

[0066] The compounds and compositions of the present invention may contain one or more carriers or carrier vehicles. These carriers may be gaseous, liquid or solid and are most often inert but may be active ingredients. Carrier vehicles may include, but are not limited to, aerosol propellants, such as freon, (present in a gaseous state at normal temperatures and pressures); inert dispersible liquid diluent carriers, including inert organic solvents, aromatic hydrocarbons (such as benzene, toluene, xylene, alkyl naphthalenes, etc.), halogenated especially chlorinated, aromatic hydrocarbons (such as chloro-benzenes, etc.), chlorinated aliphatic hydrocarbons (such as chloroethylenes, methylene chloride, etc.), cycloalkanes, (such as cyclohexane, etc.), paraffins

(such as petroleum or mineral oil fractions), acetonitrile, ketones (such as cyclohexanone, methyl ethyl ketone, acetone, methyl isobutyl ketone, etc.), alcohols (such as ethanol, methanol, propanol, glycol, butanol, etc.) as well as ethers and esters thereof (such as glycol monomethyl ether, etc.), amides (such as dimethylformamide etc.), amines (such as ethanolamine, etc.), sulfoxides (such as dimethylsulfoxide, etc.), and/or water. Carriers may also include inert, finely divided solid carriers that may be dispersible such as ground natural minerals (including, but not limited to chalk, i.e. calcium carbonate, silica, alumina, vermiculite, talc, kieselguhr, attapulgite, montmorillonite, etc.) as well as ground synthetic minerals (such as highly dispersed silicic acid, silicates, such as alkali silicates, etc.).

Finely divided solid carrier formulations

[0067] The compounds and compositions of the present invention may be formulated for dispersion with finely divided solid carriers such as dust, talc, chalk, diatomaceous earth, vermiculite, sand, sulfur, flours, attapulgite clay, kieselguhr, pyrophyllite, calcium phosphates, calcium and magnesium carbonates, and other solids capable of acting as carriers. A typical finely divided solid formulation useful for modifying vector pest behavior contains 1 part compound or composition per 99 parts of said finely divided solid carrier. In one embodiment, these finely divided solids have an average particle size of about >50 microns. In another embodiment, said finely divided solids are granules. The term “granule,” as used herein refers to particles of a diameter of about 400-2500 microns. Said granules may comprise porous or nonporous particles. Finely divided solid carriers may be either impregnated or coated with the desired compound or composition. Granules generally contain 0.05-15%, preferably 0.5-5%, of the active compound or composition. Thus, the repellent compositions of the present invention can be formulated with any of the following solid carriers such as bentonite, fullers earth, ground natural minerals (such as kaolins, quartz, attapulgite, montmorillonite, etc.), ground synthetic minerals (such as highly-dispersed silicic acid, alumina and silicates), crushed and fractionated natural rocks (such as calcite, marble, pumice, sepiolite and dolomite), synthetic granules of inorganic and organic meals, and granules of organic materials (such as sawdust, coconut shells, corn cobs, tobacco stalks, walnut or other nut shells, egg shells and other natural cast off products that may or may not be a by-product of manufacturing or harvest).

Surface-active agents

[0068] Formulations containing compounds and compositions of the present invention may include surface-active agents. “Surface-active agents” as referred to herein, are additives capable of lowering the surface tension of a liquid or between a liquid and a solid. Surface-active agents may include, but are not limited to emulsifying agents (such as non-ionic and/or anionic emulsifying agents, polyethylene oxide esters of fatty acids, polyethylene oxide ether of fatty alcohols, alkyl sulfates, alkyl sulfonates, aryl sulfonates, albumin hydrolyzates, alkyl arylpolyglycol ethers, magnesium stearate, sodium oleate, etc.) and/or dispersing agents (such as lignin, sulfite waste liquors, methyl cellulose, etc.)

Thickeners

[0069] Formulations containing compounds or compositions of the present invention may contain one or more thickeners. The term “thickener”, as used herein refers to an additive that increases the viscosity of the formulation to which it is added without significantly modifying other properties of the formulation. They may also be used to impart a uniform consistency to the formulation. They are also useful for keeping components of a given formulation in suspension. Said thickeners include, but are not limited to agar, corn starch, guar gum and potato starch. Thickeners may be present at a concentration from about 0.1% to about 5% of the total composition.

Preservatives

[0070] Formulations containing compounds or compositions of the present invention may contain one or more preservatives. The term “preservative”, as used herein refers to an additive capable of preventing decay, decomposition or spoilage in a composition. Said preservatives may be natural or synthetic; they may protect against a broad spectrum of spoilage or be targeted to one form (such as microbial, fungal or molding spoilage). Preservatives may include, but are not limited to calcium propionate, sodium nitrate, sodium nitrite, sulfur dioxide, sodium bisulfate, potassium hydrogen sulfite, disodium ethylenediaminetetraacetic acid (EDTA), formaldehyde, glutaraldehyde, ethanol, methylchloroisothiazolinone, potassium sorbate and the like. Other preservatives protect against chemical breakdown of compounds or compositions. Such

preservatives include butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT). Preservatives are typically present in formulations at a concentration from about 0.03% to about 3% by weight.

Other ingredients

[0071] The compounds and compositions of the invention may include “other ingredients” known to those skilled in the art and which may be added to formulations depending on the desired application. These include, but are not limited to milk, garlic, garlic powder, garlic oil, hot pepper, white pepper, oil of black pepper, piperine, chemically formulated pepper, clove, fish oil, optionally modified oil, onion, perfumes, bitrex, thiram, thymol, capsaicin, predator urines, urea, naphthalene (moth balls), pyrethrine, blood, blood meal, bone meal, sulfurous emitting items (eggs, sulfur, meats, etc), denatonium benzoate, formaldehyde, ammonia, methyl ammonium saccharide, ammonium of fatty acids, waxes, nutrients, butyl mercaptan, mineral oil, orange oil, kelp (seaweed), whole eggs, powdered eggs, putrescent eggs, egg whites, egg yolks, rotten eggs, rosemary, thyme, wintergreen, clay, 2-propenoic acid, potassium salt, 2-propenamide, acetic acid, iron, manganese, boron, copper, cobalt, molybdenum, zinc, latex, animal glue and stickers like nufilm p and others in the series.

Environmentally safe compounds

[0072] Formulations of compounds and compositions of the invention may contain environmentally safe compounds. As used herein, an “environmentally safe compound” is a compound that imposes reduced, limited, minimal and/or no harm to a given ecosystem or environment. Harmful chemicals are often used to control pests and biting insects. With increasing public awareness of the dangers posed by some chemicals to public health and to the environment, natural compounds have been increasingly explored as alternatives to synthetic and/or hazardous chemicals. To this end, the Environmental Protection Agency has taken legislative action to categorize certain natural compounds as safe, protecting the use of these environmentally safe compounds from certain government regulations. The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) outlines the exemptions as well as compounds covered by the act. In some embodiments, environmentally safe compounds include those identified as environmentally safe to use in pesticides by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Such compounds include, but are not limited to: (+)-butyl lactate; (+)-ethyl lactate;

1,2-propylene carbonate; 1-monolaurin; 1-monomyristin; 2-phenethyl propionate (2-phenylethyl propionate); acetyl tributyl citrate; agar; almond hulls; almond shells; alpha-cyclodextrin; aluminatesilicate; aluminum magnesium silicate; aluminum potassium sodium silicate; aluminum silicate; aluminum sodium silicate; aluminum sodium silicate (1:1:1); ammonium benzoate; ammonium stearate; amylopectin, acid-hydrolyzed, 1-octenylbutanedioate; amylopectin, hydrogen 1-octadecenylbutanedioate; animal glue; ascorbyl palmitate; attapulgit-type clay; beeswax; bentonite; bentonite, sodian; beta-cyclodextrin; bone meal; bran; bread crumbs; butyl lactate; butyl stearate; calcareous shale; calcite ($\text{Ca}(\text{CO}_3)$); calcium acetate; calcium acetate monohydrate; calcium benzoate; calcium carbonate; calcium citrate; calcium octanoate; calcium oxide silicate ($\text{Ca}_3\text{O}(\text{SiO}_4)$); calcium silicate; calcium stearate; calcium sulfate; calcium sulfate dihydrate; calcium sulfate hemihydrate; canary seed; carbon; carbon dioxide; carboxymethyl cellulose; cardboard; carnauba wax; carob gum; carrageenan; caseins; castor oil; castor oil, hydrogenated; cat food; cedar oil; cellulose; cellulose acetate; cellulose mixture (with cellulose carboxymethyl ether, sodium salt); cellulose, pulp; cellulose, regenerated; cheese; chlorophyll a; chlorophyll b; cinnamon and cinnamon oil; citric acid; citric acid, monohydrate; citronella and citronella oil; citrus meal; citrus pectin; citrus pulp; clam shells; cloves and clove oil; cocoa; cocoa shell flour; cocoa shells; cod-liver oil; coffee grounds; cookies; cork; corn cobs; corn gluten meal; corn oil; cotton; cottonseed meal; cottonseed oil; cracked wheat; decanoic acid, monoester with 1,2,3-propanetriol; dextrans; diatomaceous earth (less than 1% crystalline silica); diglyceryl monooleate; diglyceryl monostearate; dilaurin; dipalmitin; dipotassium citrate; disodium citrate; disodium sulfate decahydrate; dodecanoic acid, monoester with 1,2,3-propanetriol; dolomite; douglas fir bark; dried blood; egg shells; eggs; ethyl lactate; eugenol; feldspar; fish meal; fish oil (not conforming to 40 CFR 180.950); fuller's earth; fumaric acid; gamma-cyclodextrin; garlic and garlic oil; gelatins; gellan gum; geraniol; geranium oil; glue (as depolymd. animal collagen); glycerin; glycerol monooleate; glyceryl dicaprylate; glyceryl dimyristate; glyceryl dioleate; glyceryl distearate; glyceryl monomyristate; glyceryl monoctanoate; glyceryl monooleate; glyceryl monostearate; glyceryl stearate; granite; graphite; guar gum; gum arabic; gum tragacanth; gypsum; hematite (Fe_2O_3); humic acid; hydrogenated cottonseed oil; hydrogenated rapeseed oil; hydrogenated soybean oil; hydroxyethyl cellulose; hydroxypropyl cellulose; hydroxypropyl methyl cellulose; Iron magnesium oxide (Fe_2MgO_4); iron oxide (Fe_2O_3); iron oxide (Fe_2O_3), hydrate; iron oxide (Fe_3O_4); iron oxide

(FeO); isopropyl alcohol; isopropyl myristate; kaolin; lactose; lactose monohydrate; lanolin; latex rubber; lauric acid; lauryl sulfate; lecithins; lemon grass oil; licorice extract; lime (chemical) dolomitic; limestone; linseed oil; magnesium benzoate; magnesium carbonate; magnesium oxide; magnesium oxide silicate ($\text{Mg}_3\text{O}(\text{Si}_2\text{O}_5)_2$), monohydrate; magnesium silicate; magnesium silicate hydrate; magnesium silicon oxide ($\text{Mg}_2\text{Si}_3\text{O}_8$); magnesium stearate; magnesium sulfate; magnesium sulfate heptahydrate; malic acid; malt extract; malt flavor; maltodextrin; methylcellulose; mica; mica-group minerals; milk; millet seed; mineral oil (U.S.P.); mint and mint oil; monomyristin; monopalmitin; monopotassium citrate; monosodium citrate; montmorillonite; myristic acid; nepheline syenite; nitrogen; nutria meat; nylon; octanoic acid, potassium salt; octanoic acid, sodium salt; oils, almond; oils, wheat; oleic acid; oyster shells; palm oil; palm oil, hydrogenated; palmitic acid; paper; paraffin wax; peanut butter; peanut shells; peanuts; peat moss; pectin; peppermint and peppermint oil; perlite; perlite, expanded; plaster of paris; polyethylene; polyglyceryl oleate; polyglyceryl stearate; potassium acetate; potassium aluminum silicate, anhydrous; potassium benzoate; potassium bicarbonate; potassium chloride; potassium citrate; potassium humate; potassium myristate; potassium oleate; potassium ricinoleate; potassium sorbate; potassium stearate; potassium sulfate; potassium sulfate; pumice; putrescent whole egg solids; red cabbage color (expressed from edible red cabbage heads via a pressing process using only acidified water); red cedar chips; red dog flour; rosemary and rosemary oil; rubber; sawdust; sesame (includes ground sesame plant stalks) and sesame oil; shale; silica (crystalline free); silica gel; silica gel, precipitated, crystalline-free; silica, amorphous, fumed (crystalline free); silica, amorphous, precipitated and gel; silica, hydrate; silica, vitreous; silicic acid (H_2SiO_3), magnesium salt (1:1); soap (the water soluble sodium or potassium salts of fatty acids produced by either the saponification of fats and oils, or the neutralization of fatty acid); soapbark (*Quillaja saponin*); soapstone; sodium acetate; sodium alginate; sodium benzoate; sodium bicarbonate; sodium carboxymethyl cellulose; sodium chloride; sodium citrate; sodium humate; sodium lauryl sulfate; sodium oleate; sodium ricinoleate; sodium stearate; sodium sulfate; sorbitol; soy protein; soya lecithins; soybean hulls; soybean meal; soybean oil; soybean, flour; stearic acid; sulfur; syrups, hydrolyzed starch, hydrogenated; tetraglyceryl monooleate; thyme and thyme oil; tricalcium citrate; triethyl citrate; tripotassium citrate; tripotassium citrate monohydrate; trisodium citrate; trisodium citrate dehydrate; trisodium citrate pentahydrate; ultramarine blue; urea; vanillin; vermiculite; vinegar

(maximum 8% acetic acid in solution); Vitamin C; Vitamin E; walnut flour; walnut shells; wheat; wheat flour; wheat germ oil; whey; white mineral oil (petroleum); white pepper; wintergreen oil; wollastonite ($\text{Ca}(\text{SiO}_3)$); wool; xanthan gum; yeast; Zeolites (excluding erionite (CAS Reg. No. 66733-21-9)); Zeolites, NaA; zinc iron oxide; zinc metal strips (consisting solely of zinc metal and impurities); zinc oxide (ZnO) and zinc stearate.

Other aromatics

[0073] Formulations of compounds and compositions of the invention may contain other aromatic compounds or compositions. The term “aromatic” as used herein refers to a compound having a distinctive smell or aroma. Such compounds are typically volatile allowing for rapid diffusion into the surrounding air and easily sensed within the olfactory system. One such aromatic compound is cedar oil. Cedar oil may be useful in a given formulation for its ability to both repel insects as well as to kill larval mosquitoes present in a body of water. Cedar oil formulations may contain from about 0.01% to about 10%, from about 1% to about 5%, from about 2% to about 20% or from about 5% to about 50% cedar oil by weight percent.

[0074] Other aromatics that may be included in formulations of compounds and compositions of the invention include, but are not limited to camphor, pyrethrin and permethrin. Such formulations may contain from about 0.01% to about 10%, from about 1% to about 5%, from about 2% to about 20% or from about 5% to about 50% camphor, pyrethrin and/or permethrin by weight percent.

Adjuvants

[0075] Formulations of compounds and compositions of the invention may comprise adjuvants. The term “adjuvant”, as used herein refers to any substance that improves or enhances one or more properties of another component within the formulation. Said adjuvants may include, but are not limited to buffers, acidifiers, wetting agents, spreading agents, sticking agents, adhesives, colorants, stabilizers, waterproofing agents, foam retardants and the like.

Formulations with other known agents

[0076] Formulations comprising compounds and compositions of the invention may combine said compounds and compositions with other compatible active agents known in the art including pesticides, insecticides, bactericides, fungicides, acaricides, microbicides, rodenticides,

nematocides, herbicides and the like. The term “bactericide” refers to substances which may destroy or blocking the growth of bacteria; “fungicide” refers to substances which may destroy or block the growth of fungi; “acaricide” refers to substances which may destroy or block the growth of members of the *Arachnida* subclass, *Acari*; “microbicide” refers to substances which may kill or block the growth of microorganisms; “rodenticide” refers to chemical substances which may be capable of destroying rodents; “nematocide” refers to chemical substances which may be capable of destroying or blocking the growth of nematodes; “herbicide” refers to chemical substances which may be capable of destroying or blocking the growth of plant life.

Concentrations and combinations

[0077] The compounds and compositions of the invention may be produced or formulated in various concentrations depending upon the desired application, vector pest, desired effect on neuronal activity and depending upon the type of surface or area that the invention will be applied to.

