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Research Article

Identification and Characterisation of Organic Acids in Wasp (*Sceliphron caementarium*) (Sphecidae) and Ant (*Camponotus pennsylvanicus* (Formicidae)

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Abstract

The medical risk associated with the social insects of the order Hymenoptera is due to the organic acids in them. An organic compound is a type of chemical compound that contains at least one atom of carbon covalently bonded with other elements like hydrogen, oxygen or Nitrogen. The research is aimed at exploring and identifying the organic acids present in insect species: mud dauber (*Sceliphron caementarium*) and the carpenter ant *(Camponous pennsylvanicus*). The goal is to investigate the organic compound diversity in these species. The methodology involved analytical techniques using Gas-Chromatography - Mass Spectrophotometre (GC-MS) which enabled the identification and characterisation of the extracted organic acids. The findings revealed that the mud-dauber wasp (*S. caementarium*) contained sixteen (16) organic acids, including Trans -13- octadecenoic, 11-octadecenoic acid, 12 - octadecenoic acid, Cis- 13 - Eicosenoic acid and others. The Black carpenter ant (*Camponotus pennsylvanicus*) is composed of eighteen (18) organic acids, including 2 - butenedioc acid, Tridecanoic acid, Sulfurous acid and oxalic acid among others. Moreover, six (6) of the organic acids are common to both insect species. The study provides a detailed and comprehensive examination of the diverse array of organic acids. The identification and quantification of these organic acids not only contribute to our knowledge of metabolic pathways of these insects, but also open doors to potential applications in medicine and agriculture

Keywords

Stinging Insects, Organic Acids, Medicine, Agriculture, GC-MS

1. Introduction

Organic compounds are any of a large class of chemical compounds in which one or more atoms of carbon are covalently linked to atoms of other elements, most commonly hydrogen, oxygen, or nitrogen. The few carbon-containing compounds not classified as organic include carbides, carbonates, and cyanides. Organic compounds are classified into two types based on the skeleton of the carbon chain. Organic compounds are classified into Acyclic or Open-chain compounds and Cyclic or Closed-chain compounds [18, 26, 29, 32, 34].

Carboxylic acids are organic compounds containing the carboxyl group (-COOH), wherein the hydroxyl group (-OH) is directly attached to the carbonyl (C=O) group. Carboxylic

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acids constitute one of the most frequently encountered classes of organic compounds in nature. A great many carboxylic acids are encountered in nature, mostly in fruits. Indeed carboxylic acids were among the first class of organic compounds to ever be isolated from nature. The common names of some basic carboxylic acids are derived from Latin names that indicate the first original natural source of the carboxylic acid. The carbon atom of a carboxyl group has a high oxidation state. It is not surprising, therefore, that many of the chemical reactions used for their preparation are oxidations [29] Many carboxylic acids are colorless liquids with disagreeable odors. The carboxylic acids with 5 to 10 carbon atoms all have "goaty" odors (explaining the odor of Limburger cheese). These acids are also produced by the action of skin bacteria on human sebum (skin oils), which accounts for the odor of poorly ventilated locker rooms. The acids with more than 10 carbon atoms are waxlike solids, and their odor diminishes with increasing molar mass and resultant decreasing volatility. Carboxylic acids exhibit strong hydrogen bonding between molecules. They therefore have high boiling points compared to other substances of comparable molar mass. Carboxylic acids tend to have higher boiling points than water, because of their tendency to form stabilized dimers through hydrogen bonds. Most of the reactions of carboxylic acids belong to one of four principal classes, depending on the point in the molecule where the reaction occurs [29].

Carboxylic acids are organic acids characterized by the presence of one or more carboxyl groups in their molecules. A carboxyl group consists of a carbon atom attached to an oxygen atom with a double covalent bond and to a hydroxyl group by a single covalent bond. The chemical formula of the carboxyl group may be written as -C(=O)OH, -COOH, or -CO_2H. [1] Salts and anions of carboxylic acids are called carboxylates [5].

Carboxylic acids are widespread in nature, often combined with other functional groups. Simple alkyl carboxylic acids, composed of four to ten carbon atoms, are liquids or low melting solids having very unpleasant odors. The fatty acids are important components of the biomolecules known as lipids, especially fats and oils [5].

