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REPORT

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REPORT TITLE:

ORGANIC GEOCHEMICAL CHARACTERISATION OF DST AND FMT SAMPLES FROM WELL 34/7-10

REPORT NO.: 22.1840.00/01/87

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Saga Petroleum a.s., v/ E.S. Mo

SUMMARY:

One FMT and three DST fluid samples from 34/7-10 were characterised using organic geochemistry. The four oils are similar in character and may be described as low sulphur, paraffinic-naphthenic oils of moderate thermal maturity which are probably derived from a common source. The oils are similar to those previously characterised from the Snorre area.

Some variations were observed in the gas samples from these tests, mainly in the methane content/gas wetness values. These variations may reflect movement of fluid components in the oil column. All of the gas samples are of similar maturity and the carbon isotopic data from the three DST samples are similar to those observed in other samples from the Snorre area.

KEY WORDS:	
Oil and Gas Samples	Oil Characterisation
34/7-10	Biomarkers
Snorre	

168/E/anl/1

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1. INTRODUCTION

Three DST oil and gas sample sets and one FMT oil and gas sample set from well 34/7-10 (Figure 1), were characterised using organic geochemistry as requested by Saga Petroleum A/S. The analyses were carried out under IKU project number 22.1840.

The samples were assigned the following IKU numbers and certain data on the physical nature of the fluids were provided by Geco and Core Lab Norsk:

SAMPLE	DEPTH (M)	IKU No.	GAS/OIL ratio (Sm3/m3)	GAS gravity (air=1.000)	OIL density (Kg/m3)	OIL molec. wt. (gm/mole)
FMT	2532.5	C-5576(gas)				
		C-5575(oil)	89.7	1.05	836.5	---
DST 4	2549-51.5	C-5794(gas)				
		C-5793(oil)	91.2	1.066	840.6	204
DST 3	2561-70.5	C-6005(gas)				
		C-6007(oil)	79.6	-----	837.7	196
DST 2	2609.5-15	C-6004(gas)				
		C-6006(oil)	75.1	-----	838.5	201

The fluid samples were analysed using the analytical programme outlined in Saga's letter of 8 October, 1985. The analyses are as follows:

Gas Samples:

- GC of C1-C8 hydrocarbons for recombination.
- D13C stable carbon isotope ratios for the C1,C2,C3,iC4 and C4 components.
- D/H isotope ratio of methane.

Oil Samples:

- API Gravity.
- S,Ni and V content.
- GC of C2-C8 hydrocarbons for recombination.
- GC of whole oil.
- Evaporation of light compounds (>210^{o}C).
- Chromatographic separation of 'topped' oil fractions by MPLC, including asphaltene precipitation.
- GC of Saturate and Aromatic hydrocarbon fractions.
- Urea adduction of Saturate fraction and GC of branched/cyclic hydrocarbons.
- Combined GC-MS of the Saturate and Aromatic fractions.
- D13C ratio of the Saturate, Aromatic, NSO and Asphaltene fractions.

The first sample was received on 28 October, 1986 and the last samples were received on 16 Febraury, 1986.

A draft copy of the final report will be sent to Saga Petroleum for approval. On approval, ten copies of the final report will be sent to Saga Petroleum and a further five copies will be stored at IKU.

2. DISCUSSION OF RESULTS

2.1 Recombination of oil and gas samples (C1-C8 hydrocarbons).

2.1.1 Composition of gas samples (C1-C8 hydrocarbons)

The gas samples are dominated by methane, ethane and propane, especially methane (Figure 2,Table 1). The C5+ components are either absent or are present in trace amounts.

The DST gases can be divided into two groups of similar composition. One group consists of the DST 3 and 4 gas samples with methane contents of around 45%, and the second group consists of the FMT and DST 2 samples with methane contents of around 25%. The data from the FMT sample may reflect the sampling procedure by which this sample was obtained.

Gas wetness values vary from 50% to 70%, and iC4/nC4 ratios from 0.31 to 0.33 (Table 1b). With the exception of the FMT sample, the methane content of the gases shows a slight decrease with depth, with an accompanying decrease in gas wetness values. This is reflected in the increasing gas/oil ratios. The FMT sample, being the stratigraphically highest, might be expected to have the highest methane content and lowest gas wetness.

The variation in the composition of the gases may be explained in two ways. One explanation involves the movement of the gas towards the top of a continuous oil column, producing a gas-enriched zone. The second explanation lies in the samples coming from two disconnected oil columns with different gas compositions. These speculations cannot be evaluated without more detailled geological data, although a recent IKU report on the Snorre oils (Leith, 1987) indicated the existence of similar gas variations in other wells (e.g. 34/7-3 and 34/7-7).

2.1.2 Composition of the oil samples (C2-C8 hydrocarbons)

The C2-C8 hydrocarbon gas chromatograms of the oil samples in figure 3 show similar profiles. n-Alkane peaks account for the most prominent peaks in the chromatograms, although some cyclic hydrocarbon peaks are also quite well-developed. The appearance of the gas chromatograms suggests that the oils are thermally mature, as do paraffinicity indices of around 1 (Tables 1b and 2).

2.1.3 Recombination of C1-C8 hydrocarbon composition for the gas/oil samples

On the basis of gas/oil ratios supplied by Geco and Core Lab Norsk, the C1-C8 and C2-C8 hydrocarbon compositions of the well fluids were recombined in order to simulate the light hydrocarbon composition of the reservoired hydrocarbon fluids under subsurface conditions. These data are given in table 1.

2.1.4 Stable Carbon isotope composition of the gas samples.

Carbon isotope data and deuterium isotope data were obtained from IFE for the three DST samples (Table 3). The isotopic composition of the three samples is very similar. In figure 4, all three samples plot just outside the field of oil-associated gases in the Schoell plot. This may suggest that the gas samples are not directly related to the oils.

The gas isotopic data suggest that the gases are of similar maturity to the most mature samples analysed from the Snorre area.

2.2 Analysis of the oil samples

2.2.1 API Gravity

The four oil samples have similar whole oil API gravity values (Table 4), varying between 36.9^{0} and 37.6^{0}. Slight differences in API gravity follow the pattern described for the C1-C8 gas composition, i.e. with the exception of the FMT sample, the API gravities tend to show a slight increase with depth. The API gravities of these oils lie slightly above the average for the Snorre oils (i.e. 36.6^{0}) and suggest a thermally mature, moderately light oil.

2.2.2 Sulphur, Nickel and Vanadium content

All of the oil samples may be classed as low-sulphur oils based on percent sulphur contents of between 0.18% and 0.23% (Table 5). The sulphur contents of these oils lie slightly below the average for the Snorre oils (average %S = 0.3).

The nickel content of the FMT sample is twice that of the DST samples, while the vanadium content is more similar to those of the DST samples. The nickel contents of the DST oils are below average for Snorre oils, although the vanadium contents are about average. The nickel content of the FMT sample is closer to the field average.

The differences in nickel content between the FMT and DST samples may reflect either the different sampling procedures used to collect the samples, or a higher content of high molecular weight compounds in the FMT oil.

2.2.3 Gross Composition of the crude oil samples.

The low-boiling (<210^{0}C) fraction accounts for between 25% and 35% of the three DST oils (Table 6), the DST 4 oil having the highest value of 35.4%. These values are about average for the Snorre oils analysed so far. The relatively high percentage obtained for the FMT sample is not considered to be wholly reliable.

The asphaltene and NSO contents of the 'topped' oils are shown in table 7. The data indicate an increase in asphaltene content up the oil column from a low value of 0.4% in DST 2 at 2609.5-15m to 1.7% in DST 4 at 2549-51.5m, with a large increase to 16.3% in the FMT sample at 2532.5m. The content of NSO compounds in the oils is four times greater in DST oils 2 and 3 (27.9% and 22.3%, respectively) than in the DST 4 and FMT oils (8.4% and 6.4%, respectively).

The NSO content of the DST 4 and FMT oils is about average for Snorre oils, but the NSO content of the DST 2 and 3 oils is double the highest value obtained from previously-analysed Snorre oils. This variation in the NSO content of the oil samples is unexpected as the two oils with the highest NSO contents are those oils with the highest API gravity and relatively low S, Ni and V contents. The lower gas/oil ratios of these two samples may, however, reflect the higher NSO content.

The asphaltene contents of the DST oils are average for the Snorre oils, although that obtained for the FMT oil is considerably above average. The increased asphaltene content towards the top of the oil column contrasts with the variation in NSO components and may partially reflect either the different sample-collection techniques used for the DST and FMT oils or, some de-asphalting may have occurred. Reference to an earlier

IKU data report (22.1837.00), suggests that this de-asphalting, if it occurred, is relatively localised towards the top of the oil column.

2.2.4 Chromatographic Composition of the oils.

The chromatographic composition of the 'topped' oil samples is shown in table 8. A summary plot of bulk oil composition is shown in figure 5. The data for the FMT and DST 4 samples are considered to be of uncertain reliability due to a high wax content in these oils. The three DST oils have similar saturated hydrocarbon contents of around 40%. The aromatic hydrocarbon content of the DST 4 oil is half that of the other two DST oils. This composition lies about the average for the Snorre oils.

2.2.5 Whole Oil Gas Chromatograms

The whole oil gas chromatograms for the four samples are shown in figure 6. Examination of the gas chromatograms reveals a change in the character of the oils with depth. The two deepest oils, DST 2 and DST 3 have chromatograms in which the C5-C10 n-alkanes are relatively prominent. In the other two samples, DST 4 and FMT, the C10+ n-alkanes are more prominently-developed. All of the samples appear to be similar as far as the branched/cyclic peaks are concerned.

The differences in the whole oil gas chromatograms are consistent with variations in API gravity and may reflect maturity differences, the more mature oils having the higher content of low molecular weight compounds. An alternative explanation may lie in the sampling and/or storage of the samples.

2.2.6 Gas Chromatograms of the Saturated Hydrocarbons

The gas chromatograms of the three DST samples show similar n-alkane profiles (Figure 7), consisting of a smooth, unimodal decrease in peak intensity from nC15 to nC28. The gas chromatogram of the FMT sample is significantly different from the other three samples in its marked reduction of the lower molecular weight compound peaks. This variation is not thought to be representative, and may reflect sampling or experimental effects.

Excluding the data from the FMT sample, on the grounds of unreliability, the three DST samples have almost identical isoprenoid compositions which are reflected in the similar pristane/phytane ratios of between 1.3 and 1.4 (Table 10). These pristane/phytane ratios are similar to those reported from most of the other Snorre oils (Figure 8). The three DST oils have pristane/nC17 ratios of 1.0, which is slightly higher than is normally seen in the Snorre oils (average = 0.7). This may suggest a slightly lower thermal maturity-level. The carbon preference index (CPI) values of 1.0-1.1 are not wholly inconsistent with this suggestion, as this parameter often appears to be less sensitive as a maturation parameter.

2.2.7 Gas Chromatograms of the Branched/Cyclic Hydrocarbons

The three DST samples produce similar gas chromatograms for the branched/ cyclic hydrocarbons (Figure 9). The gas chromatograms show a fairly restricted range of well-developed isoprenoid peaks from iC_{16} to phytane, in addition to some unrevolsed compounds. The gas chromatogram of the FMT sample is dominated by a large 'hump' of unresolved compounds with only a few, poorly-developed isoprenoid compounds.

2.2.6 Gas chromatograms of the Aromatic Hydrocarbons

The gas chromatograms for the aromatic hydrocarbons are shown in figure 10. The three DST samples have similar gas chromatograms, with quite prominent alkyl naphthalene peaks and less prominent phenanthrene and alkyl phenanthrene peaks. All of the gas chromatograms show a marked 'hump' of unresolved, high molecular weight compounds. The gas chromatogram for the FMT sample is dominated by a prominent 'hump' of unresolved compounds with no recogniseable compound peaks.

The distribution of compounds in the three DST samples is typical of relatively mature crude oils. The 'hump' of unresolved compounds would, however, suggest a lower thermal maturity. This is consistent with the maturity suggested by the saturated hydrocarbon parameters. Calculated methyl-phenanthrene indices (MPI) of between 0.57 and 0.65 (Table 11) are also consistent with other maturity parameters discussed previously.

2.2.8 Combined Gas Chromatography-Mass Spectrometry

The m/z 191 and m/z 217 mass fragmentograms are shown in figures 11 and 12, respectively. The calculated ratios are given in tables 12 and 13.

The m/z 191 and 217 mass fragmentograms of the four oil samples are all similar in appearance. This is well-illustrated by the triangular plot showing the internal distribution of the 5α 20R regular steranes. The four samples plot close to each other and are similar to the majority of the other Snorre oils.

The similarity in the calculated biomarker ratios for the four oils suggests a common source and maturity for the oils. The biomarker ratios have values suggesting that thermally stable compound assemblages have been achieved. This, in turn, would suggest that the oils are more or less thermally mature, in contrast to the other maturity data so far considered. The GC-MS data suggest that the four 34/7-10 oils are intermediate in maturity relative to the 34/7-7 oils and the main body of the Snorre oils (Leith, 1987).

Generally, poor peak intensities for the aromatic biomarker compounds (Figure 14, Table 14) limited the conclusions which could be drawn from these compounds. All four samples appear to be similar, in terms of aromatic biomarker composition, except for an absence of low molecular weight benzenes/monoaromatics in the m/z 92 and 106 fragmentograms for the FMT sample.

The aromatic biomarker data suggest that the oils are only moderately mature, which is consistent with the majority of the data from these oils.

2.2.9 Stable Carbon Isotope data for Oil Fractions

The D13C isotope ratios were calculated for the saturate, aromatic, asphaltene and NSO oil fractions (Figure 15, Table 15). The data show quite similar values for the saturate, aromatic and asphaltene fractions. The isotope values for the NSO fraction show quite a range of values from -27.6 to -30.5 o/oo, the FMT oil having the isotopically-lightest NSO fraction.

There is a slight difference between the similar, relatively straight profiles obtained from the three DST oils, and the U-shaped profile obtained from the FMT oil. The difference in the FMT oil profile may reflect a slightly different geochemical history for this oil.

3. CONCLUSIONS

Consideration of the organic geochemical data for the three DST fluid sample sets and the FMT fluids suggest that the four fluids are essentially similar in character. The oils may be classified as moderately mature, low sulphur, paraffinic or paraffinic-naphthenic oils with a common or similar source. Vertical variations in some organic geochemical parameters (e.g. %<210^{o}C fraction and %asphaltene content) may reflect rearrangements of oil components within the oil column.

The four 34/7-10 fluid samples are similar in nature to the majority of the oils currently analysed from the Snorre field. The differences in the FMT sample may partially reflect the different sampling procedure used to obtain this sample. The 34/7-10 oils appear to have a thermal maturity intermediate between that for the thermally mature 34/7-7 oils and the main body of oils from the Snorre area.

4. REFERENCES

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Previous IKU reports concerned with block 34/7 fluids:

05.1725.00/02/84: Fluid characterisation of well 34/7-1.
05.1728.00/02/85: Hydrocarbon characterisation of well 34/7-3.
22.1767.00/03/85: Hydrocarbon characterisation of well 34/7-4.
22.1771.00/03/85: Analysis of fluid and gas samples from well 34/7-5.
22.1779.00/03/85: Analysis of fluid and gas samples from well 34/7-6 (DST 2 and DST 3b).
22.1805.00/01/86: Analysis of fluid and gas samples from well 34/7-7.
22.1830.00/01/86: Organic geochemical characterisation of oil and gas samples from well 34/7-8.
22.1830.00/02/86: Organic geochemical characterisation of an FMT oil and gas sample from well 34/7-9.
22.1831.00/01/86: Organic geochemical characterisation of oil and gas samples from well 34/4-6.
22.1837.00/01/86: Ashaltene content of core extracts from 34/7-7 and 34/7-10: Data report.
22.1851.00/01/87: Oil-oil correlation study of DST oils from blocks 34/4 and 34/7.

5. ANALYTICAL PROCEDURES

Gas analyses

Natural gas (full analysis of hydrocarbons and inert gases):

Natural gas samples were analysed on an HP 5880 gas chromatograph equipped with a capillary column and an FID for hydrocarbon analysis and two packed columns and a TCD for analysis of the inert gases (N_2, O_2, CO_2):

- 50 m x 0.2 mm i.d. fused silical column, coated with 0.5 µm OV-101.
- 3 ft steel column packed with molecular sieve 13x, 80/100 mesh.
- 6 ft steel column packed with Porapack T x 4 ft steel column packed with Porapack Q, 80/100 mesh.

Temperature program: 30°C (12 min.) - 8°C/min. - 150°C (5 min.).

A standard gas sample containing methane, ethane, propane, n-butane, n-pentane and n-hexane was used for quantification.

Evaporation of the light components in fluid samples

Prior to chromatographic separation, the oil/condensate samples were heated to 210°C at atmospheric pressure until constant weight (at 210°C) was obtained.

The fraction of light components was determined as the weight difference between the original sample and the residuum left after heating.

Medium-pressure liquid chromatography (MPLC)

The oil (>210°C) sample was diluted in DCM (1:3 mg/µl) and the asphaltenes were precipitated using excess n-pentane (40:1 pentane:(DCM+oil)). The asphaltene fraction was weighed after drying at 50°C for 12 hours.

The remaining maltenes were separated into saturated, aromatic and non-hydrocarbon fractions using an MPLC system with n-hexane as eluant (Radke et al., 1980). The various fractions were concentrated using a Büchi Rotavapor, transferred to glass vials and the remaining solvent removed.

Urea adduction

An aliquot of the saturated hydrocarbon fraction (5 mg) was diluted with n-hexane (2 ml), followed by the addition of acetone (1 ml). A saturated solution of urea in methanol (1 ml) was then added dropwise. The solvent was removed in a nitrogen stream and the adduction procedure repeated twice more. The white crystals were rinsed with hexane (3x5 ml) and the combined extract was filtered through a cotton plug covered with Al_2O_3 to produce a non-adduct containing the branched and cyclic hydrocarbons. GC analyses were performed on the non-adduct using the conditions outlined in the next section.

Gas chromatographic analysis

A whole oil sample was analysed using an HP 5730A gas chromatograph fitted with a 15 m DB-5 fused silica column. 0.02 µm of sample solution was injected in split mode (split ratio = 1:10). Hydrogen was used as a carrier gas with a flow rate of 2.5 ml/min, and the temperature programme used was -50^oC (2 min) - 4^oC/min - 280^oC.

The C_2-C_8 hydrocarbon compounds were investigated by hydrogen stripping on a Carlo Erba Fractovap gas chromatograph fitted with a 60 m x 0.32 mm (i.d.) fused silica column coated with DB-1, 1.0 µm. The temperature programme used was 50^oC (2 min) - 4^oC/min - 210^oC. An internal standard was used for quantification.

The saturated and the branched/cyclic hydrocarbon fractions were each diluted with n-hexane and analysed on an HP 5730A or an HP 5710 GC. Both GCs are equipped with 15 m DB-1 fused silica columns, and hydrogen is used as carrier gas with a flow rate of about 1.5 ml/min. Injections were performed in split mode (split ratio 1:10). The temperature programme used was 80^oC (2 min) - 4^oC/min - 280^oC.

The total aromatic fractions were diluted with n-hexane and analysed on an HP 5730A gas chromatograph, fitted with a DB-5 fused silica column (15 x 0.25 mm i.d.), using a hydrogen carrier gas with a flow rate of 2.5 ml/min. The injection split ratio was 1:10.

The temperature programme used was 80°C (2 min.) - 4°C/min - 280°C. Data processing for all the GC analyses was performed on a VG Multichrom lab data system.

Gas chromatography - mass spectrometry (GC-MS)

GC-MS analysis were performed on a VG Micromass 70-70H GC-MS-DS system. The Varian Series 3700 GC was fitted with a fused silica OV-1 capillary column (30m x 0.3 mm i.d.). Helium (1.5 ml/min) was used as carrier gas and the injections were performed in split mode (1.5 µl, split ratio 1:15).

The GC oven was programmed from 120°C (2 min.) to 280°C at 4°C/min. for analysis of the saturated hydrocarbons, and from 70°C/min. to 280°C at 4°C/min. for analysis of the aromatic hydrocarbons.

The saturated hydrocarbons were analysed in multiple ion mode (MID) at a scan cycle time of approximately 2 secs. Full data collection was applied for the aromatic hydrocarbons at a scan time of 1 sec./decade.

The mass spectrometers operated at 70eV electron energy with an ion source temperature of 200°C. Data acquisition was performed using VG data systems.

Peaks were identified by comparison with elution patterns in certain mass chromatograms. Peak ratios were calculated from peak heights in the appropriate mass chromatograms.

$\delta^{13}C$ isotope analysis

The $\delta^{13}C$ isotope analyses were performed by mass spectrometry at the Institute for Energy Technology (IFE) in Oslo according to their method. Their reference value for the standard NBS-22 is -29.8 $^{o}/oo$ (PDB).

The samples were filled in a glass capillary and transferred into a combustion system filled with copper dioxide, heated to 900°C. A stream of ultrapure helium and oxygen flushed the reaction products through silver wool (450°C) to remove traces of halogens and sulphur.

H_2O and CO_2 were trapped in separate cooltraps. After removal of the carrier gas by high vacuum, CO_2 and H_2O were sealed off separately in 6 mm glass tubes. H_2O was reduced to H_2 by zinc at 460°C.

The $^{13}C/^{12}C$ - isotope ratio (and D/H- isotope ratio) was measured with a high precision mass spectrometer Finnigan MAT 251.

Precision of the preparation lines and the mass spectrometer was daily controlled by measurements of standard substances and by double analyses.

The isotope ratios are given as delta-values (del):

$$del\ (\permil) = ((R\ sample - R\ stand.)\ /\ (R\ stand.)) * 1000$$

13C/12C- isotope ratios are calculated versus PDB.
D/H-isotope ratios are calculated versus SMOW.

The CV value is calculated after SOFER (1984) to differentiate between marine and terrestrial-sourced oils:

$$CV = (-2.53 * del^{13}C_{sat}) + (2.22 * del^{13}C_{aro}) - 11.65.$$

Table 1a:

RECOMBINATION OF OIL AND GAS(C1-C8 HYDROCARBONS)

C1-C8 YIELD
WELL 34/7-10
IKU No.,GAS: C-5576
IKU No.,OIL: C-5575, FMT
GOR : 89.7 Sm3/m3

COMPOUNDS	GAS MG/ML	GAS MG/89.7ML	OIL MG/ML	TOTAL HC IN MG/ML OF RESERVOIR FLUID
Methane	0.232	20.810	0.000	20.810
Ethane	0.136	12.199	0.000	12.199
Propane	0.227	20.362	0.000	20.362
i-Butane	0.039	3.498	0.000	3.498
n-Butane	0.128	11.482	0.000	11.482
i-Pentane	0.035	3.140	4.809	7.949
n-Pentane	0.040	3.588	8.528	12.116
Cyclo-C5+				
2,3-diMeC4	0.005	0.449	1.787	2.236
2-MeC5	0.010	0.897	4.984	5.881
3-MeC5	0.006	0.538	3.310	3.848
n-Hexane	0.012	1.076	9.625	10.701
MeCyC5	0.007	0.628	6.724	7.352
Benzene	0.001	0.090	1.492	1.582
Cyclo-C6	0.005	0.449	6.073	6.522
2-MeC6	0.002	0.179	2.894	3.073
2,3-diMeC5	0.001	0.090	1.203	1.293
3-MeC6	0.002	0.179	4.597	4.776
diMeCyC5	0.003	0.269	7.193	7.462
n-Heptane	0.003	0.269	9.393	9.462
MeCyC6	0.003	0.269	12.481	12.750
EtCyC5+				
2,5-diMeC6	0.000	0.000	1.916	1.916
2,4-diMeC6	0.000	0.000	1.250	1.250
triMeCyC5	0.000	0.000	1.281	1.281
Toluene	0.000	0.000	5.820	5.820
2+4MeC7	0.000	0.000	4.917	4.917
3-MeC7	0.000	0.000	2.462	2.462
diMeCyC6	0.000	0.000	5.803	5.803
n-Octane	0.000	0.000	8.760	8.760
2,4-diMeC7+				
diMeCyC6	0.000	0.000	1.755	1.755
EtCyC6	0.000	0.000	3.062	3.062
EtBenzene	0.000	0.000	1.695	1.695
m+p-Xylen	0.000	0.000	3.602	3.602
2+4MeC8	0.000	0.000	2.046	2.046
o-Xylene	0.000	0.000	1.548	1.548
SUM	0.897	80.461	131.010	211.471

Table 1a:

RECOMBINATION OF OIL AND GAS(C1-C8 HYDROCARBONS)

C1-C8 YIELD
WELL 34/7-10
IKU No.,GAS: C-5794
IKU No.,OIL: C-5793, DST4
GOR : 91.2 Sm3/m3

COMPOUNDS	GAS MG/ML	GAS MG/91.2ML	OIL MG/ML	TOTAL HC IN MG/ML OF RESERVOIR FLUID
Methane	1.035	94.392	0.000	94.392
Ethane	0.356	32.467	0.000	32.467
Propane	0.440	40.128	1.536	41.664
i-Butane	0.067	6.110	1.354	7.464
n-Butane	0.213	19.426	6.822	26.248
i-Pentane	0.054	4.925	6.859	11.784
n-Pentane	0.060	5.472	11.955	17.427
Cyclo-C5+				
2,3-diMeC4	0.007	0.638	2.442	3.080
2-MeC5	0.014	1.277	6.750	8.027
3-MeC5	0.008	0.730	5.008	5.738
n-Hexane	0.016	1.459	13.651	15.110
MeCyC5	0.009	0.821	9.993	10.814
Benzene	0.001	0.091	2.516	2.607
Cyclo-C6	0.005	0.456	9.023	9.479
2-MeC6	0.002	0.182	4.234	4.416
2,3-diMeC5	0.001	0.091	2.061	2.152
3-MeC6	0.002	0.182	6.904	7.086
diMeCyC5	0.004	0.365	11.438	11.803
n-Heptane	0.003	0.274	13.478	13.752
MeCyC6	0.004	0.365	17.351	17.716
EtCyC5+				
2,5-diMeC6	0.000	0.000	2.487	2.487
2,4-diMeC6	0.000	0.000	1.637	1.637
triMeCyC5	0.000	0.000	1.728	1.728
Toluene	0.000	0.000	6.323	6.323
2+4MeC7	0.000	0.000	6.846	6.846
3-MeC7	0.000	0.000	3.414	3.414
diMeCyC6	0.000	0.000	7.302	7.302
n-Octane	0.000	0.000	12.605	12.605
2,4-diMeC7+				
diMeCyC6	0.000	0.000	2.637	2.637
EtCyC6	0.000	0.000	4.611	4.611
EtBenzene	0.000	0.000	2.938	2.938
m+p-Xylen	0.000	0.000	5.841	5.841
2+4MeC8	0.000	0.000	3.637	3.637
o-Xylene	0.000	0.000	2.681	2.681
SUM	2.301	209.851	198.062	407.913

Table 1a:

RECOMBINATION OF OIL AND GAS(C1-C8 HYDROCARBONS)

C1-C8 YIELD
WELL 34/7-10
IKU No.,GAS: C-6004
IKU No.,OIL: C-6006, DST2
GOR : 75.1 Sm3/m3

COMPOUNDS	GAS MG/ML	GAS MG/75.1ML	OIL MG/ML	TOTAL HC IN MG/ML OF RESERVOIR FLUID
Methane	0.531	39.878	0.000	39.878
Ethane	0.323	24.257	0.000	24.257
Propane	0.534	40.103	0.000	40.103
i-Butane	0.092	6.909	0.000	6.909
n-Butane	0.283	21.253	0.000	21.253
i-Pentane	0.073	5.482	0.312	5.794
n-Pentane	0.076	5.708	7.190	12.898
Cyclo-C5+				
2,3-diMeC4	0.007	0.526	2.588	3.114
2-MeC5	0.016	1.202	6.946	8.148
3-MeC5	0.008	0.601	4.197	4.798
n-Hexane	0.016	1.202	13.135	14.337
MeCyC5	0.008	0.601	8.972	9.573
Benzene	0.001	0.075	1.772	1.847
Cyclo-C6	0.003	0.225	7.577	7.802
2-MeC6	0.001	0.075	3.687	3.762
2,3-diMeC5	0.001	0.075	1.469	1.544
3-MeC6	0.002	0.150	5.707	5.857
diMeCyC5	0.003	0.225	9.048	9.273
n-Heptane	0.002	0.150	12.220	12.370
MeCyC6	0.002	0.150	15.487	15.637
EtCyC5+				
2,5-diMeC6	0.000	0.000	2.488	2.488
2,4-diMeC6	0.000	0.000	1.512	1.512
triMeCyC5	0.000	0.000	1.535	1.535
Toluene	0.000	0.000	6.070	6.070
2+4MeC7	0.000	0.000	6.495	6.495
3-MeC7	0.000	0.000	3.208	3.208
diMeCyC6	0.000	0.000	7.894	7.894
n-Octane	0.000	0.000	11.560	11.560
2,4-diMeC7+				
diMeCyC6	0.000	0.000	2.221	2.221
EtCyC6	0.000	0.000	3.887	3.887
EtBenzene	0.000	0.000	2.363	2.363
m+p-Xylen	0.000	0.000	4.282	4.282
2+4MeC8	0.000	0.000	2.746	2.746
o-Xylene	0.000	0.000	1.810	1.810
SUM	1.982	148.847	158.378	307.225

Table 1a:

RECOMBINATION OF OIL AND GAS(C1-C8 HYDROCARBONS)

C1-C8 YIELD
WELL 34/7-10
IKU No.,GAS: C-6005
IKU No.,OIL: C-6007, DST3
GOR : 79.6 Sm3/m3

COMPOUNDS	GAS MG/ML	GAS MG/79.6ML	OIL MG/ML	TOTAL HC IN MG/ML OF RESERVOIR FLUID
Methane	2.106	167.638	0.000	167.638
Ethane	0.776	61.770	0.000	61.770
Propane	0.970	77.212	0.000	77.212
i-Butane	0.147	11.701	0.000	11.701
n-Butane	0.446	35.502	0.000	35.502
i-Pentane	0.103	8.199	6.989	15.188
n-Pentane	0.107	8.517	10.222	18.739
Cyclo-C5+				
2,3-diMeC4	0.010	0.796	2.135	2.931
2-MeC5	0.022	1.751	5.289	7.040
3-MeC5	0.011	0.876	3.563	4.439
n-Hexane	0.023	1.831	11.146	12.977
MeCyC5	0.012	0.955	7.483	8.438
Benzene	0.002	0.159	1.573	1.732
Cyclo-C6	0.006	0.478	6.463	6.941
2-MeC6	0.002	0.159	3.049	3.208
2,3-diMeC5	0.001	0.080	1.185	1.265
3-MeC6	0.002	0.159	4.789	4.948
diMeCyC5	0.004	0.318	7.574	7.892
n-Heptane	0.003	0.239	10.094	10.333
MeCyC6	0.004	0.318	13.055	13.373
EtCyC5+				
2,5-diMeC6	0.000	0.000	2.179	2.179
2,4-diMeC6	0.000	0.000	1.256	1.256
triMeCyC5	0.000	0.000	1.284	1.284
Toluene	0.000	0.000	5.134	5.134
2+4MeC7	0.000	0.000	5.442	5.442
3-MeC7	0.000	0.000	2.821	2.821
diMeCyC6	0.000	0.000	6.584	6.584
n-Octane	0.000	0.000	9.527	9.527
2,4-diMeC7				
diMeCyC6	0.000	0.000	1.770	1.770
EtCyC6	0.000	0.000	3.215	3.215
EtBenzene	0.000	0.000	1.892	1.892
m+p-Xylen	0.000	0.000	3.560	3.560
2+4MeC8	0.000	0.000	2.337	2.337
o-Xylene	0.000	0.000	1.495	1.495
SUM	4.757	378.658	143.105	521.763

Table 1b: Ratios calculated from C1-C8 hydrocarbon data

IKU No.	Sample ID	Depth (m)	%CH4	%Wetness	iC4/nC4	P.I.-1
C-5576/5575	FMT	2532.5	25.9	69.6	0.30	1.04
C-5794/5793	DST 4	2549-51.5	45.0	50.8	0.31	0.97
C-6005/6007	DST 3	2561-70.5	44.3	52.2	0.33	1.03
C-6004/6006	DST 2	2609.5-15	26.8	69.6	0.33	1.04

RATIOS:

%Wetness == (EC2-C5/EC1-C5)x100

P.I.-1 (after Thompson,1978) == 2-MeC6+3-MeC6/diMeCyC5(3 isomers)

IKU SINTEF-GRUPPEN

Table 2:

C_2-C_8 hydrocarbon composition of the oils.

C 5575
Well 34/7-10 FMT

	area	ug	mg/ml	% of t.oil
isoC3				
nC3	0	.000	.000	.000
iso-C4	0	.000	.000	.000
nC4	0	.000	.000	.000
iso-C5	191705	1.442	4.809	.573
nC5	339990	2.558	8.528	1.016
CyC5+2,3diMeC4	71264	.536	1.787	.213
2MeC5	198683	1.495	4.984	.594
3MeC5	131955	.993	3.310	.394
nC6	383699	2.887	9.625	1.147
MeCyC5	268065	2.017	6.724	.801
benzene	59502	.447	1.492	.177
CyC6	242112	1.822	6.073	.724
2MeC6	115365	.868	2.894	.345
2,3diMeC5	47975	.361	1.203	.143
3MeC6	183281	1.379	4.597	.548
DiMeCyC5	286742	2.157	7.193	.857
nC7	374446	2.817	9.393	1.119
MeCyC6	497574	3.744	12.481	1.488
EtCyC5+2,5diMeC6	76387	.574	1.916	.228
2,4diMeC6	49834	.375	1.250	.149
triMeCyC5	51078	.384	1.281	.152
toluene	232016	1.746	5.820	.693
2+4MeC7	196019	1.475	4.917	.586
3MeC7	98151	.738	2.462	.293
DiMeCyC6	231338	1.740	5.803	.691
nC8	349223	2.628	8.760	1.044
2,4diMeC7+diMeCyC6	69995	.526	1.755	.209
EtCyC6	122081	.918	3.062	.365
EtBenzene	67571	.508	1.695	.202
m,p-Xylene	143596	1.080	3.602	.429
2+4MeC8	81585	.613	2.046	.244
o-xylene	61724	.464	1.548	.184
sum		39.306	131.021	15.621

total oil (ug inj.): 251.610

%C2-C8(tot.area)in tot.oil: 17.770%

IKU SINTEF-GRUPPEN

Table 2:

C_2-C_8 hydrocarbon composition of the oils.

C 5793

Well 34/7-10 DST4	area	ug	mg/ml	% of t.oil
iso-C3				
nC3	56188	.461	1.536	.183
iso-C4	49531	.406	1.354	.161
nC4	249444	2.046	6.822	.812
iso-C5	250790	2.057	6.859	.817
nC5	437074	3.586	11.955	1.424
CyC5+2,3diMeC4	89283	.732	2.442	.290
2MeC5	246792	2.025	6.750	.804
3MeC5	183122	1.502	5.008	.596
nC6	499084	4.095	13.651	1.626
MeCyC5	365359	2.998	9.993	1.190
benzene	92019	.755	2.516	.299
CyC6	329885	2.706	9.023	1.074
2MeC6	154799	1.270	4.234	.504
2,3diMeC5	75376	.618	2.061	.245
3MeC6	252409	2.071	6.904	.822
DiMeCyC5	418194	3.431	11.438	1.362
nC7	492775	4.043	13.478	1.605
MeCyC6	634347	5.205	17.351	2.067
EtCyC5+2,5diMeC6	90955	.746	2.487	.296
'2,4diMeC6	59882	.491	1.637	.195
triMeCyC5	63203	.518	1.728	.205
toluene	231172	1.896	6.323	.753
2+4MeC7	250318	2.054	6.846	.815
3MeC7	124824	1.024	3.414	.406
DiMeCyC6	266988	2.190	7.302	.870
nC8	460861	3.781	12.605	1.501
2,4diMeC7+diMeCyC6	96428	.791	2.637	.314
EtCyC6	168609	1.383	4.611	.549
EtBenzene	107446	.881	2.938	.350
m,p-Xylene	213564	1.752	5.841	.695
2+4MeC8	132972	1.091	3.637	.433
o-xylene	98050	.804	2.681	.319
sum		59.424	198.081	23.597

total oil (ug inj.): 251.820

%C2-C8(tot.area)in tot.oil: 27.697%

IKU SINTEF-GRUPPEN

Table 2:

C_2-C_8 hydrocarbon composition of the oils.

C 6007
Well 34/7-10 DST3

	area	ug	mg/ml	% of t.oil
isoC3				
nC3	0	.000	.000	.000
iso-C4	0	.000	.000	.000
nC4	0	.000	.000	.000
iso-C5	255677	2.096	6.989	.835
nC5	373920	3.066	10.222	1.221
CyC5+2,3diMeC4	78108	.640	2.135	.255
2MeC5	193498	1.586	5.289	.632
3MeC5	130343	1.069	3.563	.425
nC6	407704	3.343	11.146	1.331
MeCyC5	273736	2.245	7.483	.894
benzene	57545	.471	1.573	.188
CyC6	236423	1.939	6.463	.772
2MeC6	111556	.914	3.049	.364
2,3diMeC5	43366	.355	1.185	.141
3MeC6	175207	1.436	4.789	.572
DiMeCyC5	277069	2.272	7.574	.905
nC7	369254	3.028	10.094	1.206
MeCyC6	477548	3.916	13.055	1.560
EtCyC5+2,5diMeC6	79716	.653	2.179	.260
'2,4diMeC6	45956	.376	1.256	.150
triMeCyC5	46979	.385	1.284	.153
toluene	187809	1.540	5.134	.613
2+4MeC7	199085	1.632	5.442	.650
3MeC7	103211	.846	2.821	.337
DiMeCyC6	240860	1.975	6.584	.786
nC8	348502	2.858	9.527	1.138
2,4diMeC7+diMeCyC6	64751	.531	1.770	.211
EtCyC6	117615	.964	3.215	.384
EtBenzene	69223	.567	1.890	.226
m,p-Xylene	130236	1.068	3.560	.425
2+4MeC8	85519	.701	2.337	.279
o-xylene	54710	.448	1.495	.178
sum		42.936	143.121	17.103

total oil (ug inj.): 251.040

%C2-C8(tot.area)in tot.oil: 19.551%

Table 2:

IKU SINTEF-GRUPPEN

C_2-C_8 hydrocarbon composition of the oils.

C 6006

Well 34/7-10 DST2	area	ug	mg/ml	% of t.oil
isoC3				
nC3	0	.000	.000	.000
iso-C4	0	.000	.000	.000
nC4	0	.000	.000	.000
iso-C5	9523	.093	.312	.037
nC5	218818	2.157	7.190	.860
CyC5+2,3diMeC4	78769	.776	2.588	.309
2MeC5	211405	2.084	6.946	.831
3MeC5	127754	1.259	4.197	.502
nC6	399741	3.940	13.135	1.571
MeCyC5	273069	2.691	8.972	1.073
benzene	53931	.531	1.772	.212
CyC6	230610	2.273	7.577	.906
2MeC6	112220	1.106	3.687	.441
2,3diMeC5	44718	.440	1.469	.175
3MeC6	173698	1.712	5.707	.682
DiMeCyC5	275362	2.714	9.048	1.082
nC7	371912	3.666	12.220	1.461
MeCyC6	471314	4.646	15.487	1.852
EtCyC5+2,5diMeC6	75723	.746	2.488	.297
'2,4diMeC6	46032	.453	1.512	.180
triMeCyC5	46739	.460	1.535	.183
toluene	184731	1.821	6.070	.726
2+4MeC7	197688	1.948	6.495	.777
3MeC7	97657	.962	3.208	.383
DiMeCyC6	240247	2.368	7.894	.944
nC8	351824	3.468	11.560	1.383
2,4diMeC7+diMeCyC6	67605	.666	2.221	.265
EtCyC6	118309	1.166	3.887	.465
EtBenzene	71934	.709	2.363	.282
m,p-Xylene	130337	1.284	4.282	.512
2+4MeC8	83579	.823	2.746	.328
o-xylene	55090	.543	1.810	.216
sum		47.518	158.394	18.948

total oil (ug inj.): 250.770

%C2-C8(tot.area)in tot.oil: 22.143%

Table 3: Stable isotope data for C_1-C_4 gas components.