[0078] Typically active components within a given composition will be present in the composition in a concentration of at least about 0.0001% by weight. In another embodiment, active components may be present at a concentration from about 0.001% to about 0.01%, from about 0.001% to about 0.02%, from about 0.001% to about 0.03%, from about 0.001% to about 0.04%, from about 0.001% to about 0.05%, from about 0.001% to about 0.06%, from about 0.001% to about 0.07%, from about 0.001% to about 0.08%, from about 0.001% to about 0.09%, from about 0.001% to about 0.10%, from about 0.001% to about 0.11%, from about 0.001% to about 0.12%, from about 0.001% to about 0.13%, from about 0.001% to about 0.14%, from about 0.001% to about 0.15%, from about 0.001% to about 0.16%, from about 0.001% to about 0.17%, from about 0.001% to about 0.18%, from about 0.001% to about 0.19%, from about 0.001% to about 0.20%, from about 0.001% to about 0.21%, from about 0.001% to about 0.22%, from about 0.001% to about 0.23%, from about 0.001% to about 0.24%, from about 0.001% to about 0.25%, from about 0.001% to about 0.26%, from about 0.001% to about 0.27%, from about 0.001% to about 0.28%, from about 0.001% to about 0.29%, from about 0.001% to about 0.30%, from about 0.001% to about 0.31%, from about 0.001% to about 0.32%, from about 0.001% to about 0.33%, from about 0.001% to about 0.34%, from about 0.001% to about 0.35%, from about 0.001% to about 0.36%, from about 0.001% to about 0.37%, from about 0.001% to about 0.38%, from about 0.001% to about 0.39%, from about 0.001% to about 0.40%, from

about 0.001% to about 0.41%, from about 0.001% to about 0.42%, from about 0.001% to about 0.43%, from about 0.001% to about 0.44%, from about 0.001% to about 0.45%, from about 0.001% to about 0.46%, from about 0.001% to about 0.47%, from about 0.001% to about 0.48%, from about 0.001% to about 0.49%, from about 0.001% to about 0.50%, from about 0.1% to about 1.0%, from about 0.1% to about 1.5%, from about 0.1% to about 2.0%, from about 0.1% to about 2.5%, from about 0.1% to about 3.0%, from about 0.1% to about 3.5%, from about 0.1% to about 4.0%, from about 0.1% to about 4.5%, from about 0.1% to about 5.0%, from about 0.1% to about 5.5%, from about 0.1% to about 6.0%, from about 0.1% to about 6.5%, from about 0.1% to about 7.0%, from about 0.1% to about 7.5%, from about 0.1% to about 8.0%, from about 0.1% to about 8.5%, from about 0.1% to about 9.0%, from about 0.1% to about 9.5%, from about 0.1% to about 10.0%, from about 0.1% to about 10.5%, from about 0.1% to about 11.0%, from about 0.1% to about 11.5%, from about 0.1% to about 12.0%, from about 0.1% to about 12.5%, from about 0.1% to about 13.0%, from about 0.1% to about 13.5%, from about 0.1% to about 14.0%, from about 0.1% to about 14.5%, from about 0.1% to about 15.0%, from about 0.1% to about 15.5%, from about 0.1% to about 16.0%, from about 0.1% to about 16.5%, from about 0.1% to about 17.0%, from about 0.1% to about 17.5%, from about 0.1% to about 18.0%, from about 0.1% to about 18.5%, from about 0.1% to about 19.0%, from about 0.1% to about 19.5%, from about 0.1% to about 20.0%, from about 1% to about 5%, from about 1% to about 10%, from about 1% to about 15%, from about 1% to about 20%, from about 1% to about 25%, from about 1% to about 30%, from about 1% to about 35%, from about 1% to about 40%, from about 1% to about 45%, from about 1% to about 50%, from about 1% to about 55%, from about 1% to about 60%, from about 1% to about 65%, from about 1% to about 70%, from about 1% to about 75%, from about 1% to about 80%, from about 1% to about 85%, from about 1% to about 90%, from about 1% to about 95%, from about 1% to about 100%, from about 10% to about 20%, from about 10% to about 30%, from about 10% to about 40%, from about 10% to about 50%, from about 10% to about 60%, from about 10% to about 70%, from about 10% to about 80%, from about 10% to about 90%, or from about 10% to about 100% by weight. Additionally, compounds may be combined in various embodiments such that compositions and formulations of the present invention contain 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 or more active compounds or compositions.

[0079] Units of measure used herein embrace standard units as well as metric units. It is to be understood that where compounds or compositions are measured, formulated or packaged in liquid form, the units may be in increments of ounces, cups, pints, quarts, gallons, barrels, or portions thereof. They may also be in metric increments of milliliters, cubic centimeters, deciliters, liters, cubic meters or portions thereof.

[0080] It is to be understood that where compounds and compositions are measured, formulated or packaged as solids, the units may have increments of ounces, pounds, tons, or portions thereof. They may also comprise increments of milligrams, grams, kilograms, metric tons or portions thereof.

[0081] Coverage, as it relates to the effective surface or area where vector pest behavior may be modified in response to application of a compound or composition of the invention, may be expressed in inches, feet, square feet, yards, square yards, acres, square acres, or portions thereof. They may also be in increments of millimeters, square millimeters, centimeters, square centimeters, meters, square meters, hectares, kilometers, square kilometers or portions thereof.

Methods of application or treatment

[0082] Compounds and compositions of the invention may be used to modify pest (e.g., vector pest) behavior in a given area or within the vicinity of an individual or structure. Human and non-human animal subjects may benefit from such use. As used herein, the term “subject” refers to any organism, human or non-human. Non-human animals may include, but are not limited to dogs, cats, mice, rats, rabbits, horses, cattle, sheep, goats, pigs, rodents, chickens, etc.

[0083] Many methods of application are known in the art that would be convenient for applying compounds or compositions of the present invention to a desired object, individual, surface, area or region. Such methods include, but are not limited to aerosolizing, dusting, vaporizing, misting, spraying, spreading, broadcasting, spackling, sprinkling, painting, brushing, coating, rolling, banding, side-dressing, mopping, bathing, soaking, dipping, immersing, sticking, adhering, wiping, rubbing, impregnating, embedding, injecting, sealing, dotting, dabbing, stippling, layering, stenciling, stamping, pouring and the like. In some embodiments, pests are exposed to compounds and/or compositions of the present invention on or around the surface of a wick that draws from a solution comprising compounds and/or compositions of the present invention.

[0084] Methods of application may rely on indirect methods of dispersion. In one embodiment, the compound or composition may be left in an area where it may be dispersed by active forces of nature such as wind, rain, sunlight, water current and the like. In another embodiment, a mechanical device may be used to effect the applications listed herein. In a further embodiment, said mechanical device is a timed spreaders or broadcasters, set up in predetermined areas in order to apply or disperse the compound or composition to a surface, area or substrate in a temporal fashion. Said mechanical devices may be automated or initiated remotely to apply compounds or compositions of the invention.

Assays and testing

[0085] Compounds and/or compositions of the present invention may be developed in conjunction with assays and/or testing to determine the effectiveness of such compounds and/or compositions or derivatives thereof. In some embodiments, testing is carried out to determine the effect of compounds and/or compositions of the present invention on pest behavior. Such testing may be used to determine the ability of compounds and/or compositions of the present invention to act as attractants or repellents.

[0086] In some embodiments, spatial experiments are carried out to determine the effect of compounds and/or compositions of the present invention on pest behavior (e.g. mosquito behavior). Such spatial experiments comprise the use of one or more spatial arenas. As used herein, the term “spatial arena” refers to any enclosed space. Such arenas may range in size from 1 ft³ to large arenas (including but not limited to semi-field chambers) of about 10,000 ft³. Materials used to enclose spatial arenas may vary depending upon the desired application. Materials may comprise one or more of plastic sheets, cloth, glass, netting, wood, sheetrock, fiberglass, screening, metal and the like. Spatial arenas may also be climate controlled. In such arenas, one or more of heat, light, humidity and air circulation may be controlled to limit experimental variation and/or simulate a given environment. Pest behaviors that may be observed during spatial experiments include, but are not limited to movement toward or away from a given agent, changes in pest movement level, immobilization, erratic movements and/or death.

[0087] In some embodiments, field testing is carried out to test compounds and/or compositions of the present invention. As used herein, the term “field testing” refers to testing done in one or more natural environments. Field testing may use traps to collect pests and/or

record pest numbers at, in or around trap sites. As used herein, the term “trap” refers to any device and/or object used for attracting, capturing and/or killing one or more pests. Traps may be natural or man-made. In some embodiments, traps of the present invention may be passive traps. As used herein, the term “passive trap” refers to a stationary trap that relies on the movement of pests to the trap vicinity. Such traps include those described by Ritchie et al (Ritchie, S.A. et al., A simple non-powered passive trap for the collection of mosquitoes for Arbovirus surveillance. Journal of Medical Entomology. 2013. 50(1):185-94). In some embodiments, passive traps may not have moving mechanisms, relying on stationary trap components to immobilize pests and/or prevent their escape from the trap area. In some embodiments, traps may comprise a container (such as a box, cylinder, etc) for collecting pests attracted to the trap. In some embodiments, traps may comprise a lure or bait for attracting pests to the trap. Such lures may include compounds and/or compositions provided herein.

[0088] In some embodiments, traps may be lethal traps. As used herein, the term “lethal trap” refers to a trap that kills one or more pests captured by such a trap. Such traps may comprise one or more toxic compounds that may be lethal upon exposure to one or more pests (e.g. ingestion, inhalation, etc). In some embodiments, lethal traps kill captured pests by immobilization (e.g. restriction from movement and/or nutritional sources necessary for vitality).

Kits and Devices

[0089] The compounds, compositions and combinations of the present invention may be combined with other ingredients or reagents or prepared as components of kits or other retail products for commercial sale or distribution. These kits and or formulations may be sold to retailers for the purpose of selling these retail products for public use according to the methods disclosed herein. As such the present invention embraces methods of manufacturing or production of kits and or products to be provided to an end-user. Kits may contain packaging, a vial or container comprising the compounds, compositions or combinations and optionally instructions for use.

[0090] Compounds, compositions and apparatuses of the present invention may be sold in modular form for assembly, dilution or other method of reconstruction by a subsequent individual or end user as a kit. Said kits may be provided complete with all necessary components to assemble the active composition, formulation or apparatus. In another embodiment, said kits provide a partial number of components necessary and require that the

subsequent user or end user provide one or more components separately (such as water or other solvent for dilution, rehydration, etc.)

[0091] In some embodiments, compounds and/or compositions of the present invention may be used in conjunction with devices to house, contain and/or facilitate diffusion of such compounds and/or compositions. Such devices may include decorative stands, balls, sticks (such sticks comprising of materials that may include, but are not limited to cellulose, plastic, wood, paper and the like), coils, paints, fabrics, patches, cattle/animal ear tags, bed nets, infused plastics, foggers, candles, lanterns, lamps, clip-on devices and plug-in devices (with or without air diffusers.) Such devices may comprise compounds and/or compositions of the present invention in liquid and/or solid state forms. In some embodiments, such devices may be capable of being refilled.

Patches

[0092] In some embodiments, formulations comprising compounds of the present invention may be applied to or incorporated within a patch. As used herein, the term “patch” refers to a small piece of material. Patches may act as matrices that hold compounds and/or compositions of the present invention. Patches that have been applied with or infused with formulations of the present invention may be used to modify the behavior of vector pests that come within a given vicinity of such patches, in some embodiments, acting as a spatial repellent. Compounds and/or compositions of the present invention may be applied to patches in liquid format or formulation. In some cases, patches are used while such liquid formulations are still wet, while in other embodiments, liquid formulations are allowed to dry. Patches of the present invention may comprise any of a number of materials including, but not limited to paper, plastic, metal, fabric, wax, polymeric materials, polyethylene, polypropylene, rubber, cellulose, silicon rubber and/or cellulose-based materials. Some patches are designed to be water-resistant or water-proof.

[0093] Patches may be of various sizes and shapes. In some embodiments, patches are flat and comprise an area of from about 1 cm² to about 5 cm², from about 2 cm² to about 10 cm², from about 3 cm² to about 15 cm², from about 4 cm² to about 20 cm², from about 12 cm² to about 48 cm², from about 24 cm² to about 72 cm², from about 50 cm² to about 100 cm² or at least 100 cm². Patch shapes may include, but are not limited to circles, squares, rectangles, triangles and polygons. In some embodiments, patches are square with side lengths of about 1.5 cm. Additionally, patches may comprise any color and or pattern. Non-limiting examples of patch

colors include red, orange, yellow green, blue, purple, indigo, violet, black, white, fluorescent, etc. Non-limiting examples of patch patterns include striped, checkerboard patterned, spotted, dotted, speckled, camouflaged, etc.

[0094] Patches may be applied to subjects according to any methods known to those of skill in the art. Such methods may include, but are not limited to direct application to subject skin, clothing or apparel (e.g. accessory items, hats, backpacks, scarfs, gloves, shoes, sunglasses, ear rings, etc.) Patches may be associated with such skin, clothing or apparel through adhesives (e.g. glues, pastes, gels, resins, gums, epoxies, etc.), static electrical interactions, tape, banding (such as attachment using a wrist, leg and/or waste band) or through other methods known in the art. Some adhesives that may be used may be water-resistant or water-proof adhesives. Some patches comprise a film or paper layer to protect patch adhesives. Such film or paper layers may be peeled off prior to application of such patches.

[0095] In some embodiments, patches may be placed inside or attached to a holder. As used herein, the term “holder” refers to a container or device used to house and/or grasp a patch. Holders may comprise pockets, compartments, cassettes, boxes, clips or other such devices that may be used to house or bind a patch. Some holders may comprise materials including, but not limited to metal, plastic, elastic, mesh, screen, fabric and/or wood. Holders may vary in size to accommodate home or outdoor uses.

[0096] Some patches and/or holders may be attached to subjects using accessory devices. As used herein, the term “accessory device” refers to a device of secondary importance in relation to a first device. In some embodiments, accessory devices may comprise something that is worn to attach patches and/or holders to a subject. Such accessory devices may include, but are not limited to bracelets, necklaces, wrist bands, collars, arm bands, clothing, fabric and/or clip-on devices. In some embodiments accessory devices may comprise air diffusers. As used herein, the term “air diffuser” refers to a device that circulates air, allowing for the spreading and/or dissipation of aerosols. Such air diffusers may be powered (e.g. battery powered, solar powered, etc.) or un-powered. Some air diffusers may comprise a fan. Air diffusers may be used to disperse compounds and/or compositions comprised in patches, creating a greater zone of protection.

[0097] In some embodiments, patches may be used to protect non-human animal subjects, including, but not limited to cats, pigs, dogs, horses and cattle. Patches may be associated with

such animals through an accessory device, non-limiting examples of which may include collars or bands. In other embodiments, patches are placed within a holder that is worn around the neck or other body part of such animals.

Traps

[0098] In some embodiments, compounds and/or compositions of the present invention may be used as part of a trap. In some embodiments, compounds and/or compositions of the present invention may be used as attractants and/or in combination with other attractants to lure pests to a trap. In some embodiments, compounds and/or compositions of the present invention may be used as biocides to control insects that may be overcrowding a trap and/or a bait or lure present in, on or around a trap.

Equivalents and Scope

[0099] Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments in accordance with the invention described herein. The scope of the present invention is not intended to be limited to the above Description, but rather is as set forth in the appended claims.

[00100] In the claims, articles such as “a,” “an,” and “the” may mean one or more than one unless indicated to the contrary or otherwise evident from the context. Claims or descriptions that include “or” between one or more members of a group are considered satisfied if one, more than one, or all of the group members are present in, employed in, or otherwise relevant to a given product or process unless indicated to the contrary or otherwise evident from the context. The invention includes embodiments in which exactly one member of the group is present in, employed in, or otherwise relevant to a given product or process. The invention includes embodiments in which more than one, or all of the group members are present in, employed in, or otherwise relevant to a given product or process.

[00101] It is also noted that the term “comprising” is intended to be open and permits but does not require the inclusion of additional elements or steps. When the term “comprising” is used herein, the term “consisting of” is thus also encompassed and disclosed.

[00102] Where ranges are given, endpoints are included. Furthermore, it is to be understood that unless otherwise indicated or otherwise evident from the context and understanding of one of ordinary skill in the art, values that are expressed as ranges can assume any specific value or

subrange within the stated ranges in different embodiments of the invention, to the tenth of the unit of the lower limit of the range, unless the context clearly dictates otherwise.

[00103] Where the term “about” is used, it is understood to reflect +/- 10% of the recited value.

[00104] In addition, it is to be understood that any particular embodiment of the present invention that falls within the prior art may be explicitly excluded from any one or more of the claims. Since such embodiments are deemed to be known to one of ordinary skill in the art, they may be excluded even if the exclusion is not set forth explicitly herein. Any particular embodiment of the compositions of the invention (*e.g.*, any nucleic acid or protein encoded thereby; any method of production; any method of use; *etc.*) can be excluded from any one or more claims, for any reason, whether or not related to the existence of prior art.

[00105] All cited sources, for example, references, publications, databases, database entries, and art cited herein, are incorporated into this application by reference, even if not expressly stated in the citation. In case of conflicting statements of a cited source and the instant application, the statement in the instant application shall control.

[00106] Section and table headings are not intended to be limiting.

EXAMPLES

Example 1. Identification of sensory neuron modulators-activators

[00107] Carbon dioxide receptor neurons in mosquitoes are responsible for sensing and responding to carbon dioxide levels. In the mosquito species, *Aedes aegypti*, cpA neurons of the maxillary palp are the primary CO₂ sensors while cpB and cpC neurons, whose activity can be visualized at the same time as the cpA neuron, are also responsive to skin odors (Lu, T. et al., *Odor coding in the maxillary palp of the malaria vector mosquito Anopheles gambiae*. Curr Biol. 2007 Sep 18;17(18):1533-44. Epub 2007 Aug 30).

