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**Original Research Article**

# Screening of Secondary Metabolites Produced in Camel Thorn *(Alhagi maurorum)* Leaves Under Combined Environmental Stresses Using GC-Mass Spectrometry

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**Abstract:** Plants exhibit physiological, morphological, biochemical and molecular adaptations to maintain growth, development and survival under climate change fluctuations. This research aimed to analyse the secondary metabolites produced in *Alhagi maurorum* leaves under different environmental stresses. Secondary metabolites were extracted using Ethanol solvent using Soxhlet apparatus. FTIR and GC-MS analyses were applied to detect the metabolites produced in Alhagi leaves. The results exhibit the detection of 24 compounds at different peaks that were produced in the camel thorn that was naturally grown in the field under climatic stressors. These compounds are involved in the metabolic and physiological processes to grow and survive. The research concluded that environmental fluctuations have a direct influence on the metabolic compounds produced in the plant to cope with stressors and differ from the results concluded in the literature. The number and type of compounds detected showed that the leaves exhibit morphological adaptations to cope environment rather than metabolic adaptations compared to other plant parts and compared to the literature.

**Keywords:** Camelthorn*, Alhagi Maurorum,* GC-Mass, Secondary Metabolites SM, Abiotic Stressors.

## INTRODUCTION

Plants employ physiological, morphological and metabolic adaptations to cope the environmental changes such as scarce rainfall, high light intensity and extreme temperatures, these stresses impose adverse effects and limiting plant growth, development and survival in extreme environmental fluctuations (Al Kaabi *et al*., 2023; Faiq & Noori, 2021; Raza, 2021; Zhang *et al*., 2022) Plants have inbuilt physiological adaptation encompasses larger roots and stem area, thicker cuticle, reducing leaf area and numerous large stomata (Iqbal *et al*., 2023; Saleh *et al*., 2020). Osmoprotectants like glycine betaine and proline are synthesized to maintain cellular osmotic balance under drought and salinity stress (Abasi *et al.*, 2024; Goharrizi *et al*., 2021; Singh *et al*., 2024). *Alhagi maurorum* commonly known as camelthorn, belongs to *Fabaceae* family, it is well adapted to grows and thrive in multiple areas in the world such as Europe, Asia and North Africa. It is classified as of the richest medicinal plants, it contains active constituents like flavonoids, fatty acids, vitamins, sterols, and alkaloids which manifest diuretic , anti-viral, anti-bacterial, anti-cancer, antidiarrheal, anti-ulcer, anti-inflammatory, analgesic, antipyretic, anti-depressant and other pharmaceutical properties that alleviate the biotic and abiotic stresses (Hameed *et al*., 2022; Islam & Qadir, 2024; Tavassoli *et al*., 2020; Yuan *et al*., 2022) Metabolic and morphological adaptations enable *Alhagi* to survive and thrive in fluctuated and harsh climatic conditions (Mengqi *et al*., 2023). Due to insufficient studies and focus on the metabolic role of Alhagi leaves to cope combined climatic factors surrounding Alhagi that grown in different areas and most studies focuses on biological activities of secondary metabolites as medicinal constituents, the aims of the research is to evaluate the secondary metabolites affected by environment that produced in *Alhagi maurorum* leaves under combined environmental stresses using GC-Mass technique.

# MATERIALS AND METHODS

**Collecting Plant Samples**

The samples of *A. maurorum* leaves were gained from the unfarmed, unirrigated areas that were naturally planted and not surrounded by other plants in Iraq/Salah al-Din governorate at the grid N 34° 42° 38" E 43° 45° 53". The samples were identified at the Botany Lab at Tikrit University-College of Science. The samples washed thoroughly using distilled water and kept at room temperature for drying at the end of August 2024 away from direct sunlight.

**Preparation of Plant Sample**

*A. maurorum* leaves were ground into powder, Soxhlet apparatus was used for extraction using absolute ethanol solvent. 20 g of powder was placed in the thimble with 500 ml of solvent for 6 hrs. A muslin cloth was used for filtration and rotary evaporator used to purify the sample from solvent remnants then the extract was powdered and saved for further analyses (Mohammed, 2020).

**Gas Chromatography- Mass Spectrometry GC-Mass**

To detect the chemical constituents of *A. maurorum* leaves, GC-Mass apparatus (GCMS-QP2010 Ultra) was used. 1 ml was the sample volume that was injected in the GC pipe. TR5-MS capillary standard, non-polar column, length 30 m, width 0.25 mm. GC temperature ranged from 400-2500 ºC for 50 min. The reaction time was 36 min and the mobile phase was set at 1.0 ml/min (Bharathi & Anand, 2016).

**Fourier Transform Infrared Spectroscopy FTIR**

The dried extract of *A. maurorum* leaves was analyzed using FTIR technique. 1 mg of crude extract powder was encapsulated in 10 mg of KBr pellet. FTIR spectroscope (Shimadzu, Japan) was used, and the scan range was 400 – 4000 $cm^{-1}$ (Mohammed & Abd-alkadhemand, 2022).

# RESULTS AND DISCUSSION

**Environmental conditions**

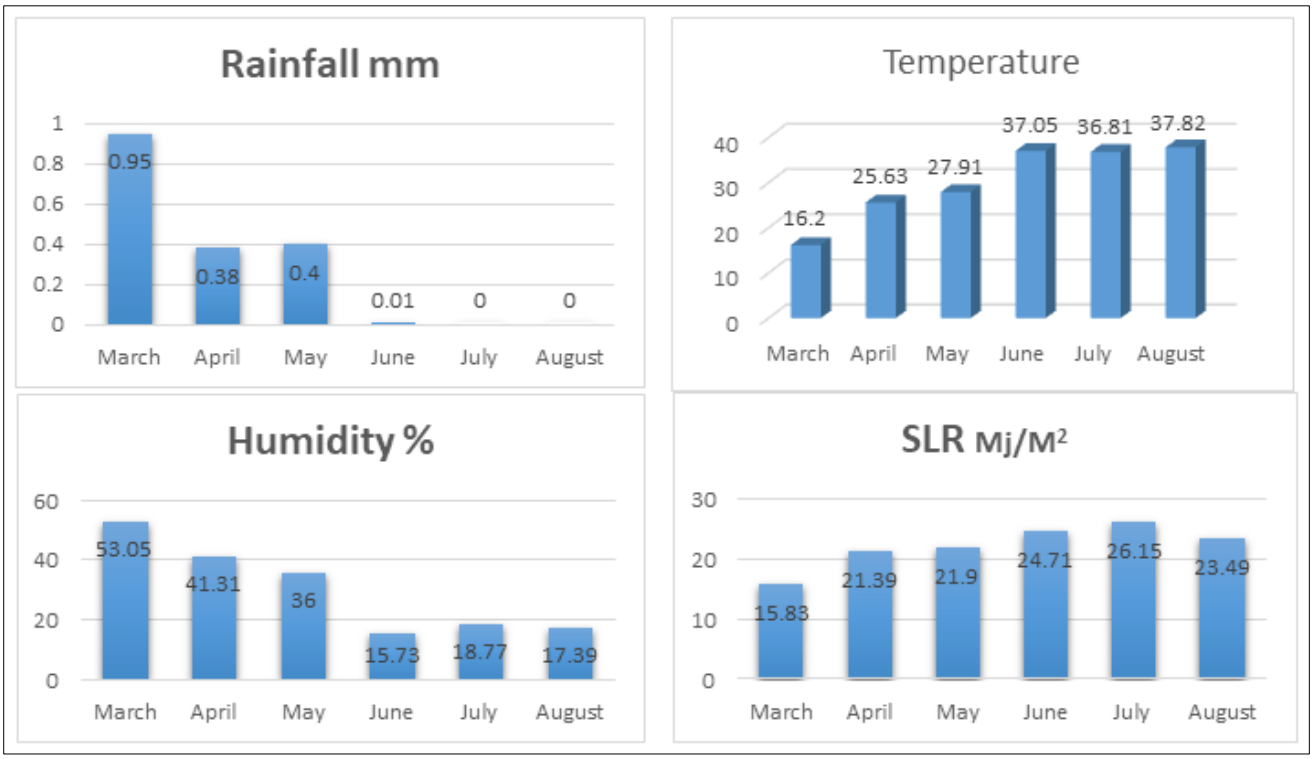



**Figure 1: Environmental conditions obtained from the general directorate of environment-Iraqi ministry of environment**