A wasp is any insect of the narrow-wasted suborder Apocrita of the order Hymenoptera which is neither a bee nor an ant; this excludes the broad-waisted sawflies (Symphyta), which look somewhat like wasps, but are in a separate suborder. The wasps do not constitute a clade, a complete natural group with a single ancestor, as bees and ants are deeply nested within the wasps, having evolved from wasp ancestors. Wasps that are members of the clade Aculeata can sting their prey [1, 20, 30, 41].

Ants are eusocial insects of the family Formicidae and, along with the related wasps and bees, belong to the order Hymenoptera. Ants evolved from vespoid wasp ancestors in the Cretaceous period. More than 13,800 of an estimated total of 22,000 species have been classified. They are easily identified by their geniculate (elbowed) antennae and the distinctive node-like structure that forms their slender waists [9, 13, 21, 22, 35].

1.1. Statement of the Problem

Ants and wasps are common stingy insects. These insects contains organic acids which they often secretes. However, the quantity of organic acids that are secreted by these insects have often be subject of great disputes. The problem associated with the varying figures as the quantity of organic acids secreted by ants, bees and wasps actually necessitated this study as it set to come up with authentic figures [22, 27, 28, 40].

1.2. Research Objectives

The objective of this study is to extract and identify organic acid found in stingy insects (ants and wasps). The specific objectives are:

1) To identify the organic acid found in ants and wasps through isolation of the compound.
2) To identify the organic acid found in ants and wasps through purification of the compound.
3) To carryout quantitative analysis of the organic acid found in ants and wasps

1.3. Scope of the Study

This study is restricted to extraction, identification and characterisation of organic acid found in stingy insects (ant and wasp).

2. Materials and Methods

2.1. Sample Collection

The process of collecting samples for analysis was carried out with great care and attention to details. The primary source of specimens were aging structures and ant hills located on various farms and houses across the Bali metropolis, Taraba state, Nigeria. The selection of these locations was deliberate, to capture a diverse range of environments that included both manmade and natural habitats. To collect the specimens, a combination of forceps, sweep nets, and brooms was employed. The sweep net was used to conduct a thorough sweep of the interior and exterior surfaces. Forceps were then used to pick up specimens residing in hard-to-reach places. Finally, the broom was employed to dislodge insects from hidden spots to ensure comprehensive sampling. After the specimens were collected, they were immediately transferred to sample bottles. Each sample contained approximately 100ml of hexane, which was chosen as a solvent for its effectiveness in preserving the specimens for subsequent analysis. Great care was taken to ensure that the sample bottles were securely sealed to prevent contamination and evaporation during transport [2, 3, 14].

2.2. Venom and Organic Acids Extraction Using Soxhlet

Methods of fire Wasps and Ants venom extraction described in the literature especially that of [33] are extremely inefficient because they are based on “milking” the venom from individual Wasps and Ants We adopted a novel venom from protein extraction method that is simpler, faster, and provides higher extraction yields [2, 3].

20g of ants sampled was weighed using a digital weighing balance, into a thimble. The thimble containing the sample was placed into a soxhlet extraction. (The 50ml of Hexanuseduse as the extraction solvent) when then poured into a round bottom flask and soxhlet was connected to the round bottom flask, followed by connecting relock condenser and step up was placed on a heating mantle [14].

2.3. Venom Extraction

Wearing protective rubber gloves, the raft of floating wasps and ants was transferred into the extraction solution.Transferring the wasps and ants required utmost care, because accidents can result in escaped ants, stings and solvent spillage.When the wasps and ants entered the organic solvent, they instinctively discharged their venom while sinking-perhaps because of their aggressive nature - and rapidly didied. These two phases were easily seperated into individual tubes using pipettes or a separating funnel (mind of using glass tubes for organic solvent). The tubes were frozen at 20°C for long term storage. The upper, organic phase contains cuticular hydrocarbons by washing this organic phase with additional hexane through a silica column and then eluting the alkaloids with acetone as described [8].

2.4. Analysis and Identification

Species identification followed by [36] using the following diagnostic characteristicsers: absence of post-petiolar process, complete mandibular costulae, presence of a frontal medical well developed median clypeal tooth, and males being distinctly black.