[00108] In an effort to identify compounds having an effect on sensory neurons, extracellular single-sensillum electrophysiology, as described in Dobritsa et al., 2003 (Dobritsa, A.A. et al., *Integrating the molecular and cellular basis of odor coding in the Drosophila antenna*. Neuron. 2003 Mar 6;37(5):827-41) and modified by Turner et al., 2011 (Turner, S.L. et al., *Ultra-prolonged activation of CO₂-sensing neurons disorients mosquitoes*. Nature. 2011 Jun 2;474(7349):87-91), was performed to test the response of cpA neurons to various compounds and compositions. To this end, various compounds and compositions were tested for their ability

to stimulate mosquito neuronal activity in CO₂-responsive neurons. Mosquitoes were immobilized and placed in line with a stream of air from an odor-delivery system. In this system a steady flow of humidified air was maintained with a controlled, minimal level of CO₂ gas. The humidified airstream was delivered at 10 ml/sec from a purified air tank. CO₂ gas was provided through a separate system capable of delivering controlled pulses (2.5 ml/sec-6.5 ml/sec) to the humidified airstream. Levels of CO₂ were manipulated by switching between 1%, and 100% CO₂ compressed air sources. Additionally, the odor-delivery system was designed to deliver a controlled level of air containing vapors from a desired chemical or chemical composition.

[00109] In order to test the cpA neuronal response to various chemical stimuli, highly purified chemicals or chemical compositions were diluted in a test solution comprising paraffin oil and applied to a cartridge comprising a Pasteur pipette with a cotton wool insert for receiving the solution as described by Turner et al., 2009 (Turner, S.L. et al., *Modification of CO₂ avoidance behaviour in Drosophila by inhibitory odorants*. Nature. 2009 Sep 10;461(7261):277-81. Epub 2009 Aug 26). Air was puffed through the odor cartridge at a controlled volume (5 ml/sec) for each puff, delivering vapors to the constant humidified airstream flowing over the mosquito.

[00110] To detect neuronal response, extracellular single-sensillum electrophysiology was performed as described in Dobritsa et al., 2003 (Dobritsa, A.A. et al., *Integrating the molecular and cellular basis of odor coding in the Drosophila antenna*. Neuron. 2003 Mar 6;37(5):827-41) and modified as described in Turner et al., 2011 (Turner, S.L. et al., *Ultra-prolonged activation of CO₂-sensing neurons disorients mosquitoes*. Nature. 2011 Jun 2;474(7349):87-91).

[00111] Following this method, neuronal action potential was detected and recorded by inserting an electrode through the wall of the sensillum and into contact with the lymph associated with the dendritic cells therein. The recording electrode was comprised of a glass capillary with a tip drawn to a diameter of <1 micrometer. The capillary was filled with sensillum lymph ringer solution (0.4% glucose, 1.3% KCl, 0.1% KH₂PO₄, 0.2% K₂HPO₄, 0.06% MgCl₂, 0.01% CaCl₂ and .0001% HCl, pH 6.5) and placed over an AgCl-coated silver wire. A second, indifferent electrode, was also filled with sensillum lymph ringer solution and put into the eye of the mosquito. The impulse signals obtained were amplified and filtered to analyze only the traces in which the neuronal activity of the different neurons in the sensillum were isolated by impulse amplitude.

[00112] The number of impulses, referred to herein as “spikes” per second (spk/sec) were recorded as an indicator of neuronal activity in response to the stimulus provided. The final activation values were obtained by subtracting the levels recorded upon stimulation from the baseline activity values. As an example of results obtained using this method, Figure 1 illustrates the basal activity of the CO₂-receptor with paraffin oil, the solvent for the chemicals tested using electrophysiology (top panel), compared to 1% concentrations of an inhibitor, 2-methoxy-3-methylpyridine (middle panel), and an activator, 2,4-lutidine (bottom panel). 2-methoxy-3-methylpyridine is approved for fragrance use and has a “nutty” odor. 2,4-lutidine has a “green” odor, is approved for cosmetic fragrance use and is listed by the Flavor and Extract Manufacturers Association (FEMA) as a “Generally Regarded as Safe” (GRAS) compound.

Example 2. Identification of activator compounds

[00113] Following the experimentals outlined in Example 1, a series of compounds were tested for their ability to activate cpA neuronal activity. A list of these compounds is provided in Table 6. The compounds are categorized according to their strength as activators where strong activators yield an increase in activity that is >60 spk/sec over baseline neuronal activity. Moderate activators yield an increase in neuronal activity that is between 40 and 60 spk/sec over baseline neuronal activity. Finally, mild activators yield an increase in neuronal activity that is between 20 and 40 spk/sec over baseline neuronal activity.

Table 6. Activator Compounds

Compound No.	Compound	Class
OLI0001	2,4-lutidine	Strong Activator
OLI0002	2-ethylpyrazine	Strong Activator
OLI0003	2-methoxypyrazine	Strong Activator
OLI0004	2-methyltetrahydrofuran-3-one	Strong Activator
OLI0005	4-ethylphenol	Strong Activator
OLI0006	5-methyl furfural	Strong Activator
OLI0007	butyl formate	Strong Activator
OLI0008	Cyclopentanone	Strong Activator

OLI0009	ethyl 2-furoate	Strong Activator
OLI0010	Ethyllactate	Strong Activator
OLI0011	Ethylvinylcarbinol	Strong Activator
OLI0012	Guaiacol	Strong Activator
OLI0013	trans-2-methyl-2-butenal	Strong Activator
OLI0014	2,3,5-trimethylpyrazine	Moderate Activator
OLI0015	2,3-dimethylpyrazine	Moderate Activator
OLI0016	2-acetyl-5-methyl furan	Moderate Activator
OLI0017	2-furyl methyl ketone	Moderate Activator
OLI0018	2-pentanone	Moderate Activator
OLI0019	allyl butyrate	Moderate Activator
OLI0020	cinnamyl nitrile	Moderate Activator
OLI0021	ethyl 3-hydroxyhexanoate	Moderate Activator
OLI0022	Ethylacetoacetate	Moderate Activator
OLI0023	Ethylvinylketone	Moderate Activator
OLI0024	gamma-heptalactone	Moderate Activator
OLI0025	methanethiol acetate	Moderate Activator
OLI0026	methyl crotonate	Moderate Activator
OLI0027	methyl levulinate	Moderate Activator
OLI0028	Phenylacetaldehyde	Moderate Activator
OLI0029	Phenylpropylaldehyde	Moderate Activator
OLI0030	2,4-dimethyl benzaldehyde	Mild Activator
OLI0031	2,4-dimethyl-3-cyclohexene-carboxaldehyde (mixture of cis/trans forms)	Mild Activator
OLI0032	2-ethyl-5(6)-methylpyrazine	Mild Activator
OLI0033	2-methoxy-4-methylphenol	Mild Activator
OLI0034	2-phenylpropionaldehyde	Mild Activator
OLI0035	3-hexanone	Mild Activator
OLI0036	4-ethylbenzaldehyde	Mild Activator
OLI0037	4-oxoisophorone	Mild Activator

OLI0038	acetyl-2-pyrazine	Mild Activator
OLI0039	butan-3-one-2-yl butanoate	Mild Activator
OLI0040	dimethyl succinate	Mild Activator
OLI0041	dipropylenglykol-monomethyl ether	Mild Activator
OLI0042	ethyl 3-hydroxybutyrate	Mild Activator
OLI0043	ethyl-2,3,5(6)-dimethyl pyrazine	Mild Activator
OLI0044	Ethylformate	Mild Activator
OLI0045	Ethylisobutyrate	Mild Activator
OLI0046	Ethylisovalerate	Mild Activator
OLI0047	Ethyllevulinate	Mild Activator
OLI0048	Furfurylethylether	Mild Activator
OLI0049	Heptaldehyde	Mild Activator
OLI0050	heptanone-4	Mild Activator
OLI0051	Hexanal	Mild Activator
OLI0052	Indole	Mild Activator
OLI0053	isobutyl acetate	Mild Activator
OLI0054	isobutyl propionate	Mild Activator
OLI0055	isobutyl trans-2-butenate	Mild Activator
OLI0056	isopropyl butyrate	Mild Activator
OLI0057	isopropyl tiglate	Mild Activator
OLI0058	methyl isovalerate	Mild Activator
OLI0059	Methylheptadienone	Mild Activator
OLI0060	m-tolualdehyde	Mild Activator
OLI0061	o-anisaldehyde	Mild Activator
OLI0062	Prenylacetate	Mild Activator
OLI0063	propyl formate	Mild Activator
OLI0064	R-+ pulegone	Mild Activator
OLI0065	trans-cinnamaldehyde	Mild Activator
OLI0066	Valeraldehyde	Mild Activator

Example 3. Identification of very strong activator combinations

[00114] Following the experimentals outlined in Example 1, a series of combinations were tested for their ability to activate cpA neuronal activity. Table 7 shows neuronal activity values (spk/sec) obtained after introducing a variety of combinations into the odor-delivery system. Combinations tested were composed of 1% of component A and 1% component B in the test solution. Each of these combinations led to neuronal activity values above 100 spk/sec. As such, these combinations are considered very strong activators. In many instances, the combination of two components or compounds produced activity which was greater than the activity of either compound alone. In this case, the combination was considered synergistic. In the Table, “Act” refers to activity and “Cmpd” refers to compound.

Table 7. Very Strong Activator Combinations

Cmpd No.	Component A	Cmpd No.	Component B	Act (spk/sec)
OLI0006	5-methylfurfural	OLI0001	2,4-lutidine	110
OLI0006	5-methylfurfural	OLI0002	2-ethylpyrazine	119
OLI0006	5-methylfurfural	OLI0003	2-methoxypyrazine	113
OLI0006	5-methylfurfural	OLI0004	2-methyltetrahydrofuran-3-one	124
OLI0006	5-methylfurfural	OLI0007	butylformate	101
OLI0006	5-methylfurfural	OLI0008	cyclopentanone	143
OLI0006	5-methylfurfural	OLI0010	ethyl lactate	159
OLI0006	5-methylfurfural	OLI0011	ethylvinylcarbinol	135
OLI0017	2-furylmethylketone	OLI0020	cinnamyl nitrile	115
OLI0017	2-furylmethylketone	OLI0022	ethylacetoacetate	112
OLI0008	cyclopentanone	OLI0001	2,4-lutidine	136
OLI0008	cyclopentanone	OLI0002	2-ethylpyrazine	156
OLI0008	cyclopentanone	OLI0003	2-methoxypyrazine	156
OLI0008	cyclopentanone	OLI0004	2-methyltetrahydrofuran-3-one	151
OLI0008	cyclopentanone	OLI0022	ethylacetoacetate	151

OLI0008	cyclopentanone	OLI0011	ethylvinylcarbinol	144
OLI0010	Ethyllactate	OLI0001	2,4-lutidine	162
OLI0010	Ethyllactate	OLI0002	2-ethylpyrazine	154
OLI0010	Ethyllactate	OLI0003	2-methoxypyrazine	167
OLI0010	Ethyllactate	OLI0004	2-methyltetrahydrofuran-3-one	164
OLI0010	Ethyllactate	OLI0007	butylformate	110
OLI0010	Ethyllactate	OLI0008	cyclopentanone	163
OLI0010	Ethyllactate	OLI0011	ethylvinylcarbinol	156
OLI0010	Ethyllactate	OLI0013	trans-2-methyl-2-butenal	126
OLI0007	Butylformate	OLI0001	2,4-lutidine	119
OLI0007	Butylformate	OLI0002	2-ethylpyrazine	118
OLI0007	Butylformate	OLI0003	2-methoxypyrazine	108
OLI0007	Butylformate	OLI0004	2-methyltetrahydrofuran-3-one	131
OLI0007	Butylformate	OLI0008	cyclopentanone	146
OLI0007	Butylformate	OLI0011	ethylvinylcarbinol	110
OLI0013	trans-2-methyl-2-butenal	OLI0001	2,4-lutidine	112
OLI0013	trans-2-methyl-2-butenal	OLI0002	2-ethylpyrazine	127
OLI0013	trans-2-methyl-2-butenal	OLI0003	2-methoxypyrazine	126
OLI0013	trans-2-methyl-2-butenal	OLI0004	2-methyltetrahydrofuran-3-one	148
OLI0013	trans-2-methyl-2-butenal	OLI0008	cyclopentanone	165
OLI0013	trans-2-methyl-2-butenal	OLI0011	ethylvinylcarbinol	128
OLI0002	2-ethylpyrazine	OLI0001	2,4-lutidine	118

OLI0002	2-ethylpyrazine	OLI0003	2-methoxypyrazine	121
OLI0002	2-ethylpyrazine	OLI0004	2-methyltetrahydrofuran-3-one	134
OLI0002	2-ethylpyrazine	OLI0011	ethylvinylcarbinol	122
OLI0003	2-methoxypyrazine	OLI0004	2-methyltetrahydrofuran-3-one	134
OLI0003	2-methoxypyrazine	OLI0011	ethylvinylcarbinol	146
OLI0015	2,3-dimethylpyrazine	OLI0024	gamma-heptalactone	102
OLI0011	ethylvinylcarbinol	OLI0004	2-methyltetrahydrofuran-3-one	124
OLI0096	cis-3-hexenyl formate	OLI0017	2-furyl methyl ketone	147
OLI0099	isoamyl propionate	OLI0017	2-furyl methyl ketone	118
OLI0097	hexyl formate	OLI0017	2-furyl methyl ketone	115
OLI0027	methyl levulinate	OLI0025	methanethiol acetate	160
OLI0027	methyl levulinate	OLI0024	gamma-heptalactone	158
OLI0027	methyl levulinate	OLI0022	ethyl acetoacetate	144
OLI0027	methyl levulinate	OLI0021	ethyl 3-hydroxyhexanoate	126
OLI0027	methyl levulinate	OLI0018	2-pentanone	125
OLI0027	methyl levulinate	OLI0014	2,3,5-trimethylpyrazine	107

Example 4. Identification of strong activator combinations

[00115] Following the experimentals outlined in Example 1, a series of combinations (listed in Table 8) were tested for their ability to activate cpA neuronal activity in electrophysiological extracellular single-sensillum studies. These combinations were added to the test solution at a concentration of 1% component A and 1% component B. Each of the combinations in the table yielded activity values of between 60 and 100 spk/sec and hence are considered strong

activators. Where the combination of two components or compounds produced activity which was greater than the activity of either compound alone, the combination was considered synergistic. In the Table, “Act” refers to activity and “Cmpd” refers to compound.

Table 8. Strong Activator Combinations

Cmpd No.	Component A	Cmpd No.	Component B	Act (spk/sec)
OLI0014	2,3,5-trimethylpyrazine	OLI0018	2-pentanone	63
OLI0014	2,3,5-trimethylpyrazine	OLI0024	gamma-heptalactone	71
OLI0014	2,3,5-trimethylpyrazine	OLI0028	phenylacetaldehyde	67
OLI0015	2,3-dimethylpyrazine	OLI0014	2,3,5-trimethylpyrazine	92
OLI0015	2,3-dimethylpyrazine	OLI0019	allylbutyrate	61
OLI0015	2,3-dimethylpyrazine	OLI0021	ethyl 3-hydroxyhexanoate	65
OLI0015	2,3-dimethylpyrazine	OLI0028	phenylacetaldehyde	77
OLI0016	2-acetyl-5-methylfuran	OLI0014	2,3,5-trimethylpyrazine	78
OLI0016	2-acetyl-5-methylfuran	OLI0021	ethyl 3-hydroxyhexanoate	60
OLI0016	2-acetyl-5-methylfuran	OLI0024	gamma-heptalactone	92
OLI0016	2-acetyl-5-methylfuran	OLI0029	phenylpropylaldehyde	64
OLI0006	5-methylfurfural	OLI0013	trans-2-methyl-2-butenal	99
OLI0017	2-furylmethylketone	OLI0014	2,3,5-trimethylpyrazine	91
OLI0017	2-furylmethylketone	OLI0015	2,3-dimethylpyrazine	78
OLI0017	2-furylmethylketone	OLI0016	2-acetyl-5-methylfuran	60
OLI0092	methylamylketone	OLI0017	2-furylmethylketone	75
OLI0092	methylamylketone	OLI0024	gamma-heptalactone	60
OLI0020	Cinnamyl nitrile	OLI0014	2,3,5-trimethylpyrazine	62
OLI0020	Cinnamyl nitrile	OLI0015	2,3-dimethylpyrazine	62
OLI0020	Cinnamyl nitrile	OLI0024	gamma-heptalactone	77

OLI0020	Cinnamyl nitrile	OLI0029	phenylpropylaldehyde	64
OLI0021	ethyl 3-hydroxyhexanoate	OLI0028	phenylacetaldehyde	62
OLI0022	ethylacetoacetate	OLI0014	2,3,5-trimethylpyrazine	76
OLI0022	ethylacetoacetate	OLI0015	2,3-dimethylpyrazine	67
OLI0022	ethylacetoacetate	OLI0016	2-acetyl-5-methylfuran	65
OLI0022	ethylacetoacetate	OLI0018	2-pentanone	62
OLI0022	ethylacetoacetate	OLI0020	cinnamyl nitrile	63
OLI0022	Ethylacetoacetate	OLI0021	ethyl 3-hydroxyhexanoate	68
OLI0022	Ethylacetoacetate	OLI0024	gamma-heptalactone	87
OLI0022	ethylacetoacetate	OLI0028	phenylacetaldehyde	60
OLI0024	gamma-heptalactone	OLI0018	2-pentanone	70
OLI0024	gamma-heptalactone	OLI0019	allylbutyrate	73
OLI0024	gamma-heptalactone	OLI0021	ethyl 3-hydroxyhexanoate	75
OLI0024	gamma-heptalactone	OLI0028	phenylacetaldehyde	69
OLI0024	gamma-heptalactone	OLI0029	phenylpropylaldehyde	64
OLI0100	methyl (E)-hex-3-enoate	OLI0014	2,3,5-trimethylpyrazine	77
OLI0100	methyl (E)-hex-3-enoate	OLI0016	2-acetyl-5-methylfuran	77
OLI0100	methyl (E)-hex-3-enoate	OLI0024	gamma-heptalactone	82
OLI0098	isoamyl formate	OLI0017	2-furyl methyl ketone	83
OLI0097	hexyl formate	OLI0024	gamma-heptalactone	82
OLI0097	hexyl formate	OLI0014	2,3,5-trimethylpyrazine	75
OLI0096	cis-3-hexenyl formate	OLI0024	gamma-heptalactone	72
OLI0098	isoamyl formate	OLI0014	2,3,5-trimethylpyrazine	69
OLI0099	isoamyl propionate	OLI0014	2,3,5-trimethylpyrazine	69
OLI0098	isoamyl formate	OLI0024	gamma-heptalactone	63
OLI0098	isoamyl formate	OLI0022	ethyl acetoacetate	63
OLI0027	methyl levulinate	OLI0015	2,3-dimethylpyrazine	97
OLI0027	methyl levulinate	OLI0029	phenyl propyl aldehyde	96

OLI0008	Cyclopentanone	OLI0063	propyl formate	92
OLI0027	methyl levulinate	OLI0026	methyl crotonate	92
OLI0091	methyl heptanoate	OLI0025	methanethiol acetate	89
OLI0018	2-pentanone	OLI0063	propyl formate	80
OLI0027	methyl levulinate	OLI0019	allyl butyrate	78
OLI0027	methyl levulinate	OLI0020	cinnamyl nitrile	70

Example 5. Identification of synergistic combinations

[00116] Following the experimentals outlined in Example 1, the combinations described in Table 9 were also used in electrophysiological extracellular single-sensillum studies. These combinations were added to the test solution at a concentration of 1% component A and 1% component B.