IKU no.	DST no.	Depth (m)	C_1 $\delta^{13}C$	C_1 δD	C_2 $\delta^{13}C$	C_3 $\delta^{13}C$	iC_4 $\delta^{13}C$	nC_4 $\delta^{13}C$
C-5794	4	2549-2551.5	-51.2	-210	-36.4	-33.4	-31.9	-33.0
C-6005	3	2561-2570.5	-51.5	-200	-36.0	-33.2	-33.7	-32.7
C-6004	2	2609.5-2615	-51.3	-208	-36.8	-33.8	-33.3	-33.1

Project No.: 22.1840
Date : 8-4-87

Table 4:

API GRAVITY OF OIL SAMPLE

IKU-No	CODE	API GRAVITY (DENSITY) Crude oil	API GRAVITY (DENSITY) >210'C
C-5575	FMT	37.1 (0.8387)	18.2 (0.9442)
C-5793	DST 4	36.9 (0.8395)	25.7 (0.8995)
C-6007	DST 3	37.4 (0.8368)	29.0 (0.8810)
C-6006	DST 2	37.6 (0.8359)	28.1 (0.8857)

Project No.: 22.1640
Date : 26-3-87

Table 5:

CONTENT OF SULPHUR, NICKEL AND VANADIUM IN OIL >210'C

IKU-No	CODE	S %	Ni (mg/kg)	V (mg/kg)
C-5575	FMT	0.23	3.76	3.27
C-5793	DST 4	0.19	1.26	2.35
C-6007	DST 3	0.18	1.96	3.09
C-6006	DST 2	0.19	1.90	2.64

Project No: 22.1640
Date: 8-5-87

Table 6:

FRACTION BOILING BELOW 210'C

IKU No.	Sample code	Crude oil (mg)	EOM >210' (mg)	Low molecular weight compounds (mg)	Low molecular weight compounds (%)
C-5575	FMT	829.4	293.8	535.6	64.6
C-5793	DST 4	880.5	568.7	311.8	35.4
C-6007	DST 3	378.0	284.0	94.0	24.9
C-6006	DST 2	383.0	280.0	103.0	26.9

Project no.: 22.1840
DATE : 8-4-87

Table 7:

AMOUNT OF ASPHALTENES AND NSO'S IN OIL

IKU No	DST No	Topped Crude Oil (mg)	Asphaltenes (mg)	Asphaltenes (%)	NSO (mg)	NSO (%)
C-5575	FMT	293.8	47.8	16.3	18.8	6.4
C-5793	4	563.7	9.4	1.7	47.7	8.4
C-6007	3	284.0	1.9	0.7	63.3	22.3
C-6006	2	280.0	1.0	0.4	78.2	27.9

Project no.: 22.1940
Well ident.: 34/7-10

Table 8:

WEIGHT OF OIL AND CHROMATOGRAPHIC FRACTIONS

IKU-No		DEPTH (m)	Crude Oil (mg)	Topped Oil >210'C (mg)	Sat. (mg)	Aro. (mg)	HC (mg)	Non HC (mg)
**C 5575	FMT	2532.50	829.4	293.8	117.3	107.8	225.1	66.6
**C 5793	DST 4	2551.50	880.5	568.7	217.6	57.7	275.3	57.1
C 6007	DST 3	2570.50	378.0	284.0	124.9	82.0	206.9	65.2
C 6006	DST 2	2615	383.0	280.0	116.6	75.1	191.7	79.2

** Results from these oils may be influenced by the high wax content of the oils.

Project no.: 22.1340
Well ident.: 34/7-10

Table 9:

COMPOSITION OF TOPPED OIL (>210'C)

IKU-No	Sample Code	Sat / EOM* %	Aro / EOM* %	HC / EOM* %	SAT / Aro x 100	Non HC / EOM* %	HC / Non HC x 100
C 5575	FMT	39.9	36.7	76.6	108.8	22.7	338.0
C 5793	DST 4	38.3	10.1	48.4	377.1	10.0	482.1
C 6007	DST 3	44.0	28.9	72.9	152.3	23.0	317.3
C 6006	DST 2	41.6	26.8	68.5	155.3	28.3	242.0

*EOM = Topped Oil (>210'C)

Table 10:

TABULATION OF DATA FROM THE GASCHROMATOGRAMS

IKU No.	Sample code	A = PRISTANE / PHYTANE	PRISTANE / n-C17	B = PHYTANE / n-C18	A / B	n-C17 / n-C27	CPI 1	CPI 2
C 5575	FMT	0.8	0.8	0.6	1.2	0.2	1.0	1.0
C 5793	DST4	1.3	1.0	0.7	1.3	2.6	1.1	1.0
C 6007	DST3	1.4	1.0	0.7	1.3	3.5	1.1	1.1
C 6006	DST2	1.4	1.0	0.8	1.3	2.9	1.0	1.0

DATE : 8 - 4 - 87.

Table 11: Ratios calculated from Aromatic Gas Chromatograms

IKU No.	Sample ID	Depth (m)	MPI-1	MPI-2
C-5575	FMT	2532.5	nc	nc
C-5793	DST 4	2549-51.5	0.65	0.65
C-6007	DST 3	2561-70.5	0.61	0.57
C-6006	DST 2	2609.5-15	0.60	0.58

MPI-1 == 1.5(mp-2+mp-3)/p+(mp-9+mp-1)

MPI-2 == 3(mp-2)/p+(mp-9+mp-1)

Table 12: Molecular ratios from sterane and terpane mass chromatograms. Maturity ratios.

IKU no.	Sample code	αβ/αβ+βα 1)	%22S 2)	%20S 3)	%ββ 4)
C-5575	FMT	0.94	60.6	78.4	43.2
C-5793	DST4	0.94	61.2	78.1	41.7
C-6007	DST3	0.94	64.0	77.5	40.0
C-6006	DST2	0.93	65.3	79.1	43.8

1) E/E+F in m/z 191
2) Average % distribution between first and second eluting isomers of extended hopanes (G-M in m/z 191)
3) 2(r+s)/(q+t+2(r+s)) in m/z 217
4) q/q+t in m/z 217

Table 13: Molecular ratios from terpane and sterane mass chromatograms. Maturity and source characteristic ratios.

IKU no.	Sample code	Q/E 1)	Tm/Ts 2)	X/E 3)	Z/E 4)	a/a+j 5)
C-5575	FMT	0.06	0.73	0.05	0.31	0.78
C-5793	DST4	0.06	0.57	0.06	0.32	0.74
C-6007	DST3	0.09	0.73	0.06	0.31	0.75
C-6006	DST2	0.07	0.74	0.06	0.37	0.77

1) Relative abundance of tricyclic terpanes (Q/E in m/z 191)
2) B/A in m/z 191
3) Relative abundance of unknown (X/E in m/z 191)
4) Relative abundance of bisnorhopane (Z/E in m/z 191)
5) Relative abundance of C_{27} rearranged steranes (a/a+j in m/z 217)

Table 14: Molecular ratios from the aromatic mass fragmentograms.

IKU no.	Sample id.	Depth (m)	$\%C_{20}/C_{26,\ 27}$ 1)	$\%C_{21}/C_{28,\ 29}$ 2)
C-5575	FMT	2532.5	52.0	44.4
C-5793	DST4	2551.5	23.8	13.4
C-6007	DST3	2570.5	35.0	45.7
C-6006	DST 2	2615	19.0	40.4

1) Relative abundance of low molecular weight triaromatic steranes (m/m+p in m/z 231).

2) Relative abundance of low molecular weight monoaromatic steranes (a/a+h in m/z 253).

Table 15: Stable carbon isotope data for the crude oil fractions.

IKU no.	DST no.	Depth (m)	SAT $\delta^{13}C$	ARO $\delta^{13}C$	ASP $\delta^{13}C$	NSO $\delta^{13}C$
C-5575	FMT	2532.5	-30.3	-30.0	-30.0	-30.5
C-5793	4	2549-2551.5	-30.7	-29.4	-29.5	-28.7
C-6007	3	2561-2570.5	-30.6	-29.9	-29.0	-29.3
C-6006	2	2609.5-2615	-30.7	-30.0	-29.0	-29.2

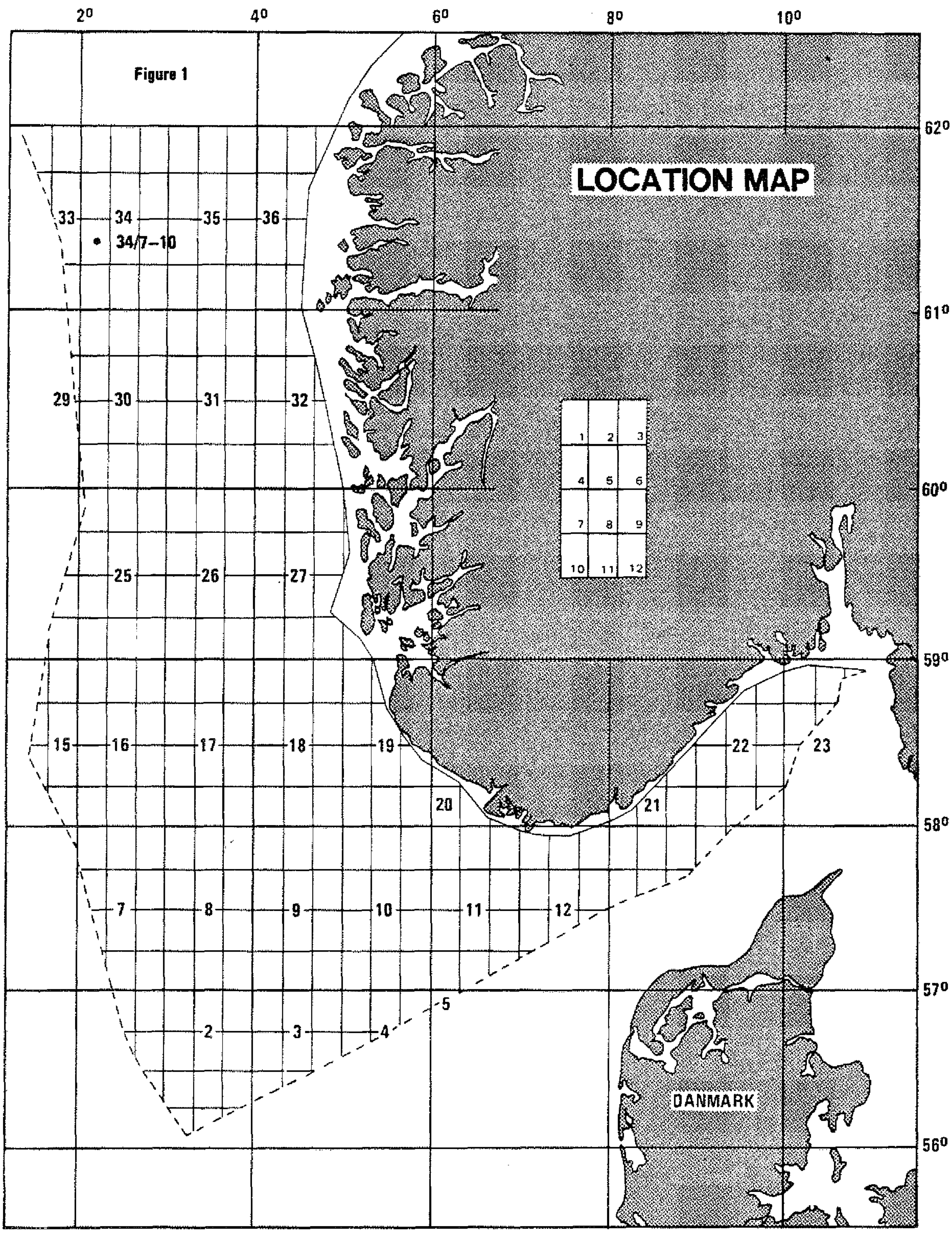
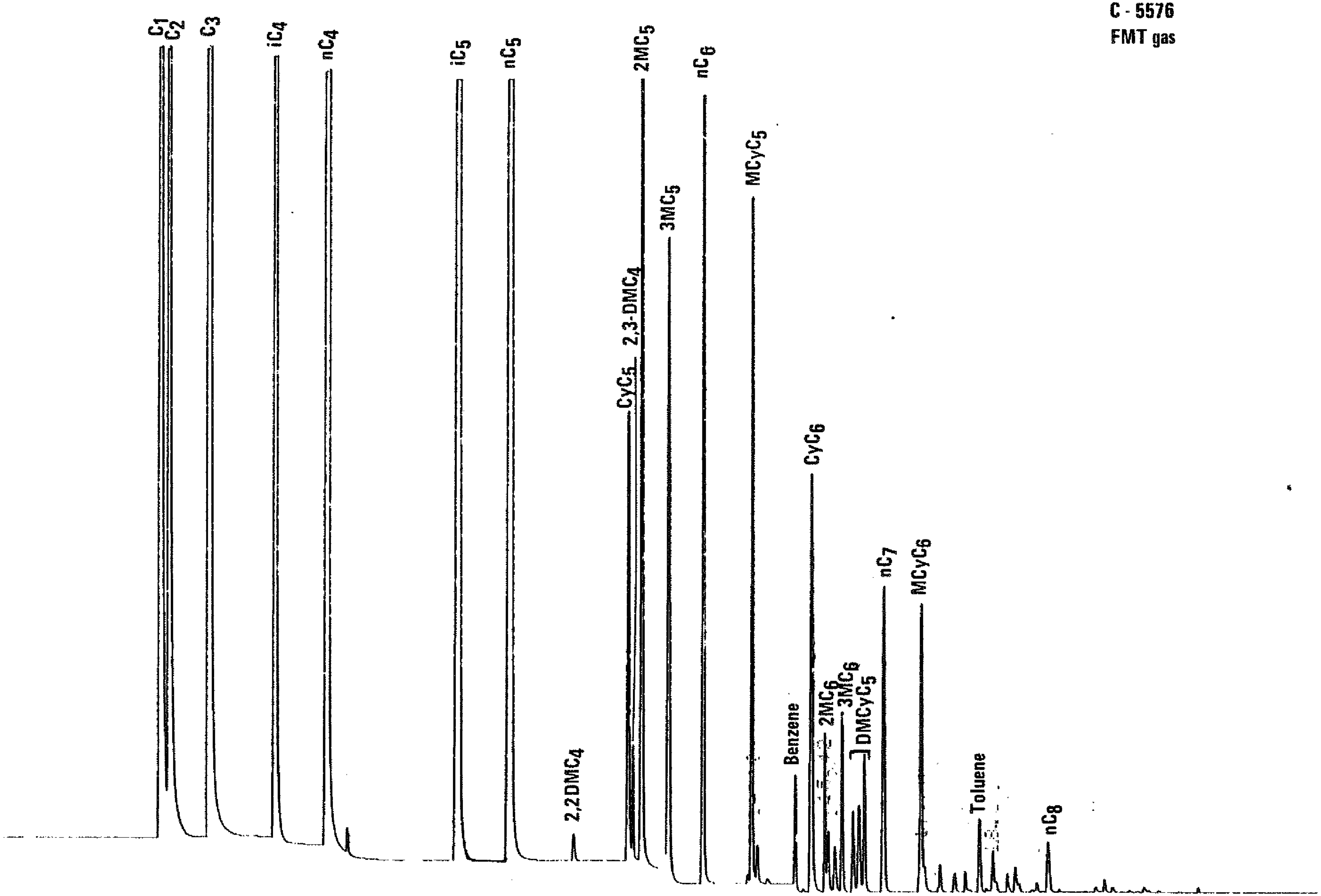


Figure 1
LOCATION MAP
34/7-10
2°
4°
6°
8°
10°
62°
61°
60°
59°
58°
57°
56°
33
34
35
36
29
30
31
32
25
26
27
15
16
17
18
19
20
21
22
23
7
8
9
10
11
12
2
3
4
5
1 2 3
4 5 6
7 8 9
10 11 12
DANMARK

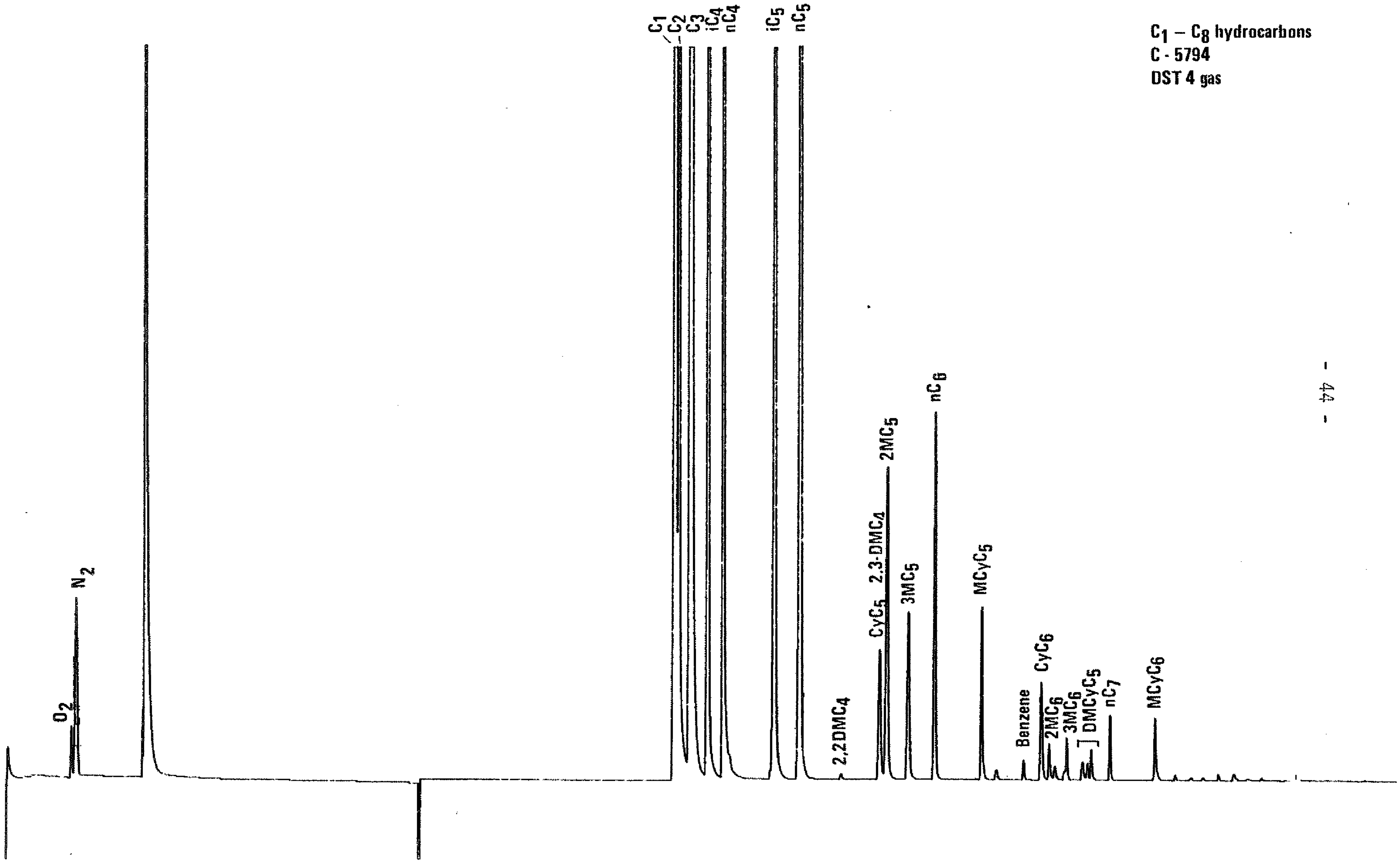
Figure 2:

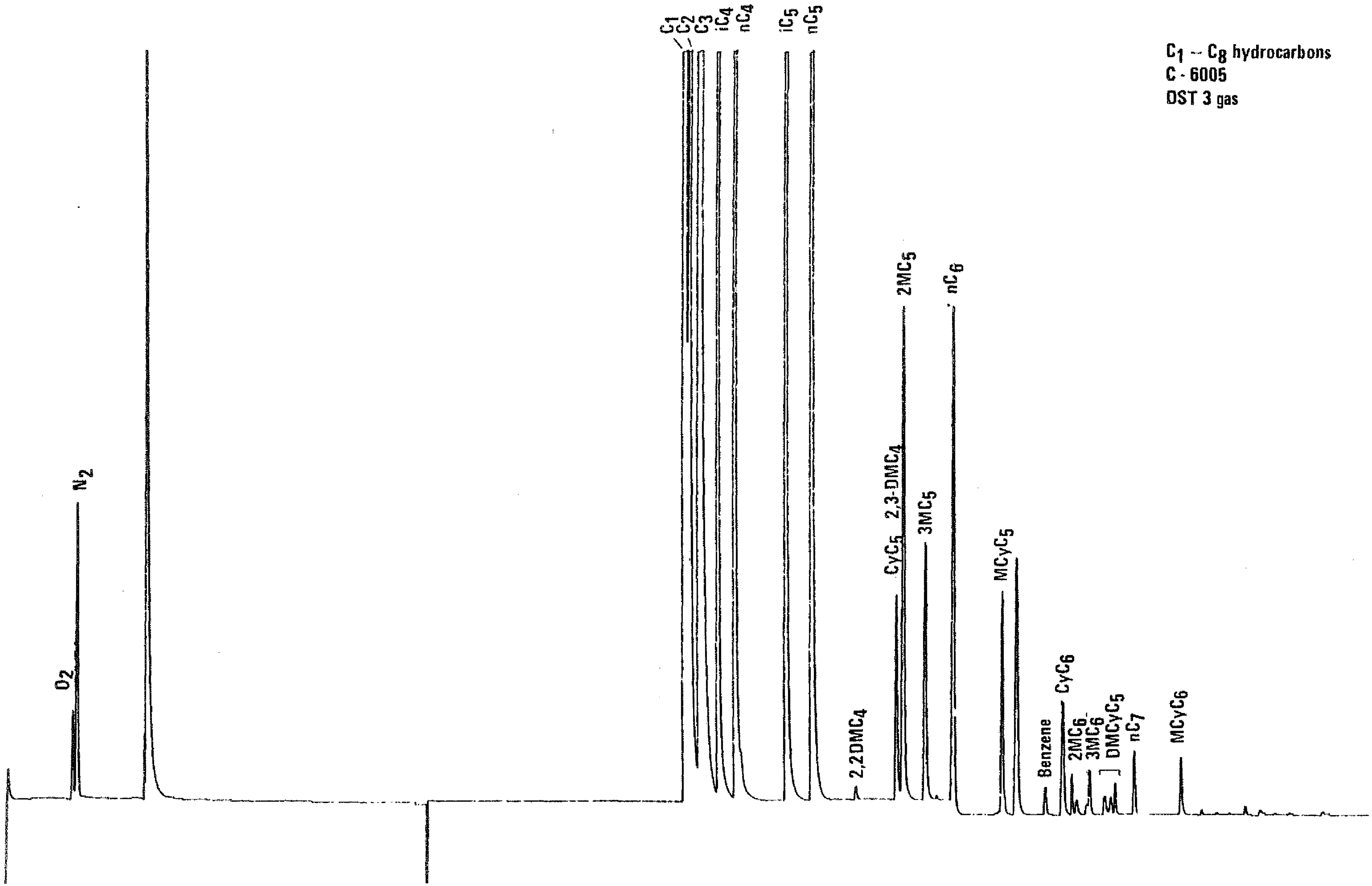
Gas chromatograms of C_1-C_8 hydrocarbons from the gas samples

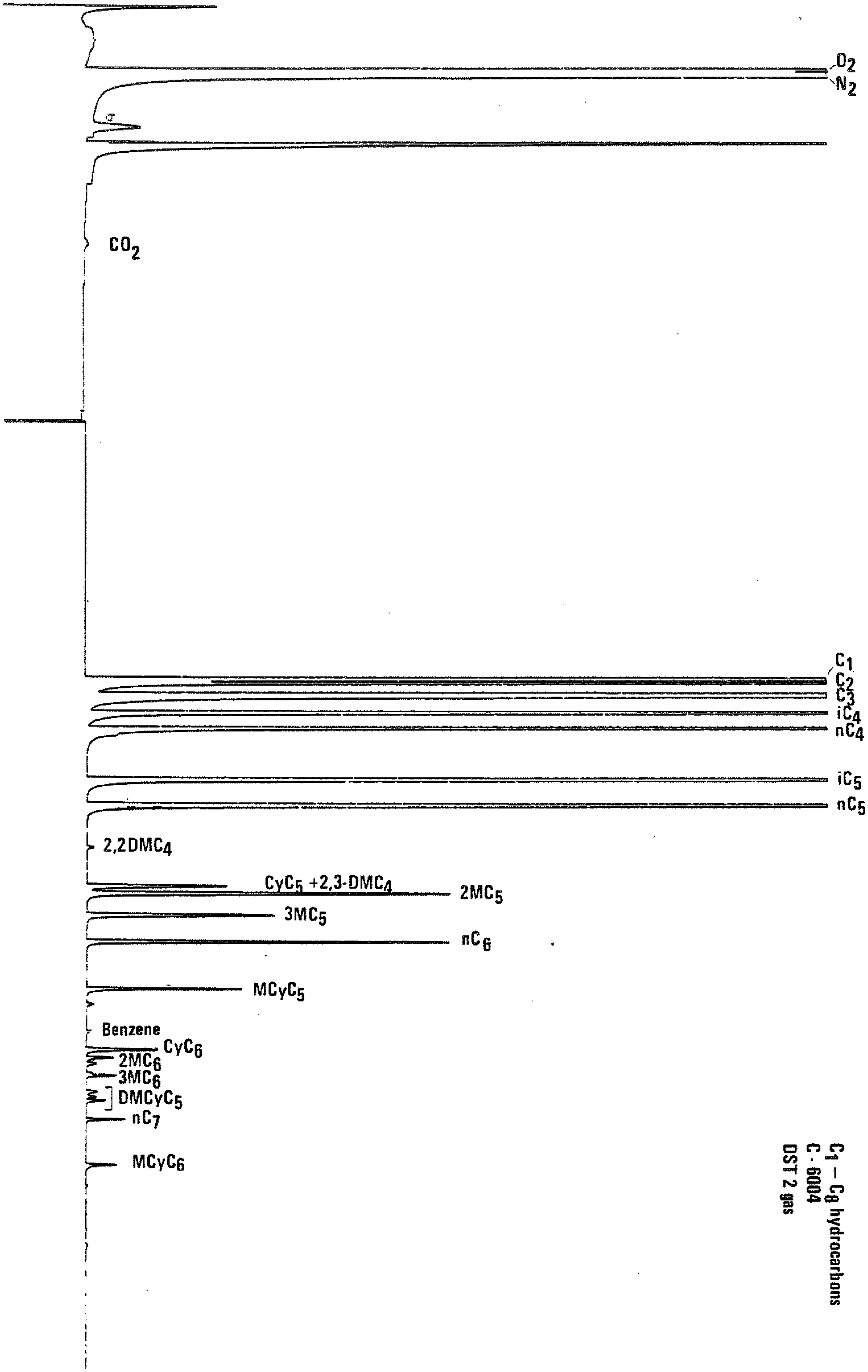
C_1 – C_8 hydrocarbons
C - 5576
FMT gas



$C_1 - C_8$ hydrocarbons
C - 5794
DST 4 gas



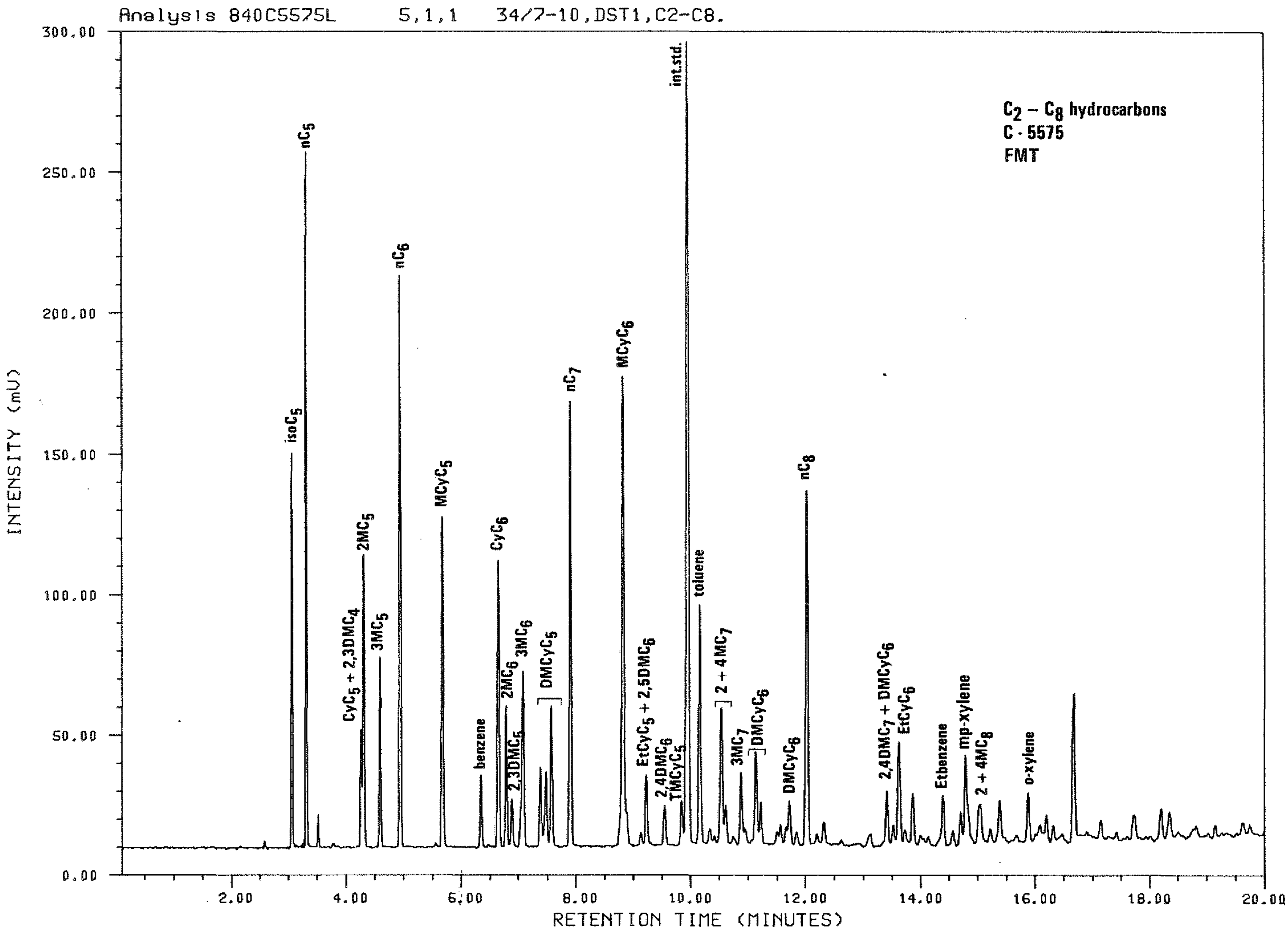

C1 -- C8 hydrocarbons
C - 6005
DST 3 gas
O2
N2
C1
C2
C3
iC4
nC4
iC5
nC5
2,2DMC4
CyC5
2,3-DMC4
2MC5
3MC5
nC6
MCyC5
Benzene
CyC6
2MC6
3MC6
DMCyC5
nC7
MCyC6

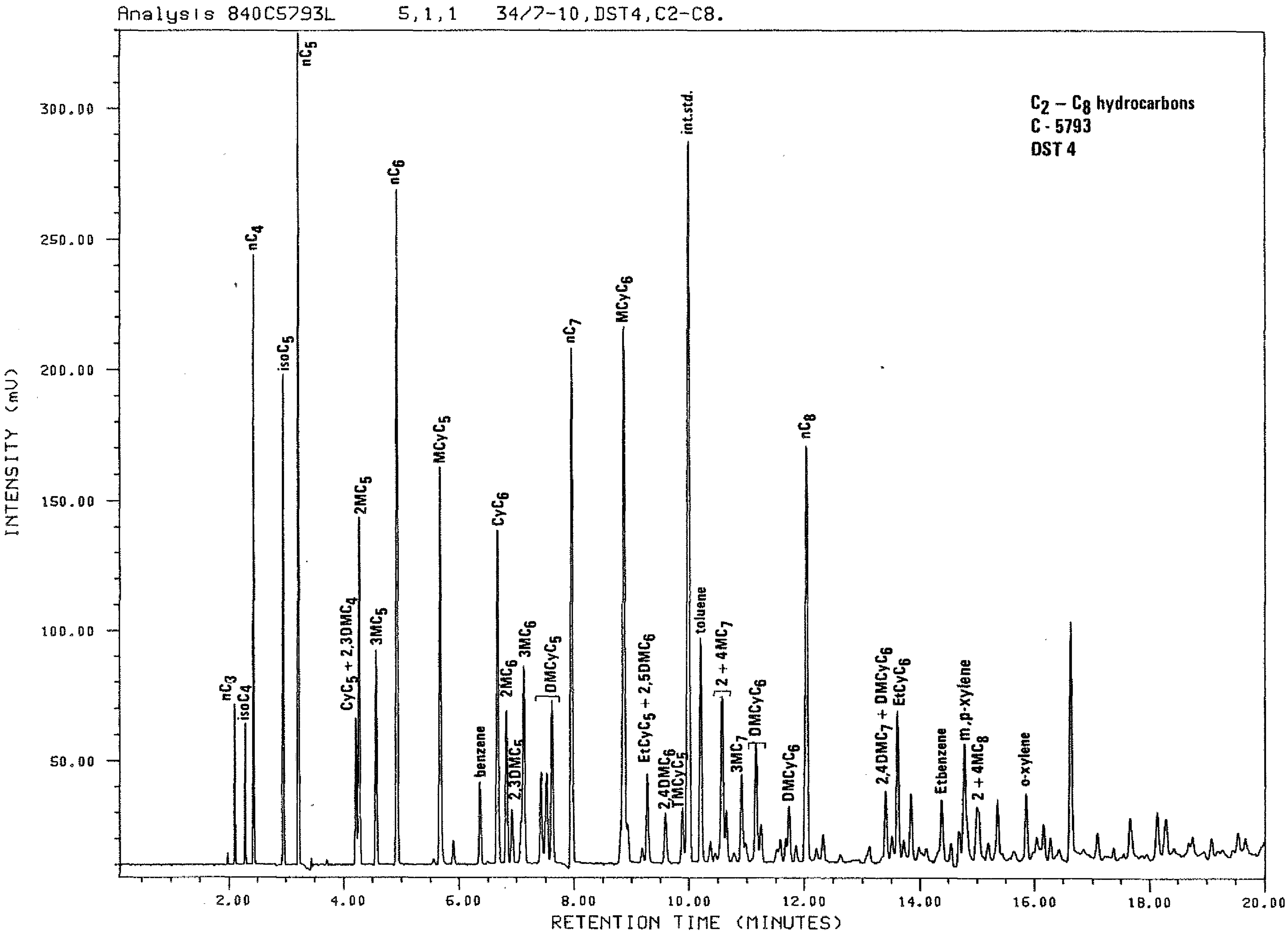


O2
N2
CO2
C1
C2
C3
iC4
nC4
iC5
nC5
2,2DMC4
CyC5 +2,3-DMC4
2MC5
3MC5
nC6
MCyC5
Benzene
CyC6
2MC6
3MC6
DMCyC5
nC7
MCyC6
C1 — C8 hydrocarbons
C-6004
DST 2 gas

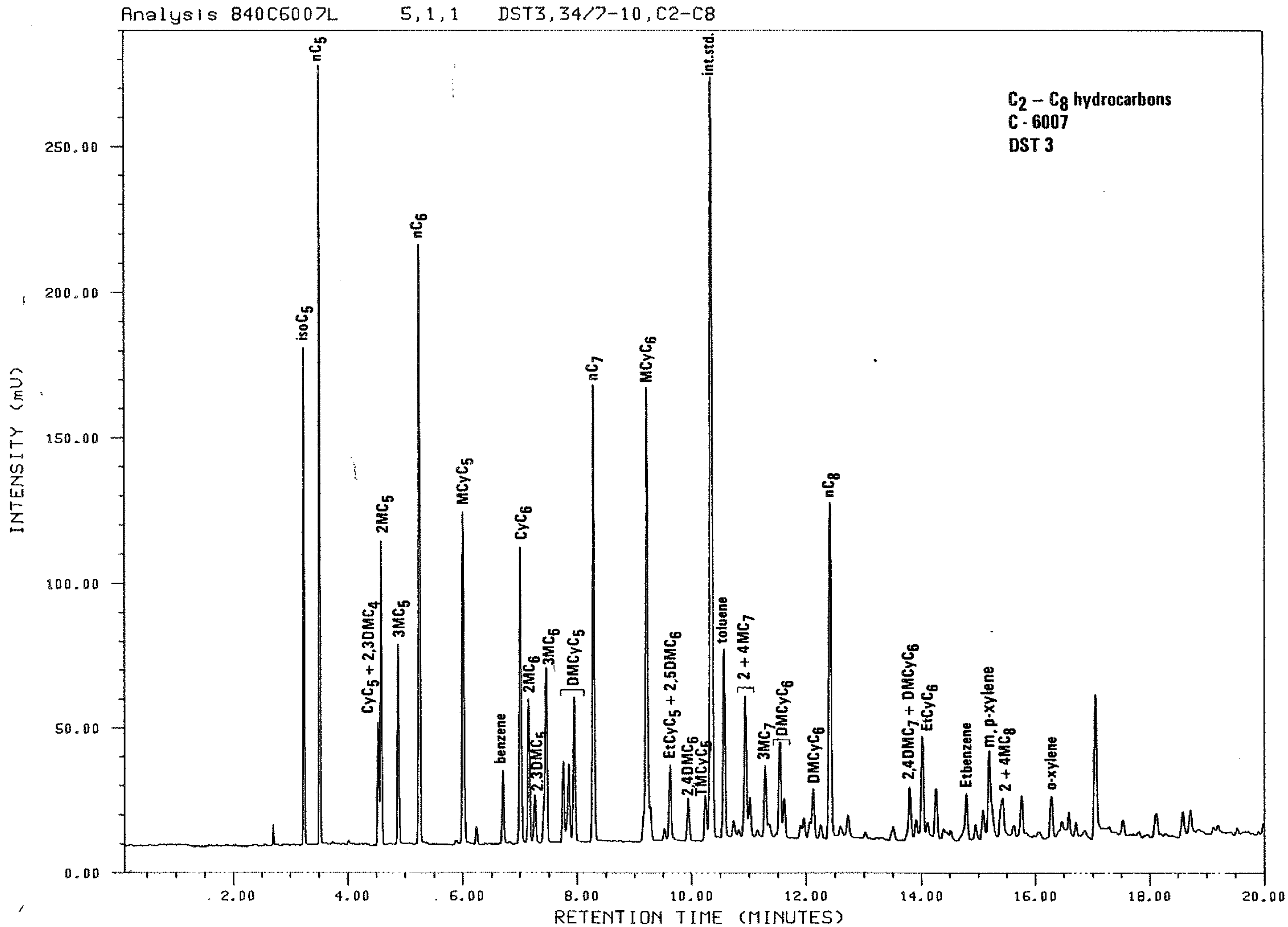
Figure 3:

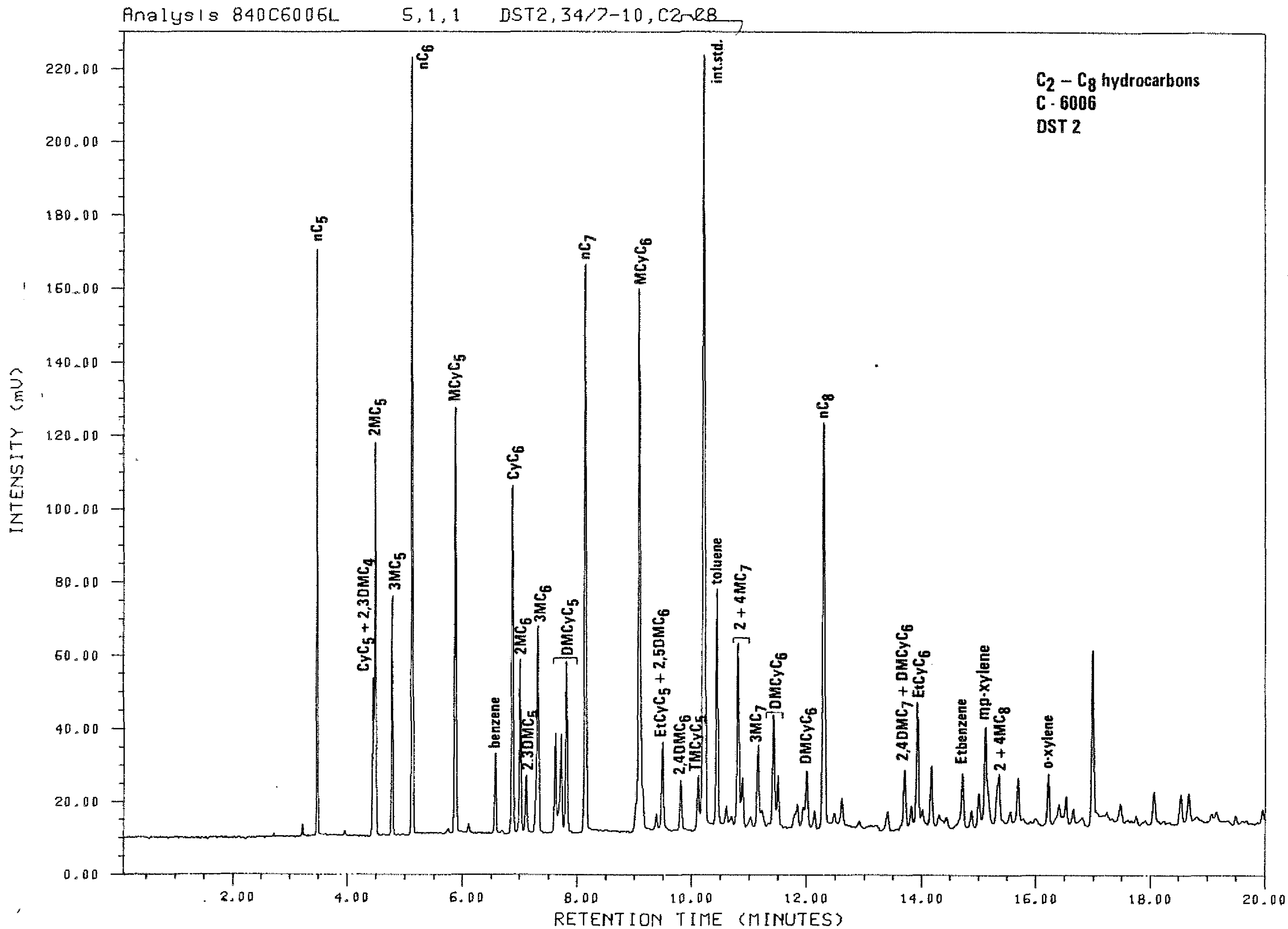
Gas chromatograms of $C_{2-}C_8$ hydrocarbons from the oil samples


Analysis 840C5575L 5,1,1 34/7-10,DST1,C2-C8.
$C_2 - C_8$ hydrocarbons
C - 5575
FMT
INTENSITY (mU)
RETENTION TIME (MINUTES)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
$isoC_5$
nC_5
$CyC_5 + 2,3DMC_4$
$2MC_5$
$3MC_5$
nC_6
$MCyC_5$
benzene
CyC_6
$2MC_6$
$2,3DMC_5$
$3MC_6$
$DMCyC_5$
nC_7
$MCyC_6$
$EtCyC_5 + 2,5DMC_6$
$2,4DMC_6$
$TMCyC_5$
int.std.
toluene
$2 + 4MC_7$
$3MC_7$
$DMCyC_6$
$DMCyC_6$
nC_8
$2,4DMC_7 + DMCyC_6$
$EtCyC_6$
Etbenzene
mp-xylene
$2 + 4MC_8$
o-xylene



Analysis 840C5793L 5,1,1 34/7-10,DST4,C2-C8.
C2 – C8 hydrocarbons
C - 5793
DST 4
INTENSITY (mV)
RETENTION TIME (MINUTES)
300.00
250.00
200.00
150.00
100.00
50.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
nC3
isoC4
nC4
isoC5
nC5
CyC5 + 2,3DMC4
2MC5
3MC5
nC6
MCyC5
benzene
CyC6
2MC6
2,3DMC5
3MC6
DMCyC5
nC7
MCyC6
EtCyC5 + 2,5DMC6
2,4DMC6
TMCyC5
int.std.
toluene
2 + 4MC7
3MC7
DMCyC6
DMCyC6
nC8
2,4DMC7 + DMCyC6
EtCyC6
Etbenzene
m,p-xylene
2 + 4MC8
o-xylene


Analysis 840C6007L 5,1,1 DST3,34/7-10,C2-C8
C2 – C8 hydrocarbons
C - 6007
DST 3
INTENSITY (mV)
RETENTION TIME (MINUTES)
0.00
50.00
100.00
150.00
200.00
250.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
isoC5
nC5
CyC5 + 2,3DMC4
2MC5
3MC5
nC6
MCyC5
benzene
CyC6
2MC6
2,3DMC5
3MC6
DMCyC5
nC7
MCyC6
EtCyC5 + 2,5DMC6
2,4DMC6
TMCyC5
int.std.
toluene
2 + 4MC7
3MC7
DMCyC6
DMCyC6
nC8
2,4DMC7 + DMCyC6
EtCyC6
Etbenzene
m, p-xylene
2 + 4MC8
o-xylene



Analysis 840C6006L 5,1,1 DST2,34/7-10,C2-C8
C2 – C8 hydrocarbons
C - 6006
DST 2
INTENSITY (mV)
RETENTION TIME (MINUTES)
nC5
CyC5 + 2,3DMC4
2MC5
3MC5
nC6
MCyC5
benzene
CyC6
2MC6
2,3DMC5
3MC6
DMCyC5
nC7
MCyC6
EtCyC5 + 2,5DMC6
2,4DMC6
TMCyC5
int.std.
toluene
2 + 4MC7
3MC7
DMCyC6
DMCyC6
nC8
2,4DMC7 + DMCyC6
EtCyC6
Etbenzene
mp-xylene
2 + 4MC8
o-xylene

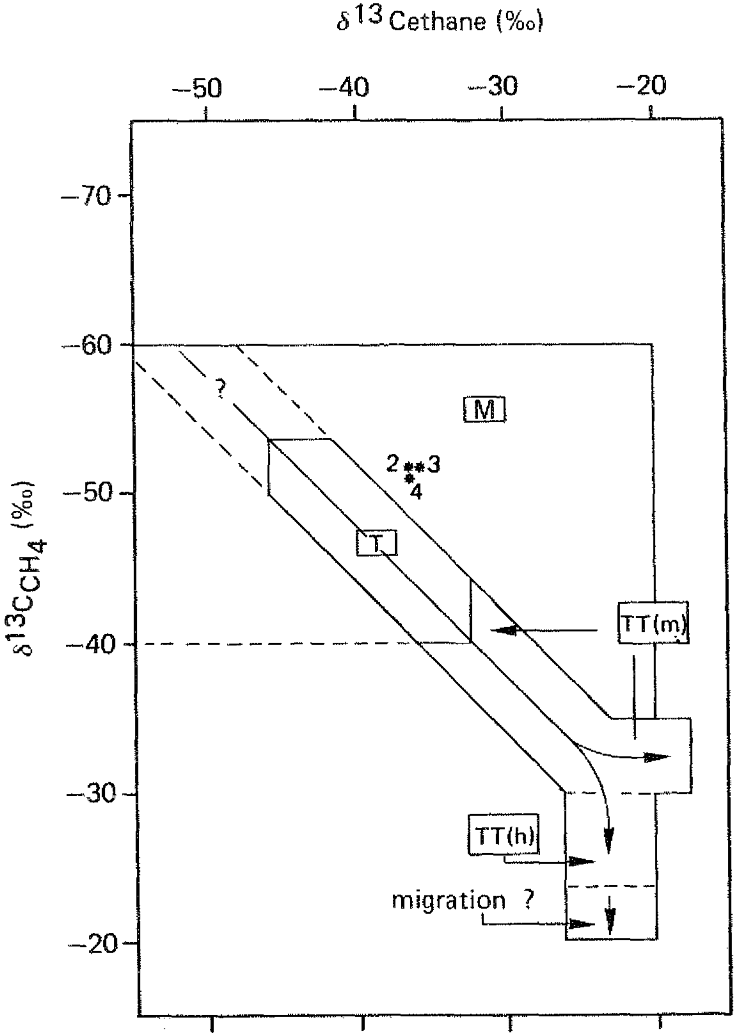


Figure 4a

The three DST gas samples have $\delta^{13}C$ isotope values which plot close to the zone of gases associated with oil/condensate, but lie just inside the zone normally associated with mixed catagenic/biogenic gases (After Schoell, 1983).

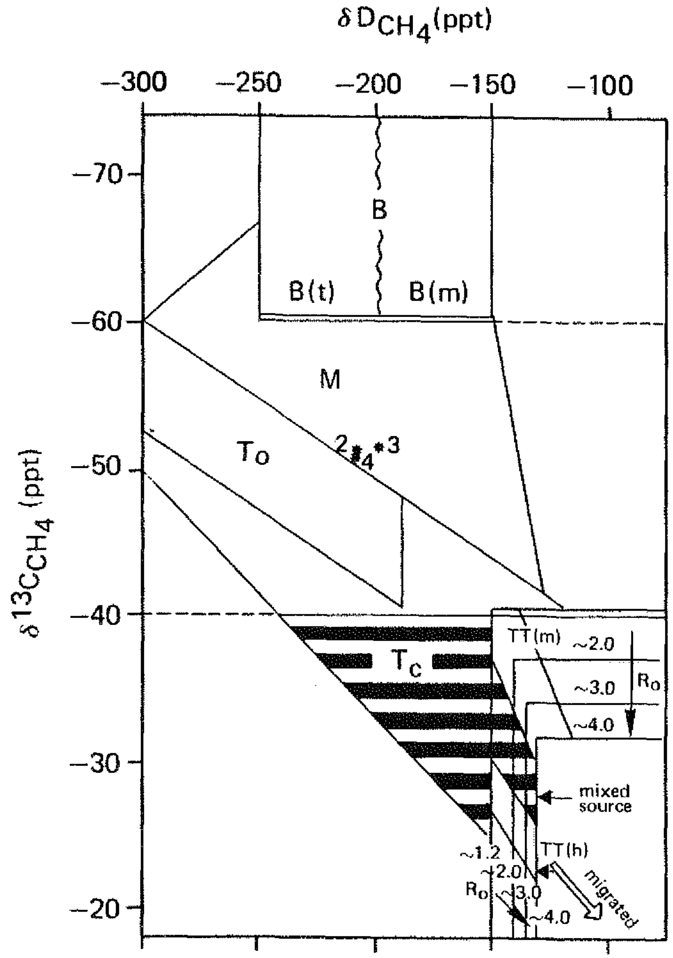
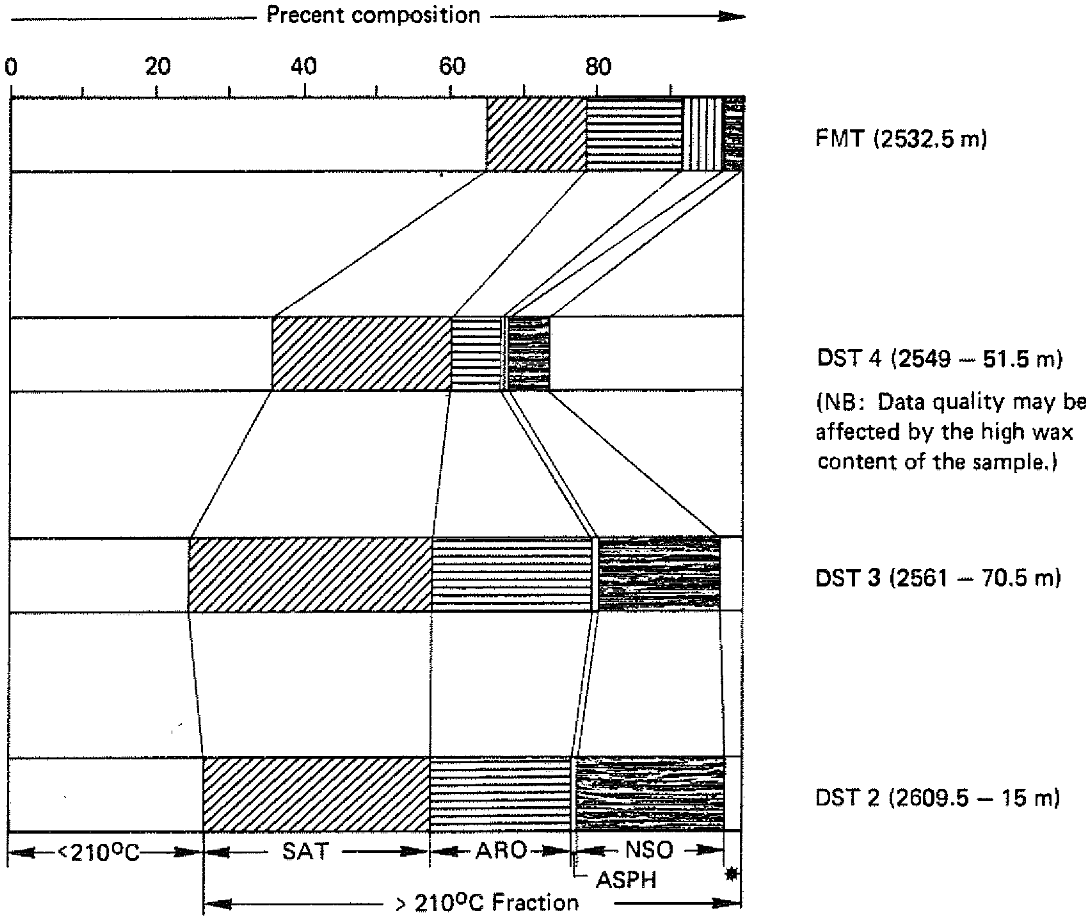


Figure 4b

All three DST gases plot close to each other in the zone of mixed biogenic/catagenic gas close to the boundary of the field associated with oil-associated gases. (After Schoell, 1983).



* Loss = amount of material lost during analytical pocedure.

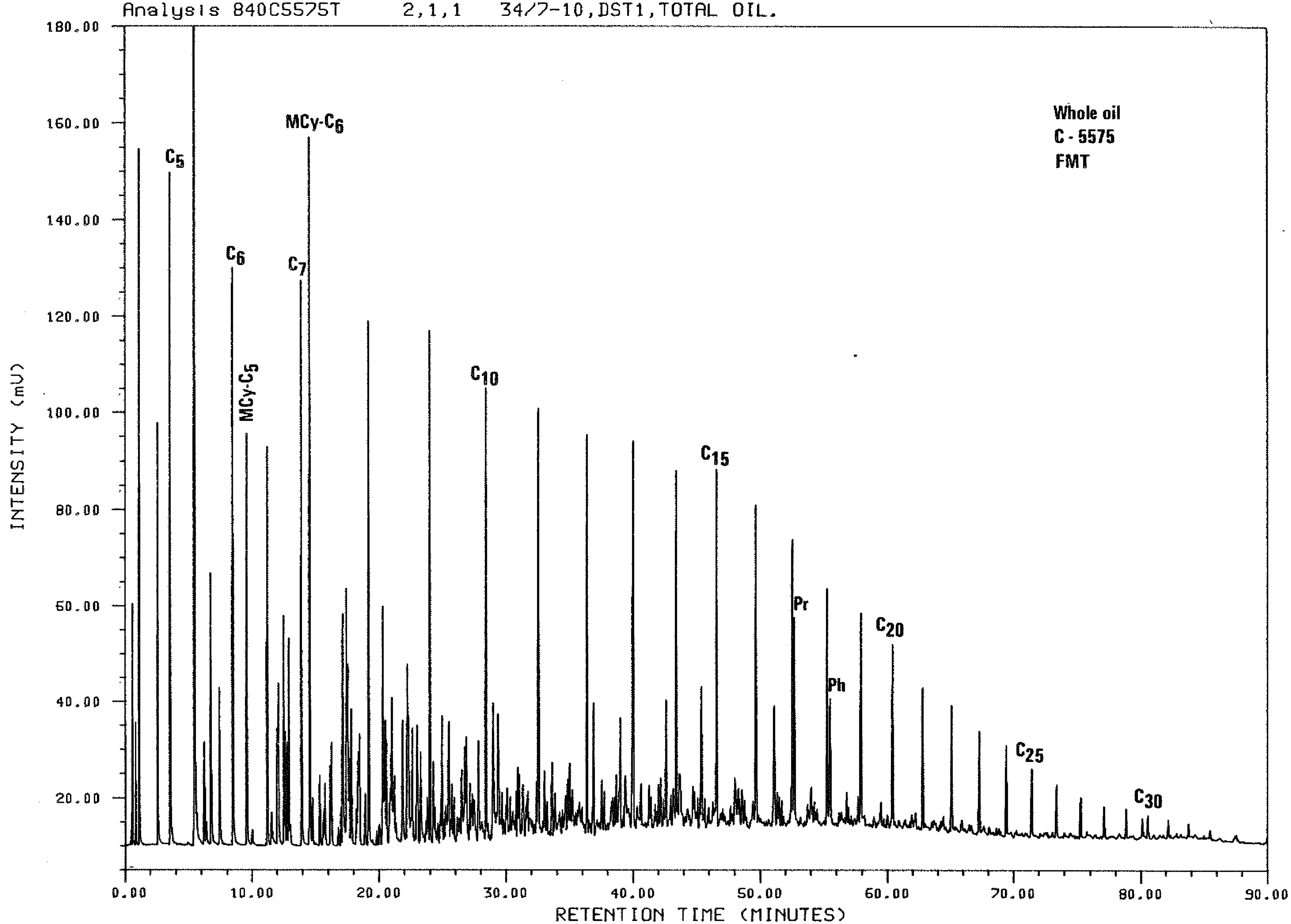
Summary diagram of bulk oil composition.

Figure 5: Summary diagram of bulk oil composition.

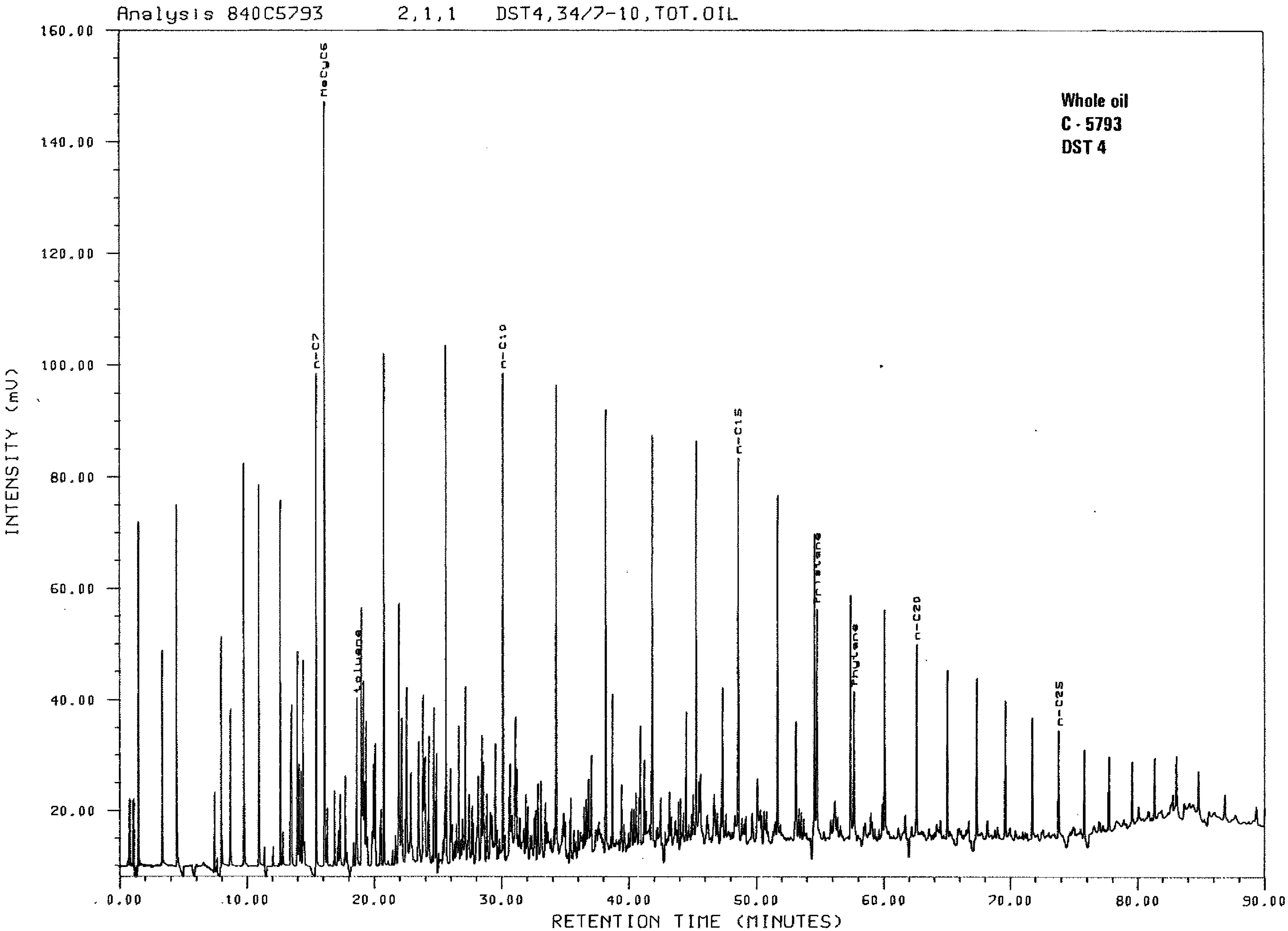
Figure 6:

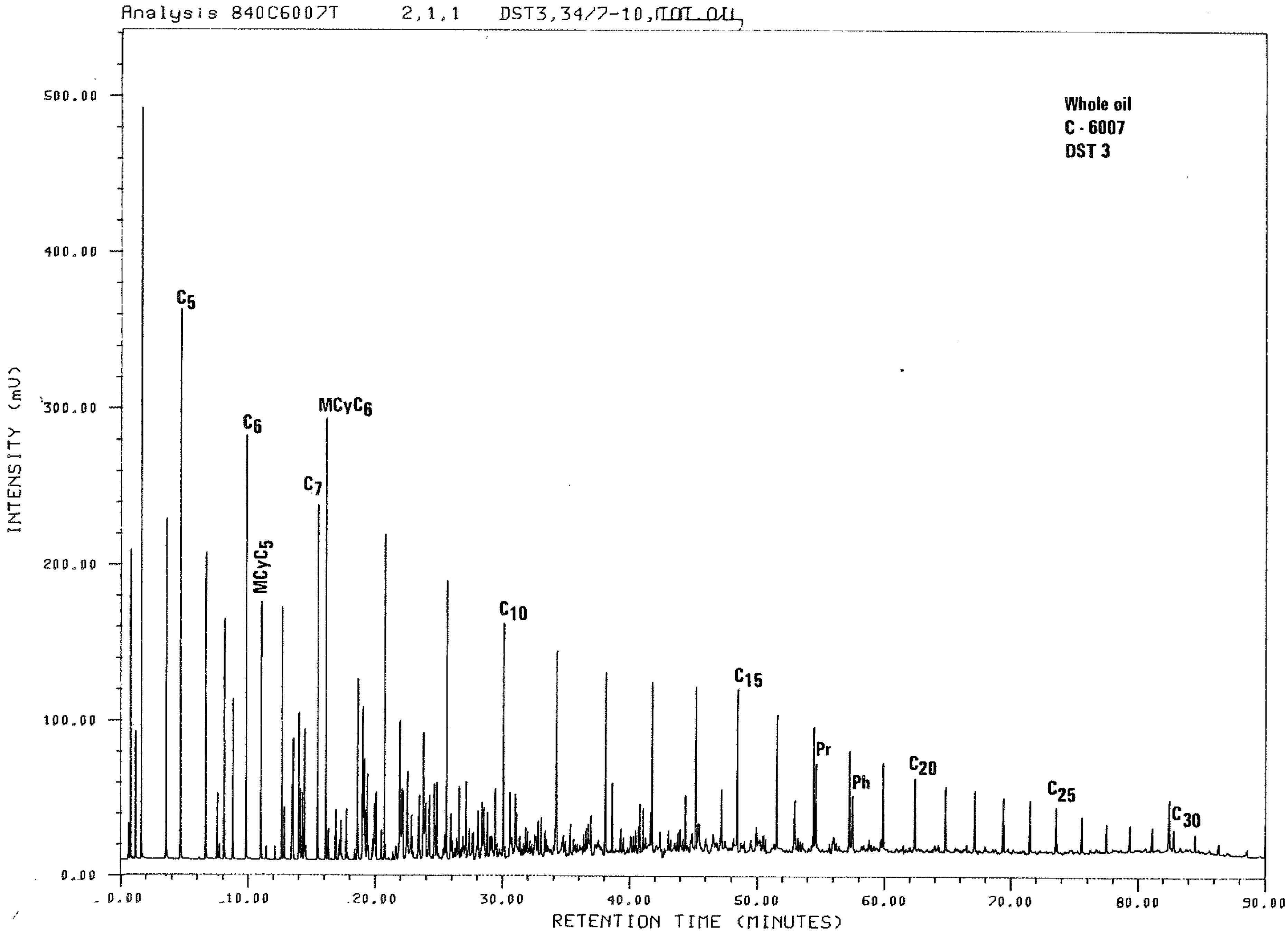
Gas chromatograms of whole oil

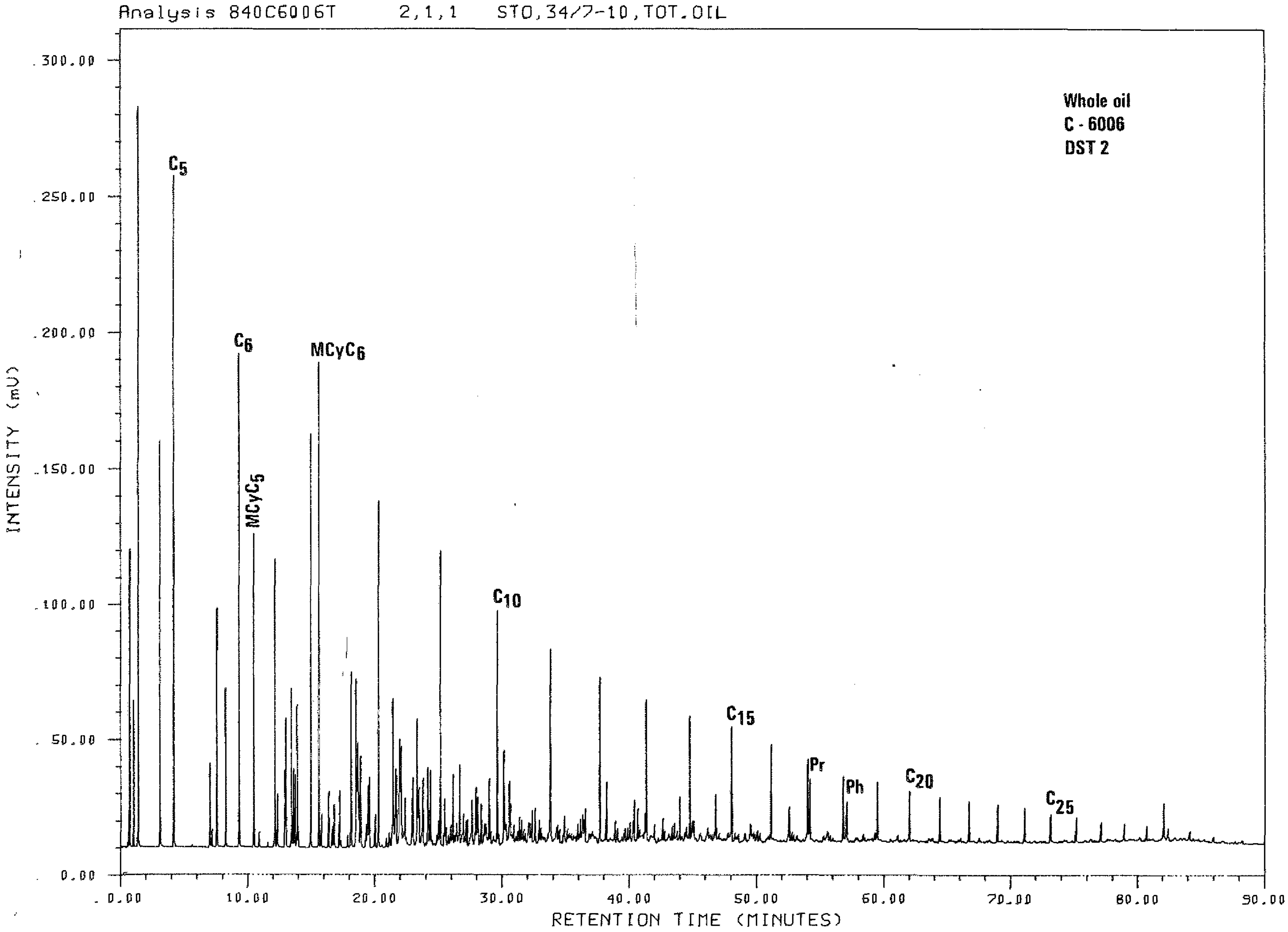
C_{10},etc.	:	n-alkanes
CyC_6	:	cyclohexane
$MeCyC_6$	:	methylcyclohexane
Pr	:	pristane
Ph	:	phytane



Analysis 840C5575T 2,1,1 34/7-10,DST1,TOTAL OIL.
Whole oil
C - 5575
FMT
C5
C6
MCy-C5
C7
MCy-C6
C10
C15
Pr
Ph
C20
C25
C30
INTENSITY (mU)
RETENTION TIME (MINUTES)


Analysis 840C5793 2,1,1 DST4,34/7-10,TOT.OIL
Whole oil
C - 5793
DST 4
INTENSITY (mV)
RETENTION TIME (MINUTES)
MeCyC6
n-C7
toluene
n-C10
n-C15
Pristane
Phytane
n-C20
n-C25


Analysis 840C6007T 2,1,1 DST3,34/7-10,TOT OIL
Whole oil
C - 6007
DST 3
INTENSITY (mV)
500.00
400.00
300.00
200.00
100.00
0.00
C5
C6
MCyC5
C7
MCyC6
C10
C15
Pr
Ph
C20
C25
C30
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
RETENTION TIME (MINUTES)

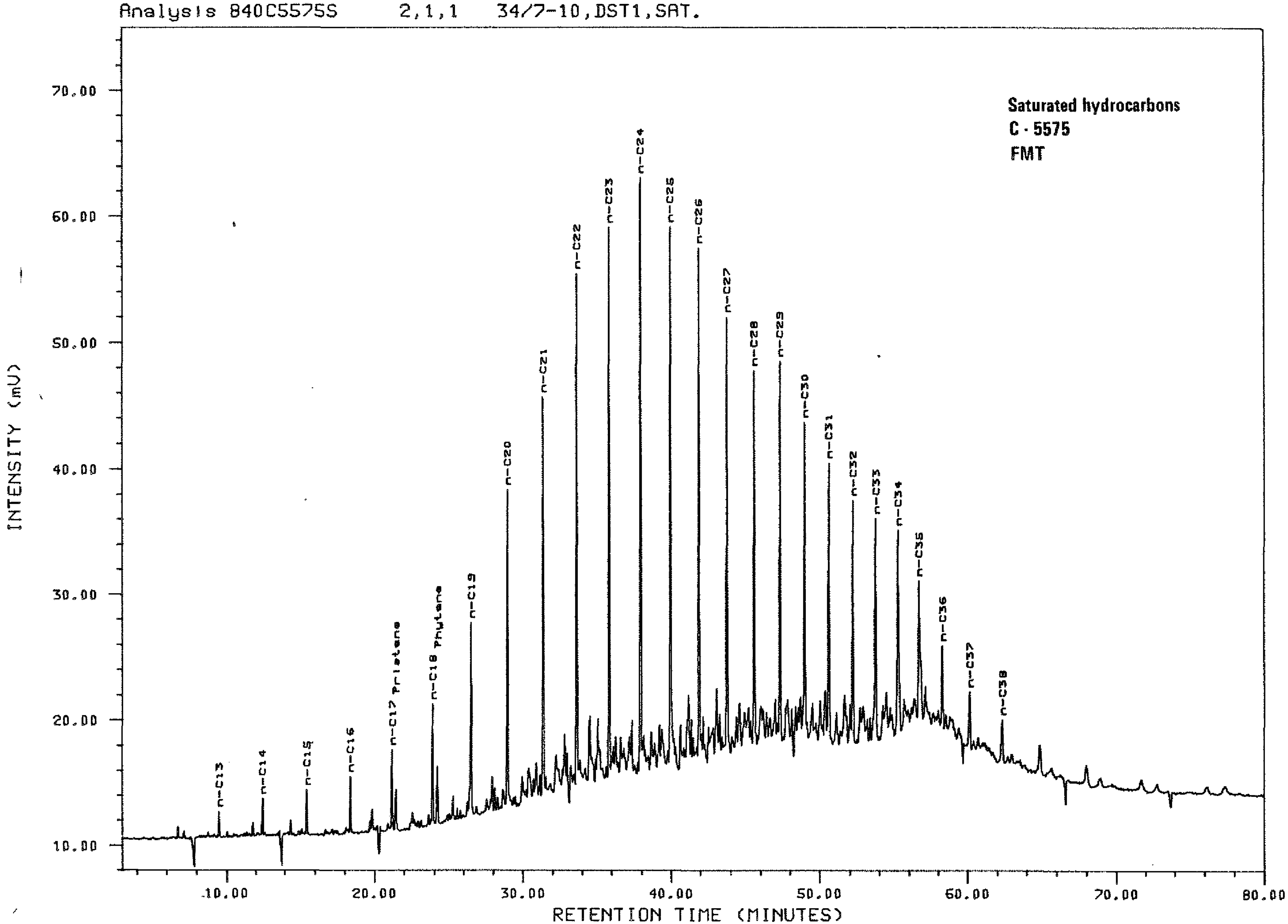


Analysis 840C6006T 2,1,1 STO,34/7-10,TOT.OIL
Whole oil
C - 6006
DST 2
INTENSITY (mV)
RETENTION TIME (MINUTES)
C5
C6
MCyC6
MCyC5
C10
C15
Pr
Ph
C20
C25

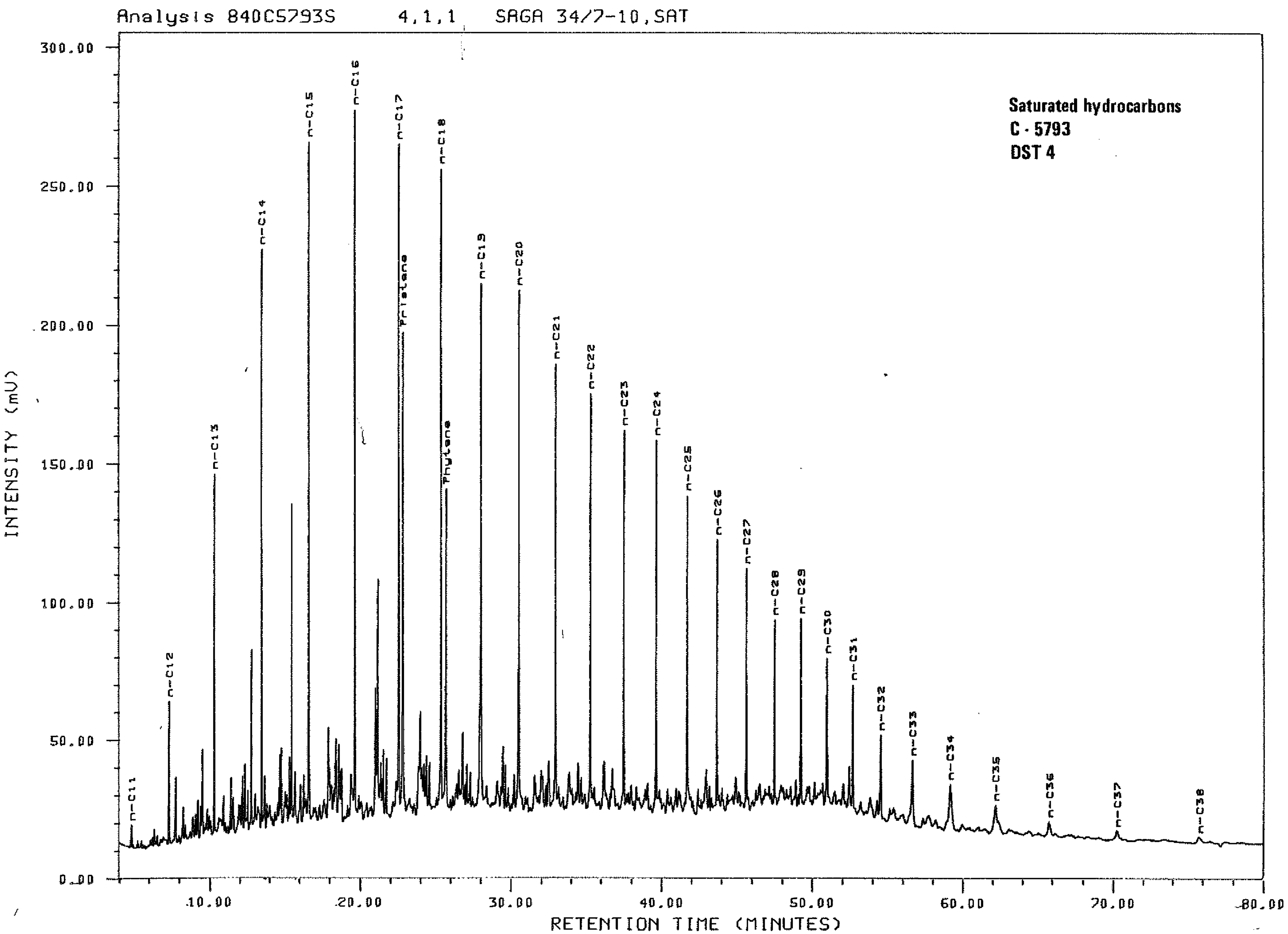
Figure 7:

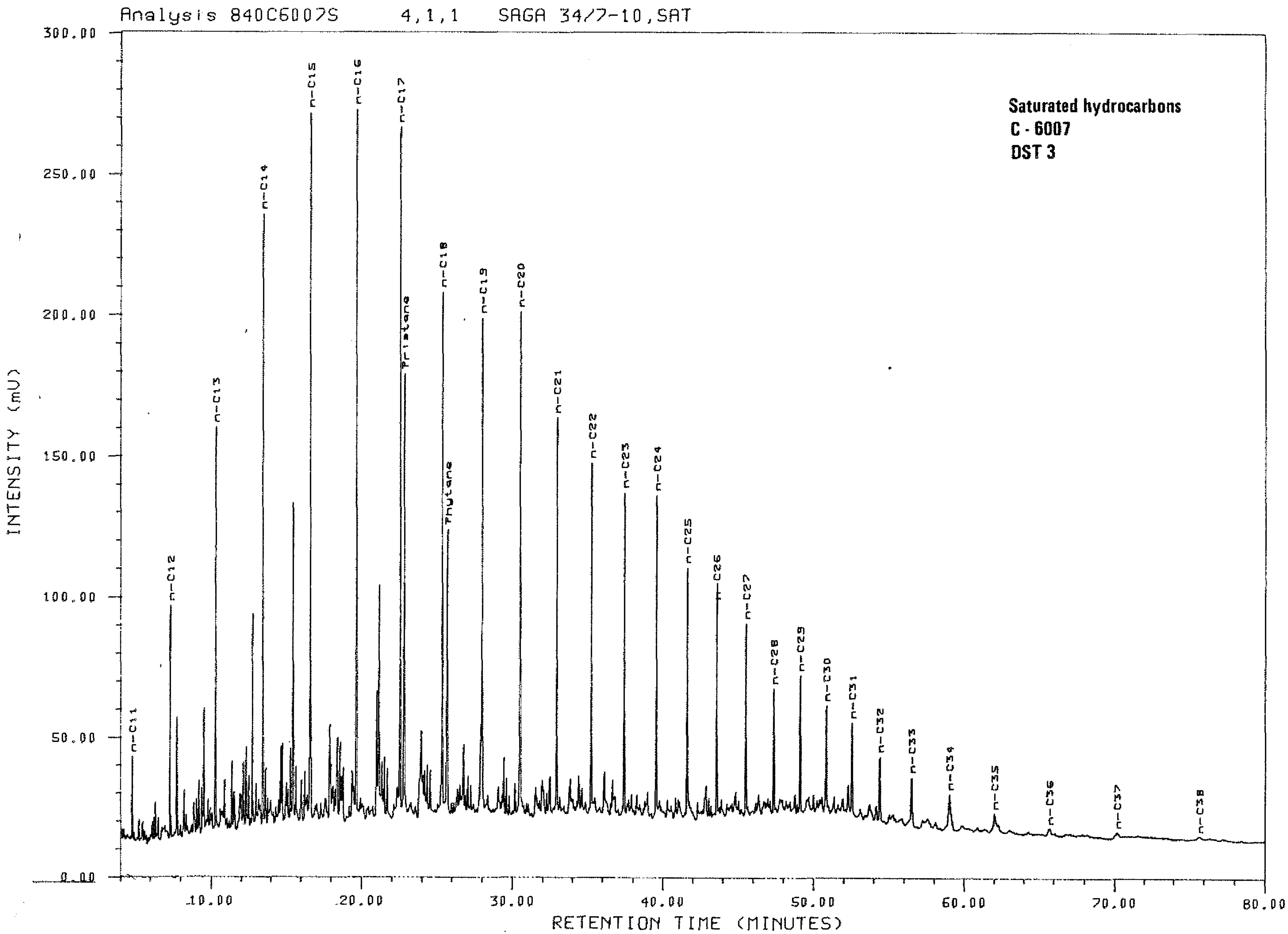
Gas chromatograms of saturated hydrocarbons