## FTIR ANALYSIS RESULTS

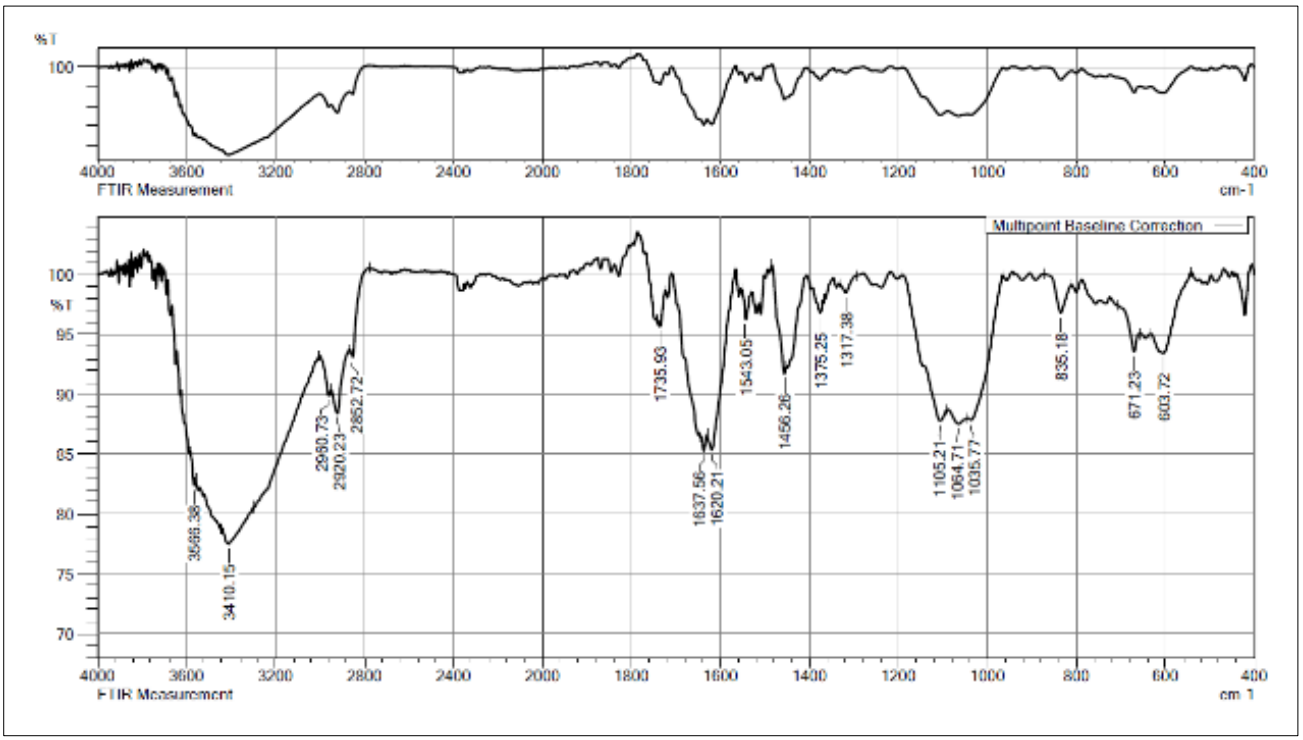



**Figure 2: FTIR analysis of plant extract sample**

The results of FTIR analysis illustrated in the figure above showed multiple peaks, (603-671 $cm^{-1)}$ indication of the presence of C-Cl chlorinated compounds and C-S sulfides). (835 $cm^{-1)}$ indication of metal-oxygen bonds. (1035, 1064, 1105,1317, 1375 $cm^{-1}$) indication of C-O, C-C and indication for alcohols, ethers and esters. (1456 $cm^{-1}$) indication for C-H bonging. (1543,1620,1637, 1735 $cm^{-1}$) indication of C=C indication for alkenes. (2852, 2920,2960 $cm^{-1}$) C-H and indication for hydrocarbon presence. (3410, 3566 $cm^{-1)}$ indication for O-H and the presence of phenols, alcohols, N-H amines and amides.

### GC-Mass Analysis

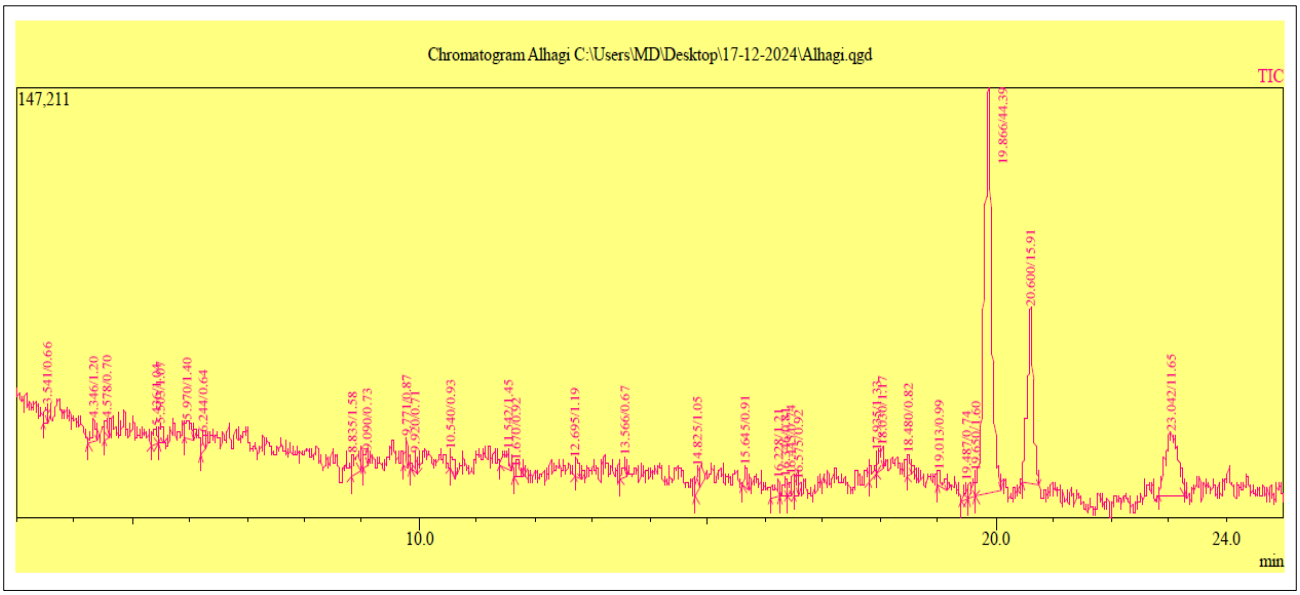
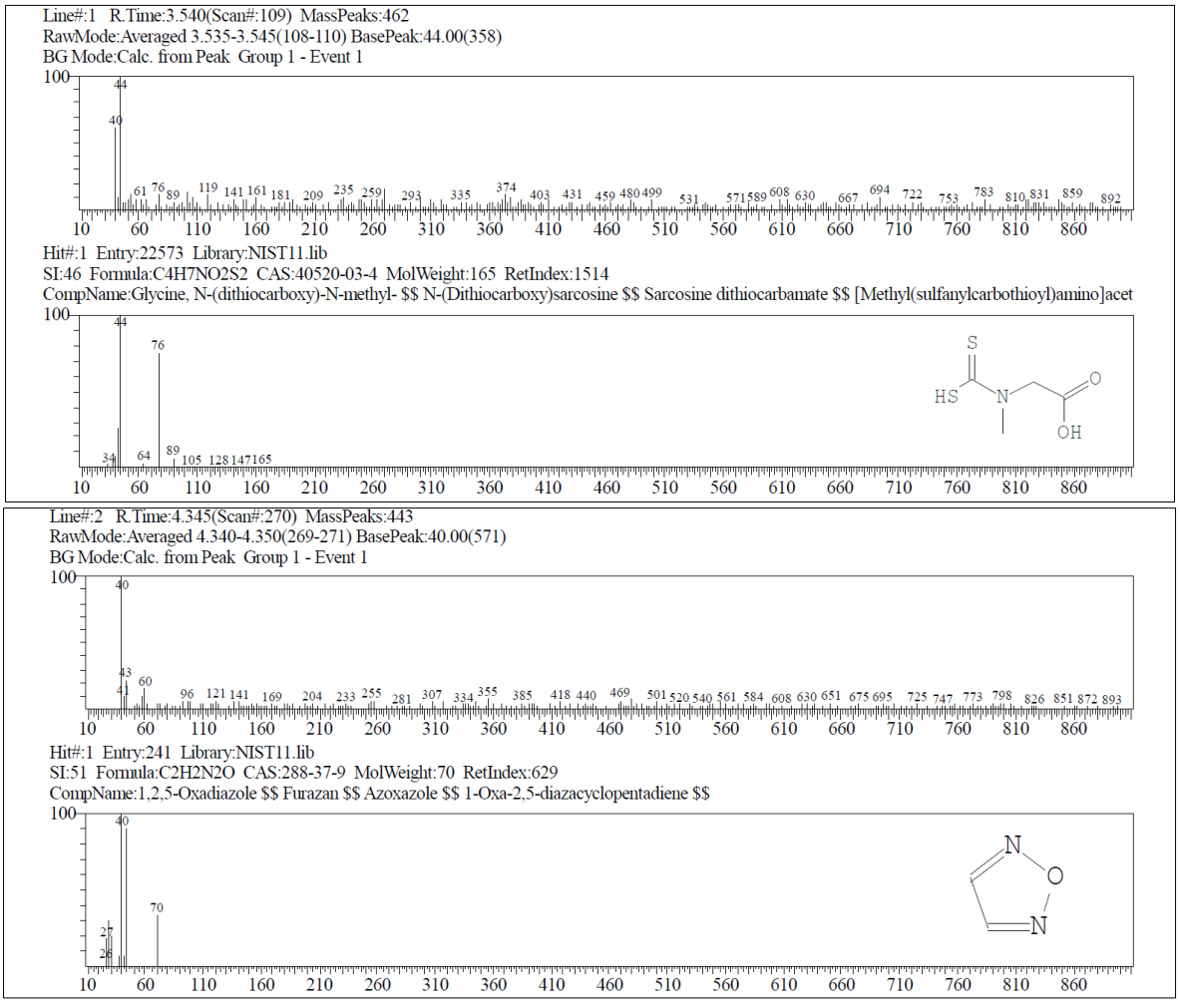