Protein quantification was made by the method of [6, 7] using bovine serum albumin as standard. The extracted venom alkaloids were air-dried and weighed using a digital precision scale (Bioprecisa FA - 2104N TDS)

3. Result

Extraction and Identification of Organic Acids in Ants

Below is the Result from the extraction and identification of Organic Acids in Black Carpenter Ants

1) 2-Butenedioc acid
2) Tridecanoic acid
3) Sulfurous acid
4) Oxalic acid
5) Pentadecanoic acid
6) Cis-vaccenic acid
7) Oleic acid
8) 1,5 hydroxy pentadecanoic acid
9) Barbituric acid
10) Thiocarbamic acid
11) 4-Quinoline carboxylic acid
12) Pyrimidine carboxylic acid
13) 1,2-Benzenedicarboxylic acid
14) Phthalic acid
15) Hexadecenoic acid
16) 9-octadecenoic acid
17) Cis-13-octadecenoic acid
18) Propanoic acid

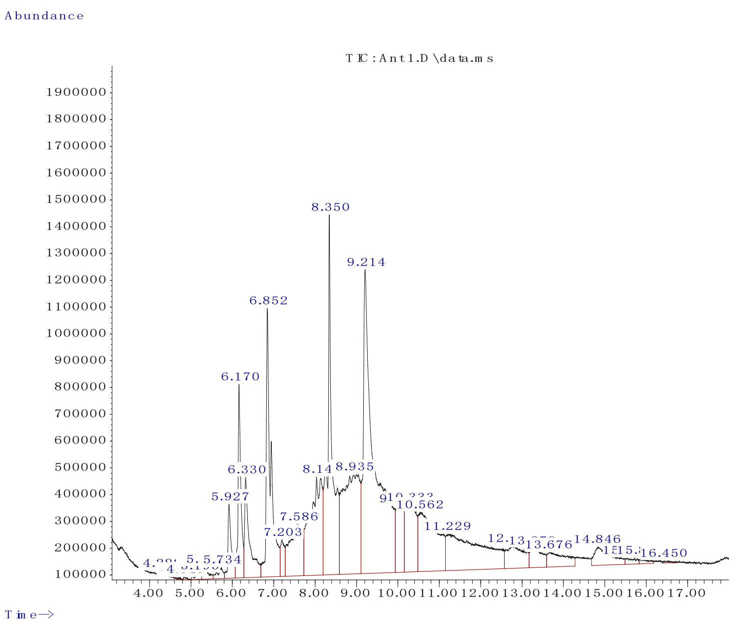

***Figure 1.** identification of organic acids in black carpenter ants using GC-MS.*

Organic acids detected in wasps only
1) Trans-13-octadecenoic
2) 11-octadecenoicnacid
3) 12-octadecenoic acid
4) Cis-13- Eicosenoic acid
5) Cis-11-Eicosenoic acid
6) Erucic acid
7) Eicosanoid acid
8) 9, 12-octadecadenoic acid
9) Methoxy acetic acid
10) Linoleic acid
11) 1,2 Benzenedicarboxylic acid
12) Phthalic acid
13) Hexadecenoic acid
14) 9-octadecenoic acid
15) Cis-13-octadecenoic acid
16) Propanoic acid