[00117] It was noted that the individual components yielded only moderate activity (moderate activator class, 40-60 spk/sec), mild activity (mild activator class, 20-40 spk/sec) or are only known to stimulate cpB and cpC neurons (beta activator class) when tested individually. Surprisingly, the components work synergistically to stimulate neuronal activity when combined as listed in Table 9, leading to activity values greater than 60 spk/sec.

[00118] Some combinations tested included the mild inhibitor methyl heptanoate or methylamylketone. Unexpectedly, compositions comprising methylamylketone and 2-furylmethylketone or gamma-heptalactone acted as strong activators of neuronal activity. Likewise, compositions comprising methyl heptanoate and methanethiol acetate also acted as strong activators of neuronal activity. In the Table, “Act” refers to activity, “Cmpd” refers to compound, “Comp” refers to component, “Mod” refers to moderate, “Inh” refers to inhibitor and “Actv” refers to activator.

Table 9. Synergistic Combinations Yielding Strong or Very Strong Activity

Cmpd No.	Comp A	Comp A Class	Cmpd No.	Comp B	Comp B Class	Act (spk/sec)
OLI0014	2,3,5-	Mod	OLI0018	2-pentanone	Mod	63

	trimethylpyrazine	Actv			Actv	
OLI0014	2,3,5-trimethylpyrazine	Mod Actv	OLI0020	cinnamyl nitrile	Mod Actv	62
OLI0014	2,3,5-trimethylpyrazine	Mod Actv	OLI0024	gamma-heptalactone	Mod Actv	71
OLI0014	2,3,5-trimethylpyrazine	Mod Actv	OLI0100	methyl (E)-hex-3-enoate	Beta Actv	77
OLI0014	2,3,5-trimethylpyrazine	Mod Actv	OLI0028	phenylacetaldehyde	Mod Actv	67
OLI0015	2,3-dimethylpyrazine	Mod Actv	OLI0014	2,3,5-trimethylpyrazine	Mod Actv	92
OLI0015	2,3-dimethylpyrazine	Mod Actv	OLI0019	allylbutyrate	Mod Actv	61
OLI0015	2,3-dimethylpyrazine	Mod Actv	OLI0020	cinnamyl nitrile	Mod Actv	62
OLI0015	2,3-dimethylpyrazine	Mod Actv	OLI0021	ethyl 3-hydroxyhexanoate	Mod Actv	65
OLI0015	2,3-dimethylpyrazine	Mod Actv	OLI0024	gamma-heptalactone	Mod Actv	102
OLI0015	2,3-dimethylpyrazine	Mod Actv	OLI0028	phenylacetaldehyde	Mod Actv	77
OLI0017	2-furylmethylketone	Mod Actv	OLI0014	2,3,5-trimethylpyrazine	Mod Actv	91
OLI0017	2-furylmethylketone	Mod Actv	OLI0015	2,3-dimethylpyrazine	Mod Actv	78
OLI0017	2-furylmethylketone	Mod Actv	OLI0016	2-acetyl-5-methylfuran	Mod Actv	60
OLI0017	2-furylmethylketone	Mod Actv	OLI0020	cinnamyl nitrile	Mod Actv	115
OLI0017	2-furylmethylketone	Mod	OLI0022	ethylacetoacetate	Mod	112

		Actv			Actv	
OLI0017	2-furylmethylketone	Mod Actv	OLI0092	methylamylketone	Mild Inh	75
OLI0016	2-acetyl-5-methylfuran	Mod Actv	OLI0014	2,3,5-trimethylpyrazine	Mod Actv	78
OLI0016	2-acetyl-5-methylfuran	Mod Actv	OLI0021	ethyl 3-hydroxyhexanoate	Mod Actv	60
OLI0016	2-acetyl-5-methylfuran	Mod Actv	OLI0024	gamma-heptalactone	Mod Actv	92
OLI0016	2-acetyl-5-methylfuran	Mod Actv	OLI0100	methyl (E)-hex-3-enoate	Beta Actv	77
OLI0016	2-acetyl-5-methylfuran	Mod Actv	OLI0029	phenylpropylaldehyde	Mod Actv	64
OLI0022	ethylacetoacetate	Mod Actv	OLI0014	2,3,5-trimethylpyrazine	Mod Actv	76
OLI0022	ethylacetoacetate	Mod Actv	OLI0015	2,3-dimethylpyrazine	Mod Actv	67
OLI0022	ethylacetoacetate	Mod Actv	OLI0016	2-acetyl-5-methylfuran	Mod Actv	65
OLI0022	ethylacetoacetate	Mod Actv	OLI0018	2-pentanone	Mod Actv	62
OLI0022	ethylacetoacetate	Mod Actv	OLI0020	cinnamyl nitrile	Mod Actv	63
OLI0022	ethylacetoacetate	Mod Actv	OLI0021	ethyl 3-hydroxyhexanoate	Mod Actv	68
OLI0022	ethylacetoacetate	Mod Actv	OLI0024	gamma-heptalactone	Mod Actv	87
OLI0022	ethylacetoacetate	Mod Actv	OLI0028	phenylacetaldehyde	Mod Actv	60
OLI0024	gamma-heptalactone	Mod	OLI0018	2-pentanone	Mod	70

		Actv			Actv	
OLI0024	gamma-heptalactone	Mod Actv	OLI0019	allylbutyrate	Mod Actv	73
OLI0024	gamma-heptalactone	Mod Actv	OLI0020	cinnamyl nitrile	Mod Actv	77
OLI0024	gamma-heptalactone	Mod Actv	OLI0021	ethyl 3-hydroxyhexanoate	Mod Actv	75
OLI0024	gamma-heptalactone	Mod Actv	OLI0100	methyl (E)-hex-3-enoate	Beta Actv	82
OLI0024	gamma-heptalactone	Mod Actv	OLI0092	methylamylketone	Mild Inh	60
OLI0024	gamma-heptalactone	Mod Actv	OLI0029	phenylpropylaldehyde	Mod Actv	64
OLI0024	gamma-heptalactone	Mod Actv	OLI0028	phenylacetaldehyde	Mod Actv	69
OLI0029	phenylpropylaldehyde	Mod Actv	OLI0020	cinnamyl nitrile	Mod Actv	64
OLI0021	ethyl 3-hydroxyhexanoate	Mod Actv	OLI0028	phenylacetaldehyde	Mod Actv	62
OLI0018	2-pentanone	Mod Actv	OLI0063	propyl formate	Mild Actv	80
OLI0091	methyl heptanoate	Mild Inh	OLI0025	methanethiol acetate	Mod Actv	89
OLI0027	methyl levulinate	Mod Actv	OLI0020	cinnamyl nitrile	Mod Actv	70
OLI0027	methyl levulinate	Mod Actv	OLI0029	phenyl propyl aldehyde	Mod Actv	96
OLI0027	methyl levulinate	Mod Actv	OLI0015	2,3-dimethylpyrazine	Mod Actv	97
OLI0027	methyl levulinate	Mod	OLI0026	methyl crotonate	Mod	92

		Actv			Actv	
OLI0027	methyl levulinate	Mod Actv	OLI0019	allyl butyrate	Mod Actv	78
OLI0027	methyl levulinate	Mod Actv	OLI0014	2,3,5-trimethylpyrazine	Mod Actv	107
OLI0027	methyl levulinate	Mod Actv	OLI0022	ethyl acetoacetate	Mod Actv	144
OLI0027	methyl levulinate	Mod Actv	OLI0025	methanethiol acetate	Mod Actv	160
OLI0027	methyl levulinate	Mod Actv	OLI0021	ethyl 3-hydroxyhexanoate	Mod Actv	126
OLI0027	methyl levulinate	Mod Actv	OLI0024	gamma-heptalactone	Mod Actv	158
OLI0027	methyl levulinate	Mod Actv	OLI0018	2-pentanone	Mod Actv	125

Example 6. Identification of sensory neuron modulators-inhibitors

[00119] Following the protocol of Example 1, compounds and combinations were tested for their ability to inhibit CO₂-responsive neuronal activity. To analyze neuronal inhibition, activity levels recorded that fell below baseline activity levels were expressed as a percent reduction in activity over the baseline level.

[00120] When tested in the present assay, a number of compounds led to a reduction in cpA neuronal activity. Depending on the percent reduction in activity compared to baseline values, these compounds were classified as strong inhibitors (reducing activity >60%), moderate inhibitors (reducing activity by 40-60%) and mild inhibitors (reducing activity by 20-40%). A list of the single compounds tested and their inhibition level or class is given in Table 10.

Table 10. Inhibitor Compounds

Compound No.	Compound	Class
OLI0067	2,3-diethyl-5-methylpyrazine	Strong Inhibitor

OLI0068	2,3-diethylpyrazine	Strong Inhibitor
OLI0069	2-ethyl-3-methylpyrazine	Strong Inhibitor
OLI0070	2-methoxy-3-methylpyrazine	Strong Inhibitor
OLI0071	2-ethyl-3-methoxypyrazine	Moderate Inhibitor
OLI0072	2-methoxy-3(5or6)isopropylpyrazine	Moderate Inhibitor
OLI0073	cis-3-hexenylacetate	Moderate Inhibitor
OLI0074	furfurylpentanoate	Moderate Inhibitor
OLI0075	octanone-3	Moderate Inhibitor
OLI0076	phenethylpropionate	Moderate Inhibitor
OLI0077	trans-2-decenal	Moderate Inhibitor
OLI0078	(Z)-hept-3-enylacetate	Mild Inhibitor
OLI0079	1-ethylhexyl tiglate	Mild Inhibitor
OLI0080	1-octanol	Mild Inhibitor
OLI0081	2,5-dimethyl-4-methoxy-3(2H) furanone	Mild Inhibitor
OLI0082	alpha,alpha-dimethyl phenethyl butyrate	Mild Inhibitor
OLI0083	cis-3-hexenyl butyrate	Mild Inhibitor
OLI0084	cis-5-octen-1-ol	Mild Inhibitor
OLI0085	ethyl nicotinate	Mild Inhibitor
OLI0086	ethylheptanoate	Mild Inhibitor
OLI0087	Eucalyptol	Mild Inhibitor
OLI0088	furfurylpentenoate	Mild Inhibitor
OLI0089	geranylacetone	Mild Inhibitor
OLI0090	geranylbutyrate	Mild Inhibitor
OLI0091	methyl heptanoate	Mild Inhibitor
OLI0092	methylamylketone	Mild Inhibitor
OLI0093	rosemary oil	Mild Inhibitor
OLI0094	whiskey lactone	Mild Inhibitor
OLI0095	veratraldehyde	Mild Inhibitor

Example 7. Identification of strong inhibitor combinations

[00121] Following the protocol of Example 1, combinations listed in Table 11 were tested for their ability to inhibit CO₂-responsive neuronal activity. Combinations comprising either 2 or 3 components were tested for their ability to inhibit neuronal activity. The combinations listed in Table 11 are 2-component combinations that led to a >50% reduction in neuronal activity as compared to baseline activity. For the combinations of Table 11, the concentration of each component was 1%. In the Table, “Act” refers to activity, “Red” refers to reduction and “Cmpd” refers to compound.

Table 11. Two-Component Inhibitor Compositions

Cmpd No.	Component A	Cmpd No.	Component B	Act (% Red)
OLI0102	Eugenol	OLI0089	geranylacetone	64
OLI0102	Eugenol	OLI0078	(Z)-hept-3-enylacetate	79
OLI0102	Eugenol	OLI0080	1-octanol	81
OLI0102	Eugenol	OLI0082	alpha,alpha-dimethylphenethylbutyrate	73
OLI0102	Eugenol	OLI0083	cis-3-hexenylbutyrate	72
OLI0102	Eugenol	OLI0084	cis-5-octen-1-ol	77
OLI0102	Eugenol	OLI0074	furfurylpentanoate	72
OLI0102	Eugenol	OLI0095	veratraldehyde	68
OLI0093	rosemary oil	OLI0102	eugenol	74
OLI0093	rosemary oil	OLI0089	geranylacetone	61
OLI0093	rosemary oil	OLI0084	cis-5-octen-1-ol	64
OLI0100	methyl (E)-hex-3-enoate	OLI0071	2-ethyl-3-methoxypyrazine	63
OLI0076	Phenethylpropionate	OLI0072	2-methoxy-3(5or6)isopropylpyrazine	56
OLI0076	Phenethylpropionate	OLI0074	furfurylpentanoate	57
OLI0076	Phenethylpropionate	OLI0077	trans-2-decenal	58
OLI0076	Phenethylpropionate	OLI0071	2-ethyl-3-methoxypyrazine	73
OLI0071	2-ethyl-3-methoxypyrazine	OLI0072	2-methoxy-	78

			3(5or6)isopropylpyrazine	
OLI0071	2-ethyl-3-methoxypyrazine	OLI0073	cis-3-hexenylacetate	73
OLI0071	2-ethyl-3-methoxypyrazine	OLI0074	furfurylpentanoate	79
OLI0071	2-ethyl-3-methoxypyrazine	OLI0075	octanone-3	69
OLI0071	2-ethyl-3-methoxypyrazine	OLI0077	trans-2-decenal	76
OLI0068	2,3-diethylpyrazine	OLI0067	2,3-diethyl-5-methylpyrazine	100
OLI0068	2,3-diethylpyrazine	OLI0070	2-methoxy-3-methylpyrazine	100
OLI0068	2,3-diethylpyrazine	OLI0069	2-ethyl-3-methylpyrazine	94
OLI0015	2,3-dimethylpyrazine	OLI0100	methyl (E)-hex-3-enoate	87
OLI0067	2,3-diethyl-5-methylpyrazine	OLI0070	2-methoxy-3-methylpyrazine	100

[00122] The combinations listed in Table 12 comprise 3 components and lead to a >60% reduction in CO₂-responsive neuronal activity. In the three-component combinations tested, each component was present in the test solution at a concentration of 0.6%. In the Table, “Act” refers to activity, “Red” refers to reduction, “Comp” refers to component and “Cmpd” refers to compound.