**Figure 3: Chromatogram analysis of Alhagi**

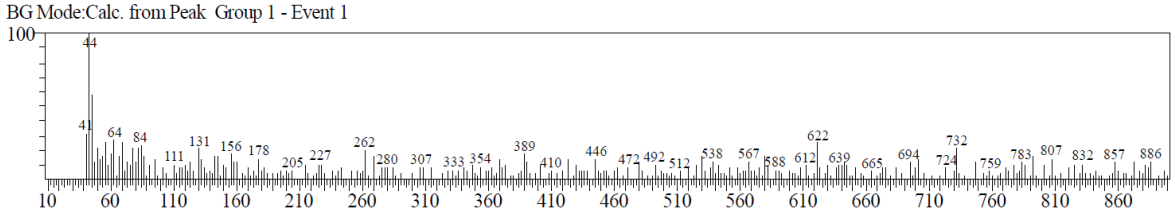
Peak Report TIC

| Peak# | R.Time | I.Time | F.Time | Area | Area% | Height | Height% | A/H | Name |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.541 | 3.475 | 3.555 | 19213 | 0.66 | 6008 | 1.43 | 3.20 | Glycine, N-(dithiocarboxy)-N-methyl- |
| 2 | 4.346 | 4.255 | 4.410 | 34975 | 1.20 | 8296 | 1.98 | 4.22 | 1,2,5-Oxadiazole |
| 3 | 4.578 | 4.535 | 4.600 | 20518 | 0.70 | 7049 | 1.68 | 2.91 | |
| 4 | 5.436 | 5.335 | 5.455 | 30364 | 1.04 | 6233 | 1.48 | 4.87 | |
| 5 | 5.503 | 5.455 | 5.565 | 31217 | 1.07 | 6869 | 1.64 | 4.54 | 1,1-Cyclopropanedicarboxamide |
| 6 | 5.970 | 5.920 | 6.075 | 40807 | 1.40 | 6254 | 1.49 | 6.52 | Urea, N,N''-(2-methylpropylidene)bis- |
| 7 | 6.244 | 6.205 | 6.280 | 18823 | 0.64 | 6618 | 1.58 | 2.84 | 3-Butyn-1-ol |
| 8 | 8.835 | 8.805 | 8.965 | 46114 | 1.58 | 7502 | 1.79 | 6.15 | 2H-Pyran, 2-(3-butynyloxy)tetrahydro- |
| 9 | 9.090 | 9.015 | 9.105 | 21390 | 0.73 | 4783 | 1.14 | 4.47 | Pyrazine, 2,6-dimethyl- |
| 10 | 9.771 | 9.710 | 9.795 | 25431 | 0.87 | 10382 | 2.47 | 2.45 | 3-Butynoic acid |
| 11 | 9.920 | 9.850 | 9.975 | 20765 | 0.71 | 6746 | 1.61 | 3.08 | 1,2,3-Butanetriol |
| 12 | 10.540 | 10.515 | 10.615 | 27217 | 0.93 | 7208 | 1.72 | 3.78 | 3-Isothiazolecarboxamide, 4-amino- |
| 13 | 11.542 | 11.405 | 11.590 | 42231 | 1.45 | 6547 | 1.56 | 6.45 | |
| 14 | 11.670 | 11.650 | 11.815 | 26998 | 0.92 | 3162 | 0.75 | 8.54 | 3-(3-Aminopropyl)-4-carboxyfurazan |
| 15 | 12.695 | 12.680 | 12.810 | 34719 | 1.19 | 6375 | 1.52 | 5.45 | Heptanal, dimethylhydrazone |
| 16 | 13.566 | 13.490 | 13.595 | 19419 | 0.67 | 7086 | 1.69 | 2.74 | Carbamimidoylsulfanylacetic acid |
| 17 | 14.825 | 14.790 | 14.875 | 30568 | 1.05 | 9144 | 2.18 | 3.34 | 1,3-Oxathiane, 2-ethyl-2-methyl- |
| 18 | 15.645 | 15.615 | 15.720 | 26655 | 0.91 | 7760 | 1.85 | 3.43 | |
| 19 | 16.228 | 16.095 | 16.255 | 35384 | 1.21 | 6455 | 1.54 | 5.48 | 2-Formylhistamine |
| 20 | 16.346 | 16.255 | 16.380 | 23633 | 0.81 | 6766 | 1.61 | 3.49 | 1-Butanol, 4-mercapto- |
| 21 | 16.445 | 16.380 | 16.460 | 21469 | 0.74 | 7088 | 1.69 | 3.03 | Trifluoromethanesulfonyl imidazole |
| 22 | 16.575 | 16.500 | 16.585 | 26824 | 0.92 | 5165 | 1.23 | 5.19 | |
| 23 | 17.935 | 17.790 | 17.945 | 38897 | 1.33 | 7606 | 1.81 | 5.11 | 1-Amino-7-guanidino-hept-3-yne |
| 24 | 18.030 | 17.945 | 18.045 | 34131 | 1.17 | 7441 | 1.77 | 4.59 | 4-Chlorobutyric acid, pentadecyl ester |
| 25 | 18.480 | 18.465 | 18.550 | 23914 | 0.82 | 7749 | 1.85 | 3.09 | Butanal, 3-methyl- |
| 26 | 19.013 | 18.990 | 19.160 | 28957 | 0.99 | 5900 | 1.41 | 4.91 | |
| 27 | 19.487 | 19.415 | 19.505 | 21700 | 0.74 | 6467 | 1.54 | 3.36 | Histidine, 4-nitro- |
| 28 | 19.650 | 19.505 | 19.660 | 46623 | 1.60 | 8986 | 2.14 | 5.19 | |
| 29 | 19.866 | 19.660 | 20.085 | 1296186 | 44.39 | 141993 | 33.82 | 9.13 | 9,12-Octadecadienoic acid, ethyl ester |
| 30 | 20.600 | 20.445 | 20.750 | 464528 | 15.91 | 61875 | 14.74 | 7.51 | (E)-9-Octadecenoic acid ethyl ester |
| 31 | 23.042 | 22.805 | 23.265 | 340040 | 11.65 | 22366 | 5.33 | 15.20 | l-(+)-Ascorbic acid 2,6-dihexadecanoate |
| | | | | 2919710 | 100.00 | 419879 | 100.00 | | |

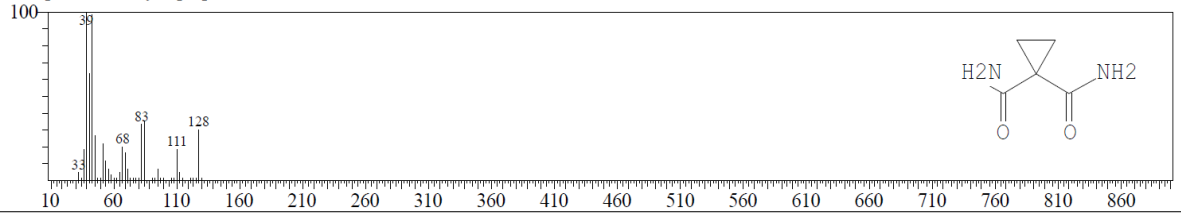
**Figure 3: GC-Mass analysis of extract sample**



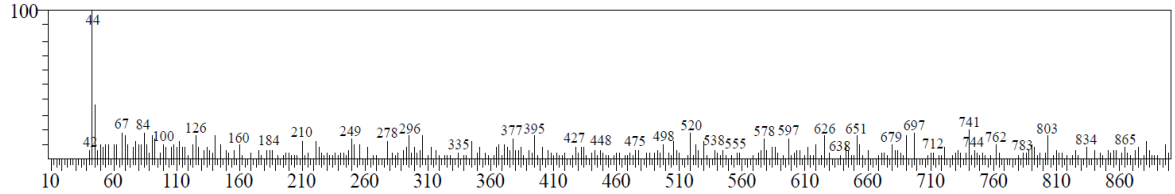
Line#:5 R.Time:5.505(Scan#:502) MassPeaks:446
RawMode:Averaged 5.500-5.510(501-503) BasePeak:44.05(202)
BG Mode:Calc. from Peak Group 1 - Event 1



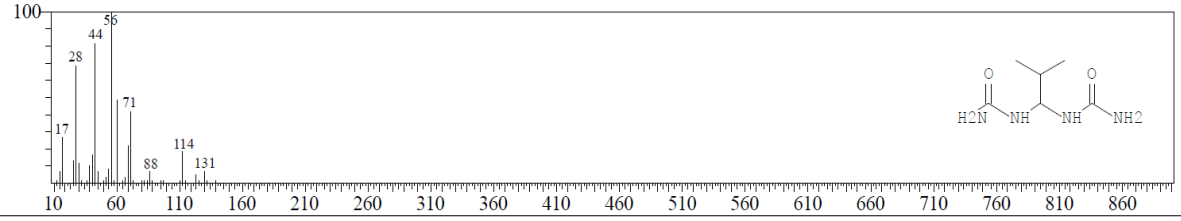
Hit#:1 Entry:6995 Library:NIST11.lib
SI:45 Formula:C5H8N2O2 CAS:5813-85-4 MolWeight:128 RetIndex:1313
CompName:1,1-Cyclopropanedicarboxamide