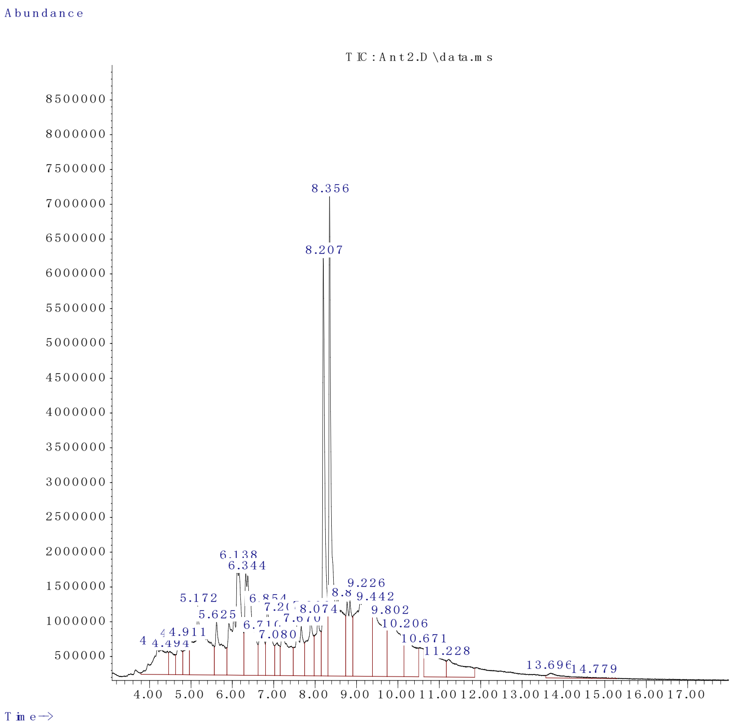

Figure 2. identification of organic acids in mud dauber wasps using GC-MS.

Organic acids detected in both insects
1) 1,2 Benzenedicarboxylic acid
2) Phthalic acid
3) Hexadecenoic acid
4) 9-octadecenoic acid
5) Cis-13-octadecenoic acid
6) Propanoic acid

4. Discussion

The result above shows that eighteen (18) organic acids were detected in ants which are 2-Butenedioc acid, tridecanoic acid, sulfurous acid, oxalic acid, pentadecanoic acids, Cis-vaccenic acid, oleic acid, 15- hydroxy pentadecanoic acid, barbituric acid, thiocarbamic acid, 4-Quinolinecarboxylic acid, yrimidine carboxylic acid, 1,2 Benzenedicarboxylic acid, phthalic acid, hexadecenoic acid, 9-octadecenoic acid, Cis-13-octadecenoic acid and propanoic acid. (Figure 1)

The result also revealed that sixteen (16) organic acids were detected in wasps they include Trans-13-octadecenoic, 11-octadecenoic acid, 12-octadecenoic acid, Cis-13-Eicosenoic acid, Cis-11-Eicosenoic acid, Erucic acid, Eicosanoid acid, 9,12-octadecadienoic acid, Methoxy acetic acid, Linoleic acid, 1,2-Benzenedicarboxylic acid, phthalic acid, hexadececenoic acid, 9-octadecenoic acid, Cis-13-octadecenoic acid and propanoic acid (Figure 2).

From the results it was revealed that six (6) of the organic acids detected were common in both ants and wasps, these are 1,2-Benzenedicarboxylic acid, phthalic acid, hexadecenoic aid, 9-octadecenoic acid, Cis-13-octadecenoic acid acid and propanoic acid.

Palmitoleic acid, or (9Z)-hexadec-9-enoic acid, is an omega-7 monounsaturated fatty acid with the formula CH3(CH2)5CH=CH(CH2)7COOH. It is a rare component of fats. It is a common constituent of the glycerides of human adipose tissue. It is present in all tissue but, in general, found in higher concentration in the liver [4]. It is biosynthesized from palmitic acid by the action of the enzyme Stearoyl-CoA desaturase-1. Animal and cell culture bodies indicate that palmitoleic acid is anti-inflammatory, and improves insulin sensitivity in liver and skeletal muscles, but more studies are required to establish its actions in humans. Many of the effects of palmitoleic acid are due to its activation of PPAR-alpha [10, 18, 26].

Octadecenoic acid (cis-9), commonly name as Oleic acid; C18:1 (cis-9) Fatty acid is a high purity unsaturated fatty acid that is ideal as a standard and for use in biological systems. Oleic acid is the most abundant natural monounsaturated fatty acid in plants and animals. Oleic acid acid and linoleic acid can modulate some of the functions of neutrophils, thereby influencing the inflammatory process [11, 38]. It inhibits protein kinase C activity in lymphocytes, the release of myeloperoxidase, and the chemotaxis of human neutrophils. It can promote necrosis and apoptosis of human lymphocytes and it has been associated with a reduction in cardiovascular disease [16], rheumatoid arthritis and a variery of cancers. Oleic acid has been demonstrated to be responsible for reducing blood pressure when consumed as a dietery source [47]. It is an insert pheromone that is release when the insert dies and is a component of pheromones used by other animals. Oleic acid and phosphatidylethanolamine form used by other animals. Oleic acid and phosphatidylethanolamine form oleoylethanolamide which has various biological functions such as anorexigenic and body fat loss properties [42-45]. Cis-13-Octadecenoic acid, also known as cis-9-octadecenoic acid, is a monounsaturated fatty acid that is found naturally in a variety of plant and animal sources. It is an important component of many cell membranes, and is involved in a number of biochemical and physiological processes in the body.Cis-13-Octadecenoic acid has a potential therapeutic effects in a variety of conditions, including obesity, diabetes, cardiovascular disease, and cancer. In addition, it has potential role in the modulation of inflammation, oxidative stress, and lipid metabolism. It has also been studied for its potential role in the treatment of neurological disease such as Alzheimer's disease and Parkinson's disease [4, 15, 17].