Table 12. Three-Inhibitor Combinations

Cmpd	Comp A	Cmpd	Comp B	Cmpd	Comp C	Act (% Red)
OLI0078	(Z)-hept-3-enyl acetate	OLI010 2	eugenol	OLI007 1	2-ethyl-3- methoxypyrazine	96
OLI0080	1-octanol	OLI010 2	eugenol	OLI007 1	2-ethyl-3- methoxypyrazine	100
OLI0068	2,3- diethylpyrazine	OLI010 2	eugenol	OLI007 8	(Z)-hept-3- enylacetate	97
OLI0068	2,3- diethylpyrazine	OLI010 2	eugenol	OLI008 0	1-octanol	97
OLI0068	2,3- diethylpyrazine	OLI007 1	2-ethyl-3- methoxypyrazine	OLI007 2	2-methoxy- 3(5or6)isopropyl	100

					pyrazine	
OLI0068	2,3-diethylpyrazine	OLI0071	2-ethyl-3-methoxypyrazine	OLI0074	furfurylpentanoate	100
OLI0072	2-methoxy-3(5or6)isopropylpyrazine	OLI0071	2-ethyl-3-methoxypyrazine	OLI0078	(Z)-hept-3-enylacetate	98
OLI0072	2-methoxy-3(5or6)isopropylpyrazine	OLI0071	2-ethyl-3-methoxypyrazine	OLI0080	1-octanol	92
OLI0072	2-methoxy-3(5or6)isopropylpyrazine	OLI0071	2-ethyl-3-methoxypyrazine	OLI0102	eugenol	98
OLI0074	furfurylpentanoate	OLI0071	2-ethyl-3-methoxypyrazine	OLI0072	2-methoxy-3(5or6)isopropylpyrazine	93
OLI0074	furfurylpentanoate	OLI0071	2-ethyl-3-methoxypyrazine	OLI0102	eugenol	98
OLI0100	methyl (E)-hex-3-enoate	OLI0068	2,3-diethylpyrazine	OLI0080	1-octanol	97
OLI0100	methyl (E)-hex-3-enoate	OLI0068	2,3-diethylpyrazine	OLI0071	2-ethyl-3-methoxypyrazine	99
OLI0100	methyl (E)-hex-3-enoate	OLI0068	2,3-diethylpyrazine	OLI0072	2-methoxy-3(5or6)isopropylpyrazine	99
OLI0100	methyl (E)-hex-3-enoate	OLI0068	2,3-diethylpyrazine	OLI0102	eugenol	94
OLI0100	methyl (E)-hex-3-enoate	OLI0068	2,3-diethylpyrazine	OLI0074	furfurylpentanoate	100
OLI0100	methyl (E)-hex-3-enoate	OLI0068	2,3-diethylpyrazine	OLI0078	(Z)-hept-3-enylacetate	96

Example 8. Identification of synergistic inhibitor combinations

[00123] Interestingly, some 2 and 3-component combinations yield >60% reduction in activity where the individual components yielded only moderate (40-60%) or mild (20-40%) inhibition or are known only to activate cpB and cpC neurons (beta activators). Unexpectedly, in one embodiment, a moderate activator, 2,3-dimethyl pyrazine, when combined with a beta activator, methyl (E)-hex-3-enoate, also led to a >60% reduction in activity.

The combinations listed in Table 13 have been shown, for the first time, to work synergistically when combined to inhibit neuronal activity in mosquitoes. In the study, two-component combinations comprised test solutions of 1% each of component A and component B while three-component combinations comprised test solutions of 0.6% of each of components A, B and C. An “x” in the Table indicates the component was not present. In the Table, “Act” refers to activity, “Cmpd” refers to compound, “Comp” refers to component, “Red” refers to reduced, “Mod” refers to moderate, “Inh” refers to inhibitor and “Actv” refers to activator.

Table 13. Inhibitor Compositions with Synergistic Effects

Cmpd No.	Comp A	Class A	Cmpd No.	Comp B	Class B	Cmpd No.	Comp C	Class C	Act (% Red)
OLI009 3	rosemary oil	Mild Inh	OLI008 9	geranyl acetone	Mild Inh		x	x	61
OLI009 3	rosemary oil	Mild Inh	OLI008 4	cis-5-octen-1-ol	Mild Inh		x	x	64
OLI009 3	rosemary oil	Mild Inh	OLI010 2	eugenol	Mild Inh		x	x	74
OLI010 2	eugenol	Mild Inh	OLI008 9	geranyl acetone	Mild Inh		x	x	64
OLI010 2	eugenol	Mild Inh	OLI007 8	(Z)-hept-3-enylacetate	Mild Inh		x	x	79
OLI010 2	eugenol	Mild Inh	OLI008 2	alpha,alpha-dimethyl phenethyl-	Mild Inh		x	x	73

				butyrate					
OLI010 2	eugenol	Mild Inh	OLI008 3	cis-3-hexenyl butyrate	Mild Inh		x	x	72
OLI010 2	eugenol	Mild Inh	OLI008 4	cis-5-octen- 1-ol	Mild Inh		x	x	77
OLI010 2	eugenol	Mild Inh	OLI007 4	furfuryl pentanoate	Mod Inh		x	x	72
OLI010 2	eugenol	Mild Inh	OLI009 5	veratraldehyd e	Mild Inh		x	x	68
OLI010 2	eugenol	Mild Inh	OLI007 8	(Z)-hept-3- enylacetate	Mild Inh	OLI007 1	2-ethyl-3- methoxy- pyrazine	Mod Inh	96
OLI010 2	eugenol	Mild Inh	OLI008 0	1-octanol	Mild Inh		x	x	81
OLI010 2	eugenol	Mild Inh	OLI008 0	1-octanol	Mild Inh	OLI007 1	2-ethyl-3- methoxy- pyrazine	Mod Inh	100
OLI007 6	phenethyl - propionat e	Mod Inh	OLI007 1	2-ethyl-3- methoxy pyrazine	Mod Inh		x	x	73
OLI007 1	2-ethyl-3- methoxy- pyrazine	Mod Inh	OLI007 2	2-methoxy- 3(5or6)iso propyl pyrazine	Mod Inh		x	x	78
OLI007 1	2-ethyl-3- methoxy- pyrazine	Mod Inh	OLI007 2	2-methoxy- 3(5or6)iso propyl pyrazine	Mod Inh	OLI007 8	(Z)-hept-3- enylacetate	Mild Inh	98
OLI007	2-ethyl-3-	Mod	OLI007	2-methoxy-	Mod	OLI008	1-octanol	Mild	92

1	methoxy-pyrazine	Inh	2	3(5or6)isopropylpyrazine	Inh	0		Inh	
OLI007 1	2-ethyl-3-methoxy-pyrazine	Mod Inh	OLI007 2	2-methoxy-3(5or6)isopropylpyrazine	Mod Inh	OLI010 2	Eugenol	Mild Inh	98
OLI007 1	2-ethyl-3-methoxy-pyrazine	Mod Inh	OLI010 0	methyl (E)-hex-3-enoate	Beta Actv		X	x	63
OLI007 1	2-ethyl-3-methoxy-pyrazine	Mod Inh	OLI007 3	cis-3-hexenyl acetate	Mod Inh		X	x	73
OLI007 1	2-ethyl-3-methoxy-pyrazine	Mod Inh	OLI007 4	furfuryl pentanoate	Mod Inh		X	x	79
OLI007 1	2-ethyl-3-methoxy-pyrazine	Mod Inh	OLI007 5	octanone-3	Mod Inh		X	x	69
OLI007 1	2-ethyl-3-methoxy pyrazine	Mod Inh	OLI007 7	trans-2-decenal	Mod Inh		X	x	76
OLI007 4	furfuryl-pentanoate	Mod Inh	OLI007 1	2-ethyl-3-methoxy pyrazine	Mod Inh	OLI007 2	2-methoxy-3(5or6)isopropyl-pyrazine	Mod Inh	93
OLI007 4	furfuryl-pentanoate	Mod Inh	OLI007 1	2-ethyl-3-methoxy pyrazine	Mod Inh	OLI010 2	Eugenol	Mild Inh	98
OLI010	methyl	Beta	OLI001	2,3-dimethyl	Mod		X	x	87

0	(E)- hex-3- enoate	Actv	5	pyrazine	Actv				
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Example 9. Identification of environmentally safe compounds

[00124] Harmful chemicals are often used to control pests and biting insects. With increasing public awareness of the dangers posed by some chemicals to public health and to the environment, natural compounds have been increasingly explored as alternatives to synthetic or hazardous chemicals. To this end, the Environmental Protection Agency has taken legislative action to categorize certain natural compounds as safe, protecting the use of these environmentally safe compounds from certain government regulations. The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) outlines the exemptions as well as compounds covered by the act. Among these compounds are eugenol (OLI0102), rosemary oil (OLI0093), peppermint oil (OLI0101) and phenethylpropionate (OLI0076.)

[00125] Eugenol, rosemary oil, peppermint oil and phenethylpropionate were tested in the present assay for their effect on neuronal activity. Rosemary oil and eugenol were found to be mild inhibitors, phenethylpropionate was found to be a moderate inhibitor and peppermint oil was found to be a beta activator.

[00126] Combinations containing environmentally safe compounds were tested for inhibitory activity in the compositions listed in Table 14 with either 2 or 3 components according to the method described in Example 1. Test solutions with two components were comprised of 1% of each component listed and test solutions with three components were comprised of 0.6% of each component listed. Component A in each combination is an environmentally safe compound. An “x” in the Table indicates that no component was present. In the Table, “Act” refers to activity, “Cmpd” refers to compound, “Comp” refers to component and “Red” refers to reduced.

Table 14. Inhibitory Combinations Containing at Least One Environmentally Safe Compound

Cmpd No.	Comp A	Cmpd No.	Comp B	Cmpd No.	Comp C	Act (% Red)

OLI0102	eugenol	OLI0078	(Z)-hept-3-enylacetate	OLI0071	2-ethyl-3-methoxy pyrazine	96
OLI0102	eugenol	OLI0078	(Z)-hept-3-enylacetate		X	79
OLI0102	eugenol	OLI0080	1-octanol	OLI0071	2-ethyl-3-methoxy pyrazine	100
OLI0102	eugenol	OLI0080	1-octanol		X	81
OLI0102	eugenol	OLI0068	2,3-diethylpyrazine	OLI0100	methyl (E)-hex-3-enoate	94
OLI0102	eugenol	OLI0068	2,3-diethylpyrazine	OLI0078	(Z)-hept-3-enylacetate	97
OLI0102	eugenol	OLI0068	2,3-diethylpyrazine	OLI0080	1-octanol	97
OLI0102	eugenol	OLI0071	2-ethyl-3-methoxy pyrazine	OLI0072	2-methoxy-3(5or6)iso propyl pyrazine	98
OLI0102	eugenol	OLI0071	2-ethyl-3-methoxy pyrazine	OLI0074	Furfuryl pentanoate	98
OLI0102	eugenol	OLI0082	alpha,alpha-dimethyl phenethyl butyrate		X	73
OLI0102	eugenol	OLI0083	cis-3-hexenyl butyrate		X	72

OLI0102	eugenol	OLI0084	cis-5-octen-1-ol		X	77
OLI0102	eugenol	OLI0074	furfuryl pentanoate		X	72
OLI0102	eugenol	OLI0089	geranyl acetone		X	64
OLI0102	eugenol	OLI0093	rosemary oil		X	74
OLI0102	eugenol	OLI0095	veratraldehyde		X	68
OLI0076	phenethyl propionate	OLI0071	2-ethyl-3-methoxy pyrazine		X	73
OLI0076	phenethyl propionate	OLI0074	furfuryl pentanoate		X	57
OLI0076	phenethyl propionate	OLI0077	trans-2-decenal		X	58
OLI0076	phenethyl propionate	OLI0072	2-methoxy-3(5or6)isopropyl pyrazine		X	56
OLI0093	rosemary oil	OLI0084	cis-5-octen-1-ol		X	64
OLI0093	rosemary oil	OLI0089	geranyl acetone		X	61

Example 10. Identification of activator combinations comprising beta activators

[00127] Carbon dioxide receptor neurons are housed within the basiconic sensilla of the mosquito maxillary palp. While activity from cpA neurons produces the largest amplitude spike,

cpB and cpC neurons present in this region are also responsive to skin odors. Activity from these neurons can also be detected through the electrophysiological methods described in Example 1.

[00128] Although the activity from cpB and cpC neurons cannot easily be distinguished from one another, their collective activity can be distinguished from cpA neurons due to their production of spikes with much lower amplitude than those produced by cpA neurons.

[00129] In the present study, compounds identified as beta activators include methyl (E)-hex-3-enoate, furfurylpentanoate, cis-5-octen-1-ol, 1-ethylhexyltiglate, peppermint oil, isoamyl formate, cis-3-hexenyl formate, hexyl formate, methyl levulinate and isoamyl propionate.

[00130] Interestingly, furfurylpentanoate is also a moderate cpA inhibitor while cis-5-octen-1-ol and 1-ethylhexyltiglate are also mild cpA inhibitors. Methyl levulinate is also a moderate cpA activator.

[00131] Combinations containing beta activator components were tested using the assay previously described in Example 1 for their effect on cpA neuronal activity. It has been determined that different combinations are capable of either increased activity or reduced activity depending on the additional components included in the combination. Combinations containing at least one beta activator component resulted in increased cpA neuronal activity. The data are shown in Table 15. For each combination, the concentration of each of the two components was 1%. Surprisingly, when these components were combined with certain moderate activators, the resulting combinations acted as strong or very strong activators. In the Table, "Act" refers to activity, "Cmpd" refers to compound, "Comp" refers to component, "Mod" refers to moderate, and "Actv" refers to activator.

Table 15. Activator combinations comprising beta activators

Cmpd No.	Comp A	Class A	Cmpd No.	Comp B	Class B	Act (spk/sec)
OLI0100	methyl (E)-hex-3-enoate	Beta Actv	OLI0014	2,3,5-trimethylpyrazine	Mod Actv	77
OLI0100	methyl (E)-hex-3-enoate	Beta Actv	OLI0016	2-acetyl-5-methylfuran	Mod Actv	77
OLI0100	methyl (E)-hex-3-	Beta	OLI0024	gamma-	Mod	82

	enoate	Actv		heptalactone	Actv	
OLI0098	isoamyl formate	Beta Actv	OLI0024	gamma- heptalactone	Mod Actv	63
OLI0098	isoamyl formate	Beta Actv	OLI0022	ethyl acetoacetate	Mod Actv	63
OLI0099	isoamyl propionate	Beta Actv	OLI0014	2,3,5- trimethylpyrazine	Mod Actv	69
OLI0098	isoamyl formate	Beta Actv	OLI0014	2,3,5- trimethylpyrazine	Mod Actv	69
OLI0096	cis-3-hexenyl formate	Beta Actv	OLI0024	gamma- heptalactone	Mod Actv	72
OLI0097	hexyl formate	Beta Actv	OLI0014	2,3,5- trimethylpyrazine	Mod Actv	75
OLI0097	hexyl formate	Beta Actv	OLI0024	gamma- heptalactone	Mod Actv	82
OLI0098	isoamyl formate	Beta Actv	OLI0017	2-furyl methyl ketone	Mod Actv	83
OLI0097	hexyl formate	Beta Actv	OLI0017	2-furyl methyl ketone	Mod Actv	115
OLI0099	isoamyl propionate	Beta Actv	OLI0017	2-furyl methyl ketone	Mod Actv	118
OLI0096	cis-3-hexenyl formate	Beta Actv	OLI0017	2-furyl methyl ketone	Mod Actv	147
OLI0027	methyl levulinate	Beta Actv	OLI0020	cinnamyl nitrile	Mod Actv	70
OLI0027	methyl levulinate	Beta Actv	OLI0029	phenyl propyl aldehyde	Mod Actv	96
OLI0027	methyl levulinate	Beta Actv	OLI0015	2,3- dimethylpyrazine	Mod Actv	97
OLI0027	methyl levulinate	Beta	OLI0026	methyl crotonate	Mod	92

		Actv			Actv	
OLI0027	methyl levulinate	Beta Actv	OLI0019	allyl butyrate	Mod Actv	78
OLI0027	methyl levulinate	Beta Actv	OLI0014	2,3,5- trimethylpyrazine	Mod Actv	107
OLI0027	methyl levulinate	Beta Actv	OLI0022	ethyl acetoacetate	Mod Actv	144
OLI0027	methyl levulinate	Beta Actv	OLI0025	methanethiol acetate	Mod Actv	160
OLI0027	methyl levulinate	Beta Actv	OLI0021	ethyl 3- hydroxyhexanoat e	Mod Actv	126
OLI0027	methyl levulinate	Beta Actv	OLI0024	gamma- heptalactone	Mod Actv	158
OLI0027	methyl levulinate	Beta Actv	OLI0018	2-pentanone	Mod Actv	125

Example 11. Identification of inhibitor combinations comprising beta activators

[00132] Further investigation of beta activators revealed combinations containing at least one beta activator component that resulted in reduced cpA neuronal activity. These data are shown in Table 16. Where two components are in the combination, the concentration of each is 1%. Where three components were tested, the concentration of each was 0.6%.

[00133] In one test, the combination included the beta activator methyl (E)-hex-3-enoate with 2,3-dimethylpyrazine, a moderate activator. Unexpectedly, this composition acts as a strong inhibitor of neuronal activity.

[00134] Furfurylpentanoate is a common flavoring agent in food products. While furfurylpentanoate can act alone as a beta activator and as a moderate inhibitor of cpA neuronal activity, assays conducted with various combinations containing furfuryl pentanoate revealed a synergistic effects leading to strong inhibition of cpA neuronal activity.

[00135] In one example, a combination comprising furfurylpentanoate and eugenol, a mild inhibitor, yielded strong inhibition when tested.

[00136] In another example, a combination comprising furfurylpentanoate and 2-ethyl-3-methoxypyrazine (a moderate inhibitor) yielded strong inhibition when tested.

[00137] In another example, a combination comprising furfurylpentanoate, 2-ethyl-3-methoxypyrazine and 2-methoxy-3(5or6)isopropylpyrazine (a moderate inhibitor) yielded strong inhibition when tested.