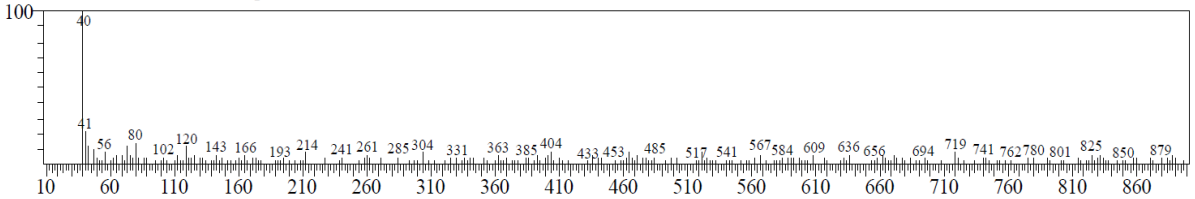

Line#:6 R.Time:5.970(Scan#:595) MassPeaks:486
RawMode:Averaged 5.965-5.975(594-596) BasePeak:44.05(258)
BG Mode:Calc. from Peak Group 1 - Event 1



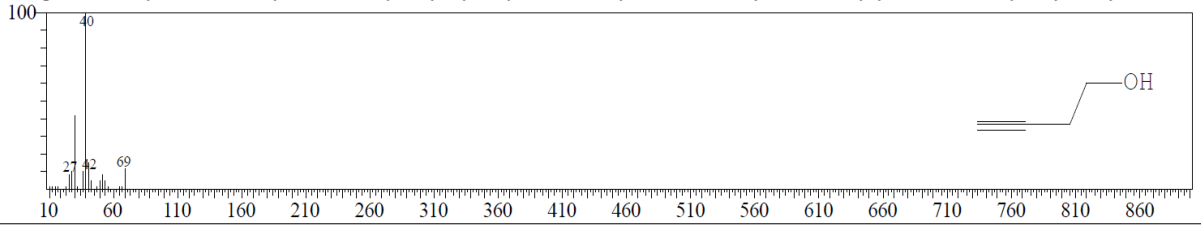
Hit#:1 Entry:27666 Library:NIST11.lib
SI:42 Formula:C6H14N4O2 CAS:6104-30-9 MolWeight:174 RetIndex:1705
CompName:Urea, N,N"-(2-methylpropylidene)bis- $$ Urea, 1,1'-isobutylidenedi- $$ Diureidoisobutane $$ 1,1-Diureidisobutane $$ IBDU $$ Isobutyldiurea



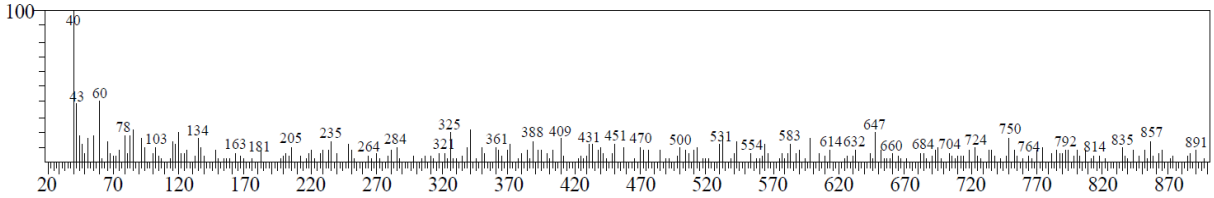

Line#:7 R.Time:6.245(Scan#:650) MassPeaks:448
RawMode:Averaged 6.240-6.250(649-651) BasePeak:40.00(447)
BG Mode:Calc. from Peak Group 1 - Event 1



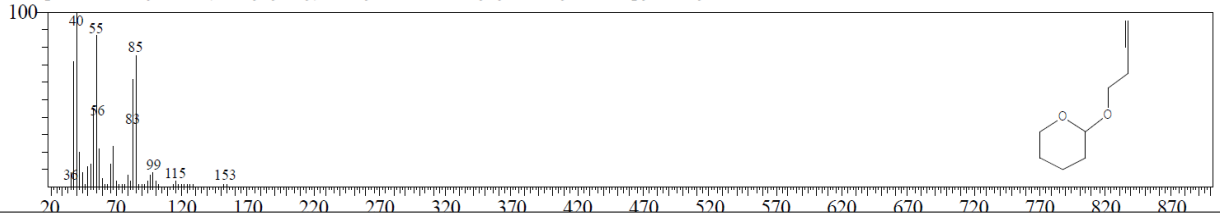
Hit#:1 Entry:249 Library:NIST11.lib
SI:44 Formula:C4H6O CAS:927-74-2 MolWeight:70 RetIndex:659
CompName:3-Butyn-1-ol $$ 1-Butyn-4-ol $$ 2-Hydroxyethylacetylene $$ 3-Butyne-1-ol $$ 3-Butynol $$ 3-Butynyl alcohol $$ 4-Hydroxy-1-butyne $$ HC



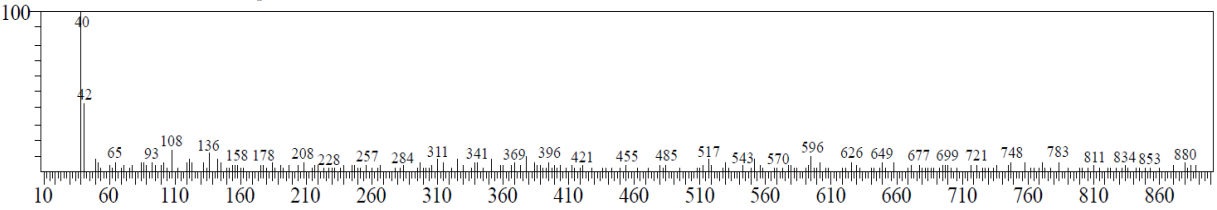
Line#:8 R.Time:8.835(Scan#:1168) MassPeaks:390
RawMode:Averaged 8.830-8.840(1167-1169) BasePeak:40.00(196)
BG Mode:Calc. from Peak Group 1 - Event 1



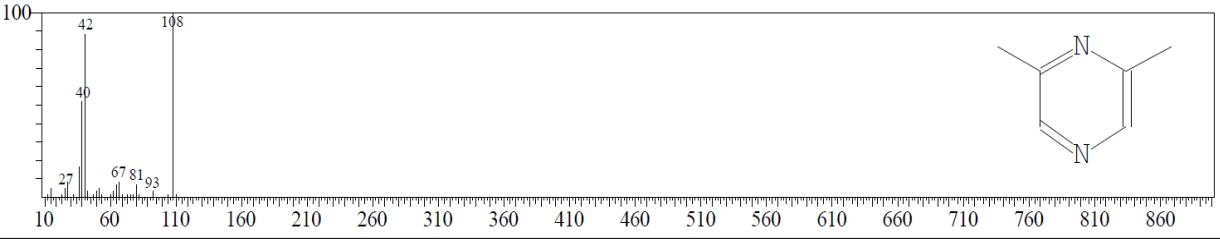
Hit#:1 Entry:17233 Library:NIST11.lib
SI:37 Formula:C9H14O2 CAS:40365-61-5 MolWeight:154 RetIndex:1141
CompName:2H-Pyran, 2-(3-butynyloxy)tetrahydro- $$ 3-Butynyl tetrahydro-2H-pyran-2-yl ether # $$



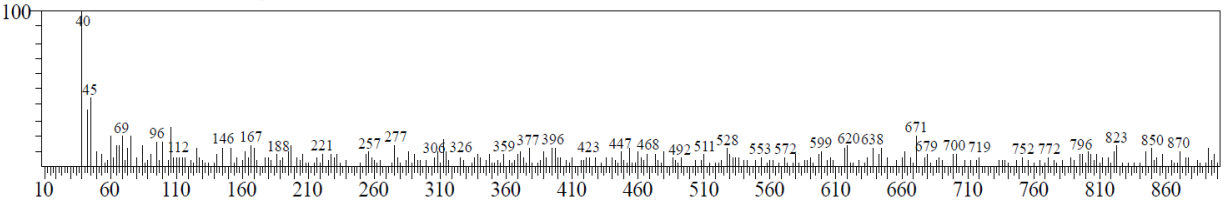
Line#:9 R.Time:9.090(Scan#:1219) MassPeaks:385
RawMode:Averaged 9.085-9.095(1218-1220) BasePeak:40.00(388)
BG Mode:Calc. from Peak Group 1 - Event 1



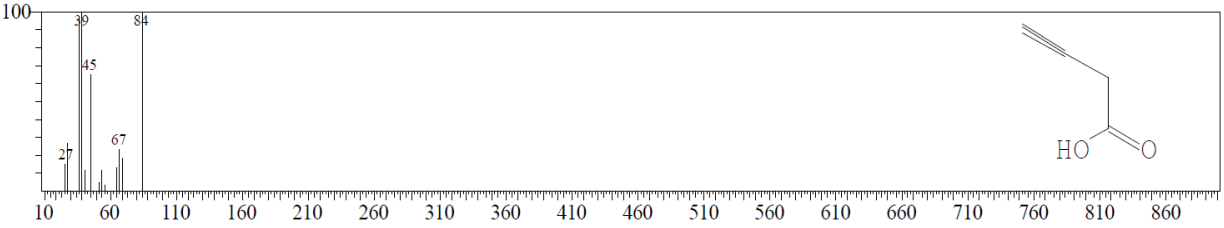
Hit#:1 Entry:2799 Library:NIST11.lib
SI:45 Formula:C6H8N2 CAS:108-50-9 MolWeight:108 RetIndex:894
CompName:Pyrazine, 2,6-dimethyl- $$ 2,6-Dimethylpyrazine $$ 3,5-Dimethylpyrazine $$