Phthalic acid, also called 1,2-benzenedicarboxylic Acid, colourless, crystalline organic compound ordinarily produce and sold in the form of its anhydride. It was used as an ingredient of polyesters, including alkyd resins (vehicles for paints and enamels), and simple esters used as plasticizers for polybyvinyl chloride and other polymers. Smaller quantities were consumed in the manufacture of anthraquinone (a dye intermediate), phenolphthlein (a laxative and acid-base indicator), and phthalocyanine pigments [31, 32, 37, 38].

Propionic acid (PA) also known as propanoic acid is a short chain fatty acid mainly used as food preservative. It is one of the main metabolic end product formed during the fermentation of undigested food in the colon by the microbiota [12]. Its manufacture by glycerol/glucose co-fermentation using Propionibacterium acidipropionici [39] Propionic acid (PA) is a naturally occurring carboxylic acid, which in its pure state exists as a colorless corrosive liquid with an unpleasant odour. It reduce food intake, lower the fatty acids content in plasma and liver, might improve tissue insulin sensitivity and exerts immunosuppressive actions.Propionic acid is an excellent raw material as it is stable, cheap and safe and can even be used as a food additive and may also be used to alter limestone in order to increase its ability of CO2 uptake [17-19, 48].

5. Conclusion

The meticulous analysis of stinging insects, specifically ants and wasps, has unveiled a diverse array of organic acids present in their composition. The comprehensive examination of these compounds has not only expanded our understanding of the chemical makeup of these inserts but has also revealed intriguing commonalities and differences for possible exploitation.

The identification of eighteen organic acids in ants and sixteen in wasps demonstrates the richness and complexity of their biochemical profiles. Notably, six organic acids were found to be shared between both species, indicating potential shared metabolic pathways or ecological roles [24, 46].

The presence of unique fatty acids such a palmitoleic acid, oleic acid, and cis-13-octadecenoic acid underscores the biological significance of these compound in insect physiology. These fatty acids have been associated with anti-inflammatory properties, modulation of lipid metabolism, and potential therapeutic effects in conditions ranging from cardiovascular diseases to neurological disorders [23, 25].

Phthalic acid, with its varied industrial applications, adds another layer to the complexity of organic compounds identified. Its presence in these insects suggests potential ecological roles or metabolic processes involving this compound.

Furthermore, propionic acid emerges as a noteworthy component, not only for its role as a food preservative but also for its potential impact on reducing food intake, improving insulin sensitivity, and exerting immunosuppressive actions [18].

In essence, the findings from this project contribute not only to the understanding of the chemical composition of stinging insects but also open avenues for further exploration into the ecological, physiological, and potential therapeutic roles of these organic acids. The intricate interplay of these compounds in the intricate web of insert biology invites continued research and exploration into the fascination word of insert chemistry.

6. Recommendation

Further studies are recommended in order to isolate the organic compound to determine their chemical structures, formulae and benefits.There is need for more studies to include bees in order to establish actions of these organic acids in human by using experimental animals. Apart from medical, explorations should include the agricultural and industrial applications of the acids. Furthermore, to make the study easier, insectaries/insects house need to be established in our institutions of learning, relevant research institutes for appropriate Applied entomological study

Abbreviations

GC-MS Gas Chromatography- Mass Spectrophotometer

Author Contributions

Lamidi Babatunde Tajudeen: Conceptualization, Funding acquisition, Methodology, Resources, Writing – review & editing

John Queen: Data curation, Funding acquisition, Investigation, Resources

Imohiosen Ojeaga: Formal Analysis, Project administration, Software, Supervision, Validation

Tajudeen Abdulmajid Omoniyi: Resources, Visualisation, Writing – review & editing

Conflicts of Interest

The authors declare that there is no conflict of interest.