[00138] In yet another example, a combination comprising furfurylpentanoate, 2-ethyl-3-methoxypyrazine and eugenol yielded strong inhibition when tested.

[00139] Another common flavoring agent, cis-5-octen-1-ol, is commonly used to impart a melon flavor in food items. This compound can act as both a beta activator as well as a mild inhibitor of cpA neuronal activity. Surprisingly, a combination including cis-5-octen-1-ol and eugenol yielded strong inhibition of cpA neuronal activity when tested. In the Table, “Act” refers to activity, “Cmpd” refers to compound, “Comp” refers to component, “Red” refers to reduction, “Mod” refers to moderate, “Strng” refers to strong, “Inh” refers to inhibitor and “Actv” refers to activator.

Table 16. Inhibitor combinations containing beta activators

Cmpd No.	Comp A	Class A	Cmpd No.	Comp B	Class B	Cmpd No.	Comp C	Class C	Act (% Red)
OLI0100	methyl (E)-hex-3-enoate	Beta Actv	OLI0015	2,3-dimethylpyrazine	Mod Actv		X		87
OLI0100	methyl (E)-hex-3-enoate	Beta Actv	OLI0068	2,3-diethylpyrazine	Strng Inh	OLI0080	1-octanol	Mild Inh	97
OLI0100	methyl (E)-hex-3-enoate	Beta Actv	OLI0068	2,3-diethylpyrazine	Strng Inh	OLI0071	2-ethyl-3-methoxy pyrazine	Mod Inh	99
OLI0100	methyl (E)-hex-3-enoate	Beta Actv	OLI0068	2,3-diethylpyrazine	Strng Inh	OLI0072	2-methoxy-3(5or6)iso propyl	Mod Inh	99

							pyrazine		
OLI0100	methyl (E)-hex-3-enoate	Beta Actv	OLI0068	2,3-diethyl-pyrazine	Strng Inh	OLI010 2	Eugenol	Mild Inh	94
OLI0100	methyl (E)-hex-3-enoate	Beta Actv	OLI0068	2,3-diethyl-pyrazine	Strng Inh	OLI008 8	furfuryl-pentanoate	Beta Actv and Mod Inh	100
OLI0100	methyl (E)-hex-3-enoate	Beta Actv	OLI0068	2,3-diethyl-pyrazine	Strng Inh	OLI007 8	(Z)-hept-3-enylacetate	Mild Inh	96
OLI0074	furfuryl-pentanoate	Beta Actv and Mod Inh	OLI0102	eugenol	Mild Inh		X		72
OLI0074	furfuryl-pentanoate	Beta Actv and Mod Inh	OLI0076	phenethyl-propionate	Mod Inh		X		57
OLI0074	furfuryl-pentanoate	Beta Actv and Mod Inh	OLI0071	2-ethyl-3-methoxy-pyrazine	Mod Inh		X		79
OLI0074	furfuryl-pentanoate	Beta Actv and Mod	OLI0071	2-ethyl-3-methoxy-pyrazine	Mod Inh	OLI006 8	2,3-diethyl-pyrazine	Strng Inh	100

		Inh							
OLI0074	furfuryl-pentanoate	Beta Actv and Mod Inh	OLI0071	2-ethyl-3-methoxy-pyrazine	Mod Inh	OLI0072	2-methoxy-3(5or6)isopropylpyrazine	Mod Inh	93
OLI0074	furfuryl-pentanoate	Beta Actv and Mod Inh	OLI0071	2-ethyl-3-methoxy-pyrazine	Mod Inh	OLI0102	Eugenol	Mild Inh	98
OLI0084	cis-5-octen-1-ol	Beta Actv and Mild Inh	OLI0102	eugenol	Mild Inh		X		77

Example 12. Area behavior assays

[00140] Behavior assays were developed to aid in the evaluation of compounds and compositions of the present invention. These assays include the landing assay and the netsphere assay. These assays were utilized to determine the effectiveness of said compounds and compositions with regard to attracting or repelling mosquitoes of the species *Aedes aegypti*. Due to the highly conserved nature of the carbon dioxide receptor across the order *Diptera*, the results obtained for *Aedes aegypti* are likely to be intuitive with regard to other members of the mosquito family *Culicidae* as well as with regard to other dipteran family members.

Landing assay

[00141] The landing assay is an assay used to test for attraction toward human skin. A human gloved hand with an opening cutout protected by 2 layers of mesh was inserted into a 12 x 12 x 12 inch cage of female mosquitoes. The first layer of mesh was used to protect the human from chemical contact as well as mosquito contact. A second layer of mesh was treated with a chemical compound or composition that had been dissolved at a concentration of 1% in acetone

and allowed to dry on said mesh for three minutes. This second layer of mesh was placed on top of the first mesh layer. The two mesh layers were separated by outer magnetic strips to hold the layers in place on the glove. This experimental design allows the test subjects, starved female mosquitoes, to be exposed to human skin odors as well as the compound or composition concurrently. The cage contained 30 female and 3 male mosquitoes. The landing of mosquitoes on the treated surface was videotaped over a 5 minute time course and the number of landings during that time period was recorded. Mesh treated with acetone alone was used as a negative control. This experiment was done in triplicate for each compound or composition tested. The results from one such experiment are pictured in Figure 2.

[00142] The data reveal that compounds cyclopentanone and 2-pentanone produced more landings, 39 and 37, respectively than the blank control, 30 landings. Furthermore, compound 2-ethylpyrazine resulted in 12 landings in the same timeframe, making it a repellent. Interestingly, this compound has been shown to be an activator of CO₂-responsive neurons. In this example, this compound acts as a masking agent, interfering with the host-seeking response of the mosquitoes, presumably by overwhelming their CO₂ receptors.

Example 13. Netsphere assay

[00143] The netsphere assay was conducted in a semi-field containment area. The containment area was 1,000 square feet in size and environmental cues such as temperature, humidity, lighting and airflow were controlled to replicate conditions that *Aedes aegypti* mosquitoes would encounter in the wild. The containment area was conditioned for 2 hours prior to experimentation to allow for equalization of environmental conditions. Fifty female and five male mosquitoes were then released into the chamber and given one hour to acclimate to the environment. Following this, a BG-Sentinel trap (Biogents AG, Regensburg, Germany) was baited with either cyclopentanone, 2-pentanone or 2,4-lutidine and placed in the chamber in the presence of a non-baited BG-Sentinel (as a negative control for trap attraction). The collection was allowed to proceed overnight during which lighting conditions in the chamber were set to mimic those of starlight. The following day, mosquitoes caught in the trap were frozen at -20°C and counted. These counts were compared to control experiments where CO₂ from a tank, at a flow rate of 250 ml/min, was used as bait. The results of one such experiment are shown in Figure 3.

[00144] The data reveal that compounds cyclopentanone and 2-pentanone act as attractants, similar to CO₂ alone. Furthermore, compound 2,4-lutidine acted as a repellent. Interestingly, this compound has been shown to be a strong activator of CO₂-responsive neurons suggesting that at the concentration used, the activation of these neurons by this compound leads to avoidance of the compound by the mosquitoes.

Example 14. Larvicidal activity assay

[00145] A 6-well plate (Corning Life Sciences, Tewksbury, MA) is used to test a compound's larvicidal activity. Approximately 20 larvae are added to each well under the following conditions: negative control (larvae are combined with 5 mL of distilled water); positive control (larvae are combined with 4.5 mL of distilled water with 0.5 mL of ethanol); treatment 1 [larvae are combined with 5 mL of a solution comprising 100 parts per million (ppm) of compound A]; treatment 2 (larvae are combined with 5 mL of a solution comprising 0.25% compound A); treatment 3 (larvae are combined with 5 mL of a solution comprising 100 ppm of compound B); treatment 4 (larvae are combined with 5 mL of a solution comprising 0.25% compound B). After a 24 hour exposure, the number of dead larvae are counted and recorded.

Example 15. Biocidal activity assay

[00146] The room is conditioned to 26°C and 60-70% relative humidity. Bottles, lids and mesh coverings to be used are washed with plain dish soap. Bottles and lids are allowed to dry completely. A piece of number 1 Whatman filter paper is added to the bottom of each bottle. Forceps are used to properly position the filter paper against the bottom of the bottle. Each bottle is labeled with the dilution concentration to be applied to the filter paper. Serial dilutions are prepared in test tubes, starting with a dilution of 20 mg/mL. Tubes are labeled with the appropriate dilution concentrations.

[00147] Test compounds are subjected to serial dilution in eppendorf tubes, starting with a dilution of 20 mg/ml in 1000 µl of acetone and generating 10-fold dilutions in each successive tube. 500 µl of each solution (including an acetone-only control) is applied to the filter paper in corresponding bottles and allowed to dry. Twenty unstarved female mosquitoes are transferred

into each bottle and the tops are sealed with mesh. Bottles are then placed into the conditioned experiment room for two hours. Mosquitoes are then observed and the number of catatonic mosquitoes in each bottle is recorded.

Example 16. Larvicidal and biocidal effect of compounds of the invention

[00148] Compounds of the present invention were analyzed according to the methods described in Examples 14 and 15. Larvicidal activity was assessed according to example 14 for compounds of the present invention at doses of 100 parts per million (ppm) and 0.25%. The results are presented in Table 17 as % lethality (the number of dead larvae divided by the total number of larvae).

Table 17. Larvicidal activity

Compound No.	Compound	% Lethality at 100 ppm	% Lethality with 0.25% compound conc.
OLI0116	Salicylaldehyde	100% lethal	100% lethal
OLI0005	4-ethylphenol	100% lethal	100% lethal
OLI0020	cinnamyl nitrile	100% lethal	100% lethal
OLI0052	Indole	100% lethal	100% lethal
OLI0101	peppermint oil	88% lethal	100% lethal
OLI0059	methyl heptadienone	58% lethal	100% lethal
OLI0075	octanone-3	50% lethal	100% lethal
OLI0017	2-furyl methyl ketone	50% lethal	100% lethal
OLI0111	Menthallactone	33% lethal	100% lethal
OLI0102	Eugenol	25% lethal	100% lethal
OLI0028	phenylacetaldehyde	25% lethal	100% lethal
OLI0104	allyl cinnamate	15% lethal	100% lethal
OLI0077	trans-2-decenal	10% lethal	100% lethal
OLI0106	cinnamic aldehyde dimethyl acetal	10% lethal	100% lethal
OLI0001	2,4-lutidine	0% lethal	100% lethal
OLI0003	2-methoxypyrazine	0% lethal	100% lethal
OLI0006	5-methyl furfural	0% lethal	100% lethal
OLI0009	ethyl 2-furoate	0% lethal	100% lethal
OLI0012	Guaiacol	0% lethal	100% lethal
OLI0016	2-acetyl-5-methyl furan	0% lethal	100% lethal
OLI0019	allyl butyrate	0% lethal	100% lethal
OLI0024	gamma-heptalactone	0% lethal	100% lethal
OLI0025	methanethiol acetate	0% lethal	100% lethal
OLI0029	phenyl propyl aldehyde	0% lethal	100% lethal
OLI0065	trans-cinnamaldehyde	0% lethal	100% lethal
OLI0067	2,3-diethyl-5-methylpyrazine	0% lethal	100% lethal

OLI0068	2,3-diethylpyrazine	0% lethal	100% lethal
OLI0069	2-ethyl-3-methylpyrazine	0% lethal	100% lethal
OLI0070	2-methoxy-3-methylpyrazine	0% lethal	100% lethal
OLI0071	2-ethyl-3-methoxypyrazine	0% lethal	100% lethal
OLI0072	2-methoxy-3(5or6) isopropylpyrazine	0% lethal	100% lethal
OLI0074	furfuryl pentanoate	0% lethal	100% lethal
OLI0076	phenethyl propionate	0% lethal	100% lethal
OLI0079	1-ethylhexyl tiglate	0% lethal	100% lethal
OLI0084	cis-5-octen-1-ol	0% lethal	100% lethal
OLI0100	methyl (E)-hex-3-enoate	0% lethal	100% lethal
OLI0105	trans-cinnamyl propionate	0% lethal	100% lethal
OLI0107	cinnamyl formate	0% lethal	100% lethal
OLI0109	cinnamyl propionate	0% lethal	100% lethal
OLI0110	ethyl cinnamate	0% lethal	100% lethal
OLI0112	methoxy cinnamic aldehyde	0% lethal	100% lethal
OLI0113	methyl cinnamate	0% lethal	100% lethal
OLI0114	methyl trans-cinnamate	0% lethal	100% lethal
OLI0115	Menthol	0 % lethal	100% lethal
OLI0117	cinnamyl isobutyrate	0% lethal	100% lethal
OLI0118	Ultrazur	0% lethal	100% lethal
OLI0073	cis-3-hexenyl acetate	0% lethal	95% lethal
OLI0026	methyl crotonate	0% lethal	87.5% lethal
OLI0008	Cyclopentanone	0% lethal	85% lethal
OLI0092	methyl amy ketone	32% lethal	73% lethal
OLI0013	trans-2-methyl-2-butenal	0% lethal	72% lethal
OLI0091	methyl heptanoate	0% lethal	72% lethal
OLI0002	2-ethylpyrazine	0% lethal	50% lethal
OLI0027	methyl levulinate	0% lethal	50% lethal
OLI0066	Valeraldehyde	0 % lethal	35% lethal
OLI0096	cis 3-hexenyl formate	0% lethal	30% lethal
OLI0011	ethyl vinyl carbinol	5% lethal	27% lethal
OLI0014	2,3,5-trimethylpyrazine	0% lethal	21% lethal
OLI0119	hexyl butyrate	0% lethal	15% lethal
OLI0097	hexyl formate	0% lethal	5% lethal
OLI0018	2-pentanone	0% lethal	0% lethal
OLI0063	propyl formate	0% lethal	0% lethal
OLI0015	2,3-dimethylpyrazine	0% lethal	0% lethal
OLI0004	2-methyltetrahydrofuran-3-one	0% lethal	0% lethal
OLI0010	ethyl lactate	0% lethal	0% lethal
OLI0021	ethyl 3-hydroxyhexanoate	0% lethal	0% lethal
OLI0103	phenethyl cinnamate	0% lethal	0% lethal
OLI0120	benzyl cinnamate	0% lethal	0% lethal
OLI0007	butyl formate	0% lethal	0% lethal
OLI0042	ethyl 3-hydroxybutyrate	0% lethal	0% lethal

OLI0022	ethyl acetoacetate	0% lethal	0% lethal
OLI0099	isoamyl propionate	0% lethal	0% lethal

[00149] Biocidal activity of compounds of the present invention was assessed according to the methods of Example 15. Compounds were tested at 0.2 mg/ml and 2 mg/ml. The results are presented in Table 18 as % mortality (the number of dead mosquitoes divided by the total number of mosquitoes).

Table 18. Biocidal activity

Compound No.	Compound	% mortality with 0.2 mg/ml	% mortality with 2 mg/ml
OLI0108	cinnamyl isobutyrate	10	100
OLI0005	4-ethylphenol	0	100
OLI0020	cinnamyl nitrile	0	100
OLI0052	Indole	0	100
OLI0076	phenethylpropionate	0	100
OLI0077	trans-2-decenal	0	100
OLI0102	Eugenol	0	100
OLI0106	cinnamic aldehyde dimethyl acetal	0	100
OLI0107	cinnamyl formate	0	100
OLI0109	cinnamyl propionate	0	100
OLI0110	ethyl cinnamate	0	100
OLI0111	menthalactone	0	100
OLI0112	methoxy cinnamic aldehyde	0	100
OLI0113	methyl cinnamate	0	100
OLI0114	methyl trans-cinnamate	0	100
OLI0084	cis-5-octen-1-ol	0	95
OLI0105	trans-cinnamyl propionate	0	85
OLI0021	ethyl 3-hydroxyhexanoate	0	75
OLI0104	allyl cinnamate	0	45
OLI0103	phenethyl cinnamate	5	25
OLI0029	phenylpropylaldehyde	0	15
OLI0079	1-ethylhexyl tiglate	0	15
OLI0014	2,3,5-trimethylpyrazine	0	0
OLI0067	2,3-diethyl-5-methylpyrazine	0	0
OLI0068	2,3-diethylpyrazine	0	0
OLI0015	2,3-dimethylpyrazine	0	0
OLI0001	2,4-lutidine	0	0
OLI0016	2-acetyl-5-methyl furan	0	0

OLI0071	2-ethyl-3-methoxypyrazine	0	0
OLI0002	2-ethylpyrazine	0	0
OLI0017	2-furyl methyl ketone	0	0
OLI0032	2-methoxy-3(5or6) isopropylpyrazine	0	0
OLI0070	2-methoxy-3-methylpyrazine	0	0
OLI0003	2-methoxypyrazine	0	0
OLI0004	2-methyltetrahydrofuran-3-one	0	0
OLI0018	2-pentanone	0	0
OLI0069	2-ethyl-3-methylpyrazine	0	0
OLI0006	5-methyl furfural	0	0
OLI0019	allyl butyrate	0	0
OLI0120	benzyl cinnamate	0	0
OLI0007	butyl formate	0	0
OLI0096	cis 3-hexenyl formate	0	0
OLI0073	cis-3-hexenyl acetate	0	0
OLI0008	cyclopentanone	0	0
OLI0009	ethyl 2-furoate	0	0
OLI0042	ethyl 3-hydroxybutyrate	0	0
OLI0022	ethyl acetoacetate	0	0
OLI0010	ethyl lactate	0	0
OLI0011	ethyl vinyl carbinol	0	0
OLI0074	furfuryl pentanoate	0	0
OLI0024	gamma-heptalactone	0	0
OLI0012	Guaiacol	0	0
OLI0119	hexyl butyrate	0	0
OLI0097	hexyl formate	0	0
OLI0100	methyl (E)-hex-3-enoate	0	0
OLI0099	isoamyl propionate	0	0
OLI0115	Menthol	0	0
OLI0025	methanethiol acetate	0	0
OLI0092	methylamylketone	0	0
OLI0026	methyl crotonate	0	0
OLI0059	methyl heptadienone	0	0
OLI0091	methyl heptanoate	0	0
OLI0027	methyl levulinate	0	0
OLI0075	octanone-3	0	0
OLI0101	Peppermint oil	0	0
OLI0028	phenylacetaldehyde	0	0
OLI0063	propyl formate	0	0
OLI0116	salicylaldehyde	0	0
OLI0013	trans-2-methyl-2-butenal	0	0
OLI0065	trans-cinnamaldehyde	0	0
OLI0118	Ultrazur	0	0
OLI0066	Valeraldehyde	0	0

[00150] Biocidal activity of combinations comprising compounds of the present invention was assessed according to the methods of Example 15. Combinations were tested at 0.2 mg/ml and 2 mg/ml (total concentration of combined compounds). The results are presented in Table 19 as % mortality (the number of dead mosquitoes divided by the total number of mosquitoes). In the Table, “Mort” refers to mortality, “Cmpd” refers to compound and “Comp” refers to component.