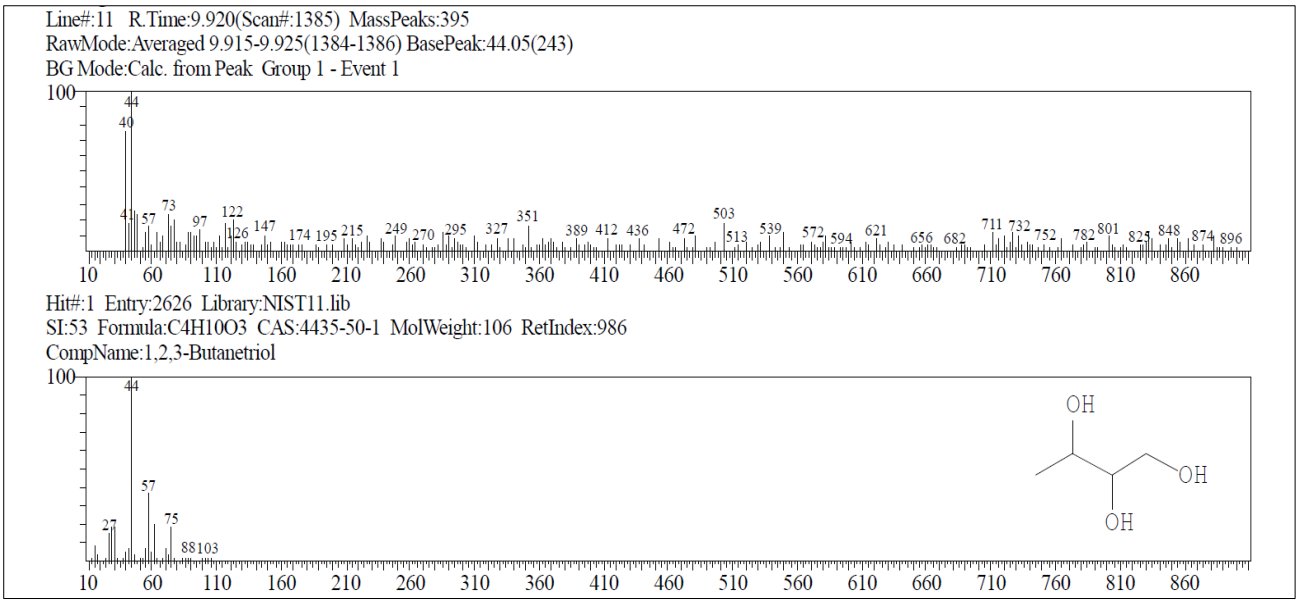


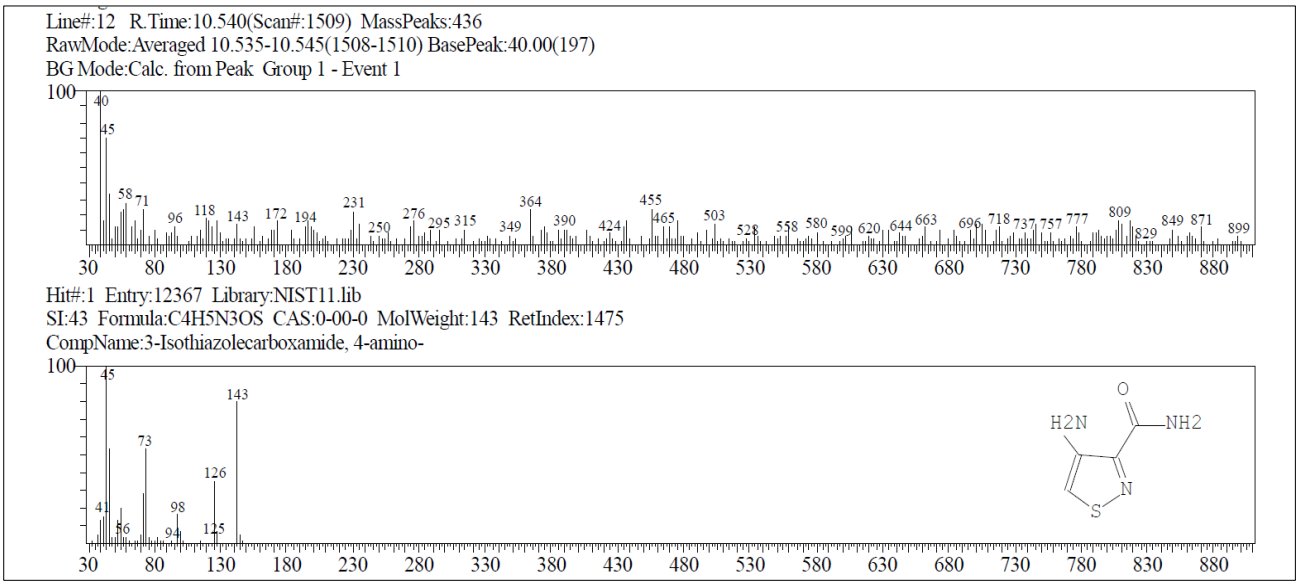
Line#:10 R.Time:9.770(Scan#:1355) MassPeaks:472
RawMode:Averaged 9.765-9.775(1354-1356) BasePeak:40.00(246)
BG Mode:Calc. from Peak Group 1 - Event 1

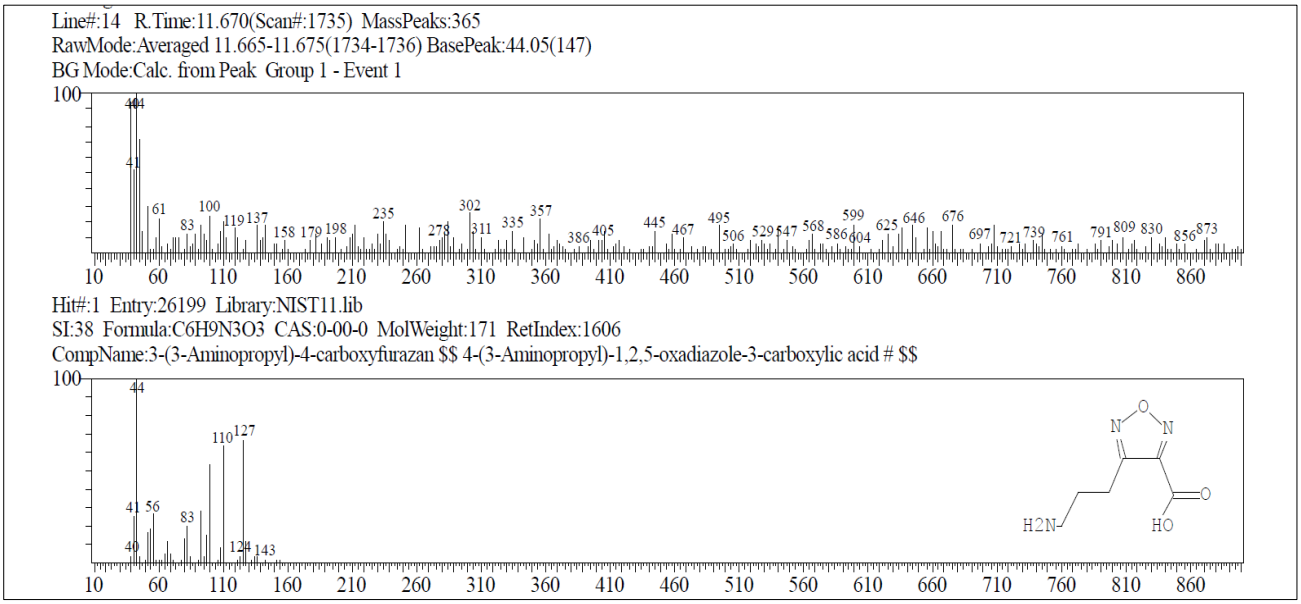


Hit#:1 Entry:652 Library:NIST11.lib
SI:39 Formula:C4H4O2 CAS:2345-51-9 MolWeight:84 RetIndex:773
CompName:3-Butynoic acid $$ CH.$.CCH2COOH $$

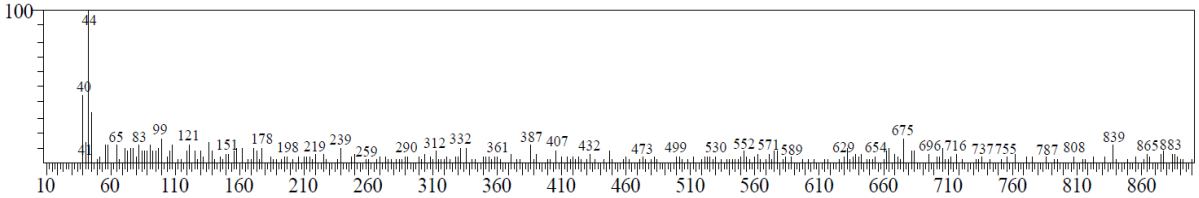



Line#:11 R.Time:9.920(Scan#:1385) MassPeaks:395
RawMode:Averaged 9.915-9.925(1384-1386) BasePeak:44.05(243)
BG Mode:Calc. from Peak Group 1 - Event 1
Hit#:1 Entry:2626 Library:NIST11.lib
SI:53 Formula:C4H10O3 CAS:4435-50-1 MolWeight:106 RetIndex:986
CompName:1,2,3-Butanetriol
OH
OH
OH