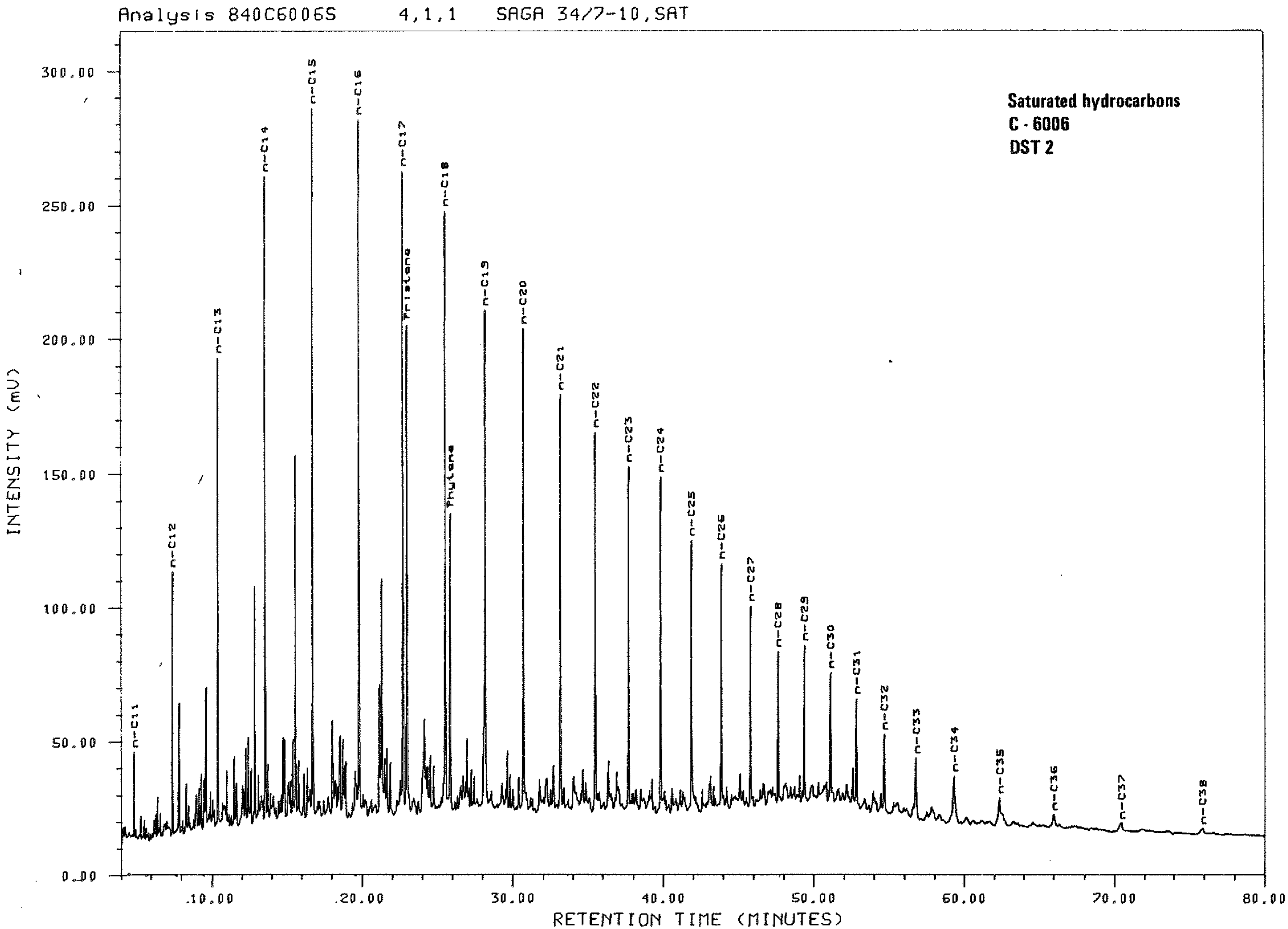
nC_{15}, etc.	:	n-alkanes
pr	:	pristane
ph	:	phytane



Analysis 840C5575S 2,1,1 34/7-10,DST1,SAT.
Saturated hydrocarbons
C - 5575
FMT
INTENSITY (mV)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
n-C13
n-C14
n-C15
n-C16
n-C17
Pristane
n-C18
Phytane
n-C19
n-C20
n-C21
n-C22
n-C23
n-C24
n-C25
n-C26
n-C27
n-C28
n-C29
n-C30
n-C31
n-C32
n-C33
n-C34
n-C35
n-C36
n-C37
n-C38
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
RETENTION TIME (MINUTES)


Analysis 840C5793S 4,1,1 SAGA 34/7-10,SAT
Saturated hydrocarbons
C - 5793
DST 4
INTENSITY (mV)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
RETENTION TIME (MINUTES)
n-C11
n-C12
n-C13
n-C14
n-C15
n-C16
n-C17
Pristane
n-C18
Phytane
n-C19
n-C20
n-C21
n-C22
n-C23
n-C24
n-C25
n-C26
n-C27
n-C28
n-C29
n-C30
n-C31
n-C32
n-C33
n-C34
n-C35
n-C36
n-C37
n-C38


Analysis 840C6007S 4,1,1 SAGA 34/7-10,SAT
Saturated hydrocarbons
C - 6007
DST 3
INTENSITY (mV)
RETENTION TIME (MINUTES)
Pristane
Phytane
n-C11
n-C12
n-C13
n-C14
n-C15
n-C16
n-C17
n-C18
n-C19
n-C20
n-C21
n-C22
n-C23
n-C24
n-C25
n-C26
n-C27
n-C28
n-C29
n-C30
n-C31
n-C32
n-C33
n-C34
n-C35
n-C36
n-C37
n-C38


Analysis 840C6006S 4,1,1 SAGA 34/7-10,SAT
Saturated hydrocarbons
C - 6006
DST 2
INTENSITY (mV)
RETENTION TIME (MINUTES)
n-C11
n-C12
n-C13
n-C14
n-C15
n-C16
n-C17
Pristane
n-C18
Phytane
n-C19
n-C20
n-C21
n-C22
n-C23
n-C24
n-C25
n-C26
n-C27
n-C28
n-C29
n-C30
n-C31
n-C32
n-C33
n-C34
n-C35
n-C36
n-C37
n-C38

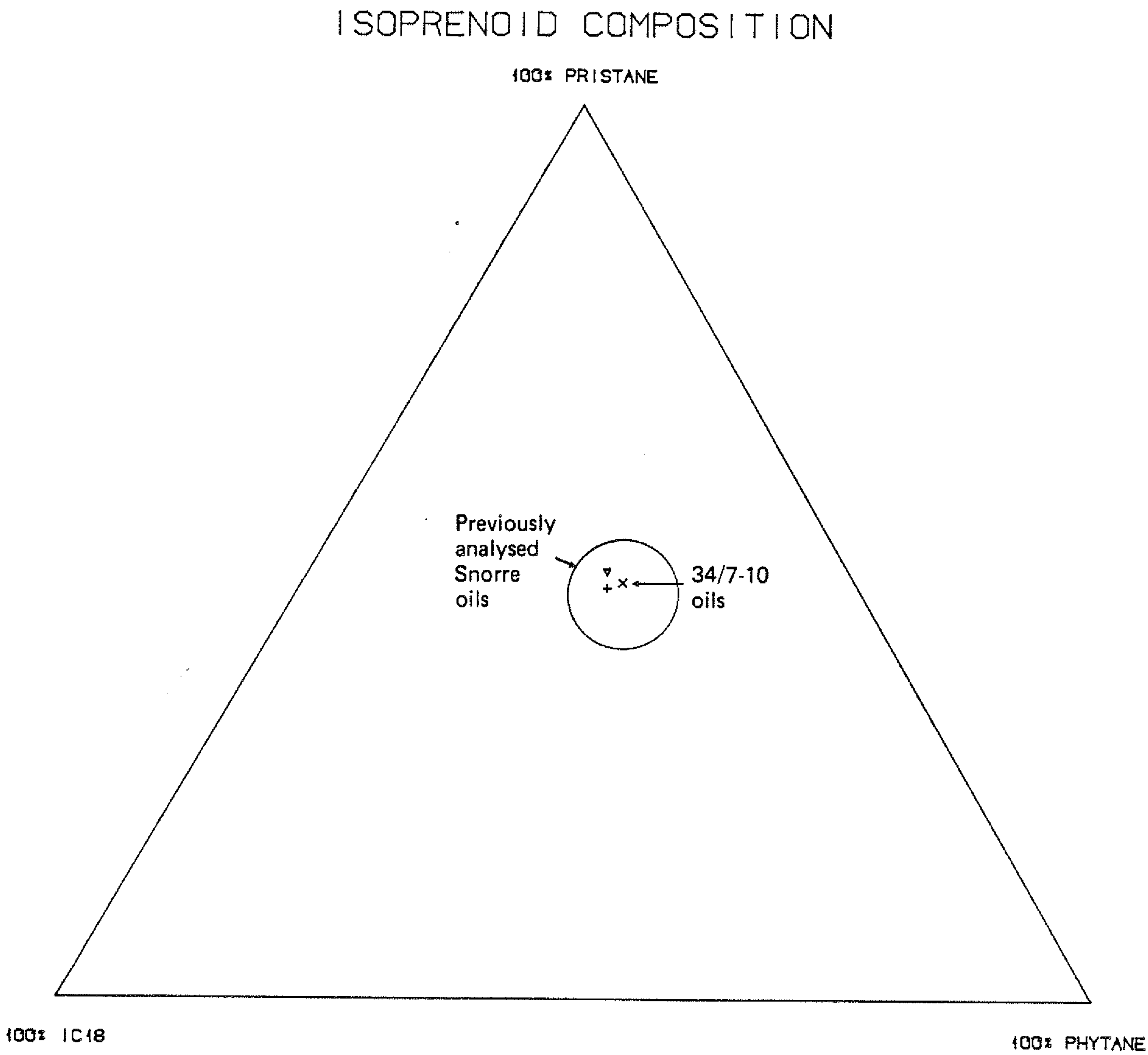
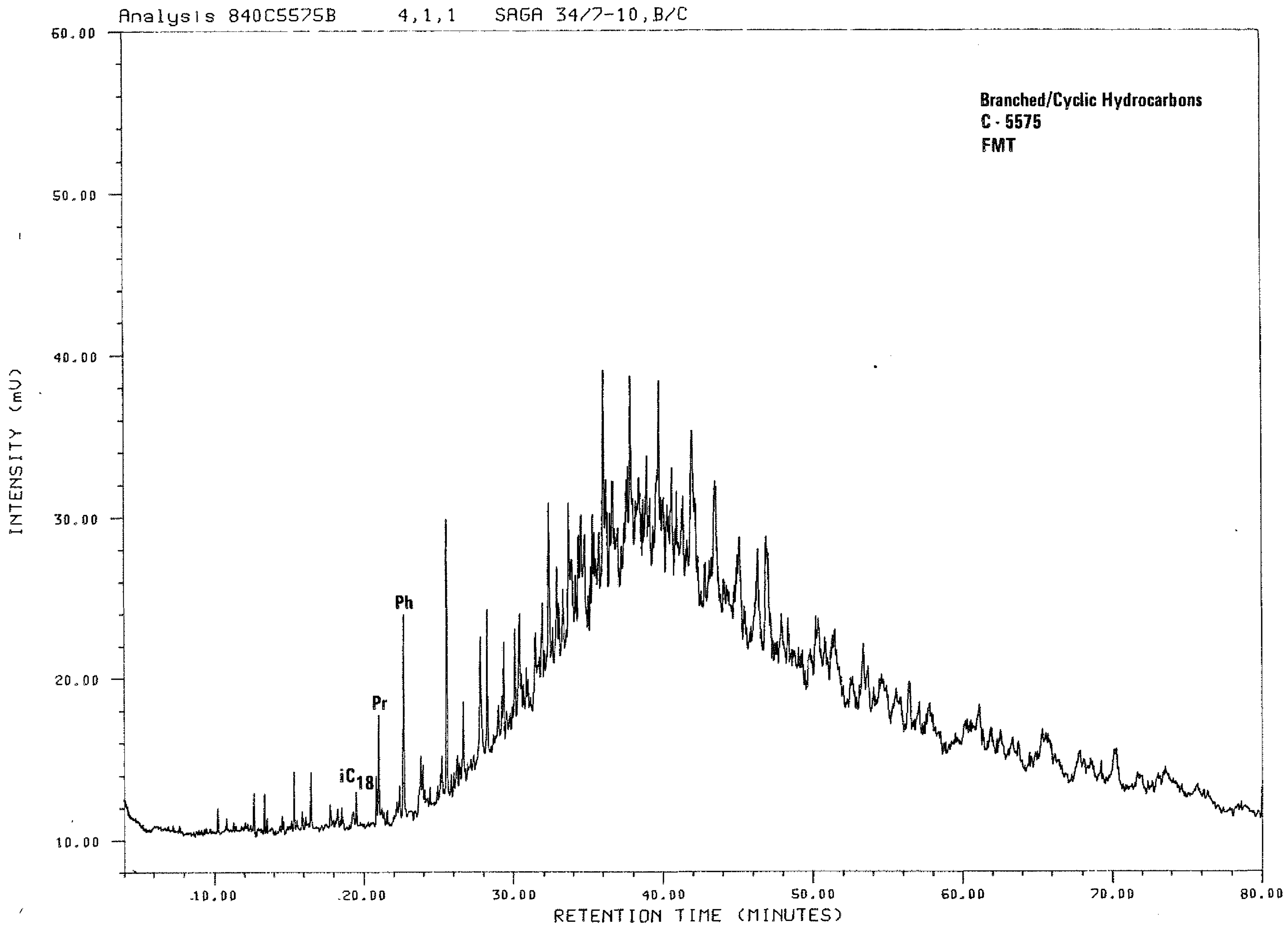


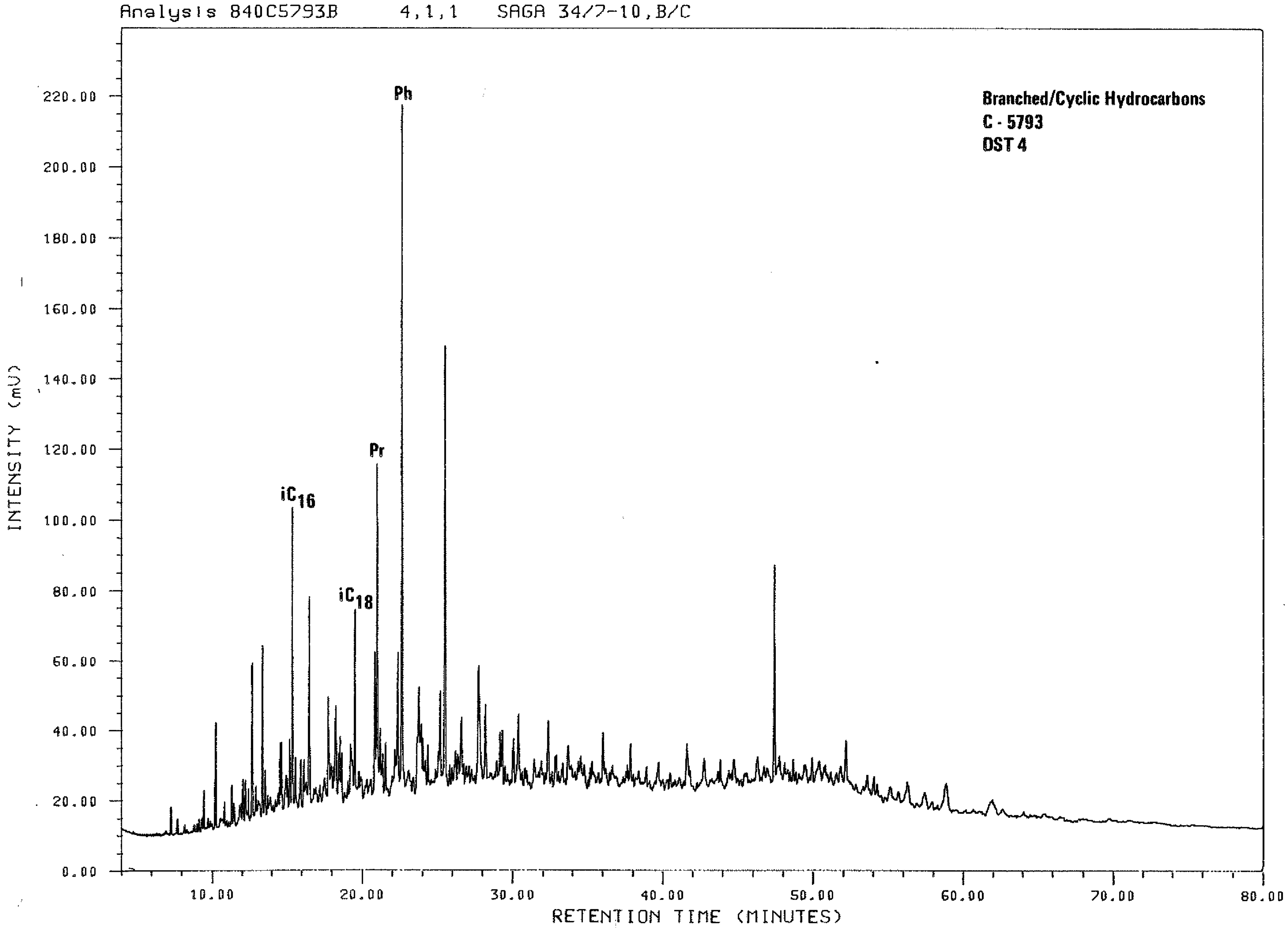
Figure 8: Isoprenoid composition of the 34/7-10 oils.

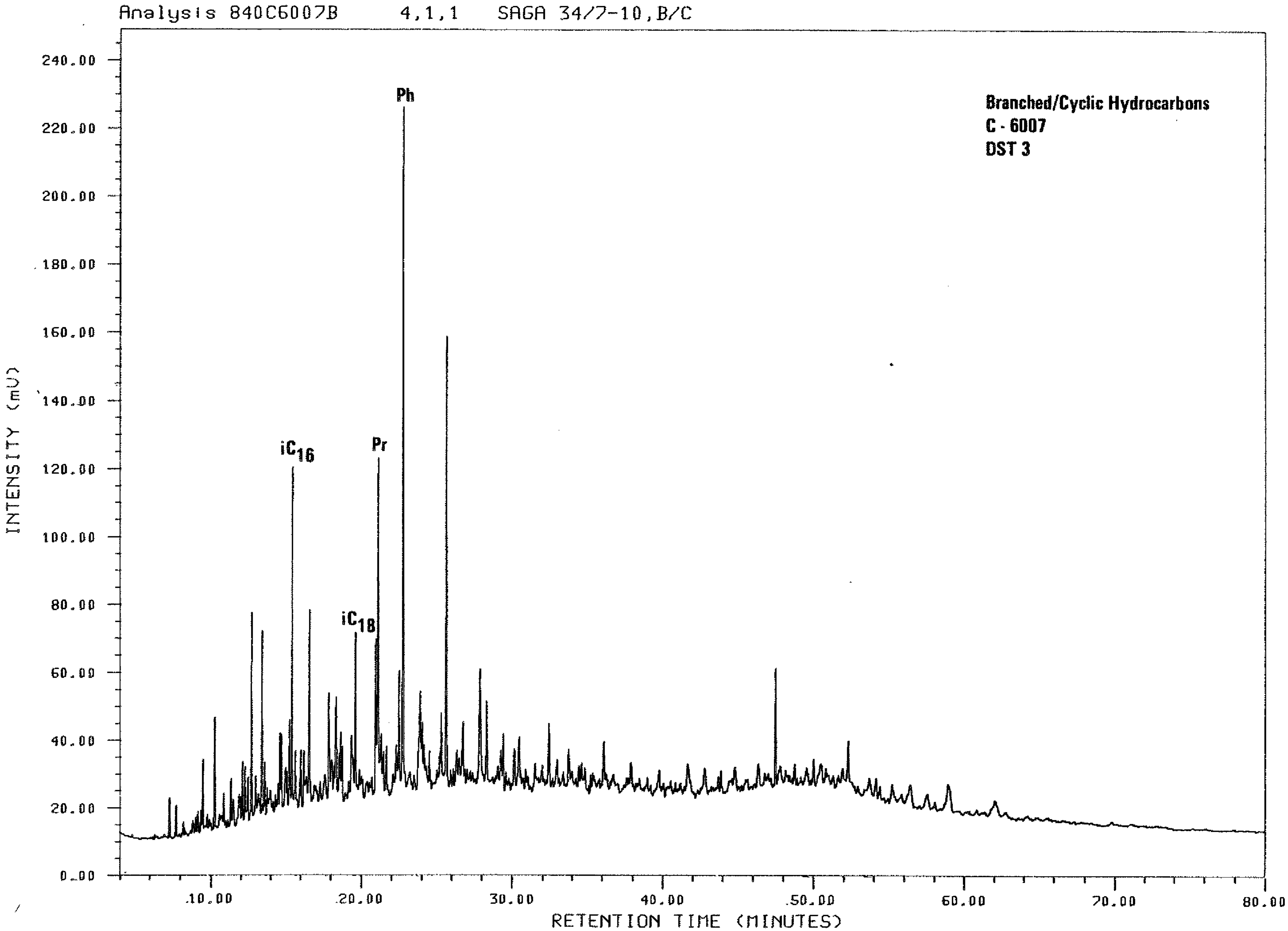
Figure 9:

Gas chromatograms of branched/cyclic hydrocarbons

iC_{16} : C_{16} isoprenoid
iC_{18} : C_{18} isoprenoid
pr : pristane
ph : phytane


Analysis 840C5575B 4,1,1 SAGA 34/7-10,B/C
Branched/Cyclic Hydrocarbons
C - 5575
FMT
INTENSITY (mV)
60.00
50.00
40.00
30.00
20.00
10.00
iC18
Pr
Ph
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
RETENTION TIME (MINUTES)


Analysis 840C5793B 4,1,1 SAGA 34/7-10,B/C
Branched/Cyclic Hydrocarbons
C - 5793
DST 4
Ph
Pr
iC16
iC18
INTENSITY (mV)
RETENTION TIME (MINUTES)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00


Analysis 840C6007B 4,1,1 SAGA 34/7-10,B/C
Branched/Cyclic Hydrocarbons
C - 6007
DST 3
INTENSITY (mV)
RETENTION TIME (MINUTES)
iC16
iC18
Pr
Ph
240.00
220.00
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00

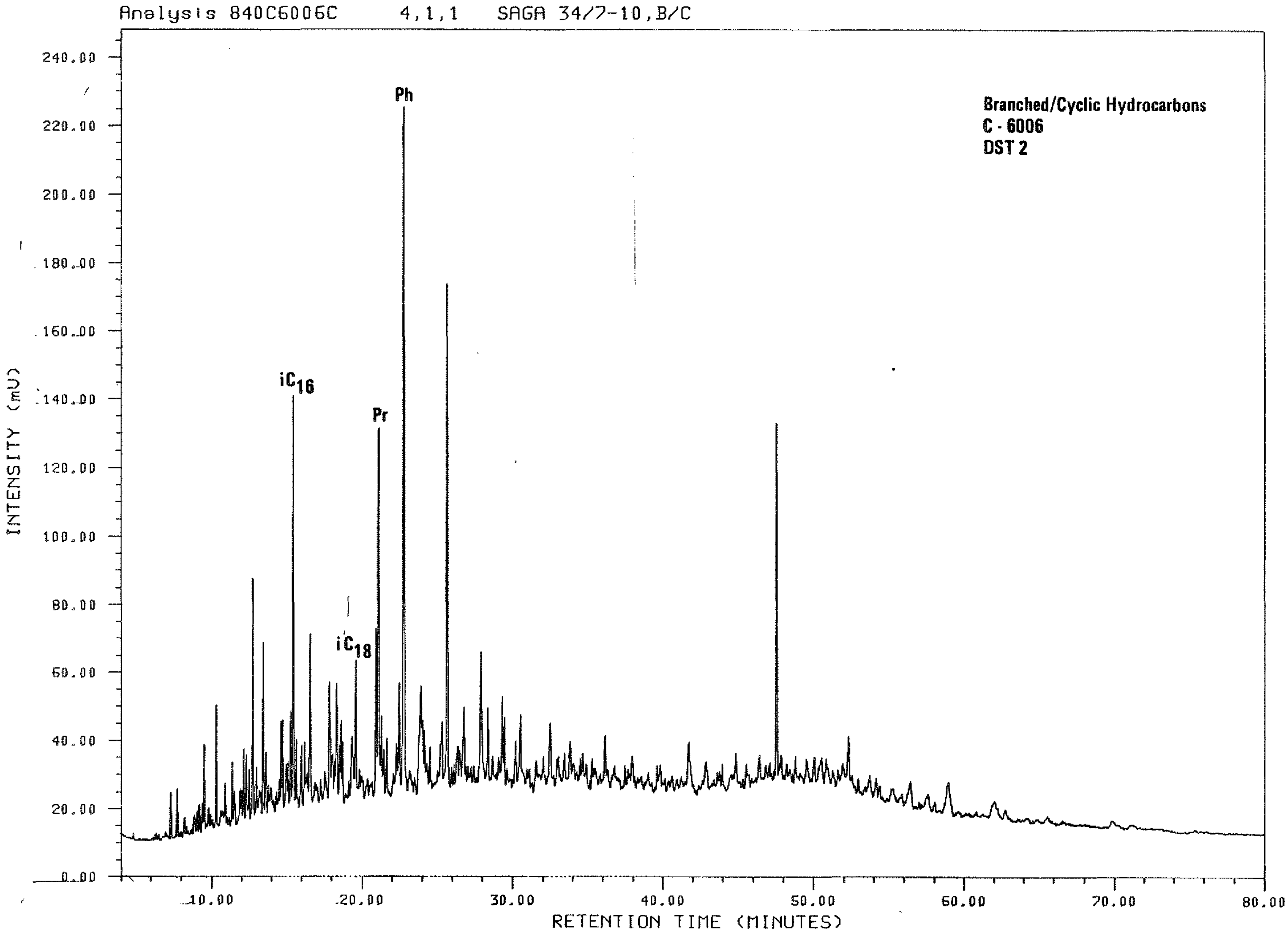
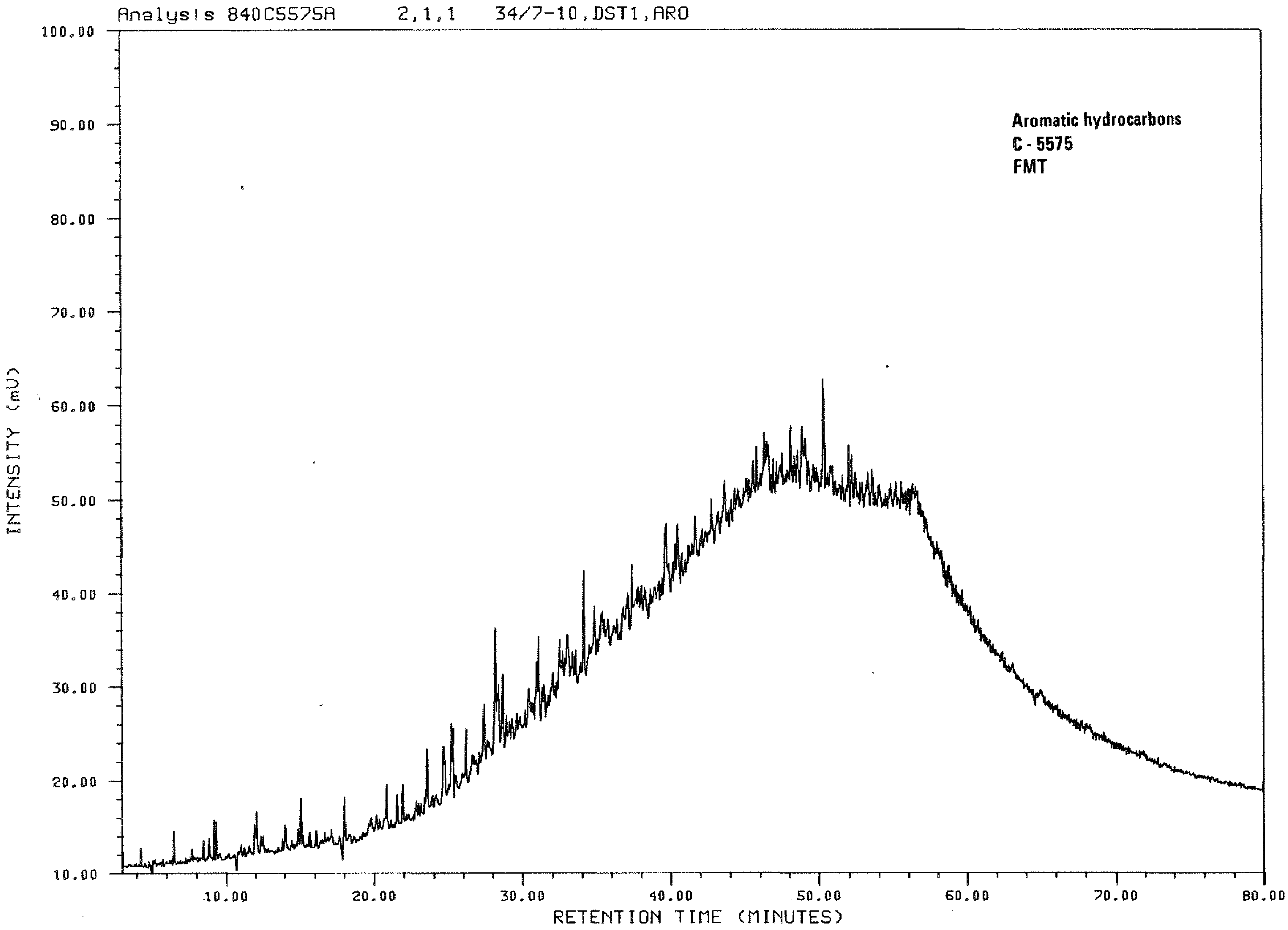
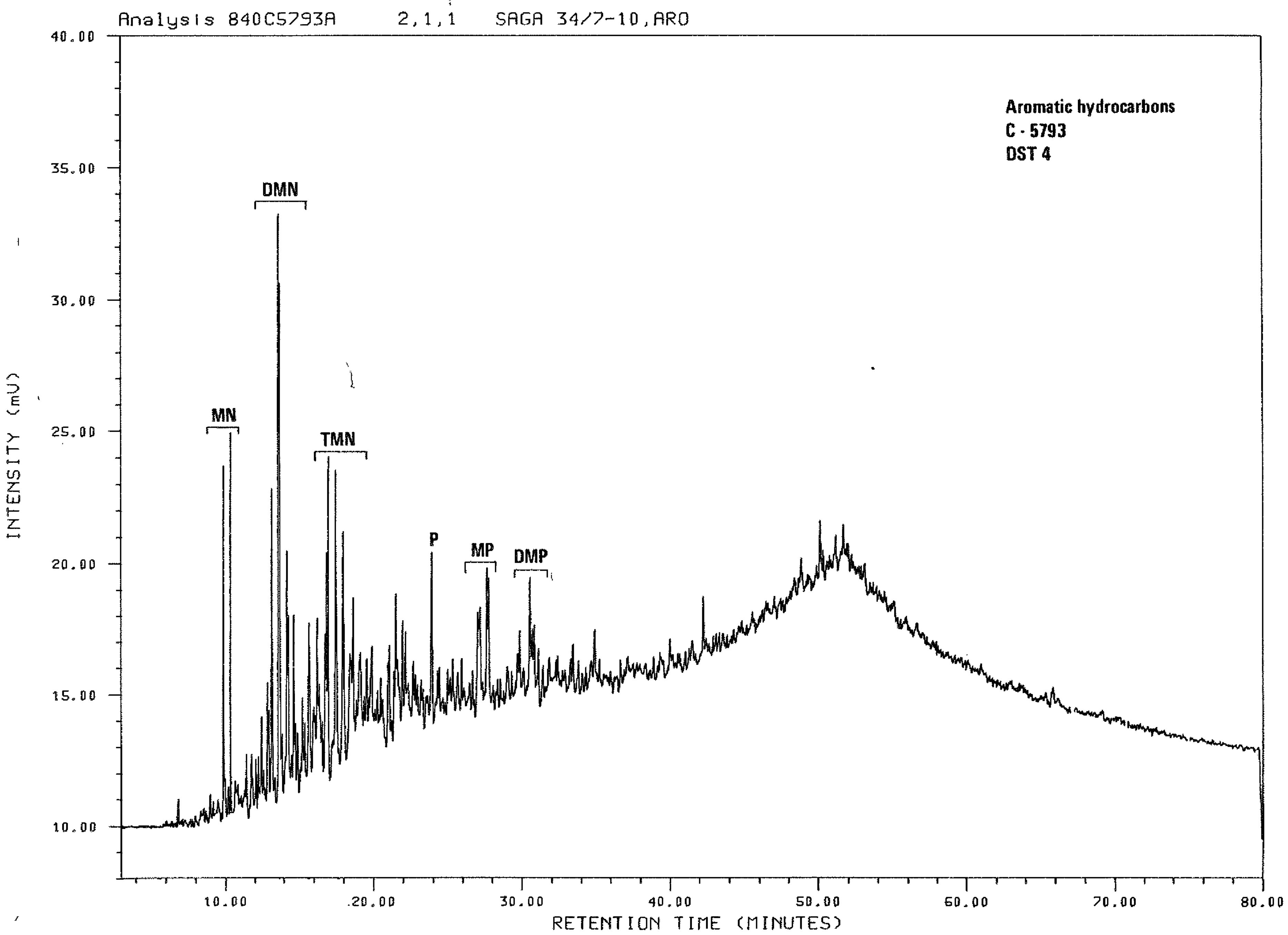

Analysis 840C6006C 4,1,1 SAGA 34/7-10,B/C
Branched/Cyclic Hydrocarbons
C - 6006
DST 2
Ph
Pr
iC16
iC18
INTENSITY (mV)
RETENTION TIME (MINUTES)

Figure 10:

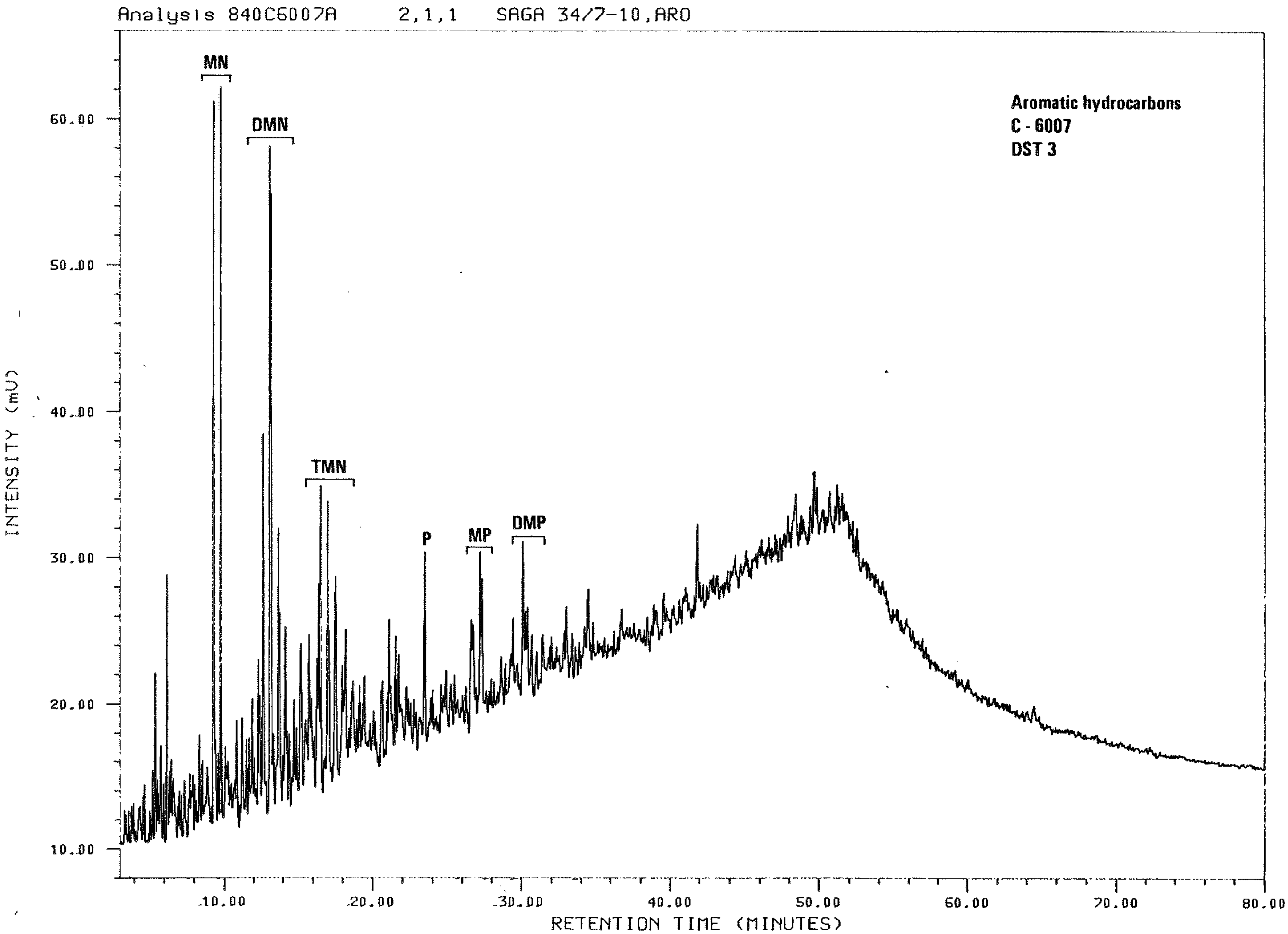
Gas chromatograms of aromatic hydrocarbons (FID detection)

MN, DMN, TMN : naphthalene and alkylated homologs
P, MP, DMP : phenanthrene and alkylated homologs