Table 19. Combination biocidal activity

Cmpd No.	Comp A	Cmpd No.	Comp B	Cmpd No.	Comp C	% Mort with 0.2 mg/ml	% Mort with 2.0 mg/ml
OLI0092	methyl amyl ketone	OLI0024	gamma-heptalactone		x	0	5
OLI0076	phenethyl propionate	OLI0088	furfuryl pentanoate		x	0	100
OLI0076	phenethyl propionate	OLI0071	2-ethyl-3-methoxy pyrazine		x	0	100
OLI0076	phenethyl propionate	OLI0072	2-methoxy-3(5or6) isopropyl pyrazine		x	0	100
OLI0076	phenethyl propionate	OLI0077	trans-2-decenal		x	0	100
OLI0071	2-ethyl-3-methoxy pyrazine	OLI0088	furfuryl pentanoate		x	0	100
OLI0071	2-ethyl-3-methoxy pyrazine	OLI0077	trans-2-decenal		x	65	100

OLI0071	2-ethyl-3-methoxy pyrazine	OLI0072	2-methoxy-3(5or6) isopropyl pyrazine		x	0	45
OLI0020	cinnamyl nitrile	OLI0017	2-furyl methyl ketone		x	0	95
OLI0020	cinnamyl nitrile	OLI0029	phenyl propyl aldehyde		x	0	100
OLI0020	cinnamyl nitrile	OLI0015	2,3-dimethyl pyrazine		x	0	100
OLI0020	cinnamyl nitrile	OLI0014	2,3,5-trimethyl pyrazine		x	0	100
OLI0020	cinnamyl nitrile	OLI0024	gamma-heptalactone		x	0	100
OLI0016	2-acetyl-5-methyl furan	OLI0029	phenyl propyl aldehyde		x	0	70
OLI0016	2-acetyl-5-methyl furan	OLI0021	ethyl 3-hydroxy hexanoate		x	10	100
OLI0089	geranyl acetone	OLI0102	eugenol		x	0	100
OLI0089	geranyl acetone	OLI0093	rosemary oil		x	0	100
OLI0093	rosemary oil	OLI0102	eugenol		x	0	100
OLI0093	rosemary oil	OLI0084	cis-5-octen-1-ol		x	0	100
OLI0102	eugenol	OLI0095	veratraldehyde		x	5	100
OLI0102	eugenol	OLI0080	1-octanol		x	0	100

OLI0102	eugenol	OLI0083	cis-3-hexenyl butyrate		x	0	100
OLI0102	eugenol	OLI0082	alpha,alpha- dimethyl phenethyl butyrate		x	0	100
OLI0102	eugenol	OLI0088	furfuryl pentanoate		x	0	100
OLI0102	eugenol	OLI0084	cis-5- octen-1-ol		x	0	100
OLI0102	eugenol	OLI0078	(Z)-hept-3- enylacetate		x	0	100
OLI0029	phenyl propyl aldehyde	OLI0024	gamma heptalactone		x	0	100
OLI0015	2,3- dimethyl pyrazine	OLI0024	gamma heptalactone		x	0	15
OLI0024	gamma- heptalactone	OLI0021	ethyl 3-hydroxy hexanoate		x	0	95
OLI0080	1-octanol	OLI0102	eugenol	OLI0071	2-ethyl-3- methoxy pyrazine	0	100
OLI0102	eugenol	OLI0078	(Z)-hept-3- enylacetate	OLI0071	2-ethyl-3- methoxy pyrazine	0	100
OLI0088	furfuryl pentanoate	OLI0071	2-ethyl- 3-methoxy pyrazine	OLI0102	eugenol	0	100

OLI0100	methyl (E)-hex-3-enoate	OLI0068	2,3-diethyl pyrazine	OLI0102	eugenol	0	85
OLI0100	methyl (E)-hex-3-enoate	OLI0068	2,3-diethyl pyrazine	OLI0080	1-octanol	0	100
OLI0100	methyl (E)-hex-3-enoate	OLI0068	2,3-diethyl pyrazine	OLI0088	furfuryl pentanoate	0	95
OLI0068	2,3-diethyl pyrazine	OLI0102	eugenol	OLI0080	1-octanol	0	100
OLI0068	2,3-diethyl pyrazine	OLI0102	eugenol	OLI0078	(Z)-hept-3-enylacetate	0	35
OLI0022	ethyl acetoacetate	OLI0021	ethyl 3-hydroxy hexanoate		x	0	5

Example 17. Bed bug repellency assay

[00151] Compounds and combinations of compounds of the present invention were assayed for their ability to repel bed bugs (*Cimex lectularius*) using a bed bug repellency assay. This assay takes advantage of the bed bug's natural tendency to seek harborage. Two petri dishes were obtained and the inner areas of each were sanded down (leaving the perimeter smooth.) Talc was applied on the perimeter and on the inside walls of the petri dishes with a small paint brush to prevent bed bugs from escaping. A cut off top portion of a solo bathroom cup was placed upside down in the center of one petri dish. A large plastic secondary container was gathered and a paper towel was laid down inside the bottom. The petri dish was then placed inside and ten bed bugs were placed inside the cut off portion of the solo cup. Next, two pieces of filter paper were cut down the middle to yield 4 equally sized halves. 3 pieces were placed inside a glass dish (100 cm x 50 cm or 90 cm x 50 cm) and the remaining piece was placed in a separate dish. All 4 pieces were folded down the middle to create a "tent" or "harborage" when laid such that the

folded crease faced up. 100 microliters of isopropyl alcohol was pipetted into 3 pieces of filter paper (all housed in the first glass dish.) In a separate 4 ml vial, 90 microliters of isopropyl alcohol was combined and vortexed with 10 microliters of the compound or compound combination being tested. 100 microliters of this solution [comprising a total of 100 mg of compound(s)] was pipetted onto the filter paper in the separate dish. All filter papers were then allowed to dry. Once dry, experiments were conducted first with two filter paper halves comprising only the isopropyl alcohol (control experiment) and then with the remaining filter paper halves [one with only isopropyl alcohol and one comprising the test compound(s).] Filter paper halves were placed on opposing sides of experimental petri dishes and bed bugs were allowed to move freely within the dishes for 5 minutes. Movement of bed bugs beneath each filter paper tent was recorded. Data obtained for each compound tested is listed in Table 20. % repellency represents the % of bed bugs that did not move beneath treated filter paper tents as compared to control. In the Table, “Rep” refers to repellency and “Cmpd” refers to compound. Many compounds and combinations comprising environmentally friendly compounds displayed surprisingly strong ability to repel bed bugs. Some such compounds included citronella oil, eugenol and geraniol.

Table 20. Bed bug repellency

Cmpd No.	Component A	Cmpd No.	Component B	% Rep
OLI0065	trans-cinnamaldehyde		X	100
OLI0102	Eugenol		X	100
OLI0005	4-ethylphenol		X	100
OLI0052	Indole		X	100
OLI0029	phenylpropylaldehyde		X	100
OLI0072	2-methoxy-3(5or6) isopropylpyrazine		X	100
OLI0067	2,3-diethyl-5-methylpyrazine		X	100
OLI0021	ethyl 3-hydroxyhexanoate		X	100
OLI0074	Furfurylpentanoate		X	100
OLI0107	cinnamyl formate		X	100

OLI0012	Guaiacol		X	100
OLI0121	phenylacetaldehyde dimethyl acetate		X	100
OLI0068	2,3-diethylpyrazine	OLI0070	2-methoxy-3-methylpyrazine	100
OLI0076	phenethyl propionate	OLI0074	furfurylpentanoate	100
OLI0020	cinnamyl nitrile	OLI0017	2-furyl methyl ketone	100
OLI0020	cinammyl nitrile	OLI0029	phenylpropylaldehyde	100
OLI0020	cinnamyl nitrile	OLI0029	phenylpropylaldehyde	100
OLI0020	cinnamyl nitrile	OLI0024	gamma-heptalactone	100
OLI0017	2-furyl methyl ketone	OLI0016	2-acetyl-5-methyl furan	100
OLI0017	2-furyl methyl ketone	OLI0015	2,3-dimethylpyrazine	100
OLI0017	2-furyl methyl ketone	OLI0014	2,3,5-trimethylpyrazine	100
OLI0016	2-acetyl-5-methyl furan	OLI0029	phenylpropylaldehyde	100
OLI0016	2-acetyl -5-methyl furan	OLI0024	gamma-heptalactone	100
OLI0093	rosemary oil	OLI0102	eugenol	100
OLI0102	Eugenol	OLI0095	veratraldehyde	100
OLI0102	Eugenol	OLI0078	(Z)-hept-3-enylacetate	100
OLI0015	2,3-dimethyl pyrazine	OLI0014	2,3,5-trimethylpyrazine	100
OLI0106	cinnamic aldehyde dimethyl acetal		X	90
OLI0020	cinnamyl nitrile	OLI0015	2,3-dimethyl pyrazine	88
OLI0100	methyl (E)-hex-3-enoate	OLI0016	2-acetyl-5-methyl furan	88
OLI0059	Methylheptadienone		X	87
OLI0016	2-acetyl-5-methyl furan		X	86
OLI0020	cinnamyl nitrile	OLI0014	2,3,5-trimethylpyrazine	85
OLI0118	Ultrazur		X	84
OLI0084	cis-5-octenol-1-ol		X	82
OLI0093	rosemary oil	OLI0084	cis-5-octen-1-ol	79
OLI0015	2,3-dimethylpyrazine		X	77
OLI0029	phenylpropylaldehyde	OLI0024	gamma-heptalactone	75

OLI0077	trans-2-decenal		X	72
OLI0076	phenethyl propionate	OLI0077	trans-2-decenal	72
OLI0071	2-ethyl-3-methoxypyrazine	OLI0077	trans-2-decenal	72
OLI0101	peppermint oil		X	71
OLI0024	gamma-heptalactone		X	71
OLI0114	methyl trans-cinnamate		X	70
OLI0113	methyl cinnamate		X	68
OLI0076	phenethyl propionate	OLI0072	2-methoxy-3(5or6) isopropylpyrazine	65
OLI0017	2-furyl methyl ketone		X	60
OLI0115	Menthol		X	60
OLI0119	hexyl butyrate		X	59
OLI0014	2,3,5-trimethylpyrazine		X	59
OLI0110	ethyl cinnamate		X	59
OLI0020	cinnanyl nitrile		X	56
OLI0104	allyl cinnamate		X	54
OLI0100	methyl (E)-hex-3-enoate	OLI0024	gamma-heptalactone	53
OLI0028	Phenylacetaldehyde		X	50
OLI0002	2-ethylpyrazine		X	49
OLI0079	1-ethylhexyl tiglate		X	49
OLI0006	5-methyl furfural		X	47
OLI0097	hexyl formate		X	44
OLI0016	2-acetyl-5-methyl furan	OLI0021	ethyl 3-hydroxyhexanoate	43
OLI0100	methyl (E)-hex-3-enoate	OLI0015	2,3-dimethylpyrazine	43
OLI0009	ethyl 2-furoate		X	41
OLI0109	cinnamyl propionate		X	41
OLI0100	methyl (E)-hex-3-enoate	OLI0014	2,3,5-trimethylpyrazine	41
OLI0001	2,4-lutidine		X	39
OLI0026	methyl crotonate		X	38
OLI0010	Ethyl lactate		X	37

OLI0004	2-methyltetrahydrofuran-3-one		X	37
OLI0105	trans-cinnamyl propionate		X	35
OLI0066	Valeraldehyde		X	33
OLI0071	2-ethyl-3-methoxypyrazine		X	29
OLI0068	2,3-diethylpyrazine		X	24
OLI0112	methoxy cinnamic aldehyde		X	23
OLI0003	2-methoxypyrazine		X	22
OLI0120	benzyl cinnamate		X	21
OLI0027	methyl levulinate		X	20
OLI0091	methyl heptanoate		X	20
OLI0099	isoamyl propionate		X	17
OLI0100	methyl (E)-hex-3-enoate		X	17
OLI0011	Ethylvinylcarbinol		X	14
OLI0111	Menthallactone		X	13
OLI0069	2-ethyl-3-methylpyrazine		X	10
OLI0019	allyl butyrate		X	8
OLI0092	Methylamylketone		X	8
OLI0096	cis 3-hexenyl formate		X	6
OLI0007	butyl formate		X	6

Example 18. Bed bug luring assay

[00152] Assays were conducted to measure the ability of compounds and compound combinations to attract bed bugs. A testing arena habitat comprising a small plastic container was placed inside of a larger, secondary container. The top half inch was removed from two bathroom sized solo cups and each cup was placed on opposite sides of the testing arena habitat, one inch away from the wall. Each outer part of the cup was textured using sandpaper, as bed bugs cannot climb smooth surfaces. A paper towel was used to line the floor of the testing arena habitat. The top, removed portion of one of the solo cups was placed mouth side down in the center of the arena. In one of the cups, a cottonball was placed and treated with 100 microliters of compound or compound combination solution [comprising a total of 100 mg of compound(s).] 10 bed bugs were placed within the center cut off cup top and the testing arena habitat was

covered and placed within a dark, climate controlled room overnight. The next day, the number of bed bugs that crawled into the baited cup were recorded and the % attractancy was calculated as the percentage of bugs that crawled into the baited cup as compared to the total number of bed bugs. The data obtained for each compound or combination of compounds tested is presented in Table 21. In the Table, “Att” refers to attractancy and “Cmpd” refers to compound. Some compounds and combinations comprising ethyllactate and/or cyclopentanone displayed surprisingly strong ability to attract bed bugs.

Table 21. Bed bug attractancy

Cmpd No.	Component A	Cmpd No.	Component B	% Att
OLI0010	Ethyllactate	OLI0011	ethylvinylcarbinol	80%
OLI0008	Cyclopentanone		X	50%
OLI0010	Ethyllactate	OLI0004	2-methyltetrahydrofuran-3-one	50%
OLI0008	Cyclopentanone	OLI0002	2-ethylpyrazine	40%
OLI0010	Ethyllactate	OLI0007	butyl formate	40%
OLI0007	butyl formate	OLI0008	cyclopentanone	40%
OLI0007	butyl formate	OLI0003	2-methoxypyrazine	40%
OLI0018	2-pentanone		X	30%
OLI0063	propyl formate		X	30%
OLI0003	2-methoxypyrazine		X	30%
OLI0097	hexyl formate		X	30%
OLI0097	hexyl formate	OLI0017	2-furyl methyl ketone	30%
OLI0025	methanethiol acetate		X	20%
OLI0026	methyl crotonate		X	20%
OLI0014	2,3,5-trimethylpyrazine	OLI0018	2-pentanone	20%
OLI0021	ethyl 3-hydroxyhexanoate	OLI0018	2-pentanone	20%
OLI0010	Ethyllactate	OLI0002	2-ethylpyrazine	20%
OLI0022	Ethylacetoacetate	OLI0017	2-furyl methyl ketone	20%
OLI0022	Ethylacetoacetate	OLI0016	2-acetyl-5-methyl furan	20%
OLI0070	2-methoxy-3-methylpyrazine		X	10%

OLI0099	isoamyl propionate		X	10%
OLI0027	methyl levulinate		X	10%
OLI0029	phenylpropylaldehyde	OLI0024	gamma-heptalactone	10%
OLI0014	2,3,5-trimethylpyrazine	OLI0028	phenylacetaldehyde	10%
OLI0008	Cyclopentanone	OLI0001	2,4-lutidine	10%
OLI0007	butyl formate	OLI0004	2-methyltetrahydrofuran-3-one	10%
OLI0008	Cyclopentanone	OLI0022	ethylacetoacetate	10%
OLI0022	Ethylacetoacetate	OLI0021	ethyl 3-hydroxyhexanoate	10%

CLAIMS

1. A composition comprising at least one of compounds OLI0001-OLI0121.
2. The composition of claim 1, wherein said composition comprises a compound selected from the group consisting of compounds OLI0001-OLI0013.
3. The composition of claim 2, wherein said compound is present at a concentration of at least 0.01%.
4. The composition of claims 2, wherein said compound is present at a concentration of from about 0.01% to about 5%.
5. The composition of claim 1, wherein said composition comprises a combination of two compounds, wherein at least one compound is selected from the group consisting of OLI0001-OLI0004, OLI0006-OLI0008, OLI0010, OLI0011, OLI0013-OLI0015, OLI0017, OLI0018, OLI0020-OLI0022, OLI0024, OLI0025, OLI0027, OLI0096, OLI0097 and OLI0099.
6. The composition of claim 5, wherein each compound is present at a concentration of at least 0.01%.
7. The composition of claim 5, wherein each compound is present at a concentration of from about 0.01% to about 5%.
8. The composition of claim 7, wherein at least one compound is a beta activator selected from the group consisting of OLI0027, OLI0096, OLI0097 and OLI0099.
9. The composition of claim 1, wherein said composition comprises a combination of two compounds, wherein each compound is independently selected from the group

consisting of OLI0006, OLI0008, OLI0013-OLI0022, OLI0024-OLI0029, OLI0063, OLI0091, OLI0092, OLI0096-OLI0100.