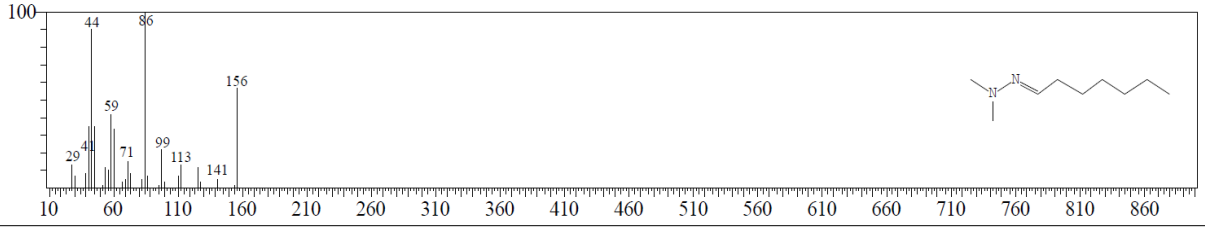

Line#:12 R.Time:10.540(Scan#:1509) MassPeaks:436
RawMode:Averaged 10.535-10.545(1508-1510) BasePeak:40.00(197)
BG Mode:Calc. from Peak Group 1 - Event 1
Hit#:1 Entry:12367 Library:NIST11.lib
SI:43 Formula:C4H5N3OS CAS:0-00-0 MolWeight:143 RetIndex:1475
CompName:3-Isothiazolecarboxamide, 4-amino-
H2N
NH2
O
N
S


Line#:14 R.Time:11.670(Scan#:1735) MassPeaks:365
RawMode:Averaged 11.665-11.675(1734-1736) BasePeak:44.05(147)
BG Mode:Calc. from Peak Group 1 - Event 1
Hit#:1 Entry:26199 Library:NIST11.lib
SI:38 Formula:C6H9N3O3 CAS:0-00-0 MolWeight:171 RetIndex:1606
CompName:3-(3-Aminopropyl)-4-carboxyfurazan $$ 4-(3-Aminopropyl)-1,2,5-oxadiazole-3-carboxylic acid # $$
N
O
N
H2N
HO
O

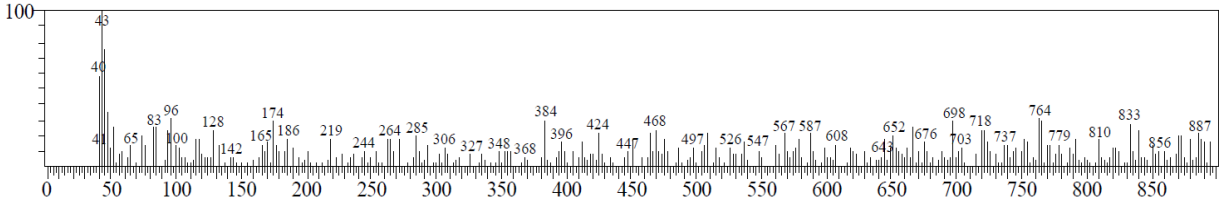
Line#:15 R.Time:12.695(Scan#:1940) MassPeaks:434
RawMode:Averaged 12.690-12.700(1939-1941) BasePeak:44.05(309)
BG Mode:Calc. from Peak Group 1 - Event 1



Hit#:1 Entry:18544 Library:NIST11.lib
SI:48 Formula:C9H20N2 CAS:67660-53-1 MolWeight:156 RetIndex:1181
CompName:Heptanal, dimethylhydrazone $$ Heptaldehyde dimethylhydrazone $$ (1E)-Heptanal dimethylhydrazone # $$



Line#:16 R.Time:13.565(Scan#:2114) MassPeaks:446
RawMode:Averaged 13.560-13.570(2113-2115) BasePeak:43.05(130)
BG Mode:Calc. from Peak Group 1 - Event 1



Hit#:1 Entry:8781 Library:NIST11.lib
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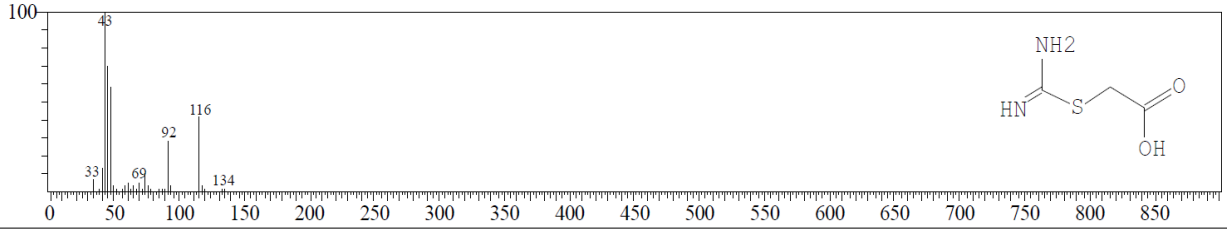
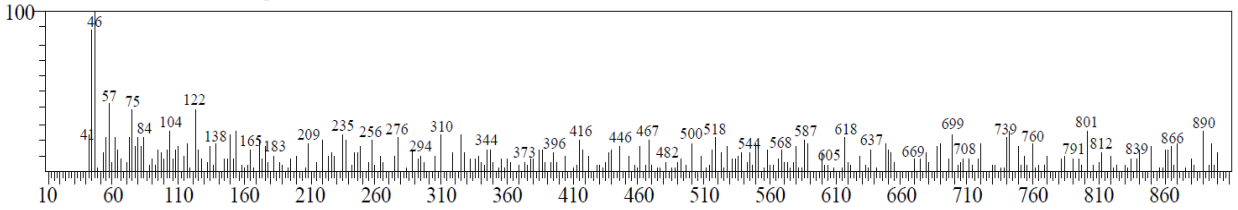
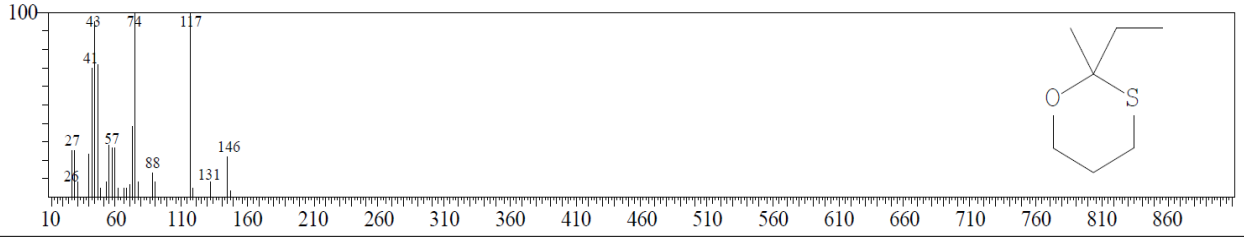
CompName:Carbamimidoylsulfanylacetic acid



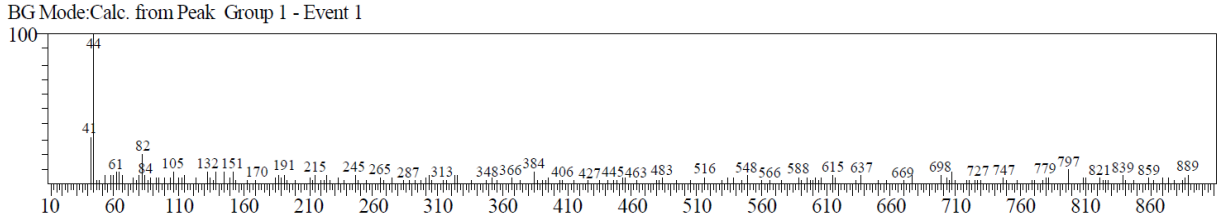
Line#:17 R.Time:14.825(Scan#:2366) MassPeaks:403
RawMode:Averaged 14.820-14.830(2365-2367) BasePeak:46.10(124)
BG Mode:Calc. from Peak Group 1 - Event 1



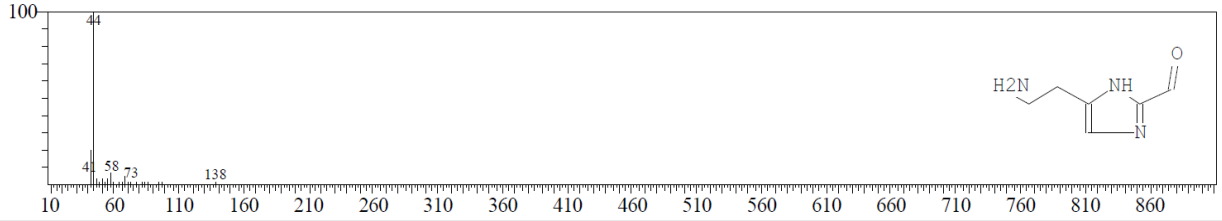
Hit#:1 Entry:13635 Library:NIST11.lib
SI:41 Formula:C7H14OS CAS:30098-80-7 MolWeight:146 RetIndex:1084
CompName:1,3-Oxathiane, 2-ethyl-2-methyl- $$ 2-Ethyl-2-methyl-1,3-oxathiane # $$



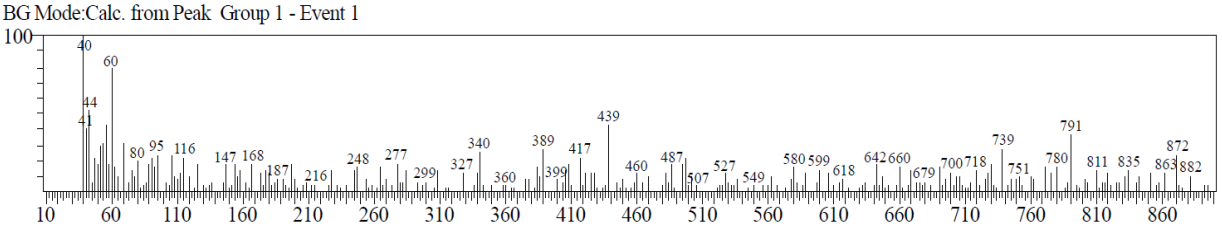
Line#:19 R.Time:16.230(Scan#:2647) MassPeaks:353
RawMode:Averaged 16.225-16.235(2646-2648) BasePeak:44.05(398)
BG Mode:Calc. from Peak Group 1 - Event 1