Appendix

Chemistry Lab Library Search Report (Ant)
Data Path: C:\msdchem\1\DATA1\GC Analysis 151119\
Data File: Ant 1.D
Acq On: 2 Sep 2023 15:19
Operator:
Sample: Ant 1
Misc:
ALS Vial: 2 Sample Multiplier: 1
1 4.283 0.15 C:\Database\NIST11.L
Undecane 8989 000067-66-3 52
Undecane 8988 000067-66-3 52
2 4.723 0.02 C:\Database\NIST11.L
2- Butenedioc acid (E)-,
bis(2-ethylhexyl)ester 8799 021181-46-4 38
1-Butene, 2,3,3-trimethyl- 3386 000594-56-9 38
3 4.849 0.05 C:\Database\NIST11.L
3-Decen-5-one 26657 032064-73-6 43
2,2-Dimethyl-4-octenal 26699 030390-60-4 43
4 5.193 0.20 C:\Database\NIST11.L
L-Leucin, Methyl ester 14943 000471-43-2 50
L-Leucin, Methyl ester 14943 000471-43-2 50
5 5.330 0.39 C:\Database\NIST11.L
Tridecanoic acid, 12-methyl-, meth 95897 005129-58-8 25
yl ester
2H-Pyran, 2-[(6-bromohexyl)oxy]tet 113467 053963-10-3
14
rahydro-
6 5.736 0.36 C:\Database\NIST11.L
Sulfurous acid, dodecyl 2-propyl e 137569 1000309-12-3
22
ster
Oxalic acid, hexyl octadecyl ester 220968 1000309-25-2 18
7 5.925 1.56 C:\Database\NIST11.L
1,2-Benzenedicarboxylic acid, bis(125896 000084-69-5 87
2-methylpropyl) ester
Phthalic acid, butyl undecyl ester 200548 1000308-91-2 78
8 6.171 3.37 C:\Database\NIST11.L
Pentadecanoic acid, 14-methyl-, 119423 005129-60-2 98
methyl ester
Hexadecanoic acid, methyl ester 119400 000112-39-0 98
9 6.331 3.03 C:\Database\NIST11.L
Hexadecanoic acid, methyl ester 119400 000112-39-0 98
1,2-Benzenedicarboxylic acid, buty 172654 000085-69-8
86
l 2-ethylhexyl ester
10 6.852 7.32 C:\Database\NIST11.L
9-Octadecenoic acid (Z)-, methyl e 141302 000112-62-9 99
ster
cis-13-Octadecenoic acid, methyl e 141299 1000333-58-3
99
ster
9-Octadecenoic acid (Z)-, methyl e 141300 000112-62-9 98
ster
11 7.201 0.85 C:\Database\NIST11.L
10-Heneicosene (c,t) 139793 095008-11-0 95
9-Methyl-Z,Z-10,12-hexadecadien-1- 139723 1000130-89-
6 83
ol acetate
12 7.584 4.01 C:\Database\NIST11.L
cis-Vaccenic acid 129339 000506-17-2 90
Oleic Acid 129337 000112-80-1 90
13 8.145 7.09 C:\Database\NIST11.L
15-Hydroxypentadecanoic acid 109130 004617-33-8 78
9-Octadecenoic acid, (E)- 129349 000112-79-8 51
14 8.351 10.31 C:\Database\NIST11.L
Bis(2-ethylhexyl) phthalate 207665 000117-81-7 91
Phthalic acid, di(2-propylpentyl) 207709 1000377-93-5 90
ester
15 8.935 10.34 C:\Database\NIST11.L
Oleic Acid 129336 000112-80-1 83
3-Eicosene, (E)- 127771 074685-33-9 64
12-Methyl-E,E-2,13-octadecadien-1- 127752 1000130-90-
4 64ol
16 9.215 20.89 C:\Database\NIST11.L
Propanoic acid,2-methyl-3-hydroxy-2,
4,4-trimethyl methyl ester 128445 000301-02-0 91
Propanoic acid,2-methyl-3-hydroxy-2,
4,4-trimethyl methyl ester 128445 000301-02-0 91
17 9.999 3.02 C:\Database\NIST11.L
2-Methyl-Z,Z-3,13-octadecadienol 127747 1000130-90-5