10. The composition of claim 9, wherein each compound is present at a concentration of at least 0.01%.

11. The composition of claim 9, wherein each compound is present at a concentration of from about 0.01% to about 5%.

12. The composition of claim 11, wherein at least one compound is a beta activator selected from the group consisting of OLI0027 and OLI0096-OLI0100.

13. The composition of claim 1, wherein said composition comprises a synergistic combination of compounds.

14. The composition of claim 13, wherein at least one compound of said synergistic combination is selected from the group consisting of OLI0014-OLI0018, OLI0022, OLI0024, OLI0025, OLI0027 and OLI0029.

15. The composition of claim 14, wherein said synergistic combination comprises at least one other compound selected from the group consisting of OLI0019-OLI0021, OLI0025, OLI0026, OLI0028, OLI0063, OLI0091, OLI0092 and OLI0100.

16. The composition of claim 1, wherein said composition comprises a compound selected from the group consisting of OLI0067-OLI0070.

17. The composition of claim 1, wherein said composition comprises a combination of two compounds, wherein at least one compound is selected from the group consisting of OLI0015, OLI0067-OLI0078, OLI0080, OLI0082-OLI0084, OLI0089, OLI0093, OLI0095, OLI0100 and OLI0102.

18. The composition of claim 14, wherein the concentration of said at least one compound is at least 0.01%.

19. The composition of claim 14, wherein the concentration of said at least one compound is from about 0.01% to about 5%.

20. The composition of claim 19, wherein said composition comprises at least one beta activator selected from the group consisting of OLI0074, OLI0084 and OLI0100.

21. The composition of claim 19, wherein said composition comprises a synergistic combination.

22. The composition of claim 19, wherein said composition comprises at least one environmentally friendly compound selected from the group consisting OLI0076, OLI0093 and OLI0102.

23. The composition of claim 1, wherein said composition comprises a combination of three compounds, wherein each compound is individually selected from the group consisting of OLI0068, OLI0071, OLI0072, OLI0074, OLI0078, OLI0080, OLI0100 and OLI0102.

24. The composition of claim 23, wherein at least one compound comprises an environmentally friendly compound, selected from the group consisting of OLI0076, OLI0093 and OLI0102.

25. The composition of claim 23, wherein at least one compound comprises a beta activator selected from the group consisting of OLI0074 and OLI0100.

26. The composition of claim 21, wherein said synergistic combination comprises at least one compound selected from the group consisting of OLI0071, OLI0093 and OLI0102.

27. The composition of claim 26, wherein said synergistic combination comprises at least one other compound selected from the group consisting of OLI0015, OLI0072-OLI0078, OLI0080, OLI0082-OLI0084, OLI0089, OLI0095 and OLI0100.

28. A method of modifying the behavior of a vector pest comprising exposing said vector pest to a composition according to claim 1.

29. The method of claim 28 wherein vector pest behavioral modification comprises increased CO₂ responsive neuronal activity and/or CO₂ receptor activity in said vector pest.

30. The method of claim 29, wherein said vector pest is a flying dipteran, mosquito, sand fly, black fly, tsetse fly, biting midge, bed bug, assassin bug, flea, louse, mite and/or tick.

31. The method of claim 30, wherein said composition comprises a compound selected from the group consisting of compounds OLI0001-OLI0013.

32. The method of claim 30, wherein said composition comprises a combination of two compounds, wherein at least one compound is selected from the group consisting of OLI0001-OLI0004, OLI0006-OLI0008, OLI0010, OLI0011, OLI0013-OLI0015, OLI0017, OLI0018, OLI0020-OLI0022, OLI0024, OLI0025, OLI0027, OLI0096, OLI0097 and OLI0099.

33. The method of claim 32, wherein the concentration of said at least one compound is at least 0.01%.

34. The method of claim 32, wherein the concentration of said at least one compound is from about 0.5% to about 5%.

35. The method of either of claims 31 or 34, wherein the flying dipteran is selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettidia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more members of the genus *Galindomyia*, one or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*, one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus *Orthopodomyia*, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the

genus *Tripteroides*, one or more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and one or more members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium metallicum*, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticatum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

36. The method of claim 29, wherein said composition comprises a combination of two compounds, wherein each compound is independently selected from the group consisting of OLI0006, OLI0008, OLI0013-OLI0022, OLI0024-OLI0029, OLI0063, OLI0091, OLI0092, OLI0096-OLI0100.

37. The method of claim 36, wherein the vector pest is a flying dipteran, mosquito, sand fly, black fly, tsetse fly, biting midge, bed bug, assassin bug, flea, louse, mite or tick.

38. The method of claim 37, wherein the flying dipteran is selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettidia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more members of the genus *Galindomyia*, one or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*, one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus *Orthopodomyia*, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the genus *Tripteroides*, one or

more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and one or more members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium metallicum*, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticatum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

39. The method of claim 38, wherein the concentration of each compound is at least 0.01%.

40. The method of claim 38, wherein the concentration of each compound is from about 0.5% to about 5%.

41. The method of claim 29, wherein said composition comprises a synergistic combination of compounds.

42. The method of claim 41, wherein at least one compound of said synergistic combination is selected from the group consisting of OLI0014-OLI0018, OLI0022, OLI0024, OLI0025, OLI0027 and OLI0029.

43. The method of claim 42, wherein said synergistic combination comprises at least one other compound selected from the group consisting of OLI0019-OLI0021, OLI0025, OLI0026, OLI0028, OLI0063, OLI0091, OLI0092 and OLI0100.

44. The method of claim 43, wherein the flying dipteran is selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettidia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more members of the genus *Galindomyia*, one or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*,

one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus *Orthopodomyia*, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the genus *Tripteroides*, one or more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and one or more members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium metallicum*, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticatum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

45. The method of claim 44, wherein the concentration of each compound is at least 0.01%.

46. The method of claim 44, wherein the concentration of each compound is from about 0.5% to about 5%.

47. The method of claim 28, wherein vector pest behavioral modification comprises reduced CO₂ responsive neuronal activity and/or CO₂ receptor activity in said vector pest.

48. The method of claim 47, wherein said vector pest is a flying dipteran, mosquito, sand fly, black fly, tsetse fly, biting midge, bed bug, assassin bug, flea, louse, mite and/or tick.

49. The method of claim 48, wherein said composition comprises a compound selected from the group consisting of OLI0067-OLI0070.

50. The method of claim 49, wherein the flying dipteran is selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettidia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more members of the genus *Galindomyia*, one

or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*, one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus *Orthopodomyia*, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the genus *Tripteroides*, one or more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and one or more members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium*

metallicum, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticatum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

51. The method of claim 48, wherein said composition comprises a combination of two compounds, wherein at least one compound is selected from the group consisting of OLI0015, OLI0067-OLI0078, OLI0080, OLI0082-OLI0084, OLI0089, OLI0093, OLI0095, OLI0100 and OLI0102.

52. The method of claim 51, wherein the concentration of said at least one compound is at least 0.01%.

53. The method of claim 51, wherein the concentration of said at least one compound is from about 0.01% to about 5%.

54. The method of claim 53, wherein the flying dipteran is selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettidia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more members of the genus *Galindomyia*, one

or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*, one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus *Orthopodomyia*, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the genus *Tripteroides*, one or more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and one or more members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium*

metallicum, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinsum* and *Simulium posticatum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

55. The method of claim 48, wherein said composition comprises a combination of three compounds, wherein each compound is individually selected from the group consisting of OLI0068, OLI0071, OLI0072, OLI0074, OLI0078, OLI0080, OLI0100 and OLI0102.

56. The method of claim 55, wherein the concentration of each compound is at least 0.01%.

57. The method of claim 55, wherein the concentration of each compound is from about 0.01% to about 5%.

58. The method of claim 57, wherein the flying dipteran is selected from the group consisting of one or more members of the mosquito family *Culicidae* (including, but not limited to one or more members of the genus *Aedeomyia*, one or more members of the genus *Aedes* (including, but not limited to *Aedes aegypti*), one or more members of the genus *Anopheles* (including, but not limited to *Anopheles gambiae* and *Anopheles annulipes*), one or more members of the genus *Armigeres*, one or more members of the genus *Ayurakitia*, one or more members of the genus *Bironella*, one or more members of the genus *Borichinda*, one or more members of the genus *Chagasia*, one or more members of the genus *Coquillettidia*, member of the genus *Culex* (including, but not limited to *Culex quinquefasciatus*, *Culex molestus*, *Culex annulirostris* and *Culex australicus*), one or more members of the genus *Culiseta*, one or more members of the genus *Deinocerites*, one or more members of the genus *Eretmapodites*, one or more members of the genus *Ficalbia*, one or more members of the genus *Galindomyia*, one

or more members of the genus *Haemagogus*, one or more members of the genus *Heizmannia*, one or more members of the genus *Hodgesia*, one or more members of the genus *Isostomyia*, one or more members of the genus *Johnbelkinia*, one or more members of the genus *Kimia*, one or more members of the genus *Limatus*, one or more members of the genus *Lutzia*, one or more members of the genus *Malaya*, one or more members of the genus *Mansonia*, one or more members of the genus *Maorigoeldia*, one or more members of the genus *Mimomyia*, one or more members of the genus *Onirion*, one or more members of the genus *Opifex*, one or more members of the genus *Orthopodomyia*, one or more members of the genus *Psorophora*, one or more members of the genus *Runchomyia*, one or more members of the genus *Sabethes*, one or more members of the genus *Shannoniana*, one or more members of the genus *Topomyia*, one or more members of the genus *Toxorhynchites*, one or more members of the genus *Trichoprosopon*, one or more members of the genus *Tripteroides*, one or more members of the genus *Udaya*, one or more members of the genus *Uranotaenia*, one or more members of the genus *Verrallina*, one or more members of the genus *Wyeomyia*, one or more members of the genus *Zeugomyia*), Tsetse flies of the genus *Glossina* (including, but not limited to *Glossina austeni*, *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni*, *Glossina fusca fusca*, *Glossina fuscipleuris*, *Glossina frezili*, *Glossina haningtoni*, *Glossina longipennis*, *Glossina medicorum*, *Glossina nashi*, *Glossina nigrofusca nigrofusca*, *Glossina severini*, *Glossina schwetzi*, *Glossina tabaniformis*, *Glossina vanhoofi*, *Glossina caliginea*, *Glossina fuscipes fuscipes*, *Glossina fuscipes martinii*, *Glossina pallicera pallicera*, *Glossina pallicera newsteadi*, *Glossina palpalis palpalis*, *Glossina palpalis gambiensis* and *Glossina tachinoides*), biting midges of the family *Ceratopogonidae* (including, but not limited to one or more members of the genus *Culicoides* (including, but not limited to *Culicoides sonorensis*), one or more members of the genus *Leptoconops* (including, but not limited to *Leptoconops albiventris* and *Leptoconops torrens*) and one or more members of the genus *Forcipomyia*), black flies of the family *Simuliidae* (including, but not limited to one or more members of the genus *Simulium* (including, but not limited to *Simulium damnosum*, *Simulium neavei*, *Simulium callidum*, *Simulium*

metallicum, *Simulium ochraceum*, *Simulium colombaschense*, *Simulium pruinosum* and *Simulium posticatum*) and sand flies (including but not limited to one or more members of the genus *Lutzomyia* (including, but not limited to *Lutzomyia longipalpis*) and one or more members of the genus *Phlebotomus* (including, but not limited to *Phlebotomus papatasi*)).

59. The method of claim 28, wherein said composition comprises at least one compound selected from the group consisting of OLI0001-OLI0012, OLI0014-OLI0022, OLI0024-OLI0029, OLI0052, OLI0059, OLI0063, OLI0065-OLI0072, OLI0074, OLI0076-OLI0079, OLI0084, OLI0091-OLI0093, OLI0095-OLI0097, OLI0099-OLI0102, OLI0104-OLI0107, OLI0109-OLI0115 and OLI0118-OLI0121.

60. The method of claim 59, wherein said vector pest is a bed bug.

61. The method of claim 60, wherein said bed bug is repelled by said composition.

62. The method of claim 61, wherein said composition comprises a combination of at least two compounds, wherein at least one compound is selected from the group consisting of OLI0014-OLI0017, OLI0020, OLI0024, OLI0029 and OLI0102.

63. The method of claim 60, wherein said bed bug is attracted to said composition.

64. The method of claim 63, wherein said composition comprises a combination of at least two compounds, wherein at least one compound is selected from the group consisting of OLI0007, OLI0008 and OLI0010.

65. A method of killing a vector pest comprising exposing said vector pest to a composition according to claim 1.

66. The method of claim 65, wherein said composition comprises one or more biocidal agents selected from the group consisting of OLI0001-OLI0003, OLI0005, OLI0006, OLI0009, OLI0011-OLI0014, OLI0016, OLI0017, OLI0019, OLI0020, OLI0021, OLI0024-OLI0029, OLI0052, OLI0059, OLI0065-OLI0077, OLI0079, OLI0084, OLI0091, OLI0092, OLI0096, OLI0097 and OLI0100-OLI0119.

67. The method of claim 66, wherein said one or more biocidal agents are present at a concentration of from about 0.2 mg/ml to about 2 mg/ml.

68. The method of claim 67, wherein said one or more biocidal agents comprise biocidal activity toward a flying dipteran, mosquito, sand fly, black fly, tsetse fly, biting midge, bed bug, assassin bug, flea, louse, mite and/or tick.

69. The method of claim 66, wherein said one or more biocidal agents are present at a concentration of from about 50 ppm to about 150 ppm.

70. The method of claim 66, wherein said one or more biocidal agents are present at a concentration of from about 0.1% to about 0.5%.

71. The method of either of claims 69 or 70, wherein said one or more biocidal agents comprise a larvicidal agent selected from the group consisting of OLI0001-OLI0003, OLI0005, OLI0006, OLI0008, OLI0009, OLI0011-OLI0014, OLI0016, OLI0017, OLI0019, OLI0020, OLI0024-OLI0029, OLI0052, OLI0059, OLI0065-OLI0077, OLI0079, OLI0084, OLI0091, OLI0092, OLI0096, OLI0097, OLI0100-OLI0102, OLI0104-OLI0107 and OLI0109-OLI0119.

72. The method of claim 71, wherein said larvicidal agent comprises larvicidal activity toward a larvae from one or more of a flying dipteran, mosquito, sand fly, black fly, tsetse fly or biting midge.

73. A device comprising at least one of compounds OLI0001-OLI0102.

74. The device of claim 73, wherein said device comprises a patch.

75. The device of claim 74, wherein said patch is comprised of one or more materials selected from the group consisting of paper, plastic, metal, fabric, wax, polymeric materials, polyethylene, polypropylene, rubber, cellulose, silicon rubber and cellulose-based materials.

76. The device of claim 75, wherein said patch comprises an area from about 1 cm² to about 5 cm².

77. The device of claim 76, wherein said patch comprises a shape selected from the group consisting of a circle, a square, a rectangle, a triangle and a polygon.

78. The device of claim 77, wherein said patch comprises an adhesive.

79. The device of claim 78, comprising a film or paper layer to protect said adhesive prior to application of said patch.

80. The device of claim 79, wherein said patch is square in shape with side lengths comprising 1.5 cm each.

81. A method of repelling a vector pest comprising a device according to any of claims 73, 77 or 80.

82. The method of claim 81, wherein said device is applied to a subject's skin, clothing or apparel.

83. The method of claim 81, wherein said device is placed inside or attached to a holder selected from the group consisting of a pocket, a compartment, a cassette, a box or a clip.

84. The method of claim 83, wherein said holder is attached to a subject using an accessory device selected from the group consisting of a bracelet, a necklace, a wrist band, a collar, an arm band, an article of clothing or a clip-on device.

85. The method of claim 84, wherein said accessory device comprises an air diffuser.