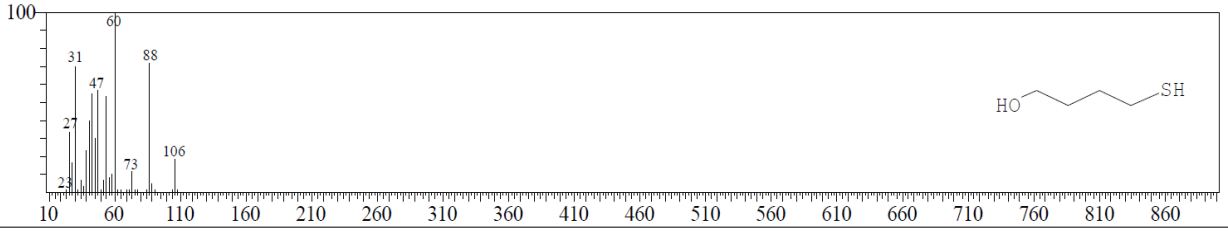
Hit#:1 Entry:10654 Library:NIST11.lib
SI:53 Formula:C6H9N3O CAS:0-00-0 MolWeight:139 RetIndex:1517
CompName:2-Formylhistamine $$ 5-(2-Aminoethyl)-1H-imidazole-2-carbaldehyde # $$



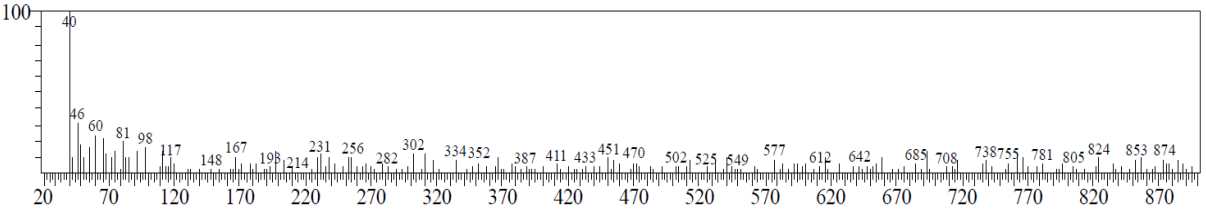

Line#:20 R.Time:16.345(Scan#:2670) MassPeaks:375
RawMode:Averaged 16.340-16.350(2669-2671) BasePeak:40.00(125)
BG Mode:Calc. from Peak Group 1 - Event 1



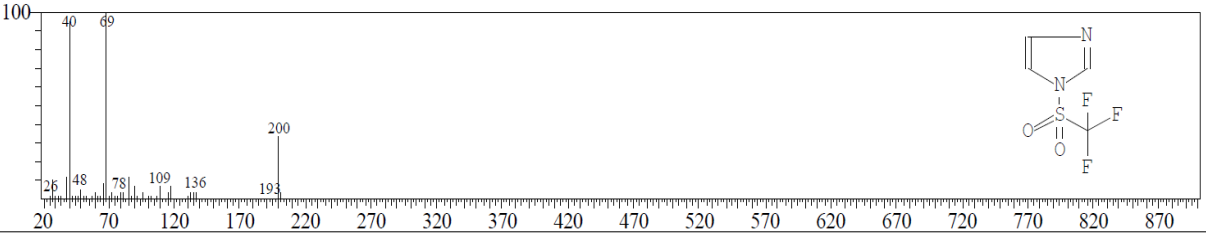
Hit#:1 Entry:2622 Library:NIST11.lib
SI:38 Formula:C4H10OS CAS:14970-83-3 MolWeight:106 RetIndex:965
CompName:1-Butanol, 4-mercapto- $$ 4-Sulfanyl-1-butanol # $$



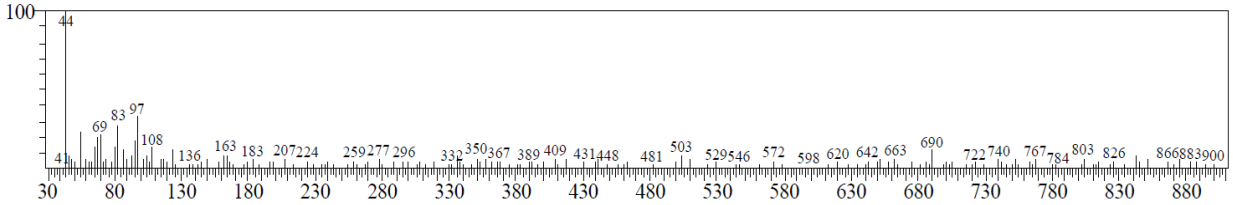

Line#:21 R.Time:16.445(Scan#:2690) MassPeaks:348
RawMode:Averaged 16.440-16.450(2689-2691) BasePeak:40.00(244)
BG Mode:Calc. from Peak Group 1 - Event 1



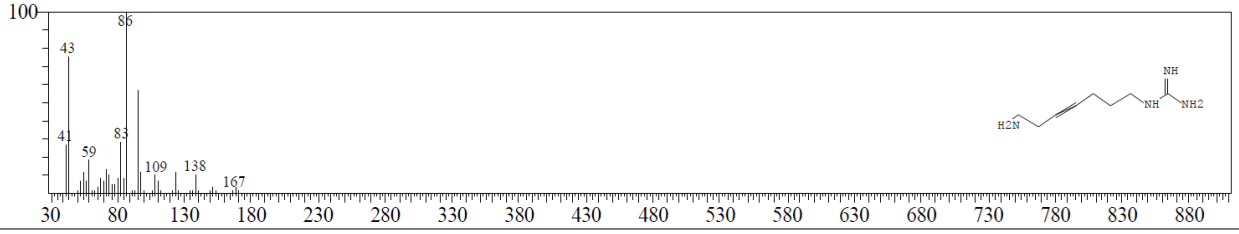
Hit#:1 Entry:43384 Library:NIST11.lib
SI:40 Formula:C4H3F3N2O2S CAS:29540-81-6 MolWeight:200 RetIndex:1056
CompName:Trifluoromethanesulfonyl imidazole $$ 1-(Trifluoromethanesulfonyl)imidazole $$ N-Trifluoromethanesulfonylimidazole $$ 1-(Trifluoromethyls



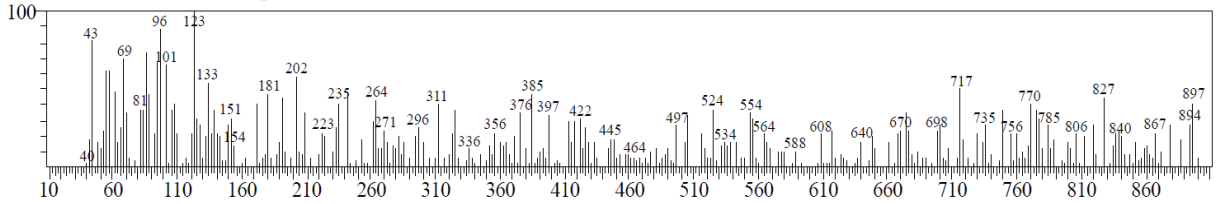
Line#:23 R.Time:17.935(Scan#:2988) MassPeaks:323
RawMode:Averaged 17.930-17.940(2987-2989) BasePeak:44.05(318)
BG Mode:Calc. from Peak Group 1 - Event 1



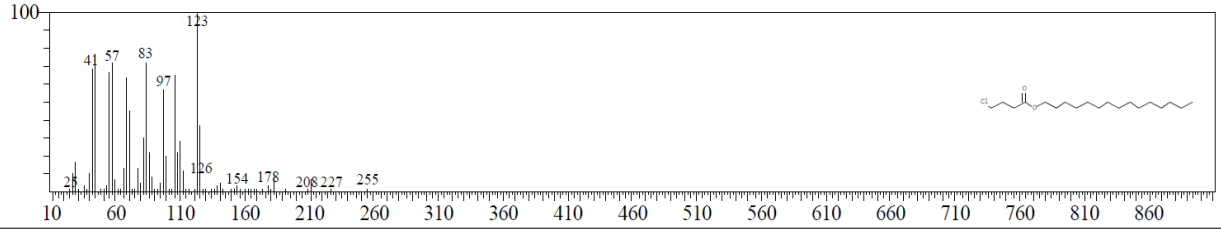
Hit#:1 Entry:24297 Library:NIST11.lib
SI:61 Formula:C8H16N4 CAS:0-00-0 MolWeight:168 RetIndex:1477
CompName:1-Amino-7-guanidino-hept-3-yne $$ N-(7-Amino-4-heptynyl)guanidine # $$



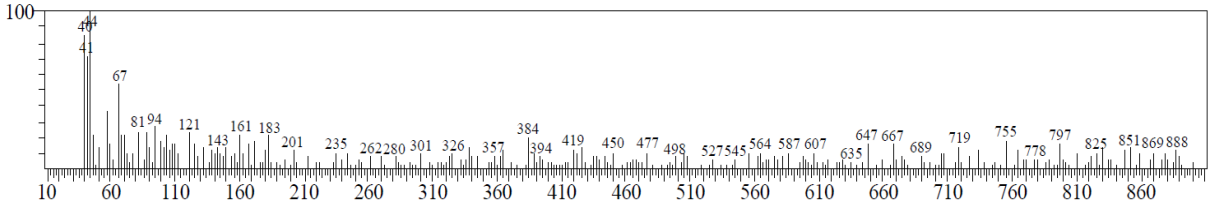
Line#:24 R.Time:18.030(Scan#:3007) MassPeaks:389
RawMode:Averaged 18.025-18.035(3006-3008) BasePeak:123.10(72)
BG Mode:Calc. from Peak Group 1 - Event 1