87
13-Octadecenal, (Z)- 115867 058594-45-9 70
12-Methyl-E,E-2,13-octadecadien-1- 127752 1000130-90-4 64
ol
18 10.331 4.45 C:\Database\NIST11.L
Oleic Acid 129336 000112-80-1 70
3-Eicosene, (E)- 127771 074685-33-9 64
19 10.560 6.62 C:\Database\NIST11.L
Ethyl oleate 115867 058594-45-9 80
1,19-Eicosadiene 126192 014811-95-1 50
20 11.229 8.02 C:\Database\NIST11.L
E-2-Methyl-3-tetradecen-1-ol aceta 117494 1000130-81-2 45
te
Oleic Acid 129336 000112-80-1 41
21 12.769 2.39 C:\Database\NIST11.L
9-Octadecenoic acid, (E)- 129353 000112-79-8 62
Cyclopentadecanone, 2-hydroxy- 94142 004727-18-8 42
22 13.278 1.43 C:\Database\NIST11.L
i-Propyl 9-tetradecenoate 117466 1000336-60-7 72
Benzene, 1,2,3,5-tetramethyl-4,6-d 80454 004674-22-0 27
initro-
23 13.678 1.67 C:\Database\NIST11.L
Barbituric acid, 5-allyl-5-(cycloh 100428 077409-34-8 46
ex-2-en-1-yl)-
1H-Indole, 5-methyl-2-phenyl- 67012 013228-36-9 41
24 14.846 1.79 C:\Database\NIST11.L
Thiocarbamic acid, N,N-dimethyl, S 153800 1000192-89-2 27
-1,3-diphenyl-2-butenyl ester
Adamantane-1-(3,3-dichloropropyn-1 95425 139185-48-1 27
-yl)
25 15.544 0.35 C:\Database\NIST11.L
4-Quinolinecarboxylic acid, 2-chlo 66606 005467-57-2 38
ro-
Pyrido[2,3-d]pyrimidine, 4-phenyl- 66974 028732-75-4 38
26 15.881 0.24 C:\Database\NIST11.L
Cyclohexa-2,5-diene-1,4-dione, 2-m 66749 002158-89-6 38
ethyl-5-(4-morpholinyl)-
Hexahydropyridine, 1-methyl-4-[4,5 66899 094427-47-1 38
-dihydroxyphenyl]-
27 16.448 0.08 C:\Database\NIST11.L
[1,2,4]Triazolo[1,5-a]pyrimidine-6 67119 1000351-62-2 43
-carboxylic acid, 4,7-dihydro-7-im ino-, ethyl ester
1,1,1,3,5,5,5-Heptamethyltrisiloxa 79666 001873-88-7 38
Sat Sep 02 16:59:16 2023
Chemistry Lab Library Search Report (Wasp)
Data Path: C:\msdchem\1\DATA1\GC Analysis 151119\
Data File: Ant 2.D
Acq On: 2 sep 2020 20:32
Operator:
Sample: Wasp
Misc:
ALS Vial: 6 Sample Multiplier: 1
1 4.203 2.88 C:\Database\NIST11.L
Tetracontane, 3,5,24-trimethyl- 241176 055162-61-3 53
Hexadecane, 1-chloro- 110905 004860-03-1 50
2 4.495 1.00 C:\Database\NIST11.L
Didodecyl phthalate 235532 002432-90-8 90
1,2-Benzenedicarboxylic acid, mono 78837 000131-70-4 38
butyl ester
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Hexadecane 83023 000544-76-3 56
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Propanoic acid,2-methyl-, 125785 000084-74-2 60
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Phthalic acid, isoporpyl propyl es 102165 1000314-99-7 60
ter
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Dodecane, 2,6,11-trimethyl- 71406 031295-56-4 90
Methoxyacetic acid, 2-tetradecyl e 132964 1000282-04-8 53
ster
6 5.622 2.80 C:\Database\NIST11.L
Oleic Acid 142070 000112-80-1 93
Butyl 9-octadecenoate or 9-18:1 195600 1000336-74-7 83
7 6.137 7.04 C:\Database\NIST11.L
1,2-Benzenedicarboxylic acid, buty 125900 017851-53-5 90
l 2-methylpropyl ester
Phthalic acid, hexyl octadecyl est 235535 1000309-06-2 87
er
8 6.343 5.98 C:\Database\NIST11.L
Dibutyl phthalate 125785 000084-74-2 90
1,2-Benzenedicarboxylic acid, buty 172619 000084-78-6 90
l octyl ester
9 6.709 1.91 C:\Database\NIST11.L
Dibutyl phthalate 125787 000084-74-2 53
1,2-Benzenedicarboxylic acid, bis(102198 000605-45-8 53
1-methylethyl) ester
10 6.852 2.69 C:\Database\NIST11.L
trans-13-Octadecenoic acid, methyl 141314 1000333-61-3 95
ester
9-Octadecenoic acid, methyl ester, 141310 001937-62-8 90
(E)-
11 7.081 1.15 C:\Database\NIST11.L
Linoleic acid ethyl ester 167365 000544-35-4 99
Linoleic acid ethyl ester 167366 000544-35-4 99
12 7.207 3.01 C:\Database\NIST11.L
Hexadecenoic acid 117507 001120-25-8 99
Hexadecanoic acid, 15-methyl-, 131321 006929-04-0 96