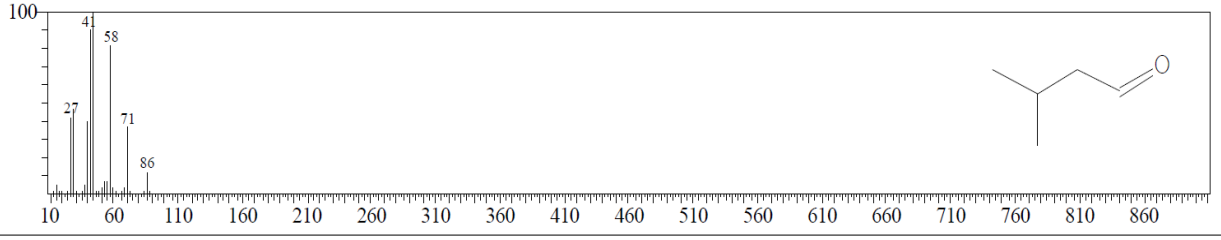
Hit#:1 Entry:143083 Library:NIST11.lib
SI:41 Formula:C19H37ClO2 CAS:0-00-0 MolWeight:332 RetIndex:2302
CompName:4-Chlorobutyric acid, pentadecyl ester



Line#:25 R.Time:18.480(Scan#:3097) MassPeaks:392
RawMode:Averaged 18.475-18.485(3096-3098) BasePeak:44.05(193)
BG Mode:Calc. from Peak Group 1 - Event 1



Hit#:1 Entry:854 Library:NIST11.lib
SI:50 Formula:C5H10O CAS:590-86-3 MolWeight:86 RetIndex:643
CompName:Butanal, 3-methyl- $$ Isovaleraldehyde $$ .beta.-Methylbutanal $$ Isopentanal $$ Isovaleral $$ Isovaleric aldehyde $$ Isovalerylaldehyde $$ 3



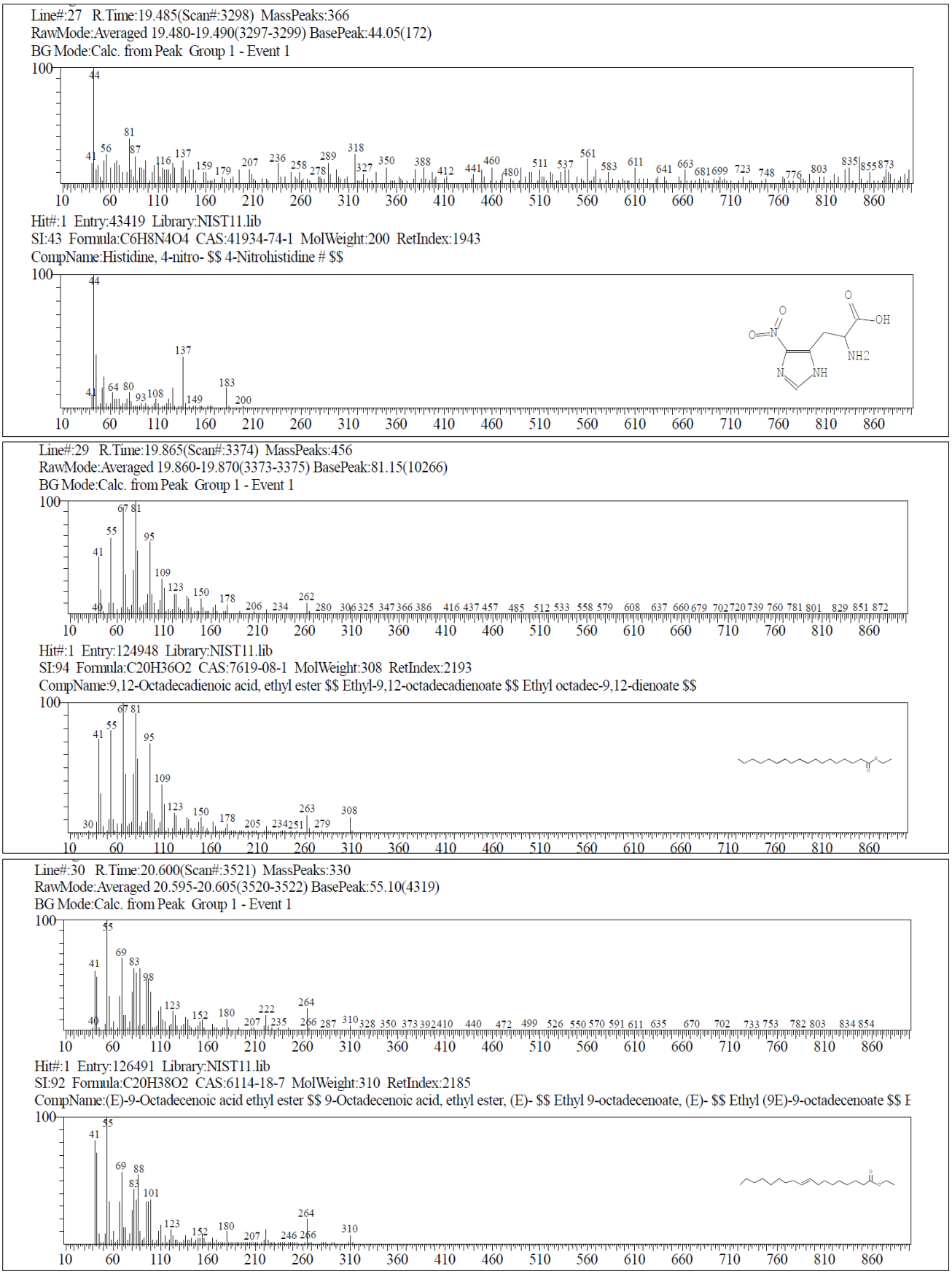



**Figure 4: peaks and chemical formula for each compound detected by GC-Mass analysis**

The figures detailed above are the 24 compounds peaks resulted from GC-Mass analysis. The results of FTIR and GC-MS analyses illustrated in the figures listed above exhibited a variety of compounds that are produced as a secondary metabolite SM in *A. maurorum* leaves that are grown in the field under different environmental conditions, (24) compounds detected in GC-Mass analysis in different peaks, these metabolites involved in a different physiological and metabolic response in plant body to cope biotic and climatic stresses and maintain survival. The SM protect against the ROS reactive oxygen species that are produced in plants subjected to stressors that cause cellular damage and degradation of proteins and enzymes affect genes that are essential for metabolic pathways (Choudhury *et al*., 2013). 1,1-Cyclopropanedicarboxamide, 3-Butyn-1-ol, 1,2,3-Butanetriol, stabilizing cellular compartments osmoprotection under salinity and water deficiency 4-Chlorobutyric Acid, Pentadecyl Ester, 9,12-Octadecadienoic Acid, Ethyl Ester, (E)-9-Octadecenoic Acid Ethyl Ester, 1-Butanol, 4-mercapto Lipid related compounds stabilizing membranes, enhancing fluidity, maintain membrane integrity and signals pathways under stresses (Rawat *et al*., 2021). 1,3,4-Oxadiazole derivatives exhibited promising antimicrobial properties that eliminate biotic threats such as sects and pathogenic bacteria that could harm the plant (Tiwari *et al.*, 2022; Zhong *et al*., 2023). 2H-Pyran, 2-(3-butynyloxy) has been reported to exhibit antimicrobial activity against the bacteria *Pseudomonas aeruginosa*, *Escherichia coli* and *Staphylococcus aureus* (Bennett *et al*., 2024). 2-Formylhistamine, Butanal, 3-methyl-, 3-(3-Aminopropyl)-4-carboxyfurazan, 1-Amino-7-guanidino-hept-3-yne, ascorbic acid involved in regulating photosynthesis pathway, hormone biosynthesis, and other antioxidants regeneration. Ascorbic acid involved in cell division and growth and signal transduction and other compounds support signaling, detoxification and stabilizing cellular structures under stresses (Gallie, 2013).

Due to the differences in climate conditions among regions, the results obtained in this study were differ significantly from other rare previous studies that focus on the metabolic role of reduced Alhagi leaves in terms of the compounds produced in the leaves and this resorted to the difference climate conditions surrounding the plant species. Climate fluctuations, absence of neighbour plants, genetic variations and plant variety are factors decisive to the SM produced (AE, 2015; Al Allan, 2024; Mohammed & Abd-alkadhemand, 2022; Montesinos-Navarro *et al*., 2024; Mostafa & Essawy, 2019; Muhammad *et al*., 2015; Wagay & Rothe, 2016).

## CONCLUSION

The study aimed to evaluate the metabolites of *A. maurorum* camel thorn that was grown naturally under fluctuated environmental conditions compared to other studies. The metabolites were strongly affected by the environmental conditions compared to the rare literature that was focused on roots and other parts that neglect the climatic factors surrounding the plants and neighbouring plants. The number and type of compounds detected showed that the reduced leaves exhibit morphological adaptations to cope environment rather than metabolic adaptations compared to other plant parts and compared to the previous studies.

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