methyl ester
13 7.670 2.84 C:\Database\NIST11.L
11-Octadecenoic acid, methyl ester 141291 052380-33-3 96
12-Octadecenoic acid, methyl ester 141284 056554-46-2 96
14 7.899 2.64 C:\Database\NIST11.L
9-Octadecenoic acid (Z)-, methyl e 141300 000112-62-9 99
ster
cis-13-Octadecenoic acid, methyl e 141299 1000333-58-3 99
15 8.077 2.22 C:\Database\NIST11.L
cis-13-Eicosenoic acid, methyl est 164512 1000333-52-1 99
er
cis-11-Eicosenoic acid, methyl est 164513 1000333-63-8 99
16 8.208 7.96 C:\Database\NIST11.L
Phthalic acid, di(oct-3-yl) ester 207673 1000377-72-3 80
Phthalic acid, 2-ethylhexyl hexyl 192015 1000309-02-5 72
ester
17 8.357 13.86 C:\Database\NIST11.L
Phthalic acid, di(2-propylpentyl) 207709 1000377-93-5 86
ester
Phthalic acid, 2-ethylhexyl hexyl 192015 1000309-02-5 72
ester
18 8.849 3.15 C:\Database\NIST11.L
Nonacosane 215180 000630-03-5 94
Hexadecane, 1-iodo- 184946 000544-77-4 93
19 9.227 9.58 C:\Database\NIST11.L
9,12-Octadecadienoic acid (Z,Z)- 127647 000060-33-3 70
Erucic acid 175492 000112-86-7 56
20 9.444 5.57 C:\Database\NIST11.L
Erucic acid 175492 000112-86-7 56
Tetrapentacontane, 1,54-dibromo- 243727 1000156-09-4 91
21 9.805 5.32 C:\Database\NIST11.L
Methyl 18-methylnonadecanoate 166215 1000352-20-6 98
Eicosanoic acid, methyl ester 166219 001120-28-1 97
22 10.205 3.39 C:\Database\NIST11.L
9,12-Octadecadienoic acid (Z,Z)- 127648 000060-33-3 96
9,17-Octadecadienal, (Z)- 114272 056554-35-9 95
23 10.674 3.29 C:\Database\NIST11.L
1-Octadecanthiol 193365 018835-33-1 68
2-Dodecen-1-yl(-)succinic anhydrid 115650 019780-11-1 55
24 11.229 2.36 C:\Database\NIST11.L
Colesta-3,5-diene 129490 000112-95-8 90
1,19-Eicosadiene 126192 014811-95-1 70
25 13.696 0.60 C:\Database\NIST11.L
2-Ethylacridine 66996 055751-83-2 25
1-Bromo-11-iodoundecane 190167 139123-69-6 25
26 14.777 0.07 C:\Database\NIST11.L
3-Eicosene, (E)- 127771 074685-33-9 53
9-Eicosene, (E)- 127770 074685-29-3 38
Indole-2-one, 2,3-dihydro-N-hydrox 66750 1000129-52-1 35
y-4-methoxy-3,3-dimethyl-
Sat Sep 02 18:22:46 2023

Figure 3. *Mud dauber Wasp- Sceliphron caementarium.*

Figure 4. *black carpenter Ant - Camponotus pennsylvanicus.*

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