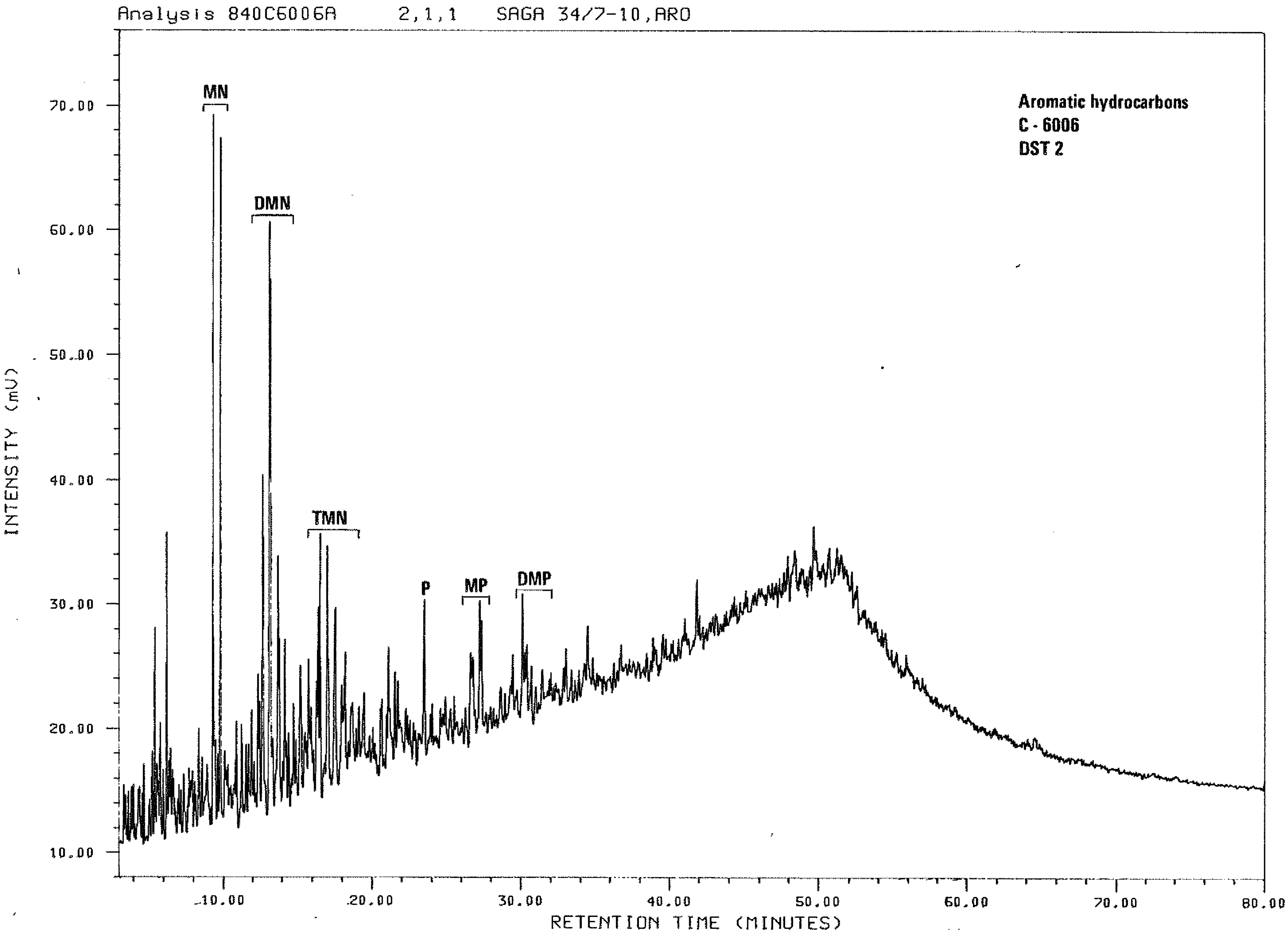

Analysis 840C5575A 2,1,1 34/7-10,DST1,ARO
Aromatic hydrocarbons
C - 5575
FMT
INTENSITY (mV)
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
RETENTION TIME (MINUTES)



Analysis 840C5793A 2,1,1 SAGA 34/7-10,ARO
Aromatic hydrocarbons
C - 5793
DST 4
MN
DMN
TMN
P
MP
DMP
INTENSITY (mV)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
RETENTION TIME (MINUTES)



Analysis 840C6007A 2,1,1 SAGA 34/7-10,ARO
Aromatic hydrocarbons
C - 6007
DST 3
MN
DMN
TMN
P
MP
DMP
INTENSITY (mV)
RETENTION TIME (MINUTES)
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00

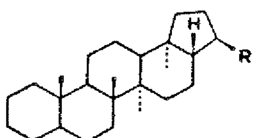


Analysis 840C6006A 2,1,1 SAGA 34/7-10,ARO
Aromatic hydrocarbons
C - 6006
DST 2
MN
DMN
TMN
P
MP
DMP
INTENSITY (mV)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
RETENTION TIME (MINUTES)

Figure 11:

Mass chromatograms representing terpanes (m/z 191)

A	T_s, 18α(H)-trisnorneohopane	$C_{27}H_{46}$	(III)
B	T_m, 17α(H)-trisnorhopane	$C_{27}H_{46}$	(I,R=H)
C	17α(H)-norhopane	$C_{29}H_{50}$	(I,R=C_2H_5)
D	17β(H)-normoretane	$C_{29}H_{50}$	(II,R=C_2H_5)
E	17α(H)-hopane	$C_{30}H_{52}$	(I,R=C_3H_7)
F	17β(H)-moretane	$C_{30}H_{52}$	(II,R=C_3H_7)
G	17α(H)-homohopane (22S)	$C_{31}H_{54}$	(I,R=C_4H_9)
H	17α(H)-homohopane (22R)	$C_{31}H_{54}$	(I,R=C_4H_9)
	+ unknown triterpane (gammacerane?)		
I	17β(H)-homomoretane	$C_{31}H_{54}$	(II,R=C_4H_9)
J	17α(H)-bishomohopane (22S,22R)	$C_{32}H_{56}$	(I,R=C_5H_{11})
K	17α(H)-trishomohopane (22S,22R)	$C_{33}H_{58}$	(I,R=C_6H_{13})
L	17α(H)-tetrakishomohopane (22S,22R)	$C_{34}H_{60}$	(I,R=C_7H_{15})
M	17α(H)-pentakishomohopane (22S,22R)	$C_{35}H_{62}$	(I,R=C_8H_{17})
Z	bisnorhopane	$C_{28}H_{48}$	
X	unknown triterpane	$C_{30}H_{52}$	
P	tricyclic terpane	$C_{23}H_{42}$	(IV,R=C_4H_9)
Q	tricyclic terpane	$C_{24}H_{44}$	(IV,R=C_5H_{11})
R	tricyclic terpane (17R,17S)	$C_{25}H_{46}$	(IV,R=C_6H_{13})
S	tetracyclic terpane	$C_{24}H_{42}$	(V)
T	tricyclic terpane (17R,17S)	$C_{26}H_{48}$	(IV,R=C_7H_{15})



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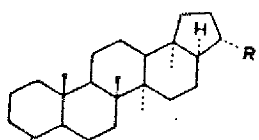
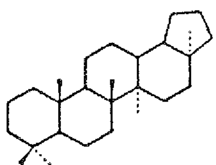
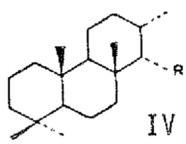


I



III



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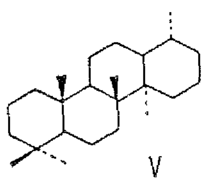
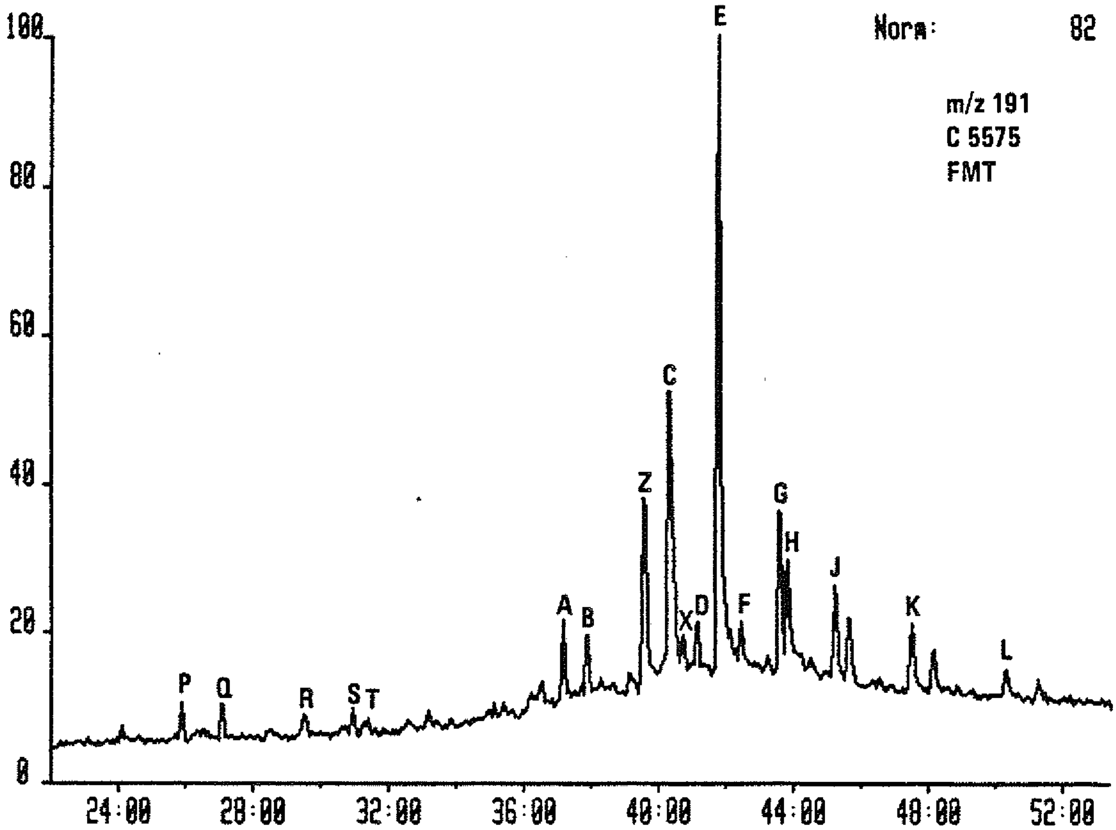
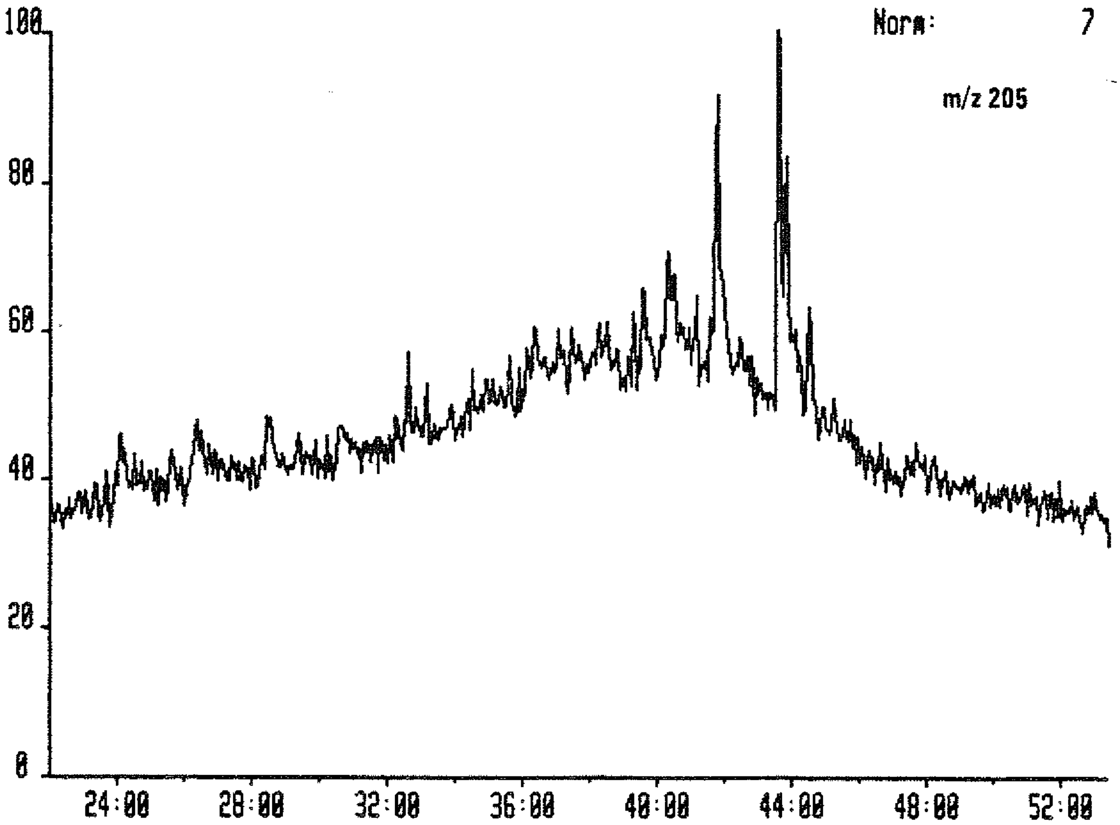


V

C5575SAT   3-DEC-86   Sir:Voltage 7070H   Acnt:IKU   System:TRIT
Sample 1   Injection 1   Group 1   Mass 191.1000
Text:

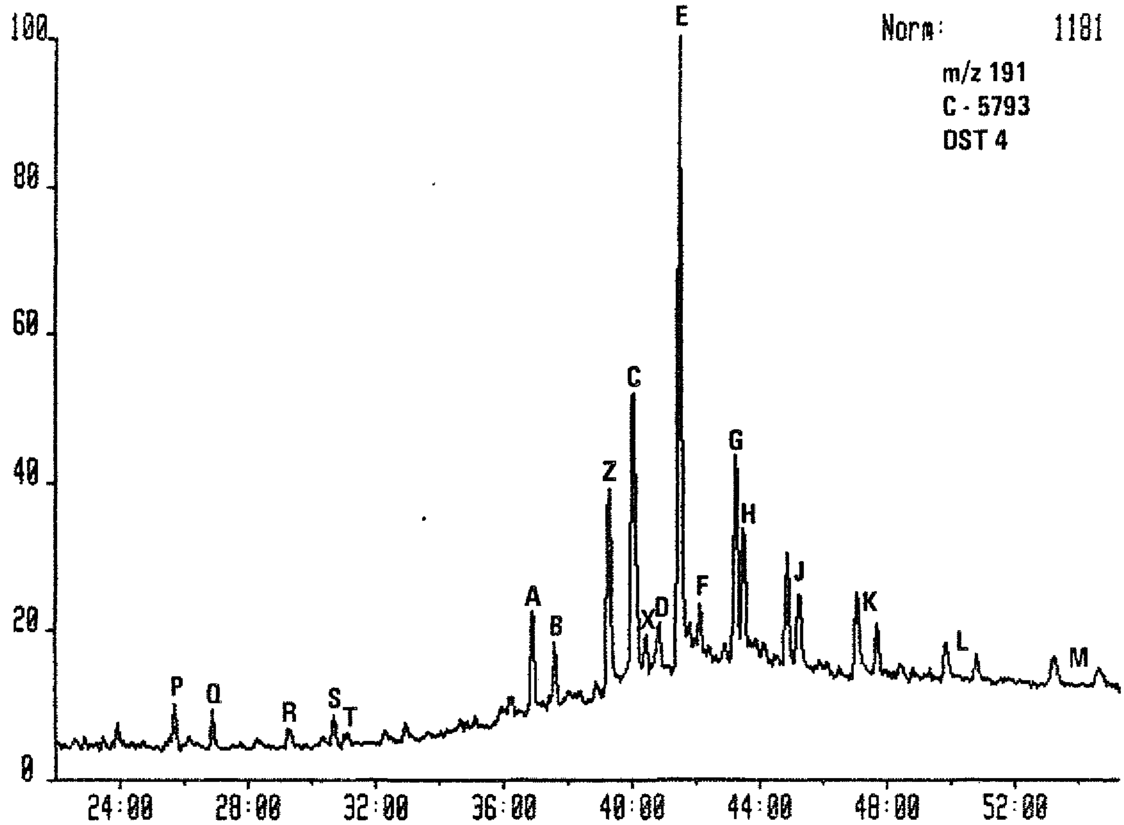


C5575SAT   3-DEC-86   Sir:Voltage 7070H   Acnt:IKU   System:TRIT
Sample 1   Injection 1   Group 1   Mass 205.1000
Text:

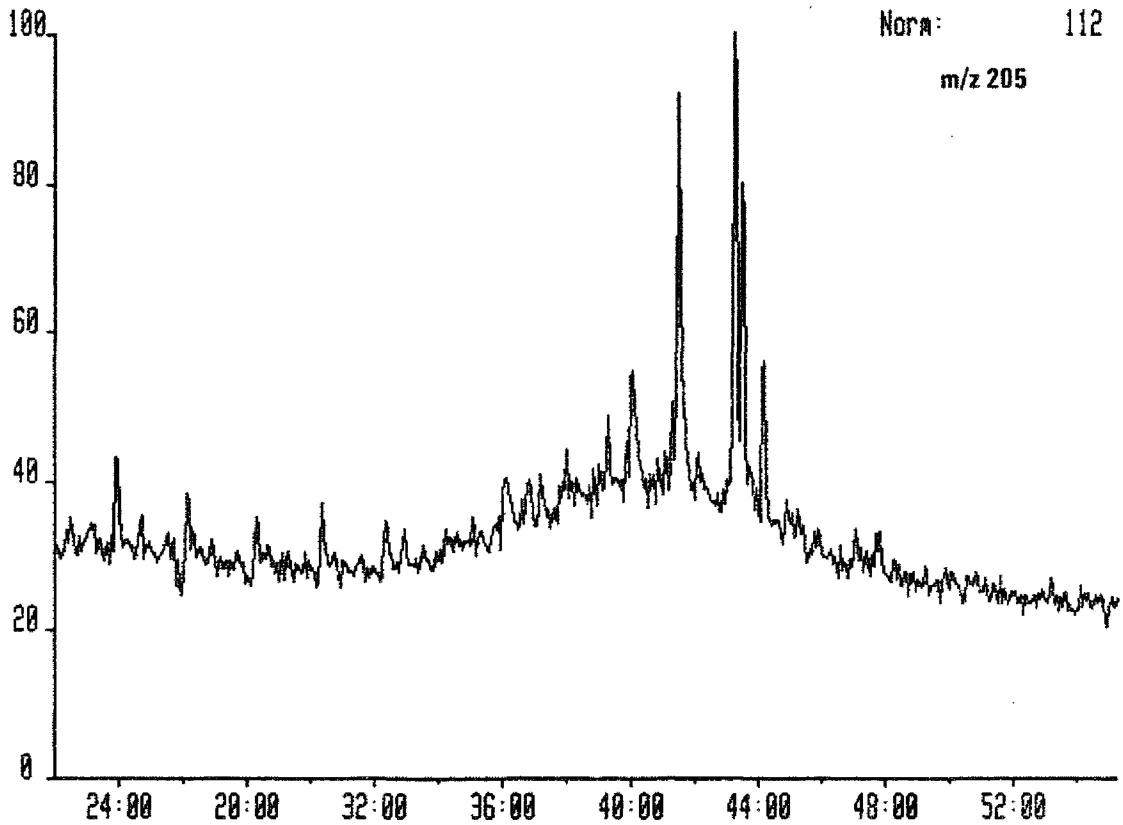


IKU SINTEF-GRUPPEN

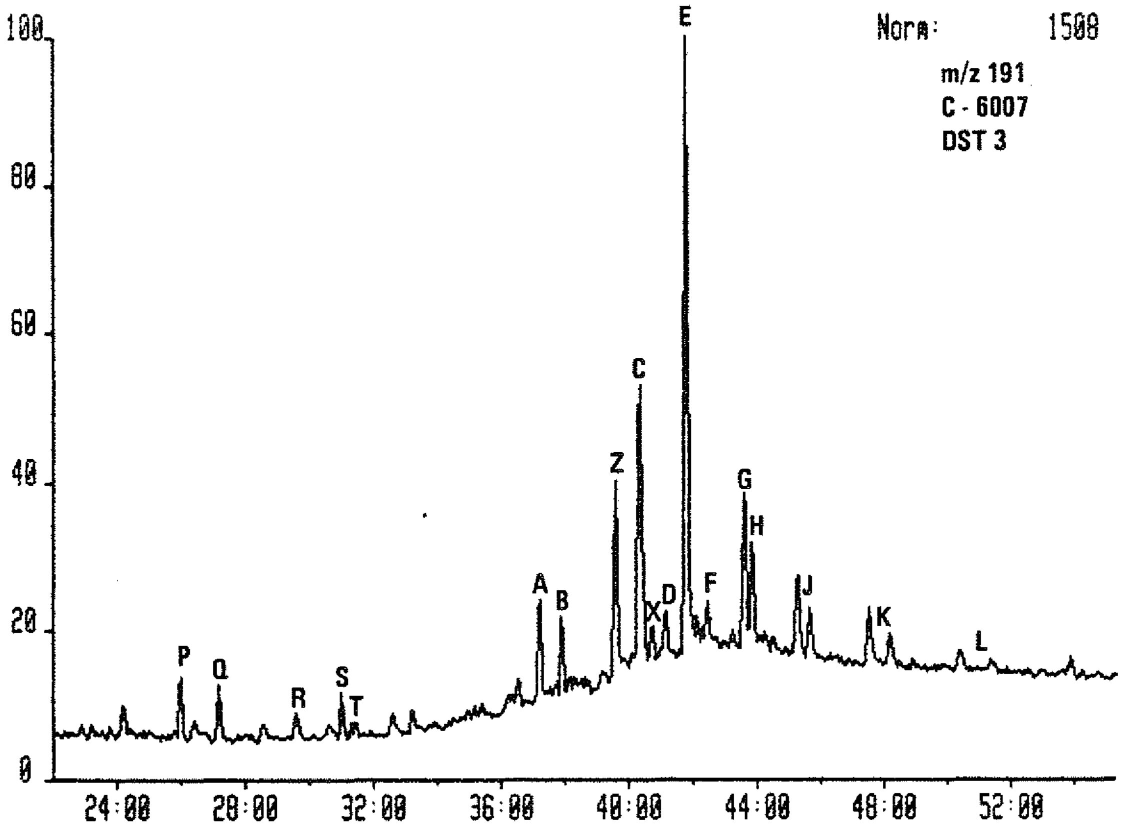
C5793SAT 3-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 191.1000
Text:



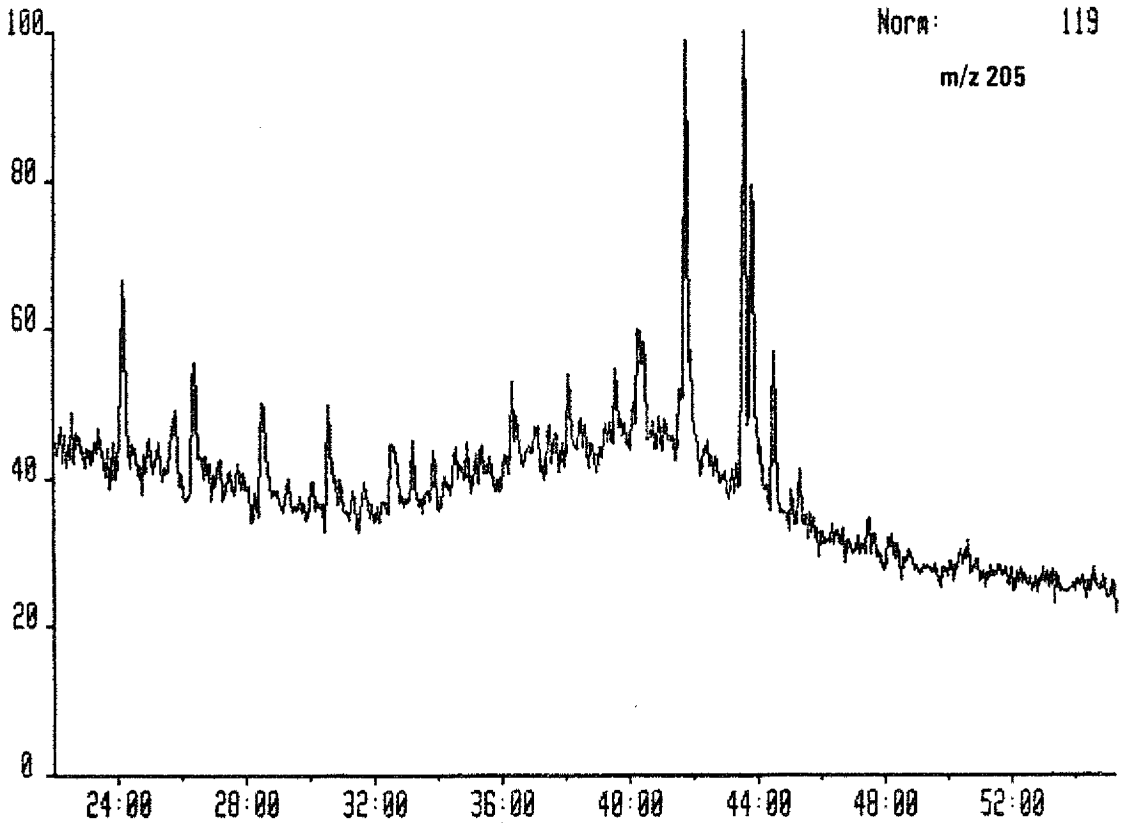
C5793SAT 3-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 205.1000
Text:



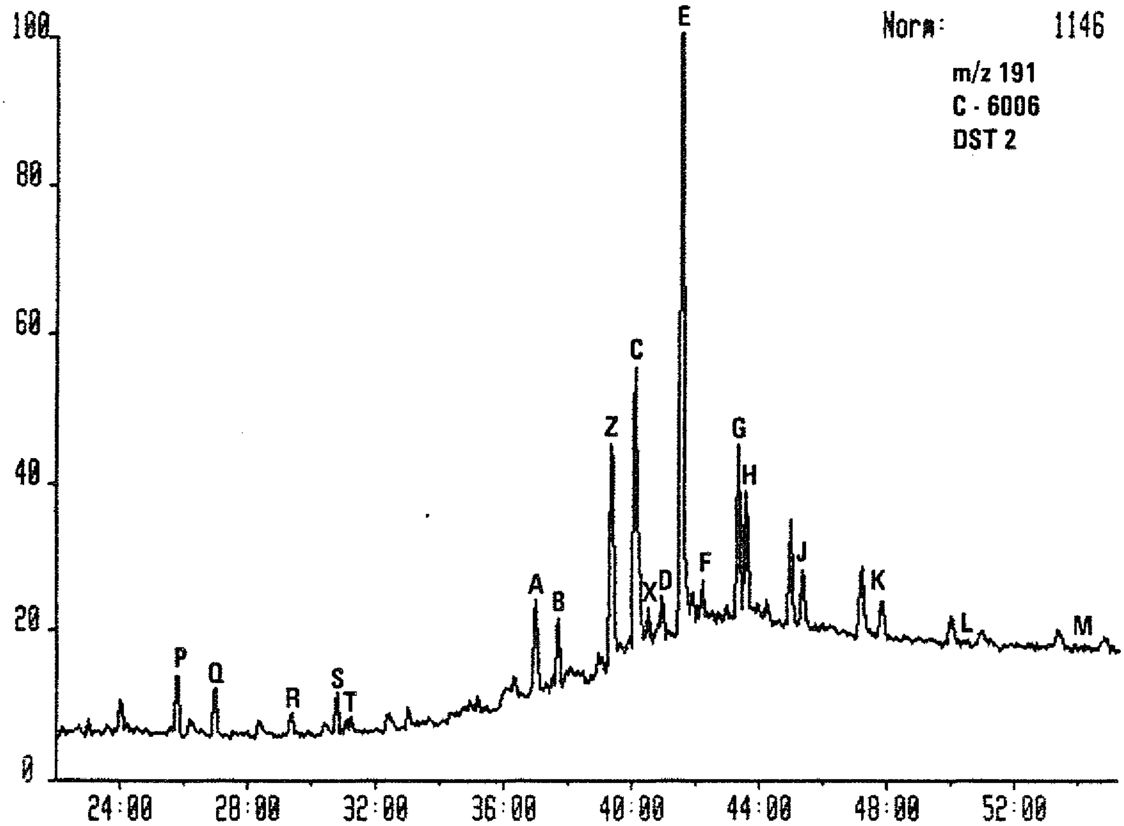
C6007SAT 2-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 191.1000
Text:



C6007SAT 2-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 205.1000
Text:



C6006SAT 2-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 191.1000
Text:



C6006SAT 2-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 205.1000
Text:

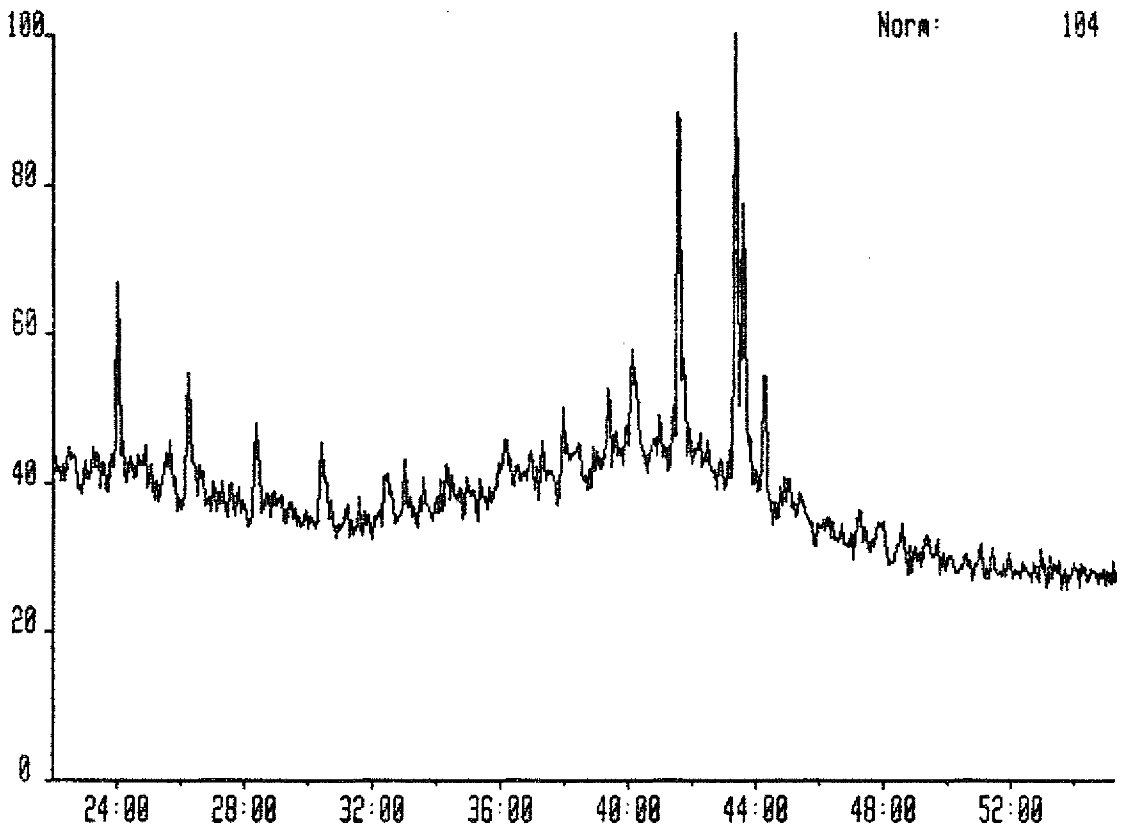
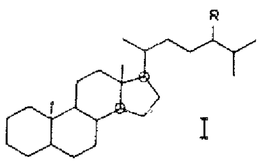


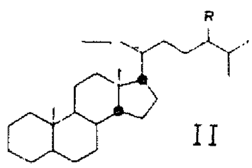
Figure 12:

Mass chromatograms representing steranes (m/z 217 and 218)

a	13β(H),17α(H)-diasterane (20S)	$C_{27}H_{48}$	(III,R=H)
b	13β(H),17α(H)-diasterane (20R)	$C_{27}H_{48}$	(III,R=H)
c	13α(H),17β(H)-diasterane (20S)	$C_{27}H_{48}$	(IV,R=H)
d	13α(H),17β(H)-diasterane (20R)	$C_{27}H_{48}$	(IV,R=H)
e	13β(H),17α(H)-diasterane (20S)	$C_{28}H_{50}$	(III,R=CH_3)
f	13β(H),17α(H)-diasterane (20R)	$C_{28}H_{50}$	(III,R=CH_3)
g	13α(H),17β(H)-diasterane (20S)	$C_{28}H_{50}$	(IV,R=CH_3)
	+ 14α(H),17α(H)-sterane (20S)	$C_{27}H_{48}$	(I,R=H)
h	13β(H),17α(H)-diasterane (20S)	$C_{29}H_{52}$	(III,R=C_2H_5)
	+ 14β(H),17β(H)-sterane (20R)	$C_{27}H_{48}$	(II,R=H)
i	14β(H),17β(H)-sterane (20S)	$C_{27}H_{48}$	(II,R=H)
	+ 13α(H),17β(H)-diasterane (20R)	$C_{28}H_{50}$	(IV,R=CH_3)
j	14α(H),17α(H)-sterane (20R)	$C_{27}H_{48}$	(I,R=H)
k	13β(H),17α(H)-diasterane (20R)	$C_{29}H_{52}$	(III,R=C_2H_5)
l	13α(H),17β(H)-diasterane (20S)	$C_{29}H_{52}$	(VI ,R=C_2H_5)
m	14α(H),17α(H)-sterane (20S)	$C_{28}H_{50}$	(I,R=CH_3)
n	13α(H),17β(H)-diasterane (20R)	$C_{29}H_{52}$	(VI ,R=C_2H_5)
	+ 14β(H),17β(H)-sterane (20R)	$C_{28}H_{50}$	(II,R=CH_3)
o	14β(H),17β(H)-sterane (20S)	$C_{28}H_{50}$	(II,R=CH_3)
p	14α(H),17α(H)-sterane (20R)	$C_{28}H_{50}$	(I,R=CH_3)
q	14α(H),17α(H)-sterane (20S)	$C_{29}H_{52}$	(I,R=C_2H_5)
r	14β(H),17β(H)-sterane (20R)	$C_{29}H_{52}$	(II,R=C_2H_5)
	+ unknown sterane		
s	14β(H),17β(H)-sterane (20S)	$C_{29}H_{52}$	(II,R=C_2H_5)
t	14α(H),17α(H)-sterane (20R)	$C_{29}H_{52}$	(I,R=C_2H_5)
u	5α(H)-sterane	$C_{21}H_{36}$	(V,R=C_2H_5)
v	5α(H)-sterane	$C_{22}H_{38}$	(V,R=C_3H_7)



I



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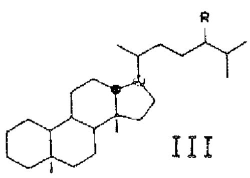
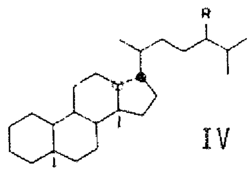
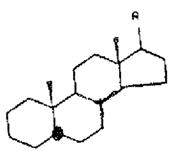


III

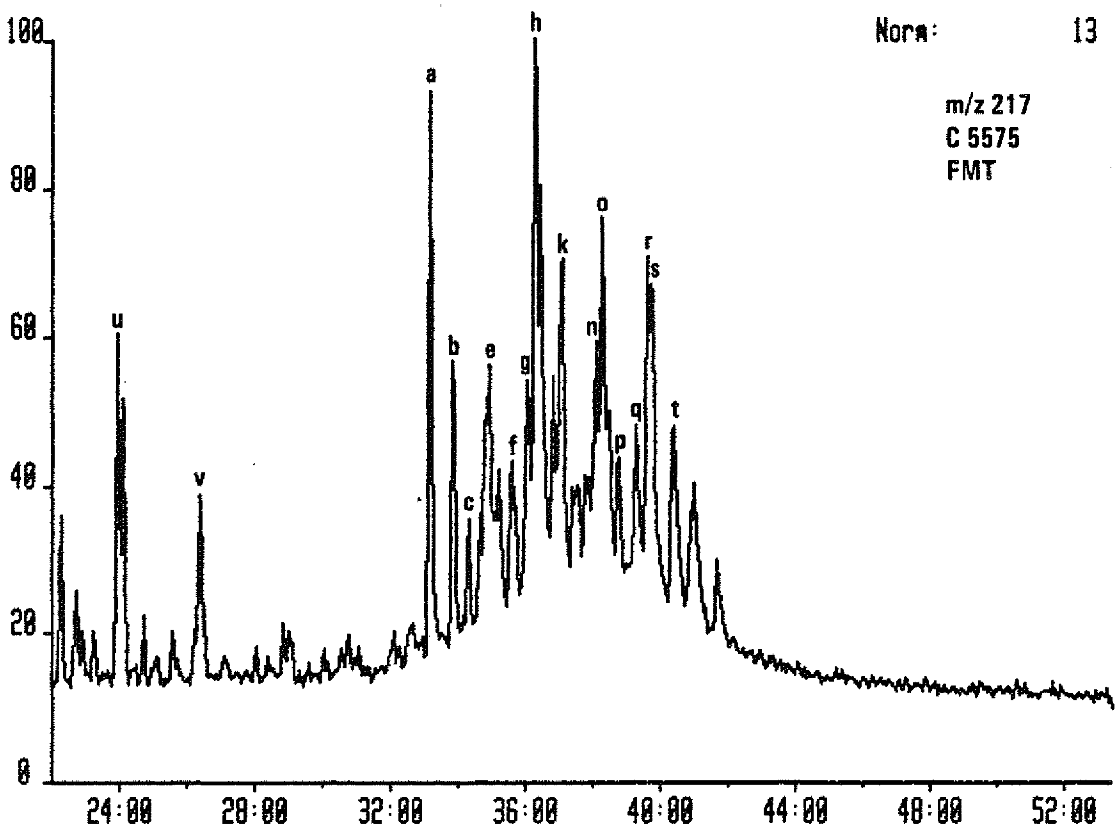


IV

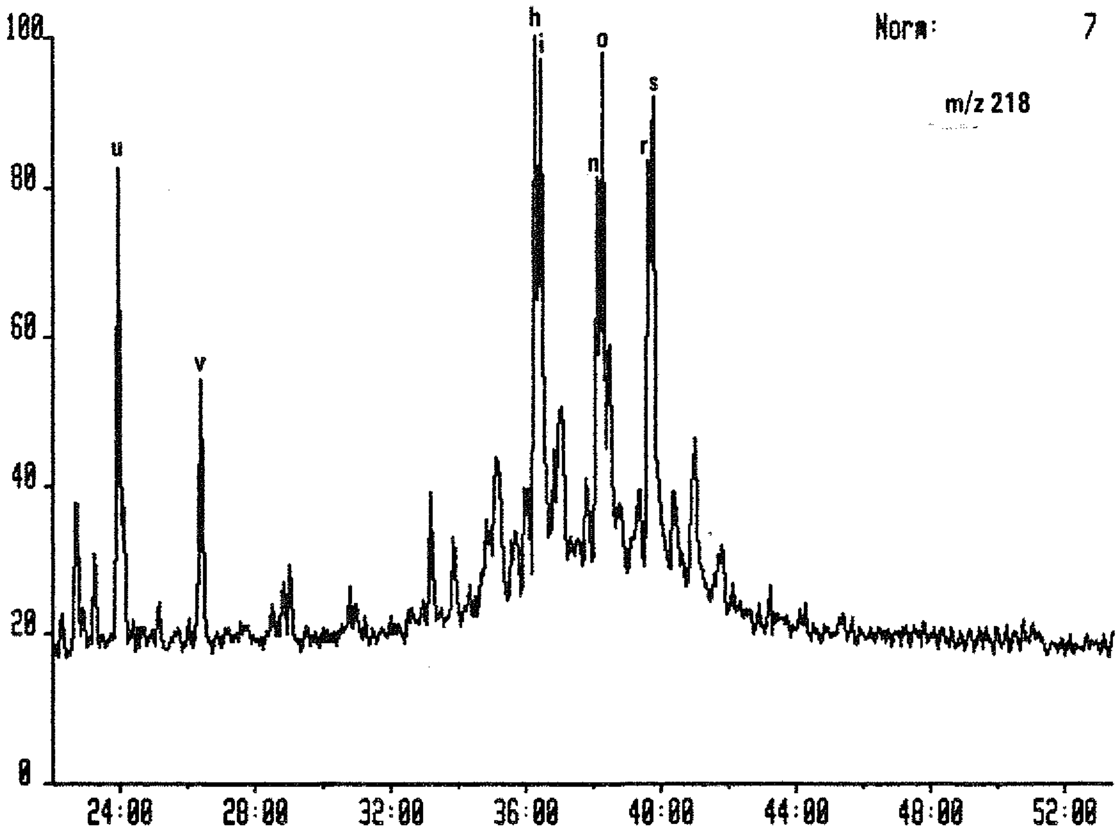


V

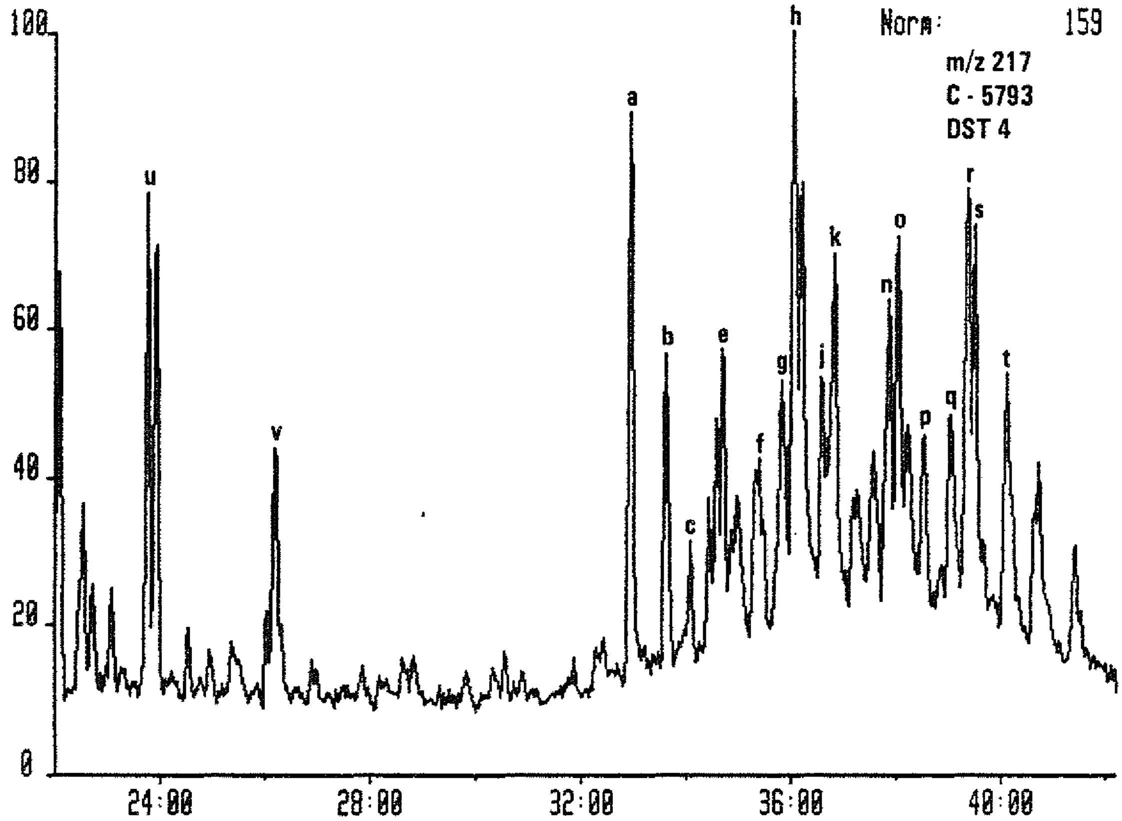
C5575SAT 3-DEC-86 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 217.1000
Text:



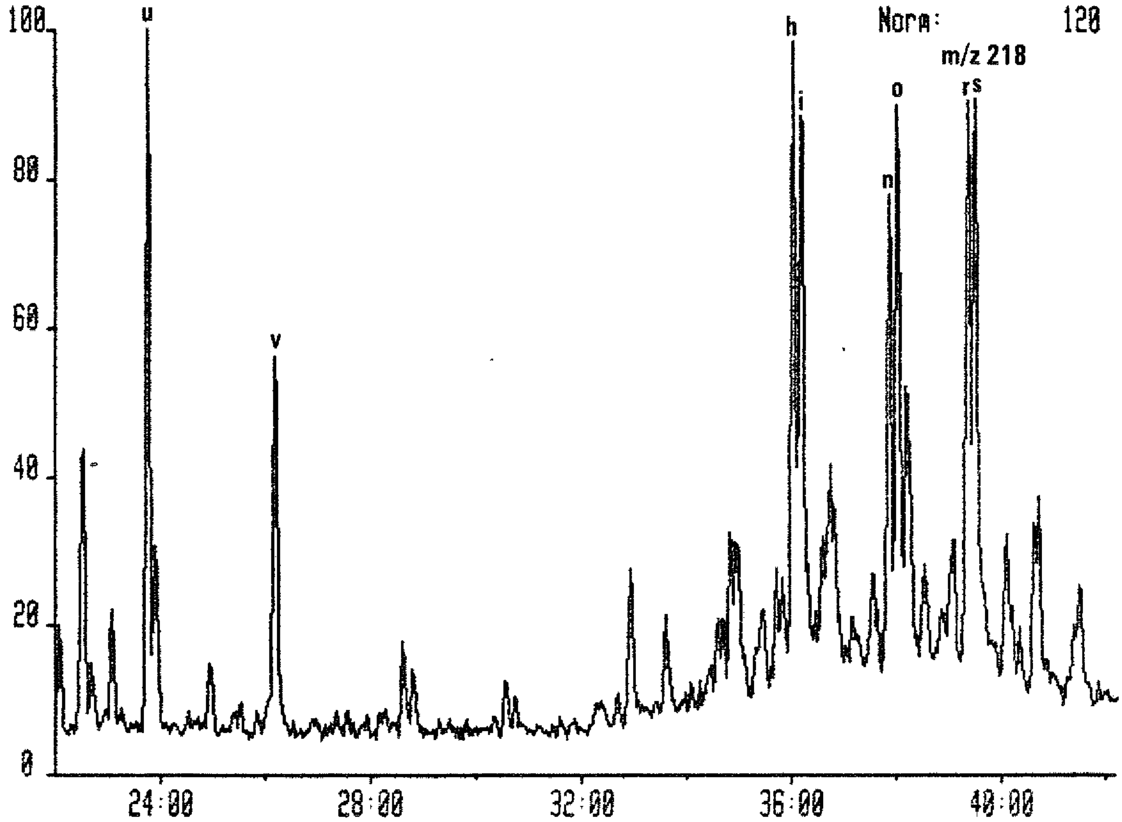
C5575SAT 3-DEC-86 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 218.1000
Text:



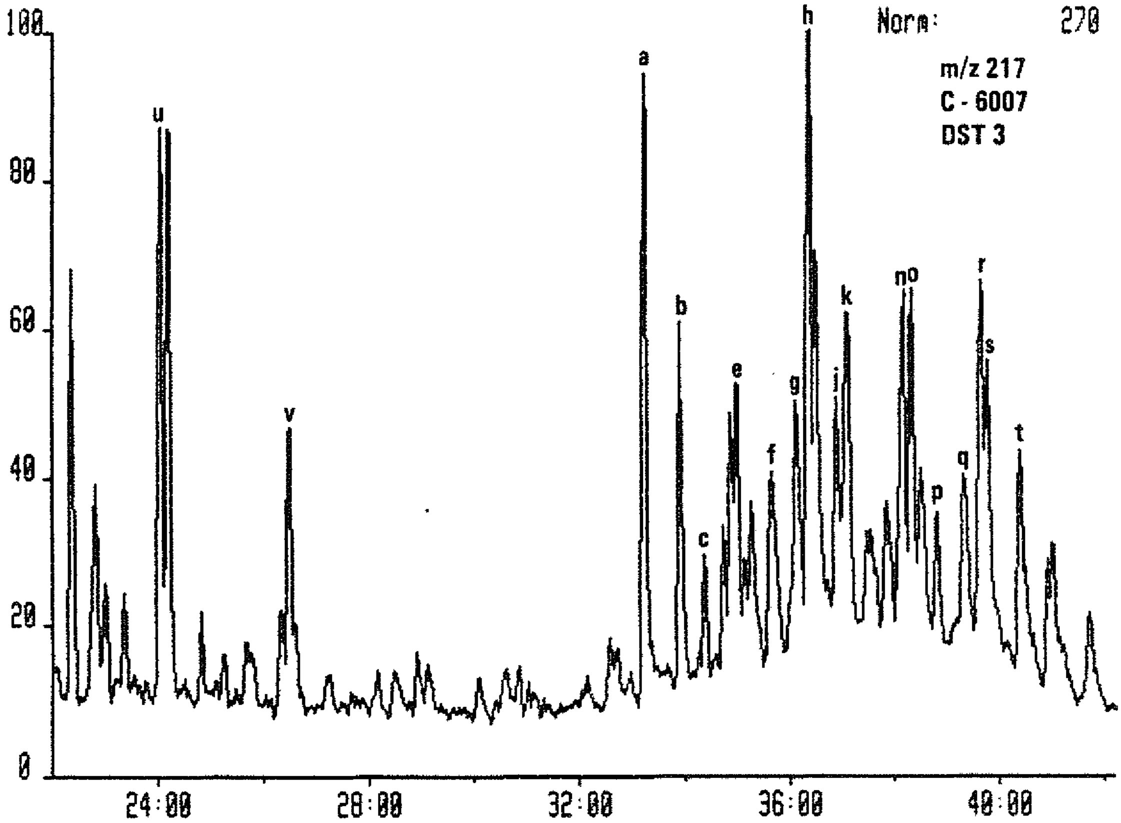
C5793SAT 3-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 217.1000
Text:



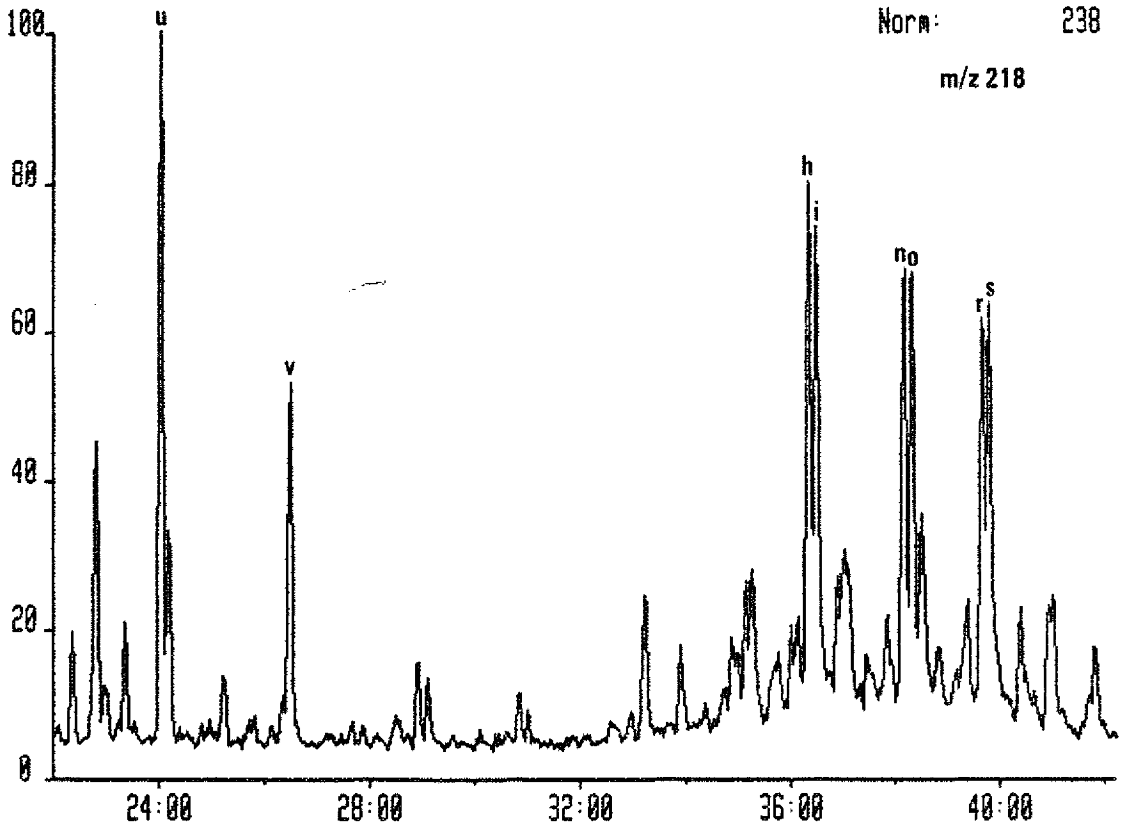
C5793SAT 3-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 218.1000
Text:



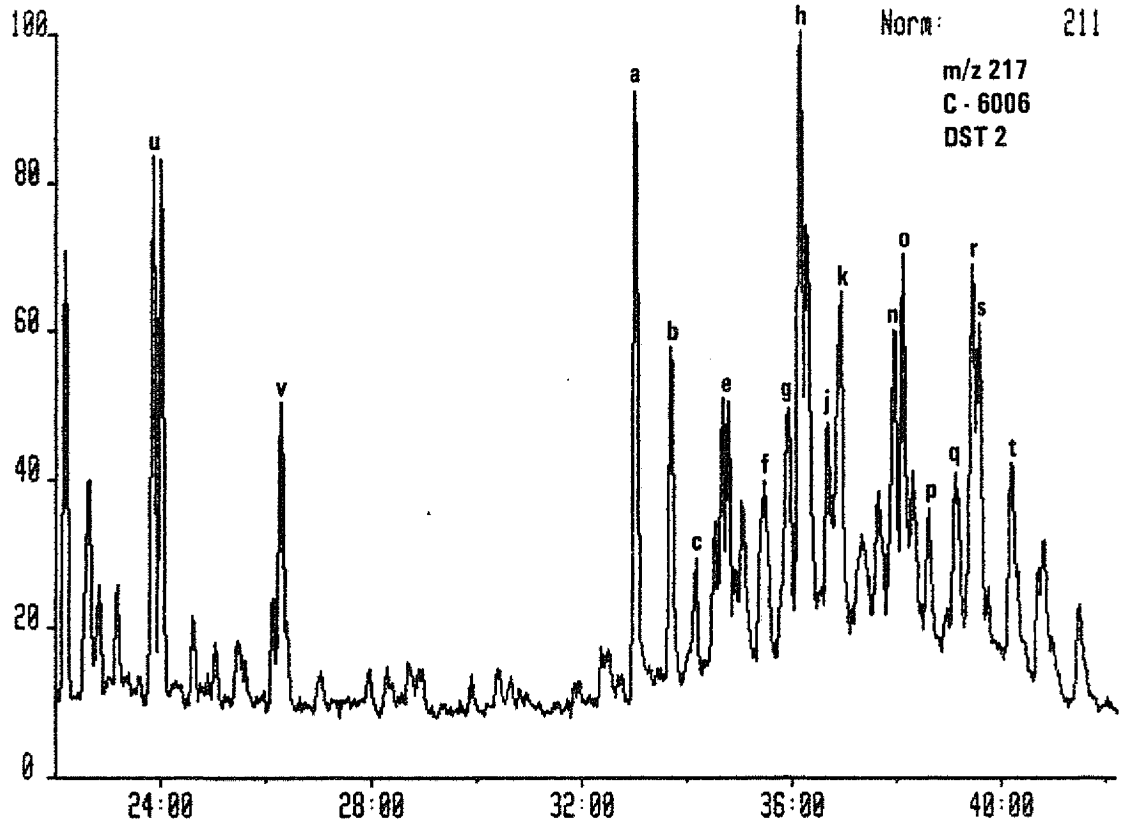
C6007SAT 2-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 217.1000
Text:



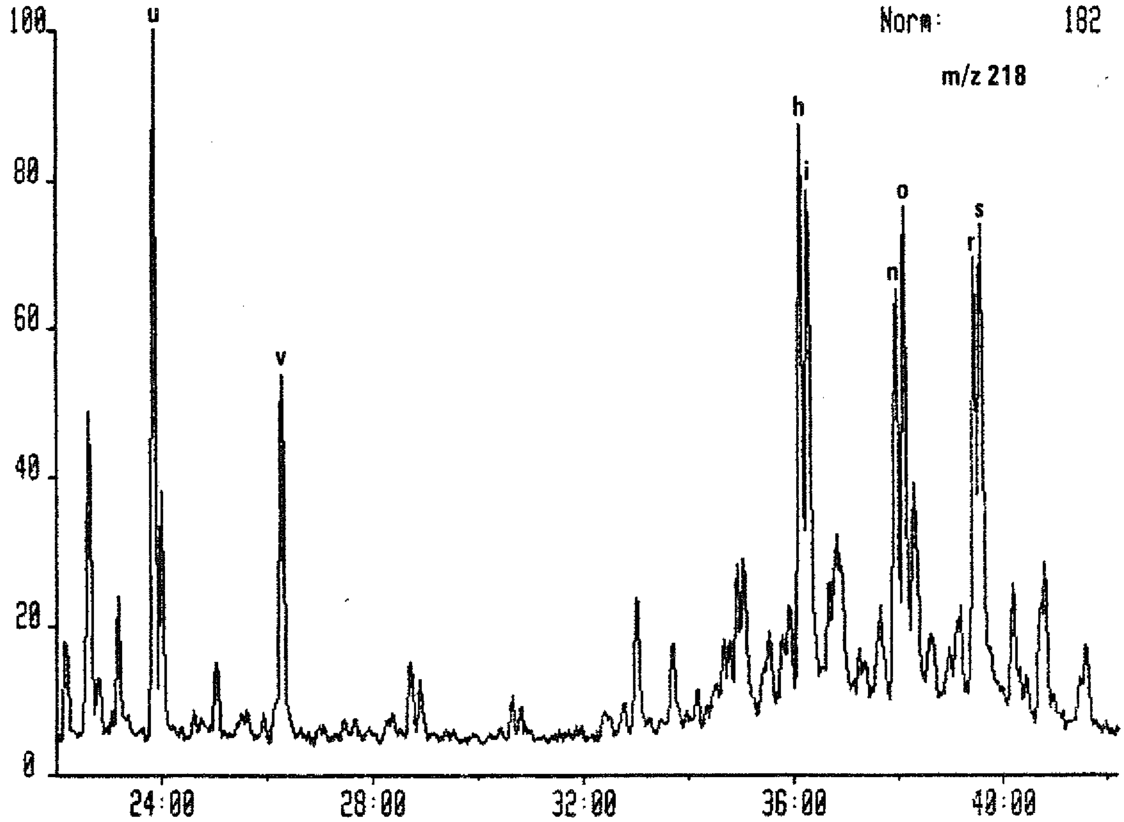
C6007SAT 2-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 218.1000
Text:



C6006SAT 2-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 217.1000
Text:



C6006SAT 2-MAR-87 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 218.1000
Text:



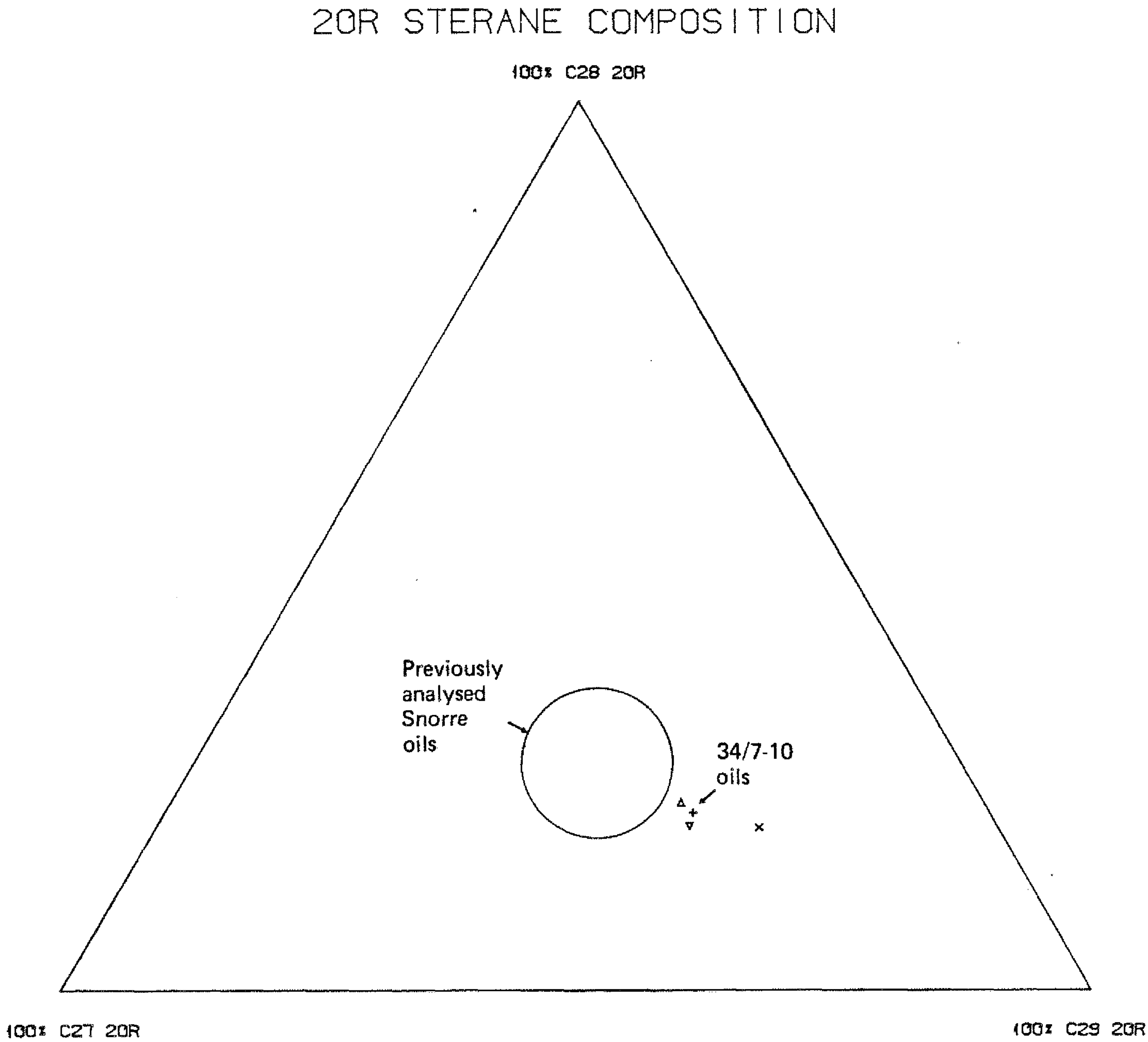


Figure 13: 5α 20R sterane composition of the 34/7-10 oils.

Figure 14:

Mass chromatograms representing aromatic hydrocarbons

TIC:	Total Ion Current chromatogram
m/z 92,106:	alkylbenzenes
m/z 142,156,170:	alkylnaphthalenes
m/z 178,192,206:	phenanthrene and alkylphenanthrenes
m/z 184,198,212:	dibenzothiophene and alkyldibenzothiophenes
m/z 231:	triaromatic steranes
m/z 253:	monoaromatic steranes

Mass chromatograms representing monoaromatic (m/z 239 and 253) and triaromatic (m/z 231) steranes.

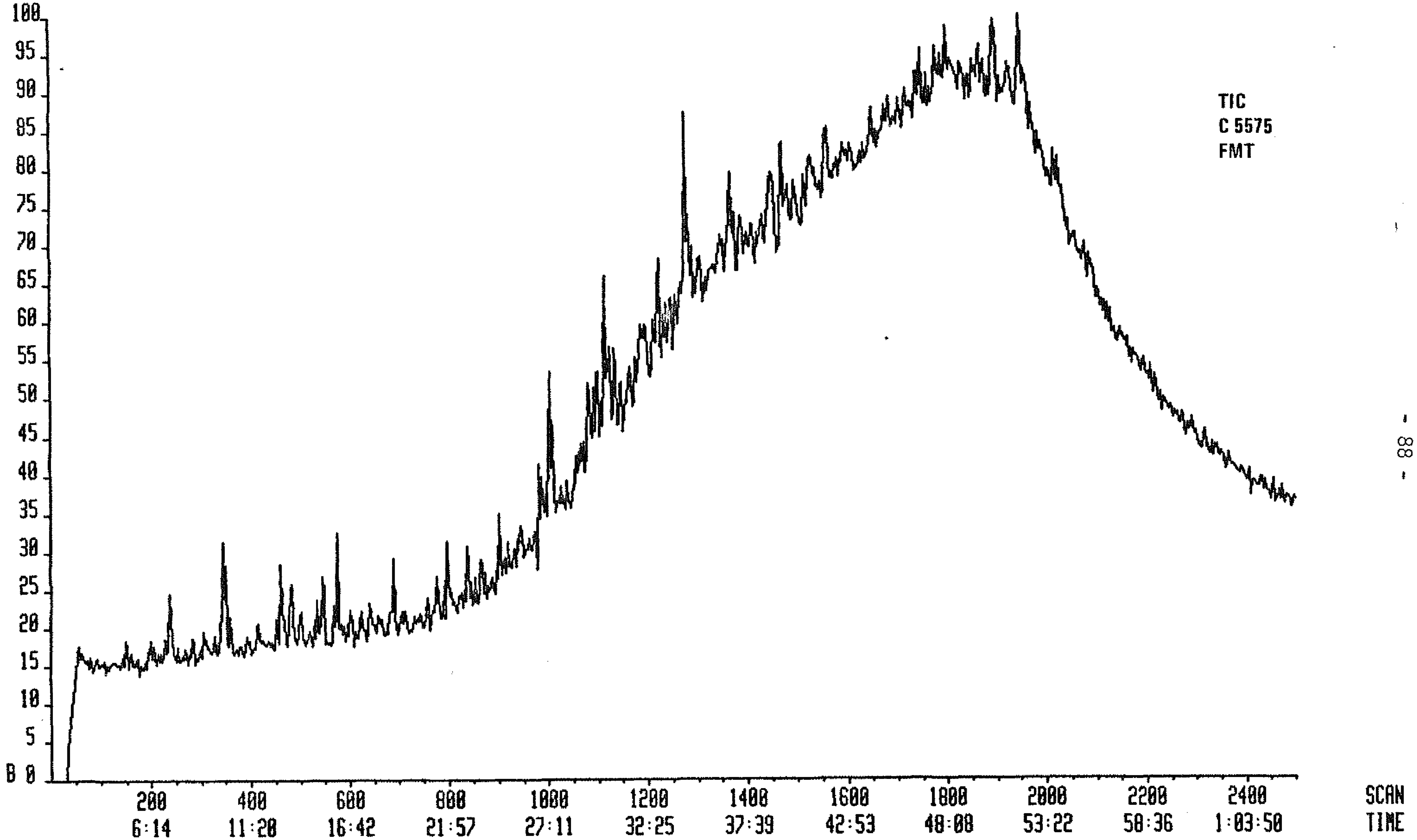
m/z 253

a - C_{21} monoaromatic sterane
b - C_{22} monoaromatic sterane
c - unidentified
d - C_{27} monoaromatic sterane
e - C_{27} monoaromatic sterane
f - C_{28} monoaromatic sterane
g - C_{27} monoaromatic sterane
h - C_{28} + C_{29} monoaromatic sterane
i - C_{29} monoaromatic sterane
j - C_{29} monoaromatic sterane
k - unidentified
l - unidentified

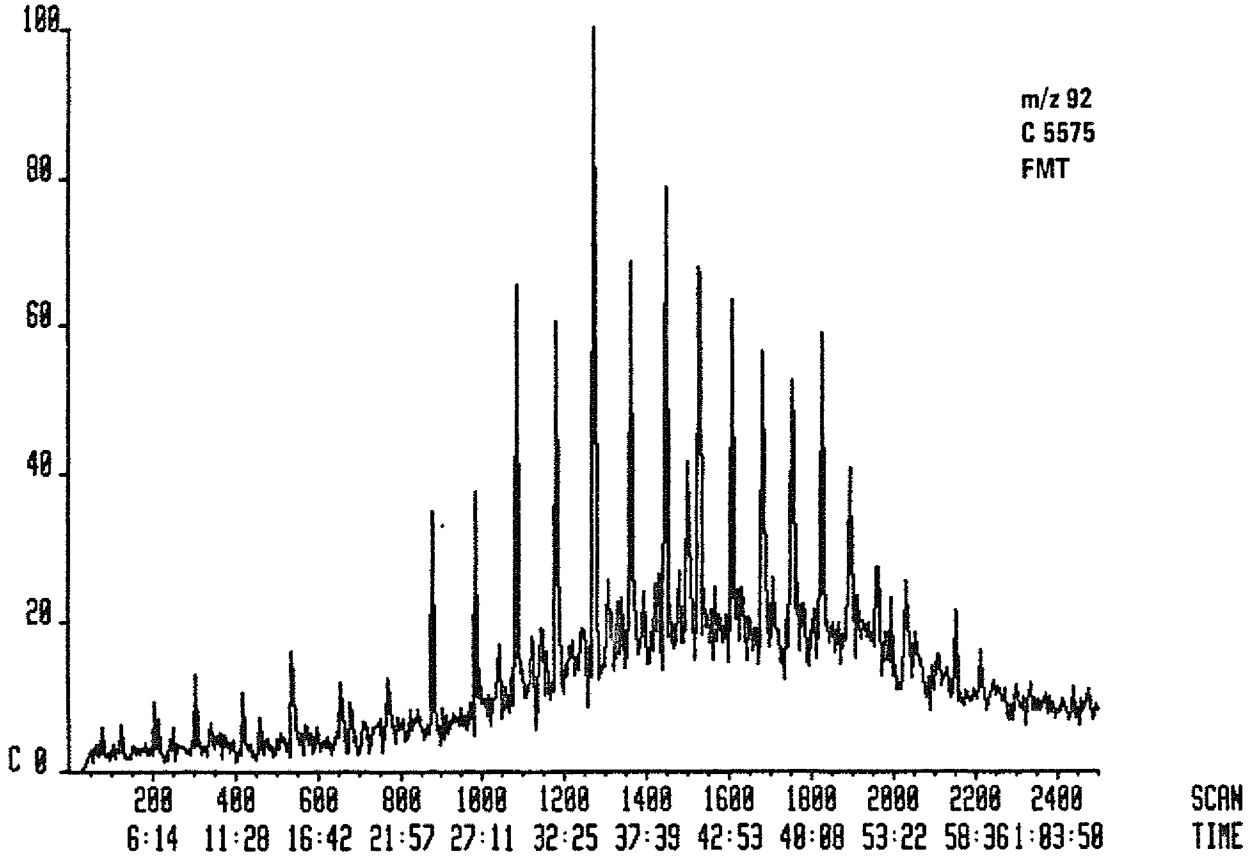
m/z 231

M - C_{20} triaromatic sterane
N - C_{21} triaromatic sterane
O - C_{26} triaromatic sterane
P - C_{26} + C_{27} triaromatic sterane
Q - C_{28} triaromatic sterane
R - C_{27} triaromatic sterane
S - C_{28} triaromatic sterane

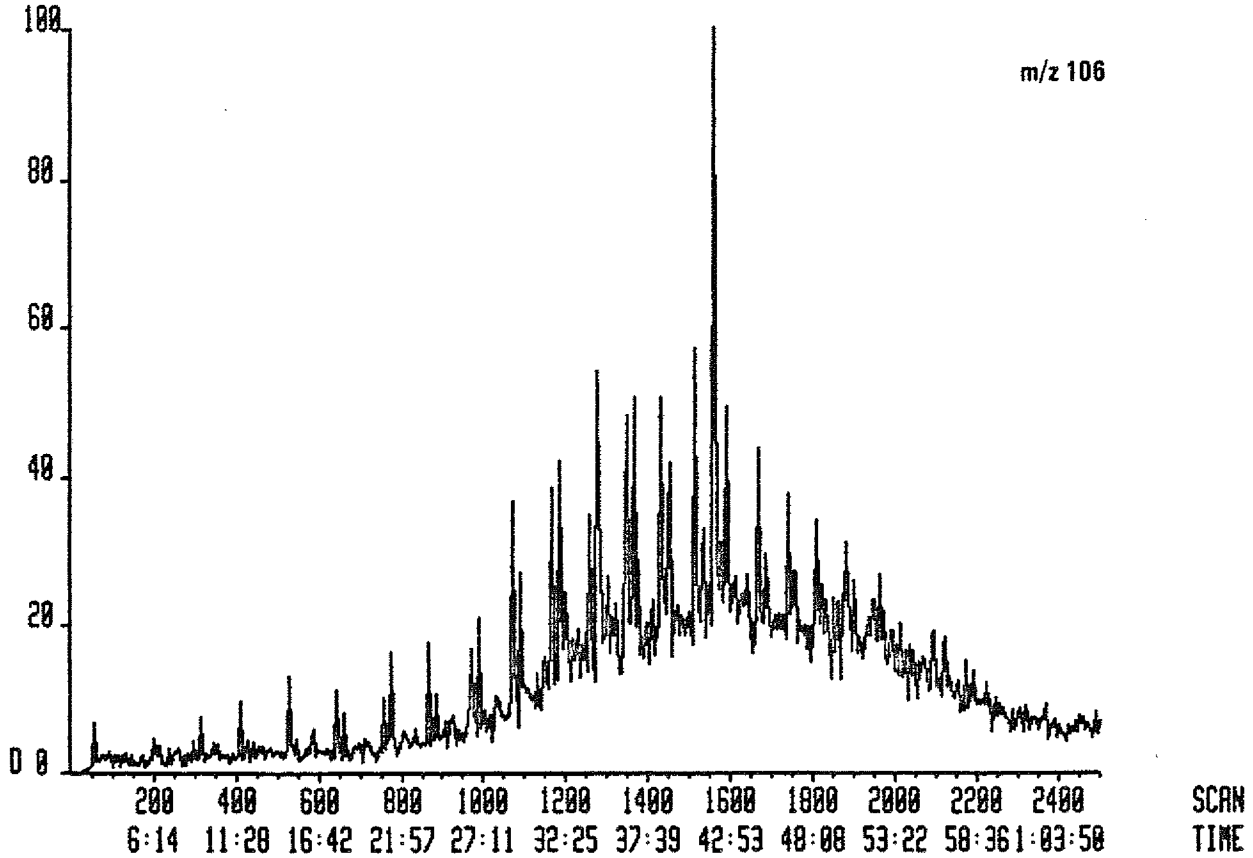
C5575AR01 #1-2500 8-DEC-86 15:08 7070H acnt:IKU System:AR070 IHP
Chromatogram Identifiers : B1:TIC B: 274032000
Text:



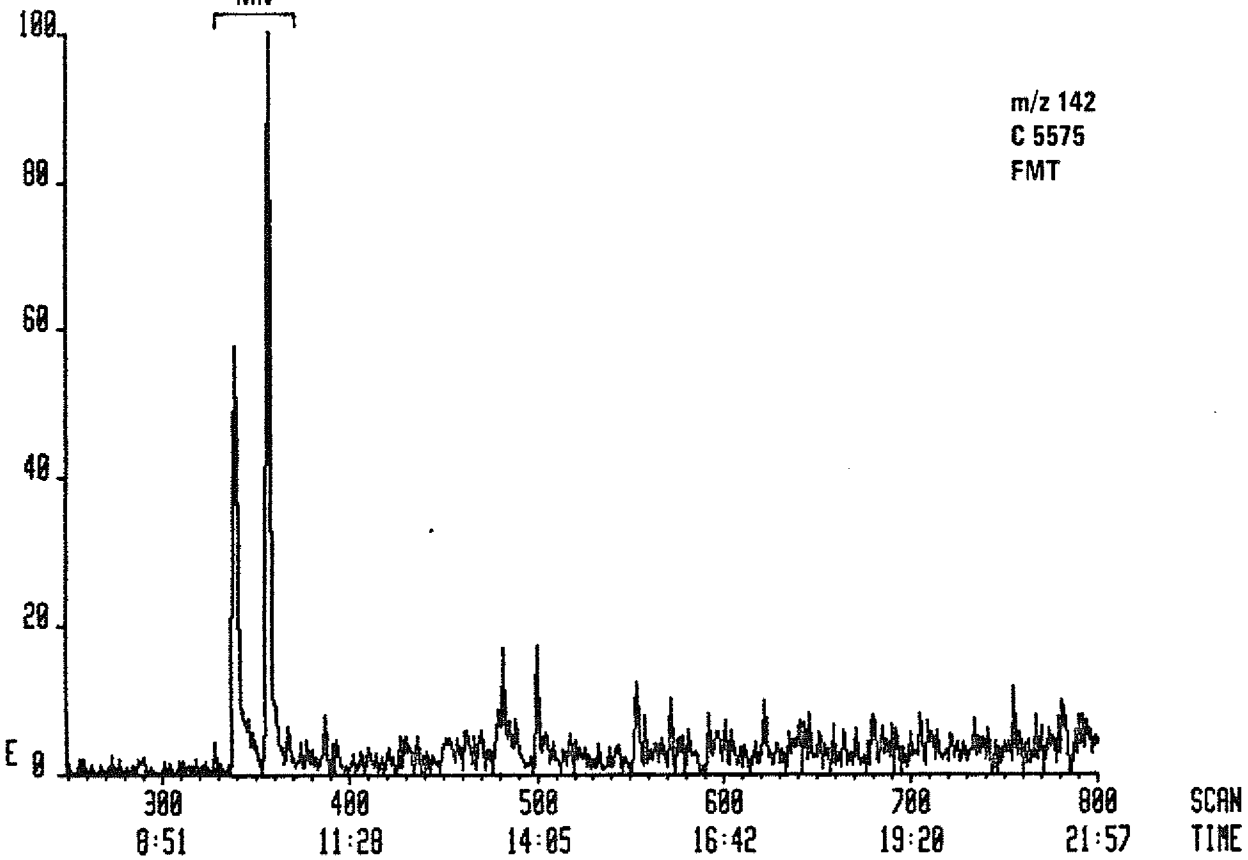
C5575AR01 #1-2500 8-DEC-86 15:08 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : C1:92 C: 5904000
Text:



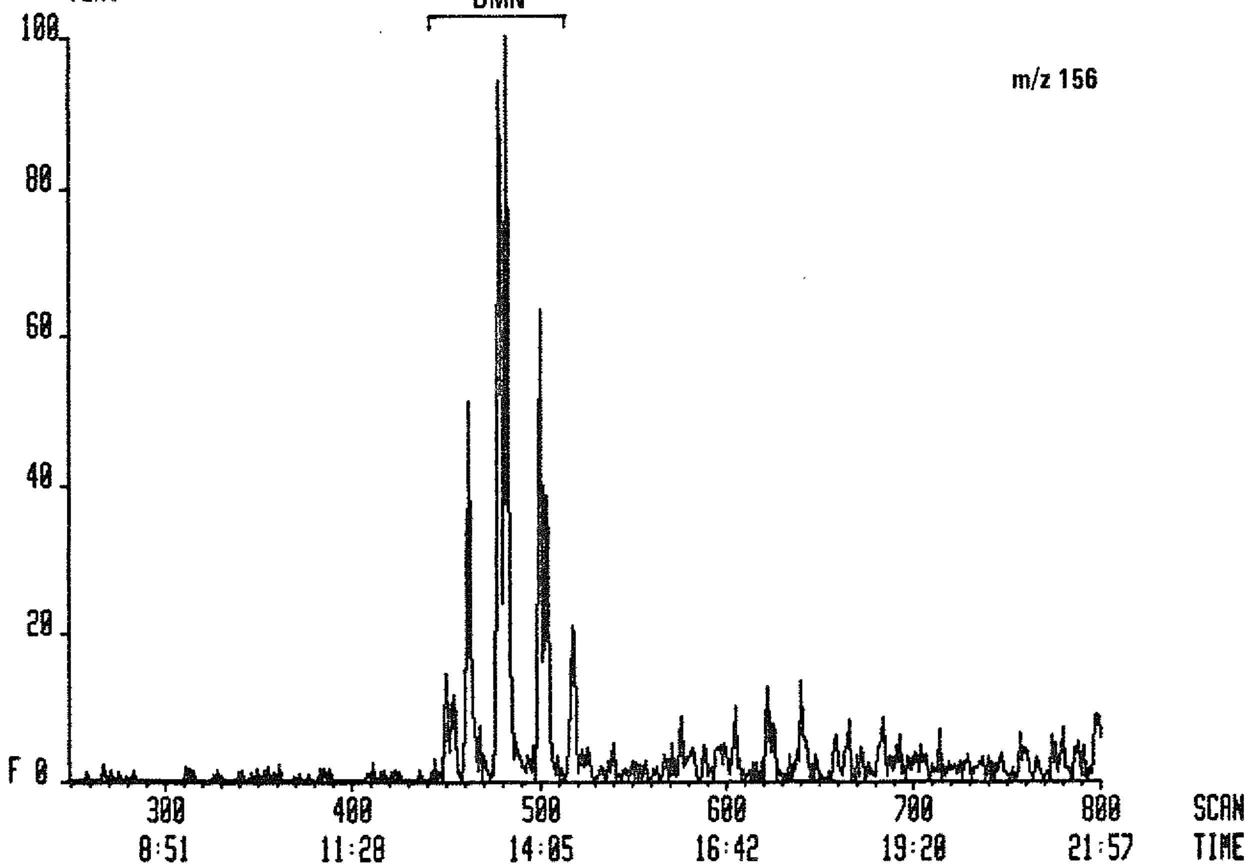
C5575AR01 #1-2500 8-DEC-86 15:08 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : D1:106 D: 9205000
Text:



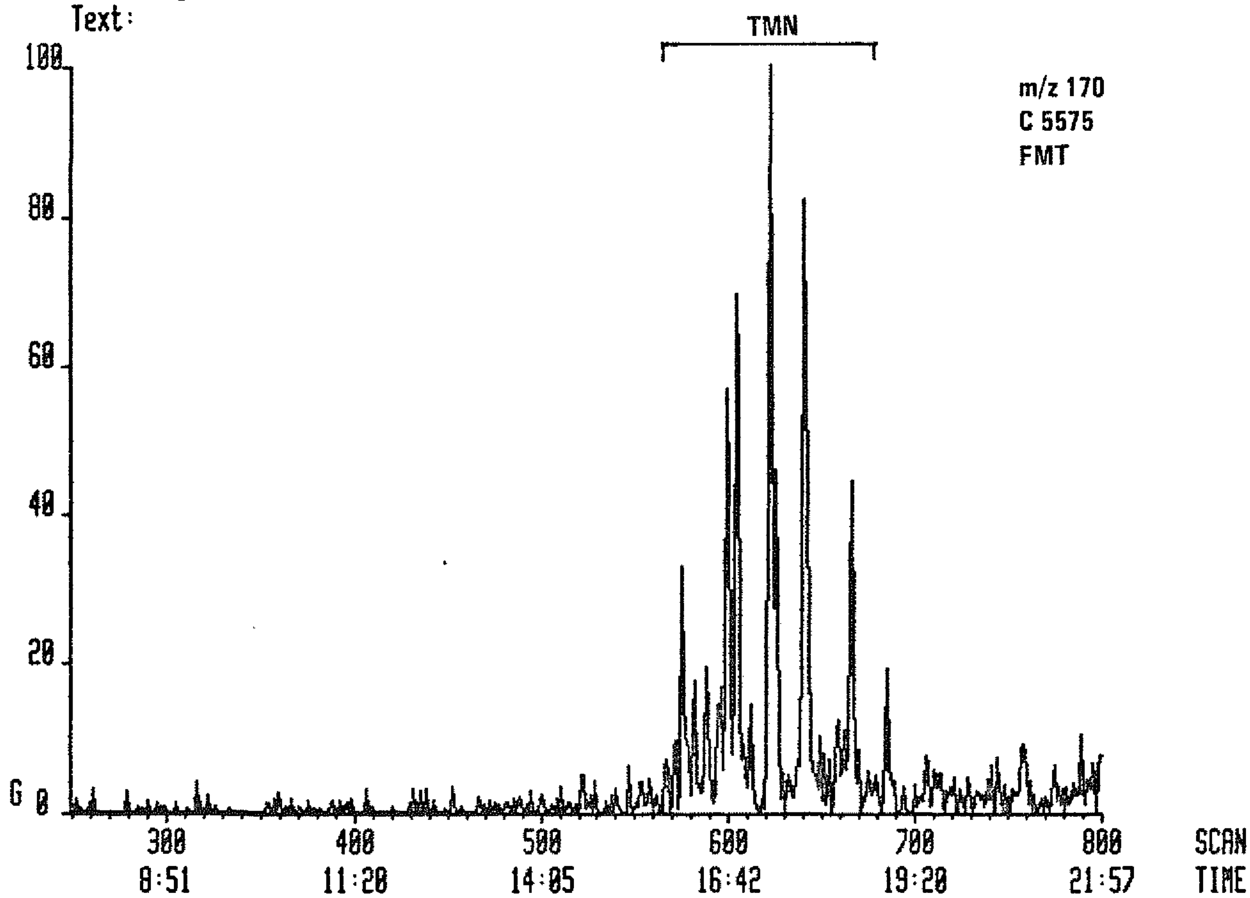
C5575AR01 #250-800   8-DEC-86 15:08 7070H   acnt:IKU   System:AR070HP
Chromatogram Identifiers :   E1:142   E: 3920000
Text:



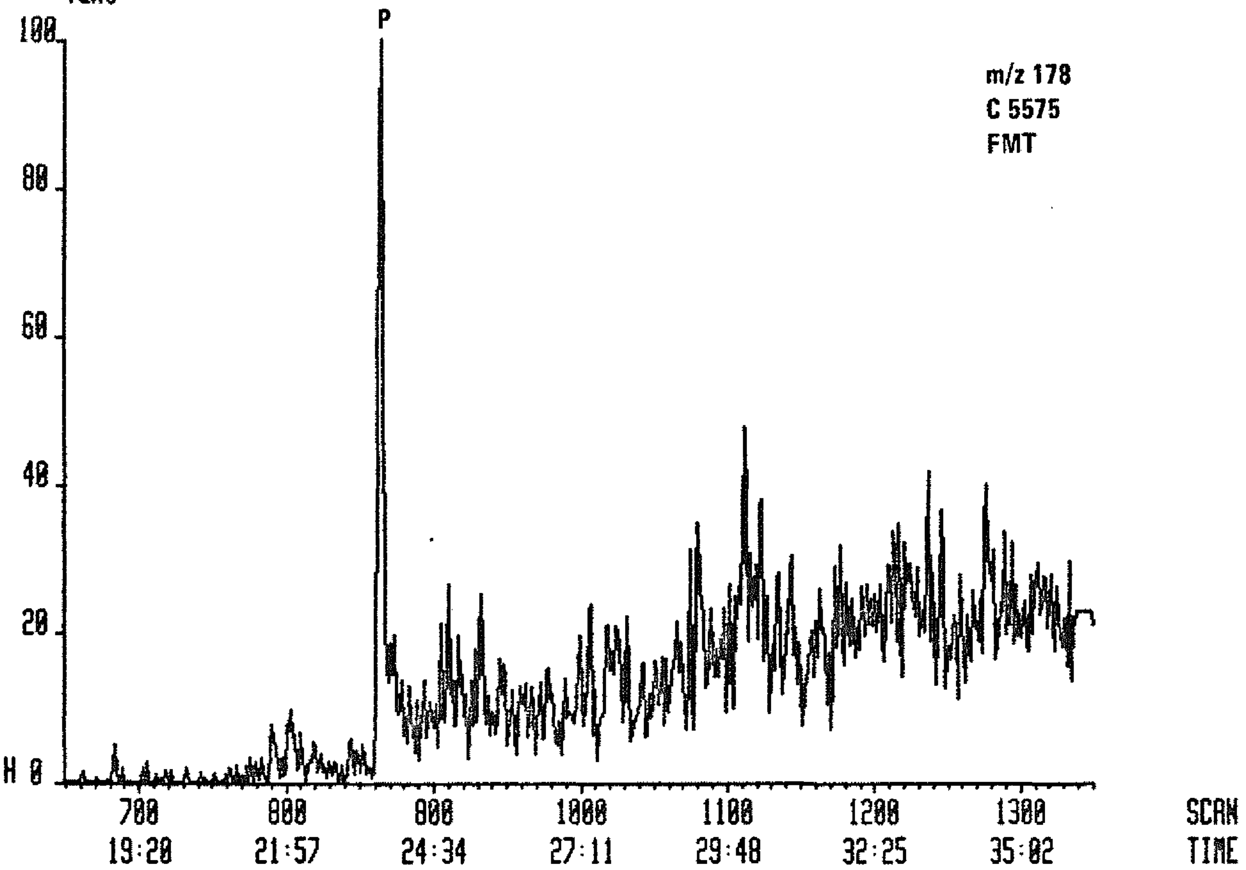
C5575AR01 #250-800   8-DEC-86 15:08 7070H   acnt:IKU   System:AR070HP
Chromatogram Identifiers :   F1:156   F: 4370000
Text:



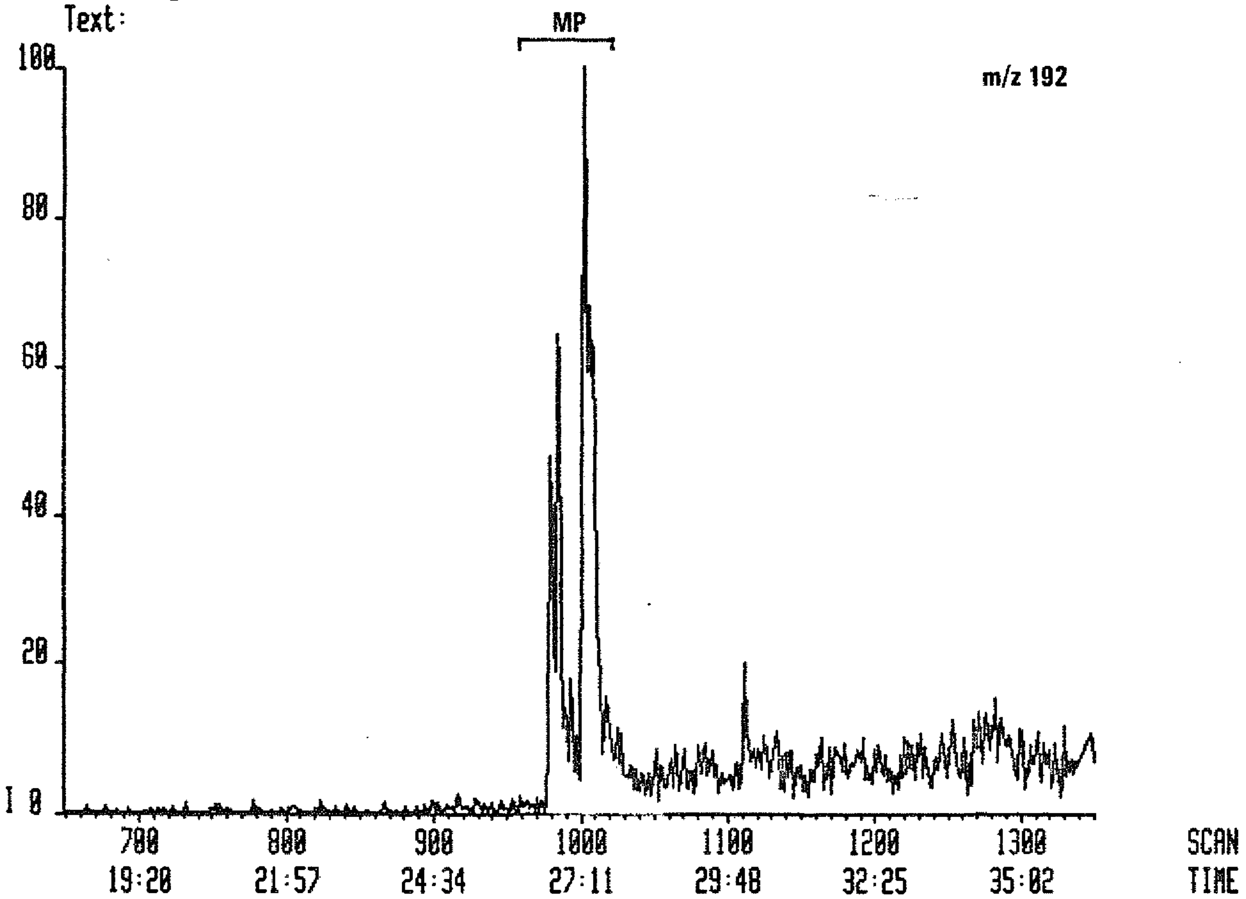
C5575AR01 #250-800 8-DEC-86 15:08 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : G1:170 G: 3559000
Text:



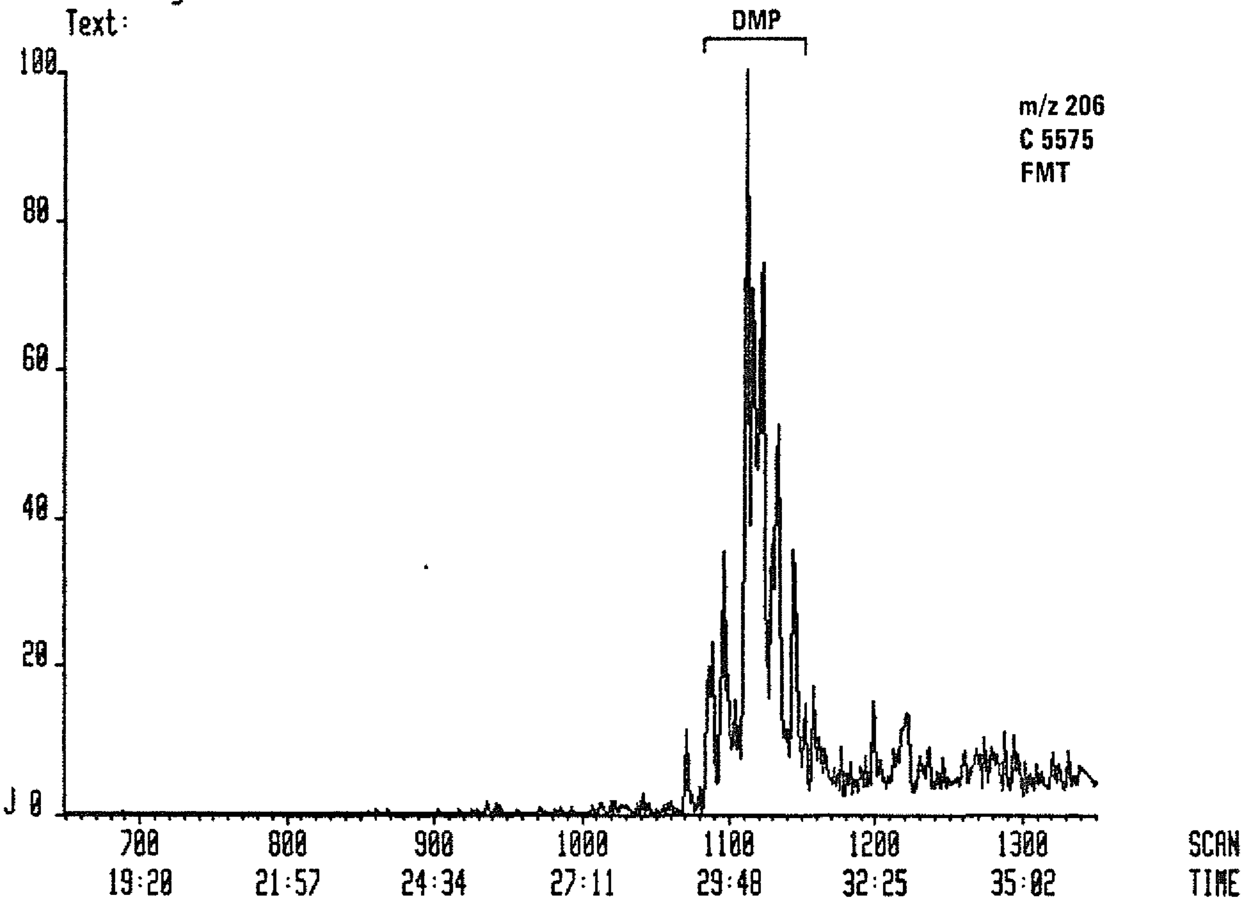
C5575AR01 #650-1350 8-DEC-86 15:08 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : H1:178 H: 4530000
Text:



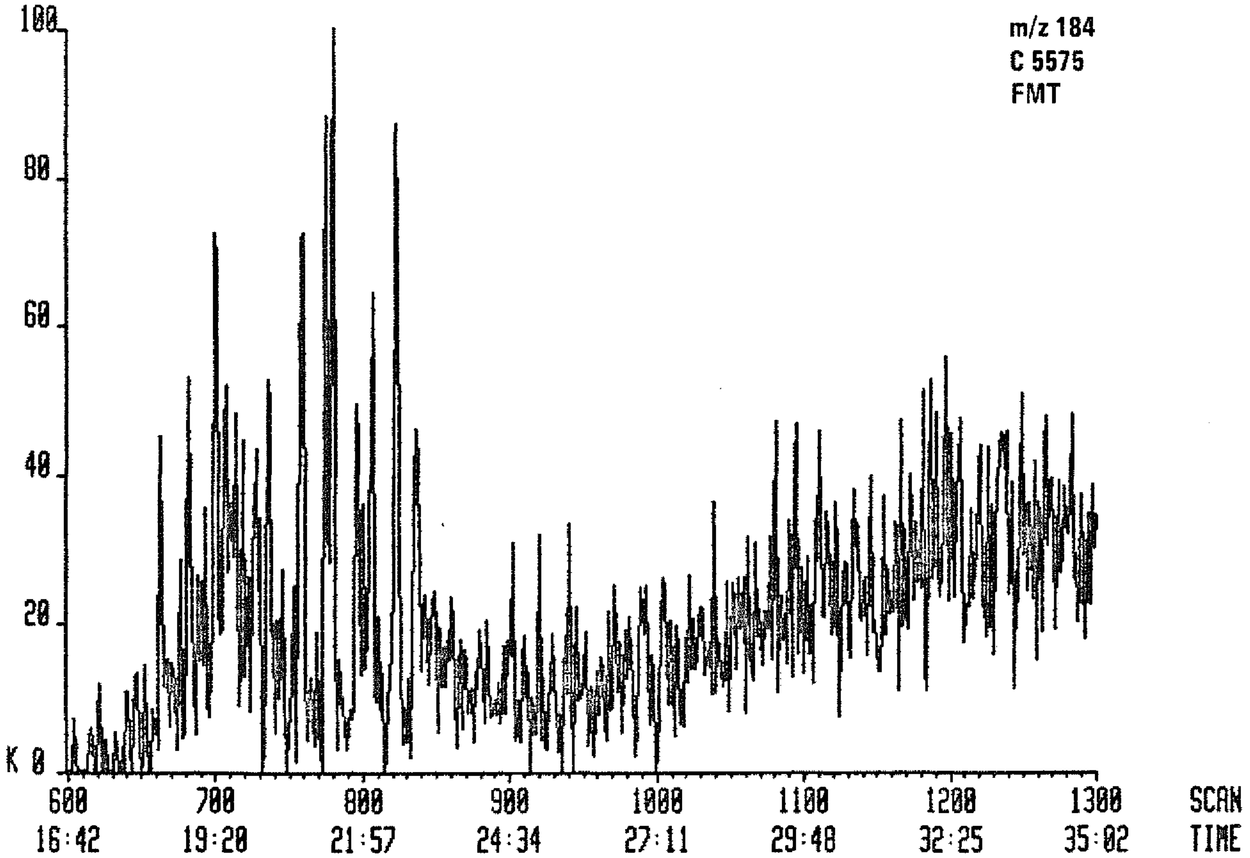
C5575AR01 #650-1350 8-DEC-86 15:08 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : I1:192 I: 8159000
Text:



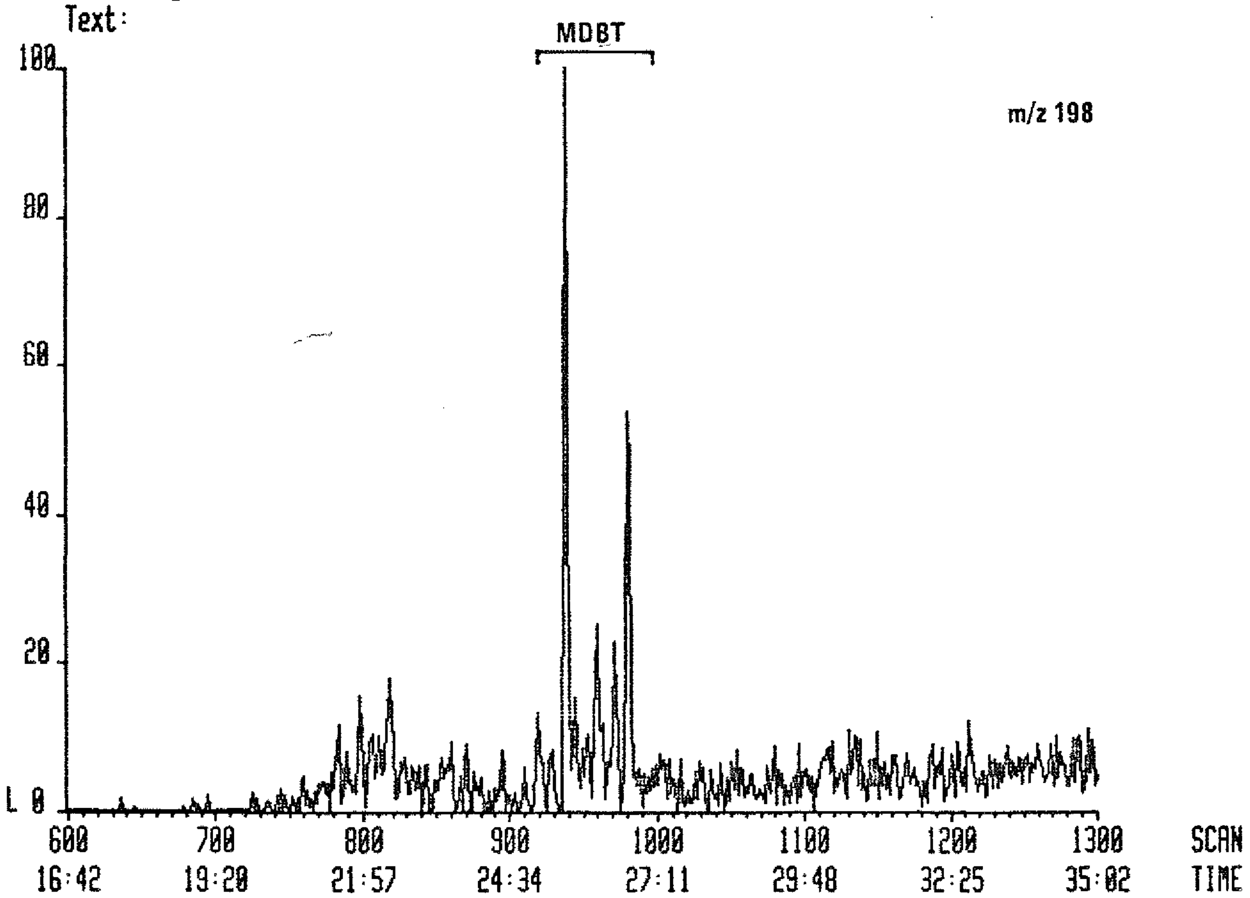
C5575AR01 #650-1350 8-DEC-86 15:08 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : J1:206 J: 8971000
Text:

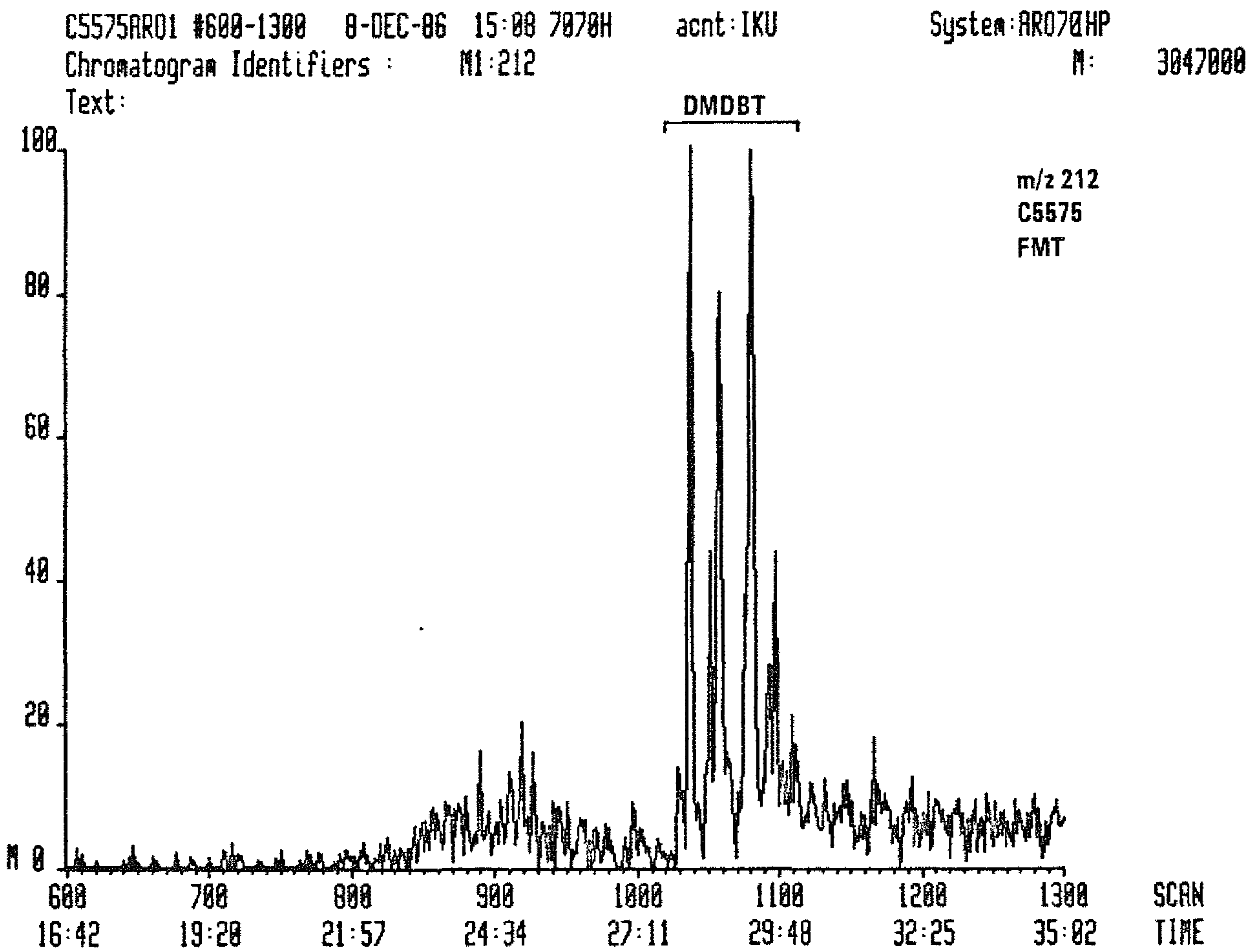


C5575AR01 #600-1300 8-DEC-86 15:08 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : K1:184 K: 1193000
Text:

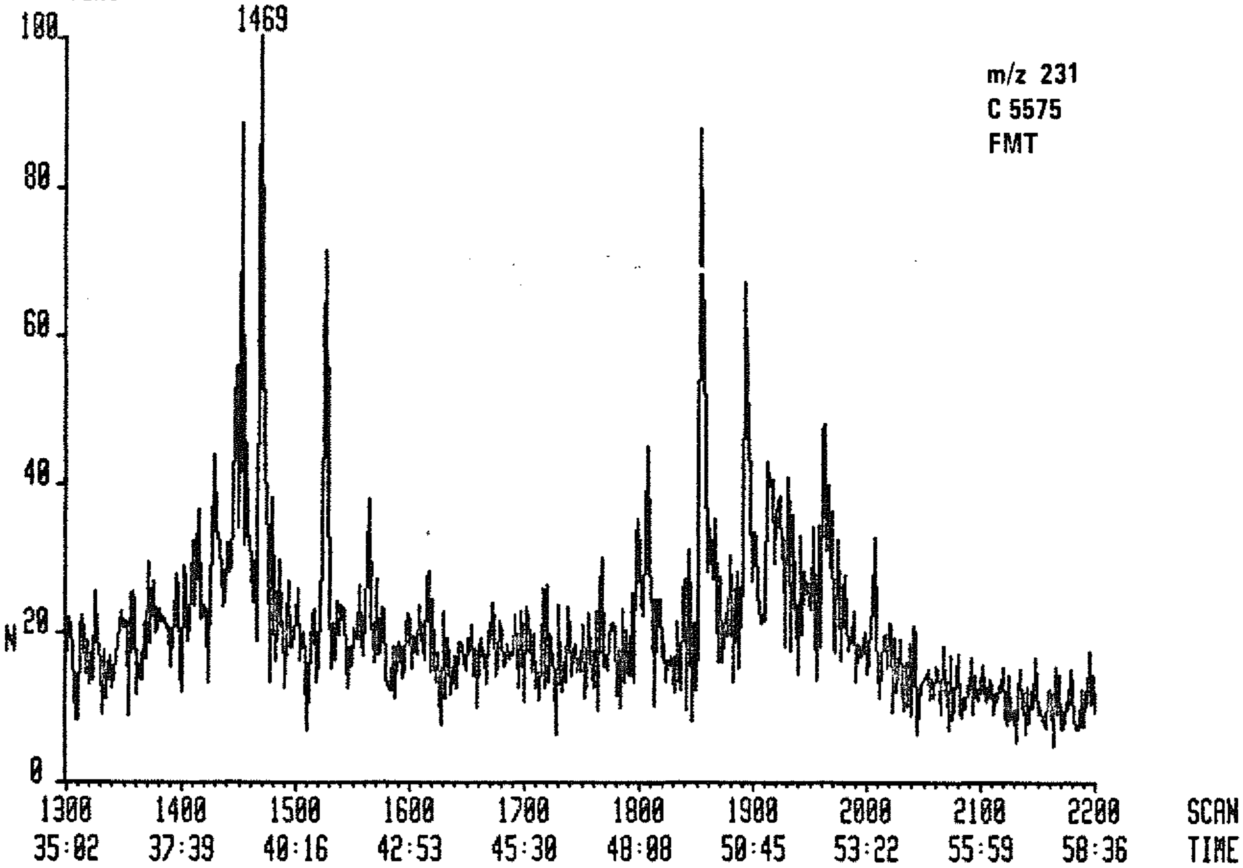


C5575AR01 #600-1300 8-DEC-86 15:08 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : L1:198 L: 3751000
Text:

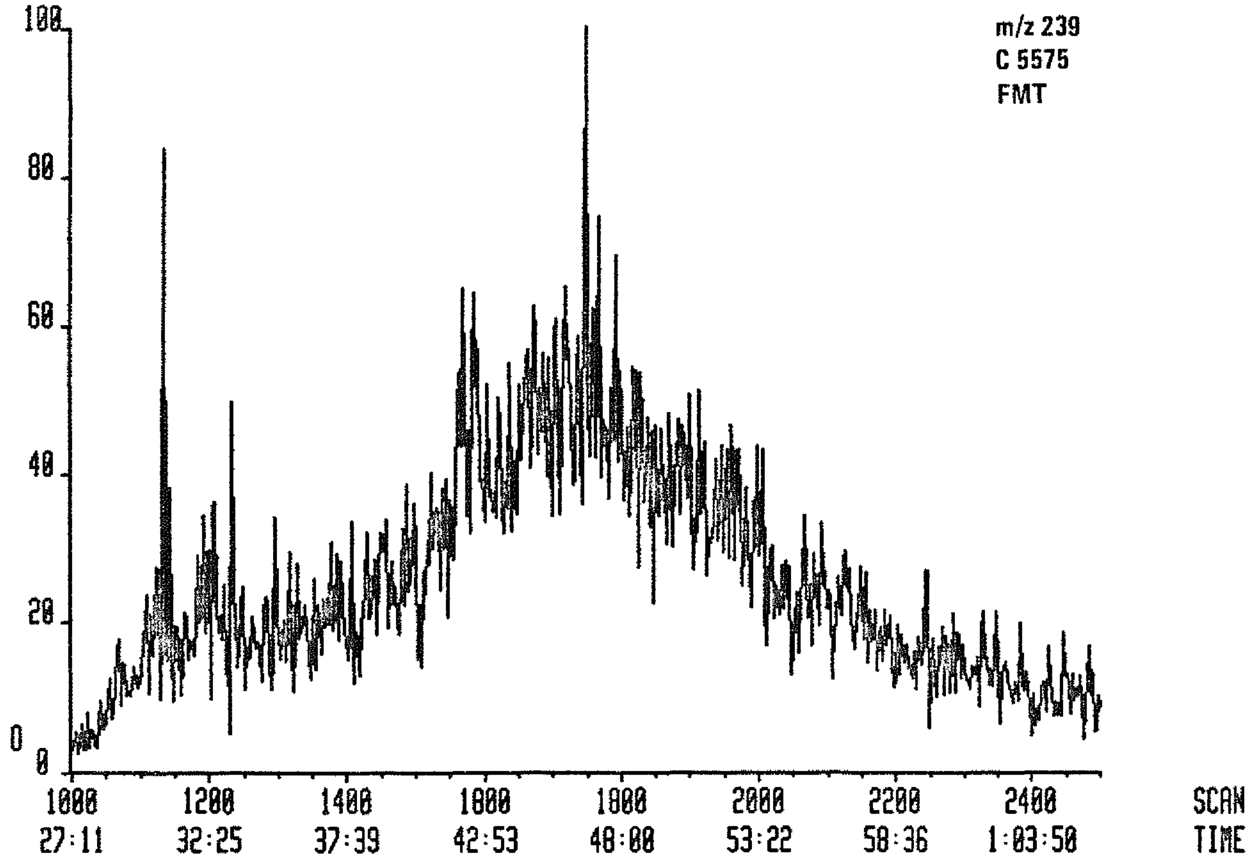



C5575AR01 #600-1300 8-DEC-86 15:08 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : M1:212 M: 3047000
Text:
DMDBT
m/z 212
C5575
FMT
100
80
60
40
20
M 0
600 700 800 900 1000 1100 1200 1300 SCAN
16:42 19:20 21:57 24:34 27:11 29:48 32:25 35:02 TIME

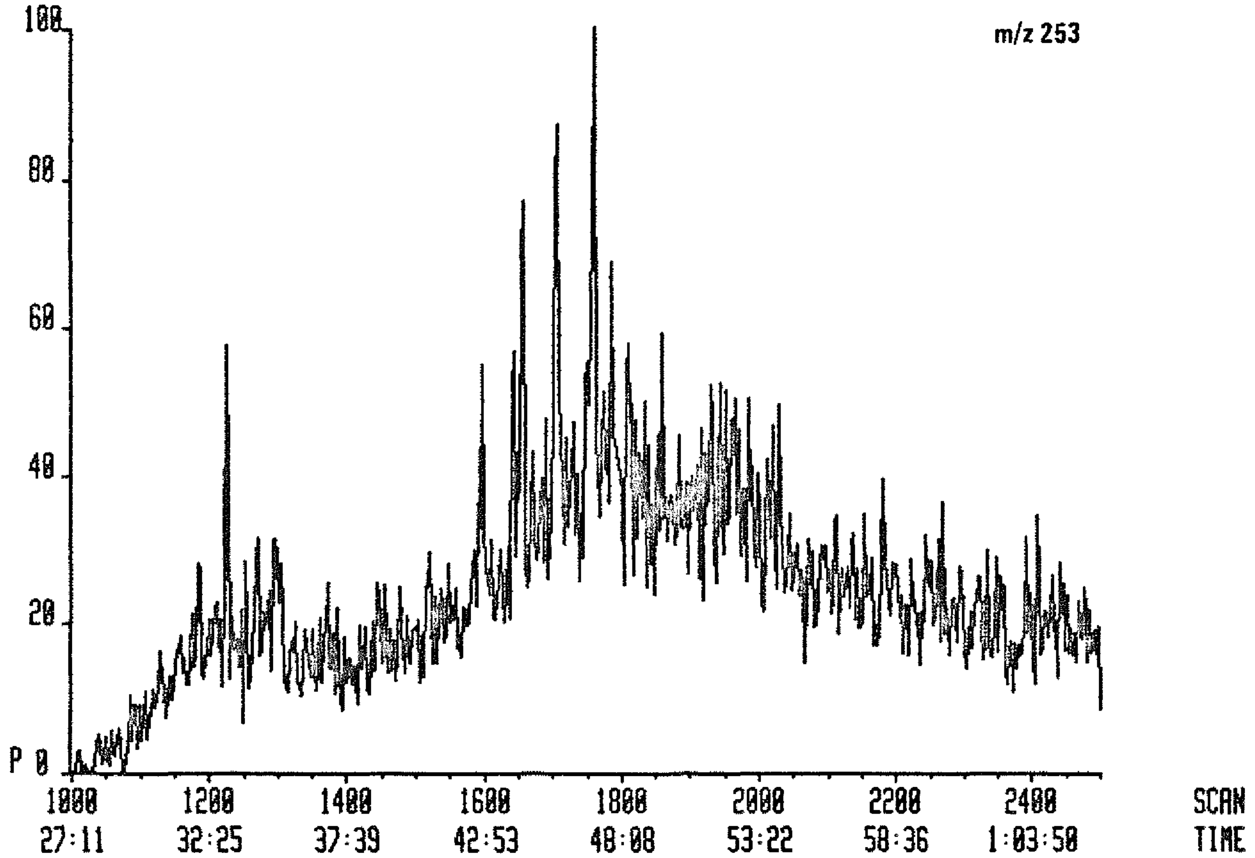
C5575AR01 #1300-2200 8-DEC-86 15:00 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : N1:231 N: 5043000
Text:



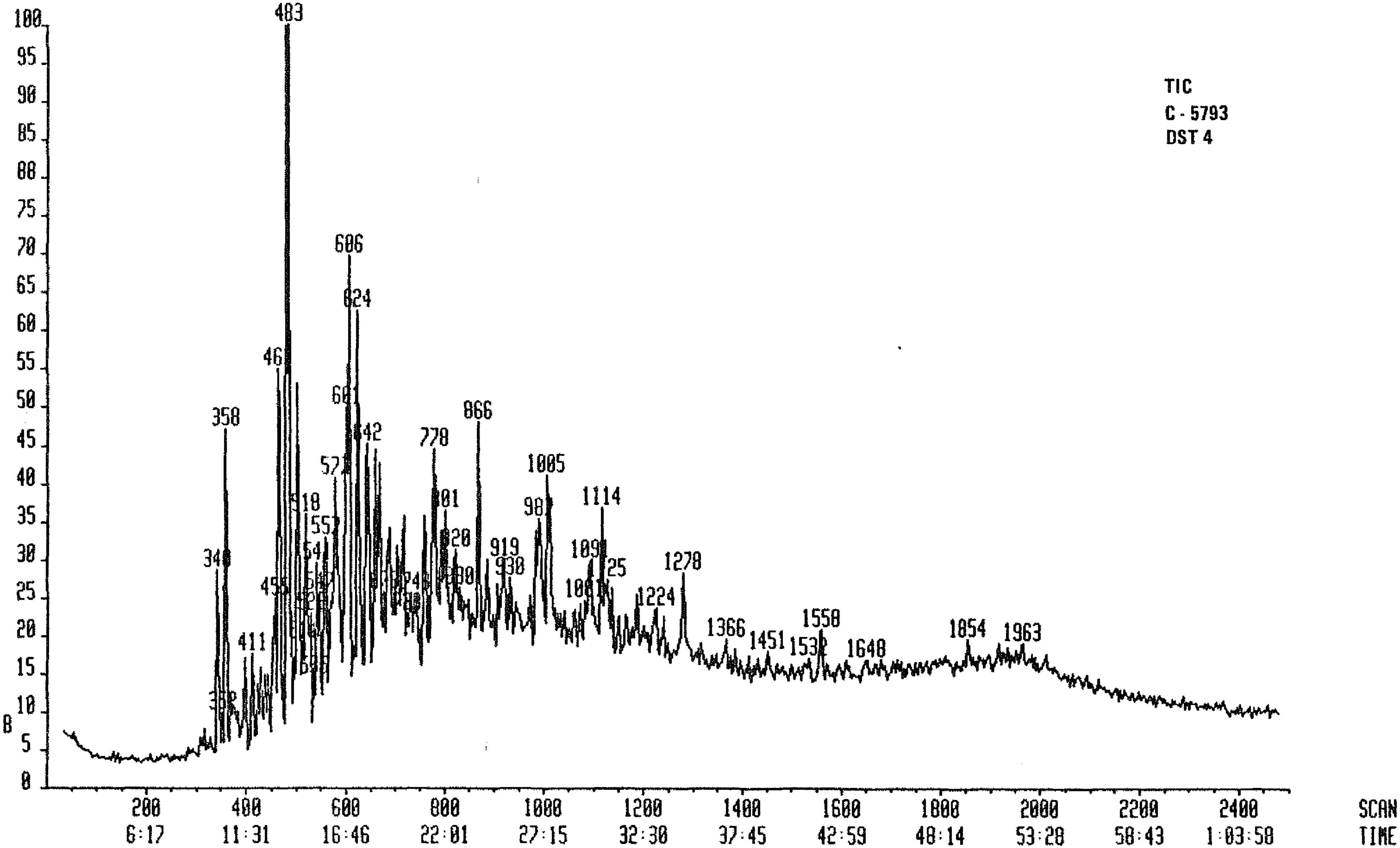
C5575AR01 #1000-2500 8-DEC-86 15:08 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : 01:239 0: 2162000
Text:



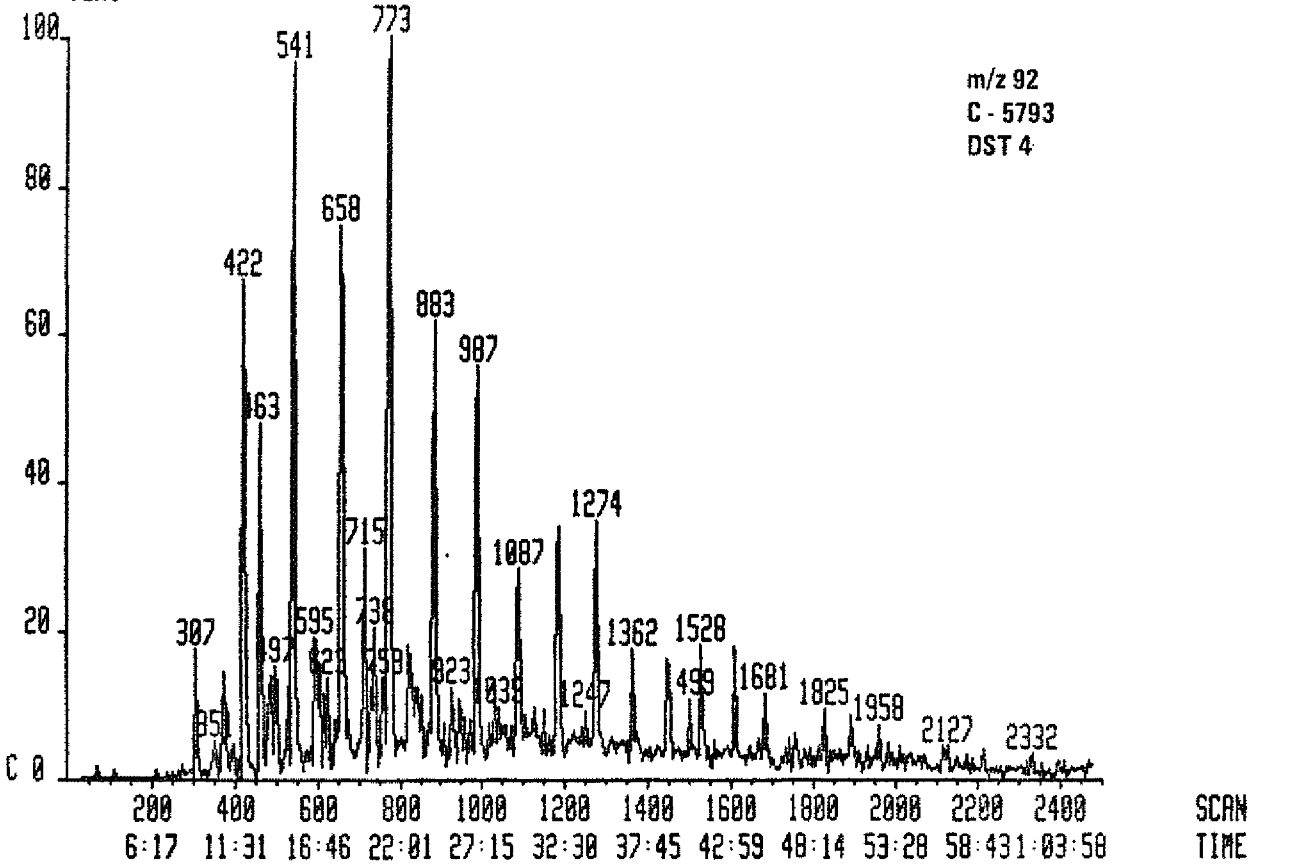
C5575AR01 #1000-2500 8-DEC-86 15:08 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : P1:253 P: 2271000
Text:



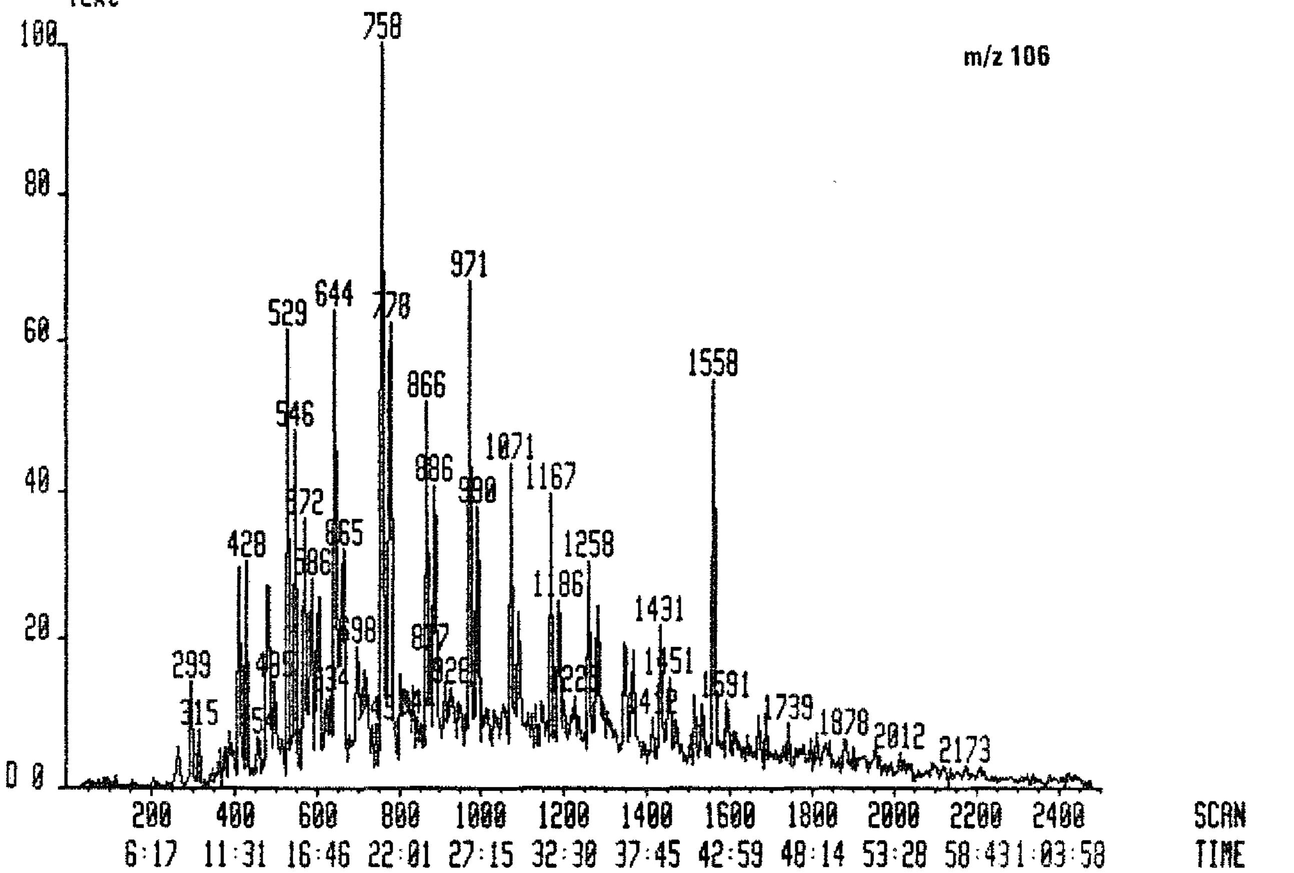
C5793ARO #1-2478 2-MAR-87 14:52 7070H acnt:IKU System:ARO70 IHP
Chromatogram Identifiers : 01:TIC B: 296534016
Text:



C5793ARO #1-2478 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : C1:92 C: 10595000
Text:

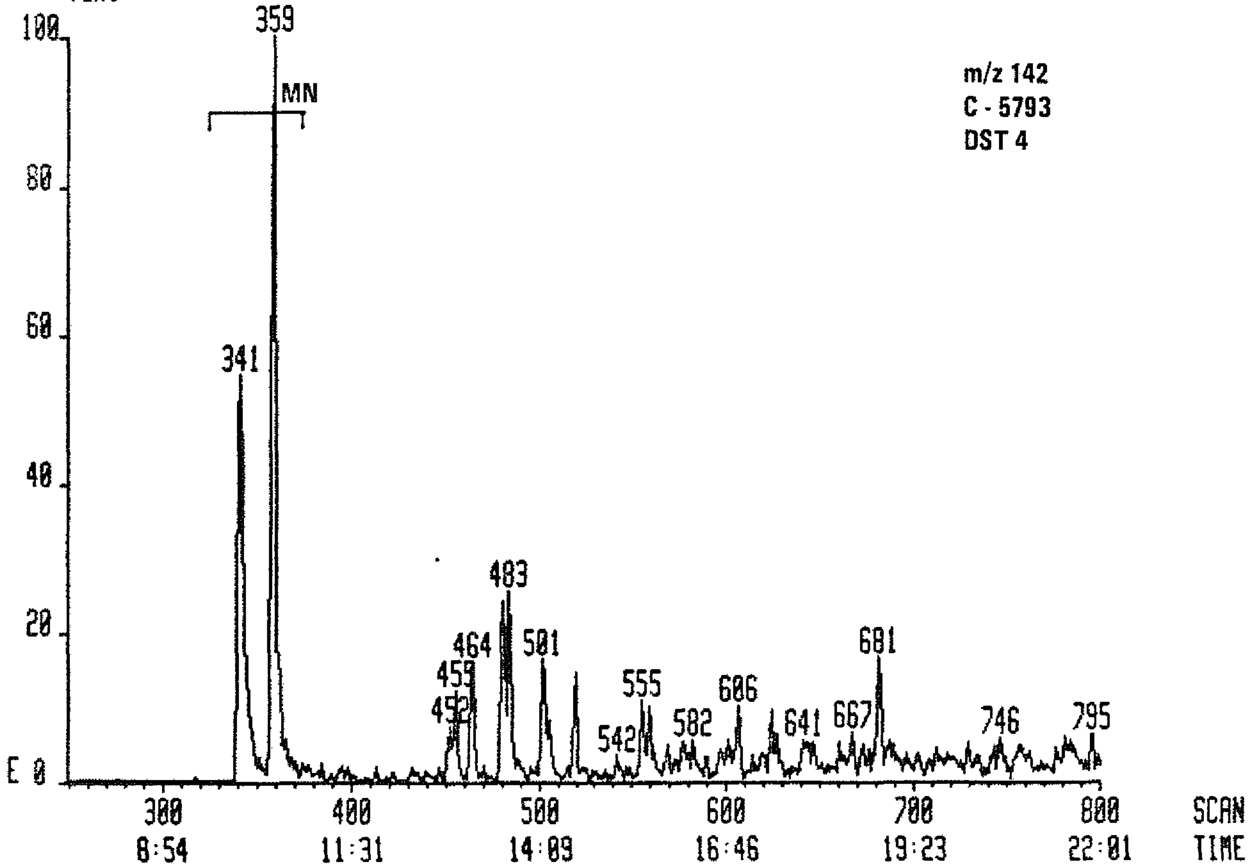


C5793ARO #1-2478 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : D1:106 D: 13227000
Text:

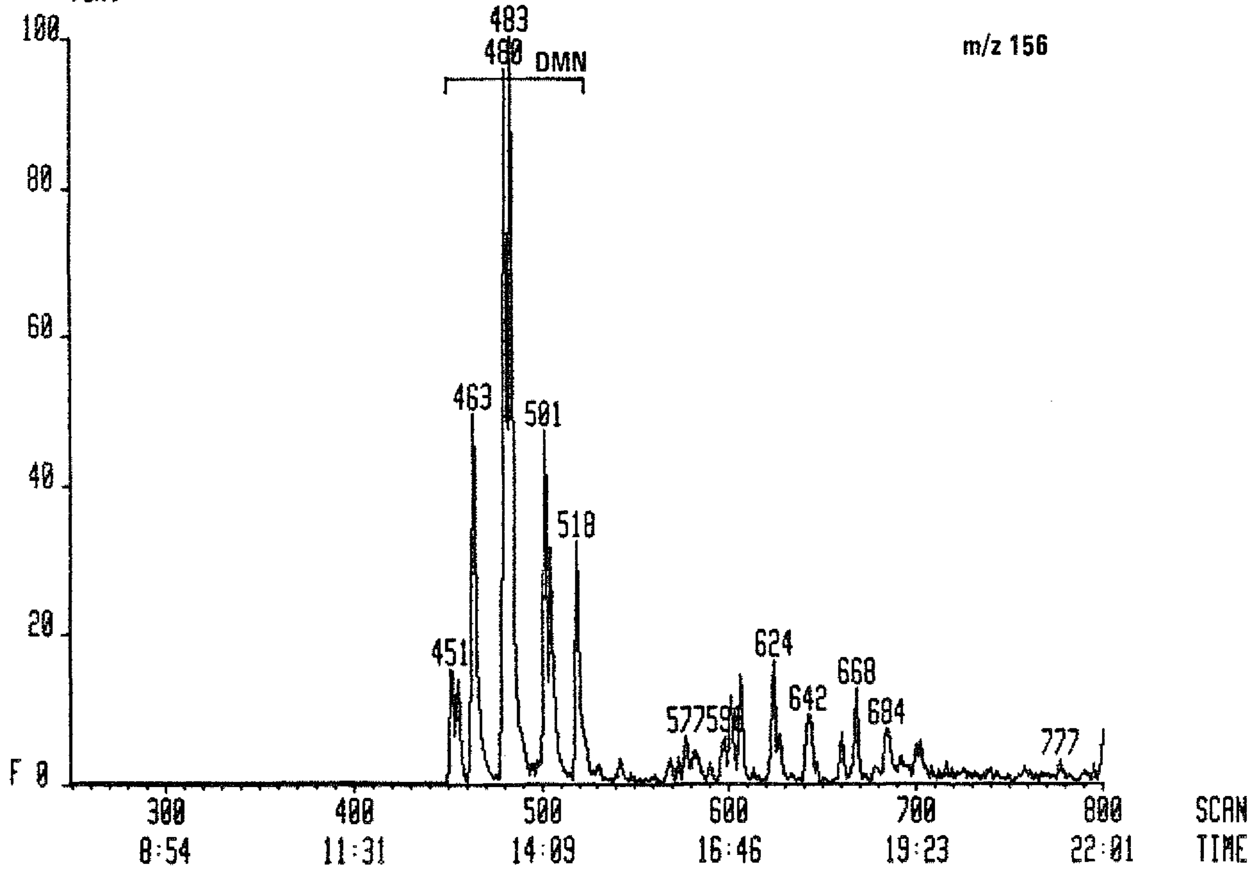


IKU SINTEF-GRUPPEN

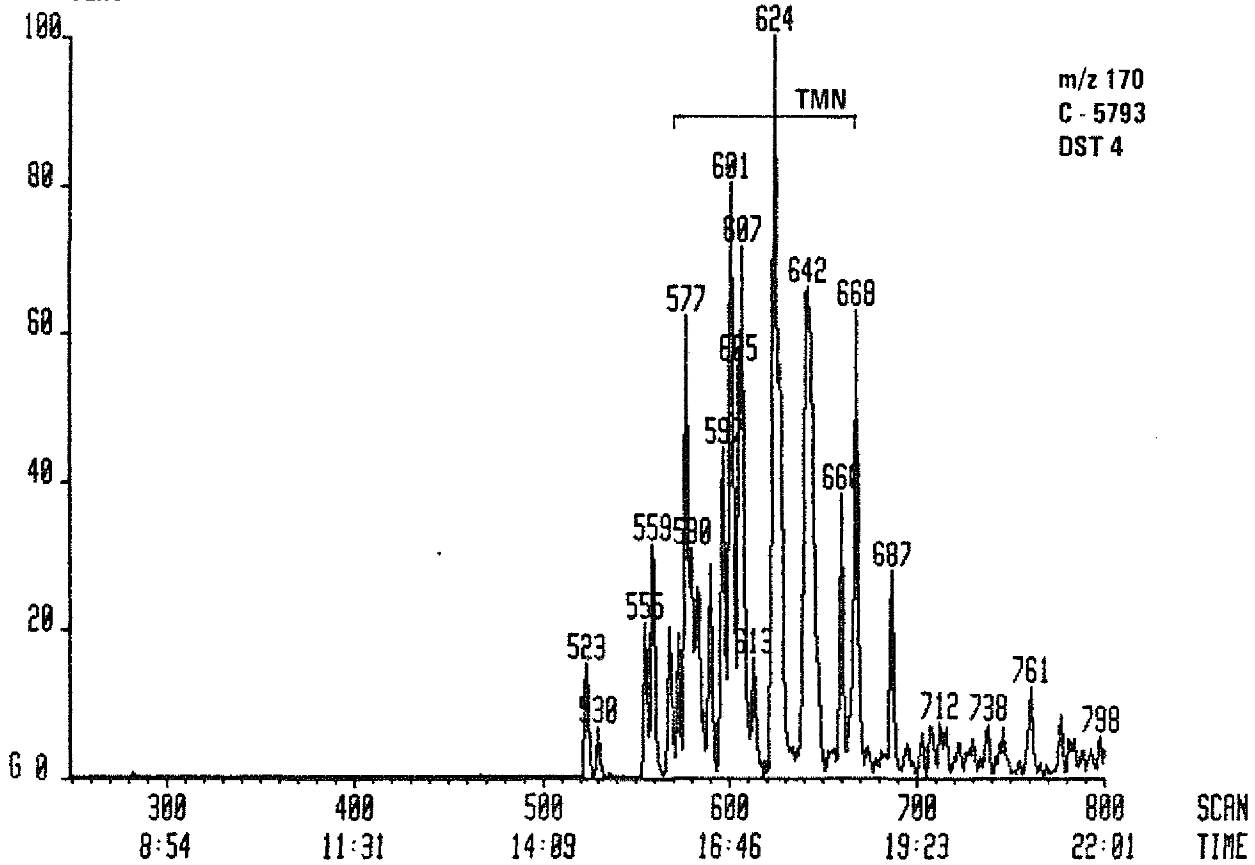
C5793ARO #250-800 2-MAR-87 14:52 7070H acnt:IKU System:ARO70ØHP
Chromatogram Identifiers : E1:142 E: 24544000
Text:



C5793ARO #250-800 2-MAR-87 14:52 7070H acnt:IKU System:ARO70ØHP
Chromatogram Identifiers : F1:156 F: 35951000
Text:

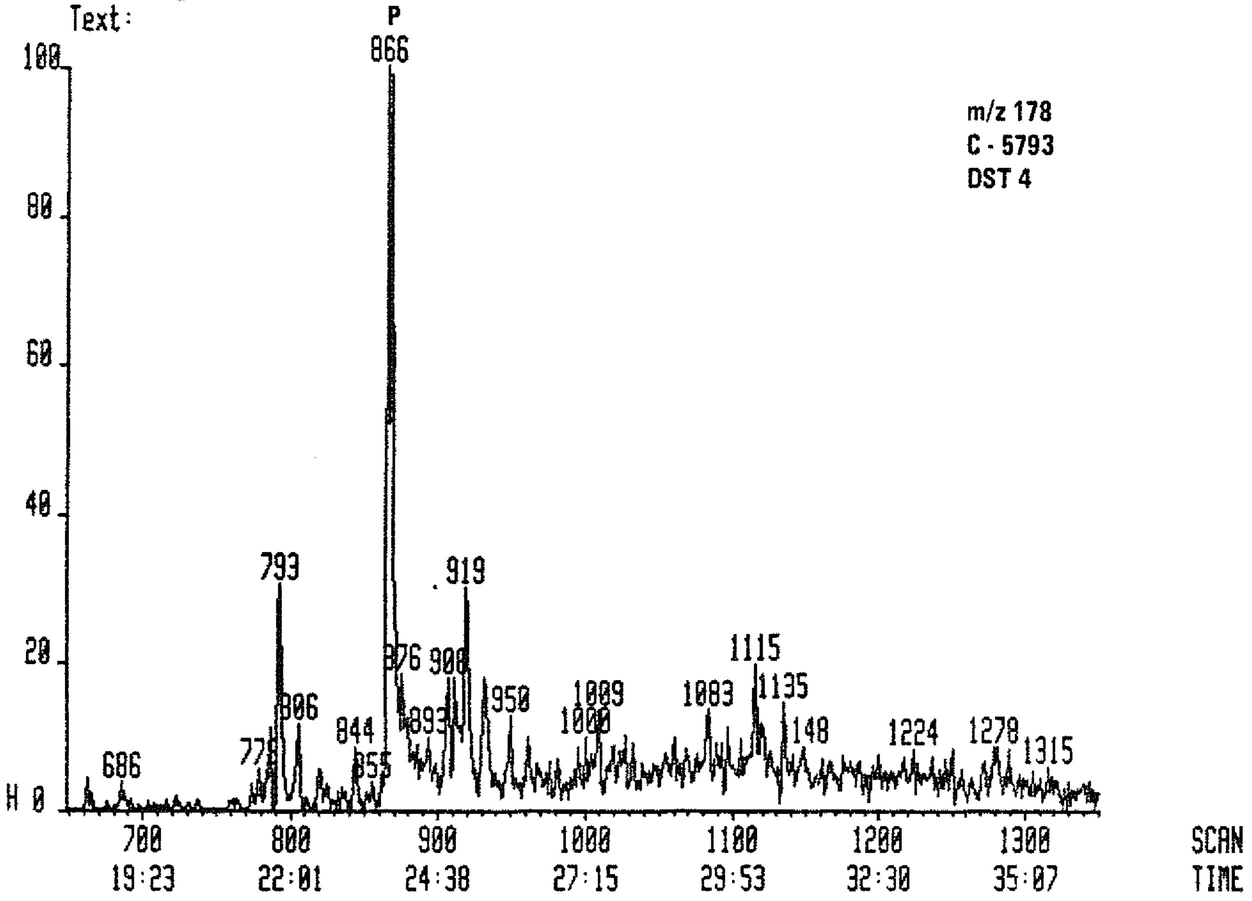


C5793ARO #250-800 2-MAR-87 14:52 7070H acnt:IKU System:ARO70AP
Chromatogram Identifiers : G1:170 G: 16590000
Text:

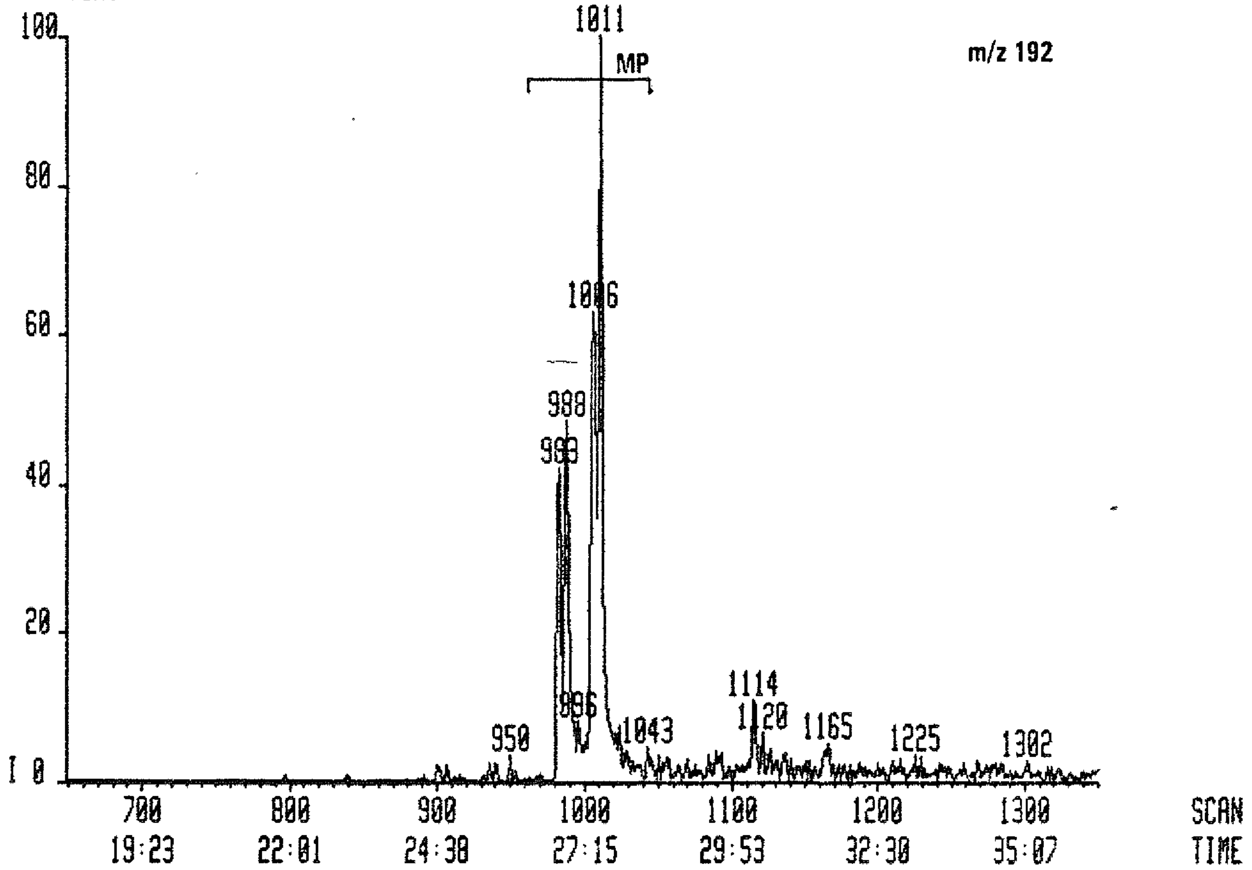


IKU SINTEF-GRUPPEN

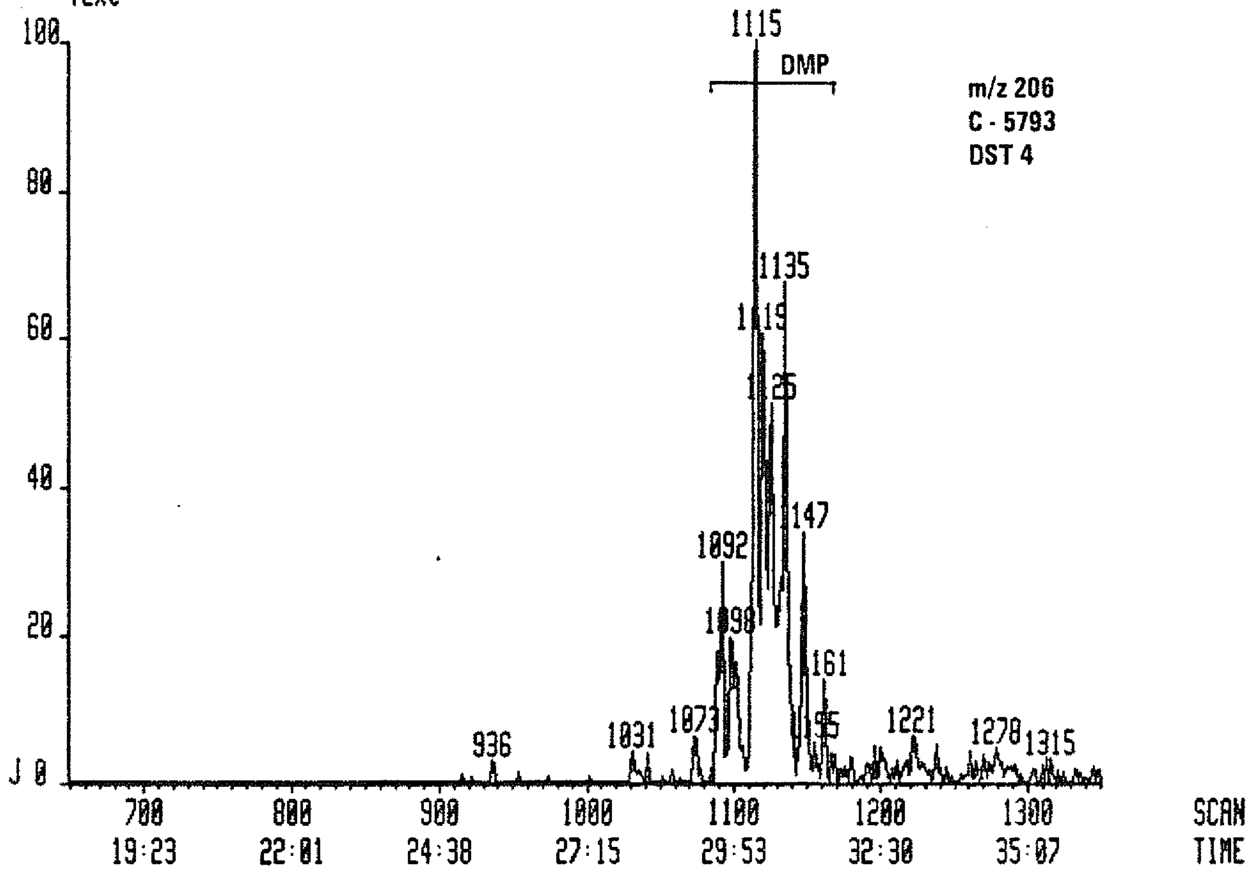
C5793ARO #650-1350 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : H1:178 H: 10429000
Text:



C5793ARO #650-1350 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : I1:192 I: 14903000
Text:

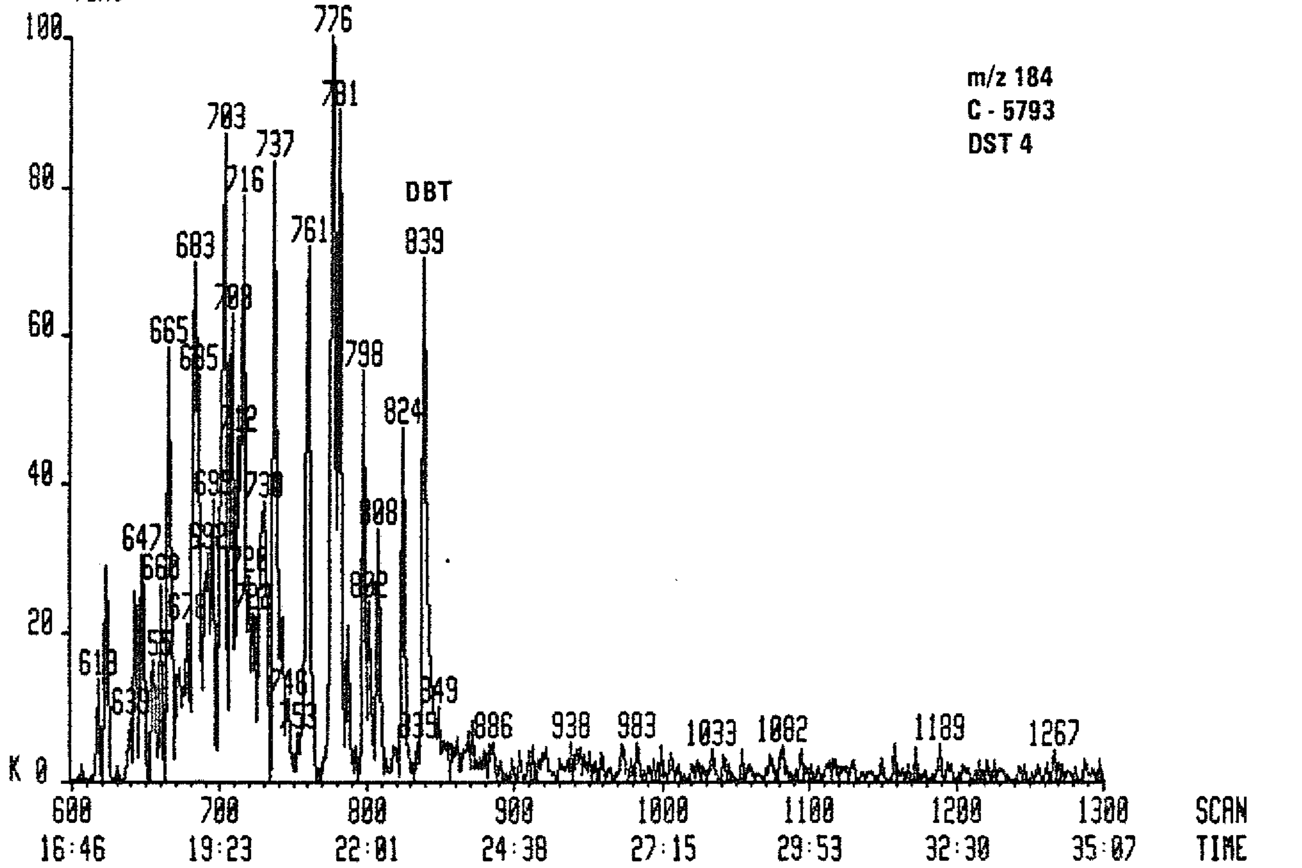


C5793ARO #650-1350 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : J1:206 J: 8927000
Text:

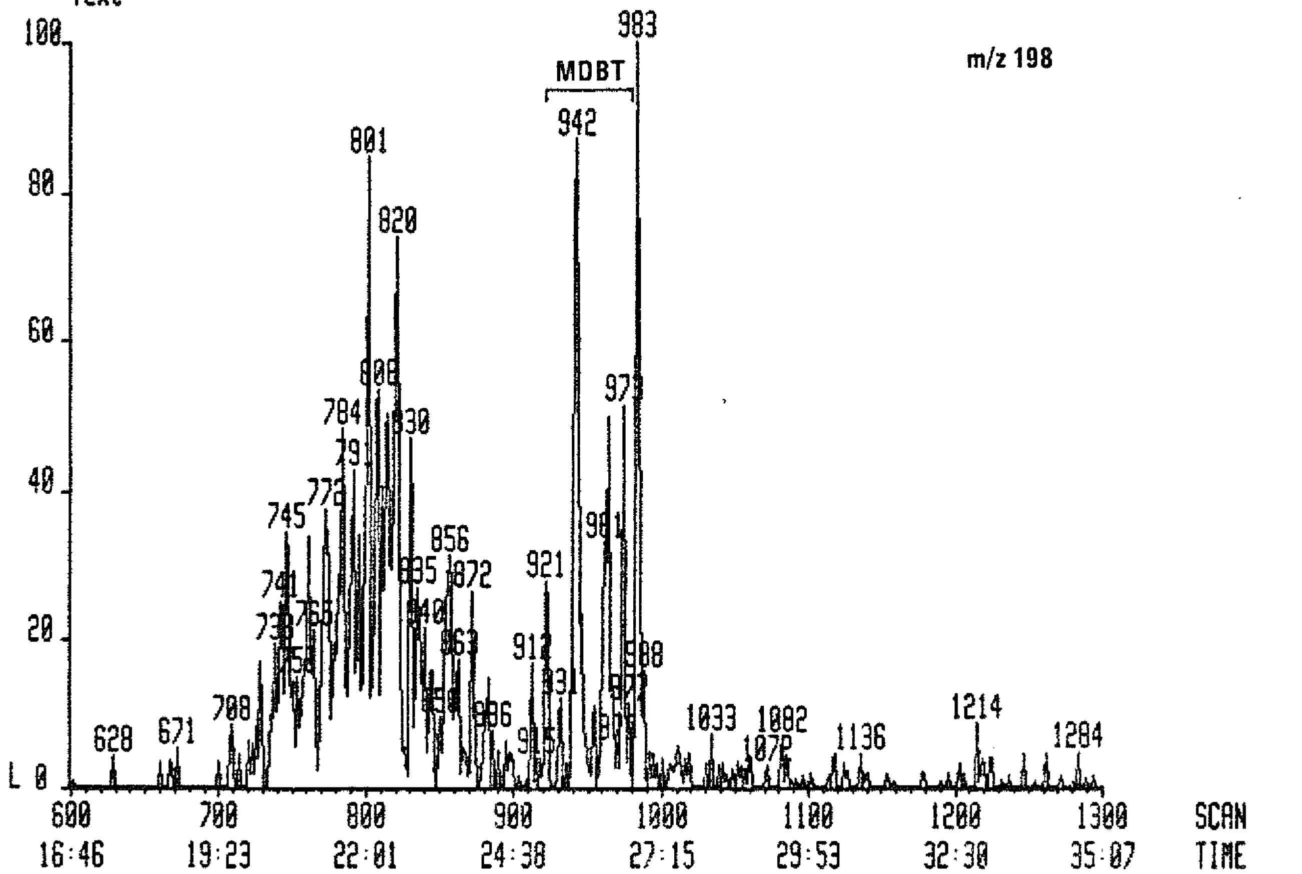


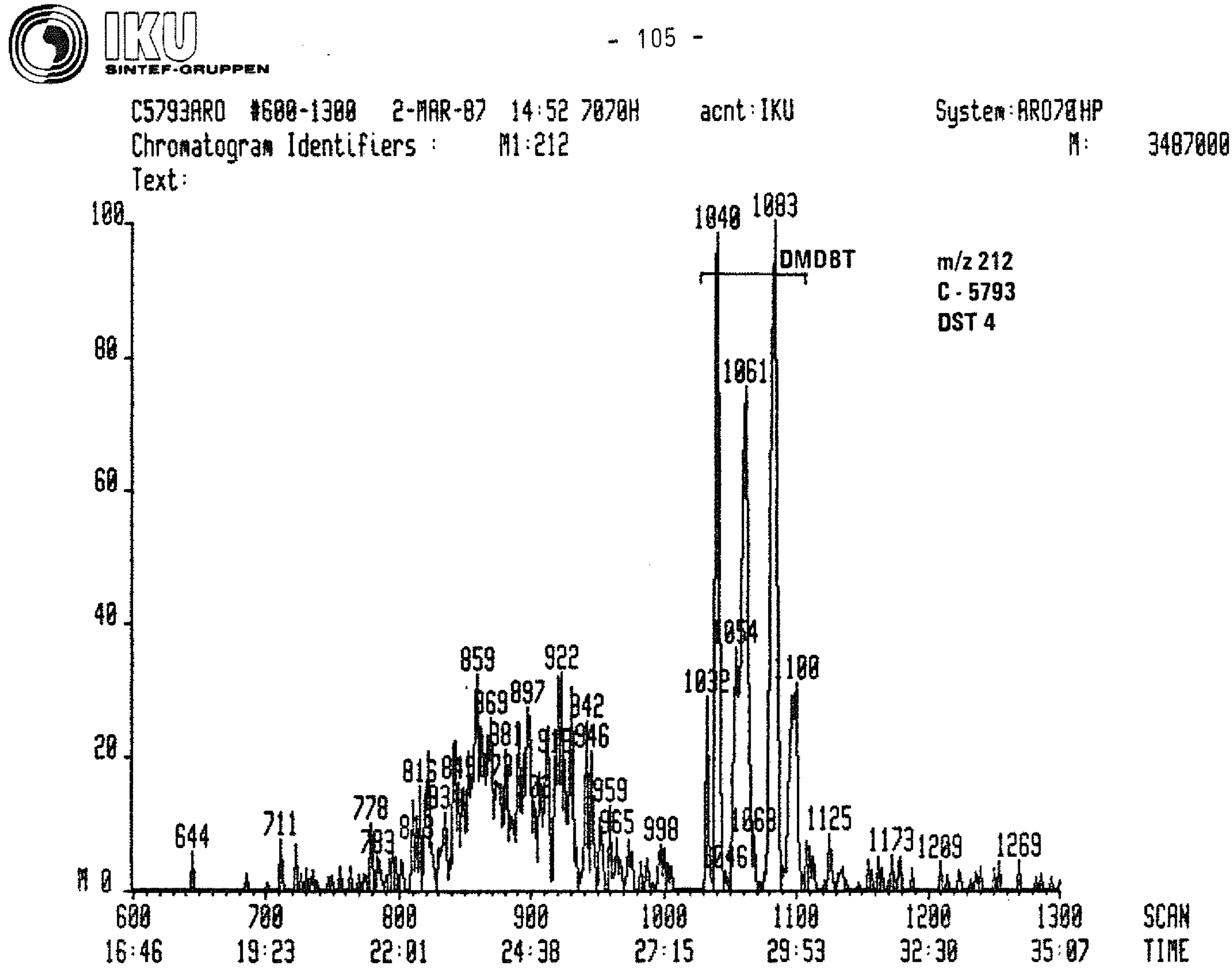
IKU SINTEF-GRUPPEN

C5793ARO #600-1300 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : K1:184 K: 7409000
Text:

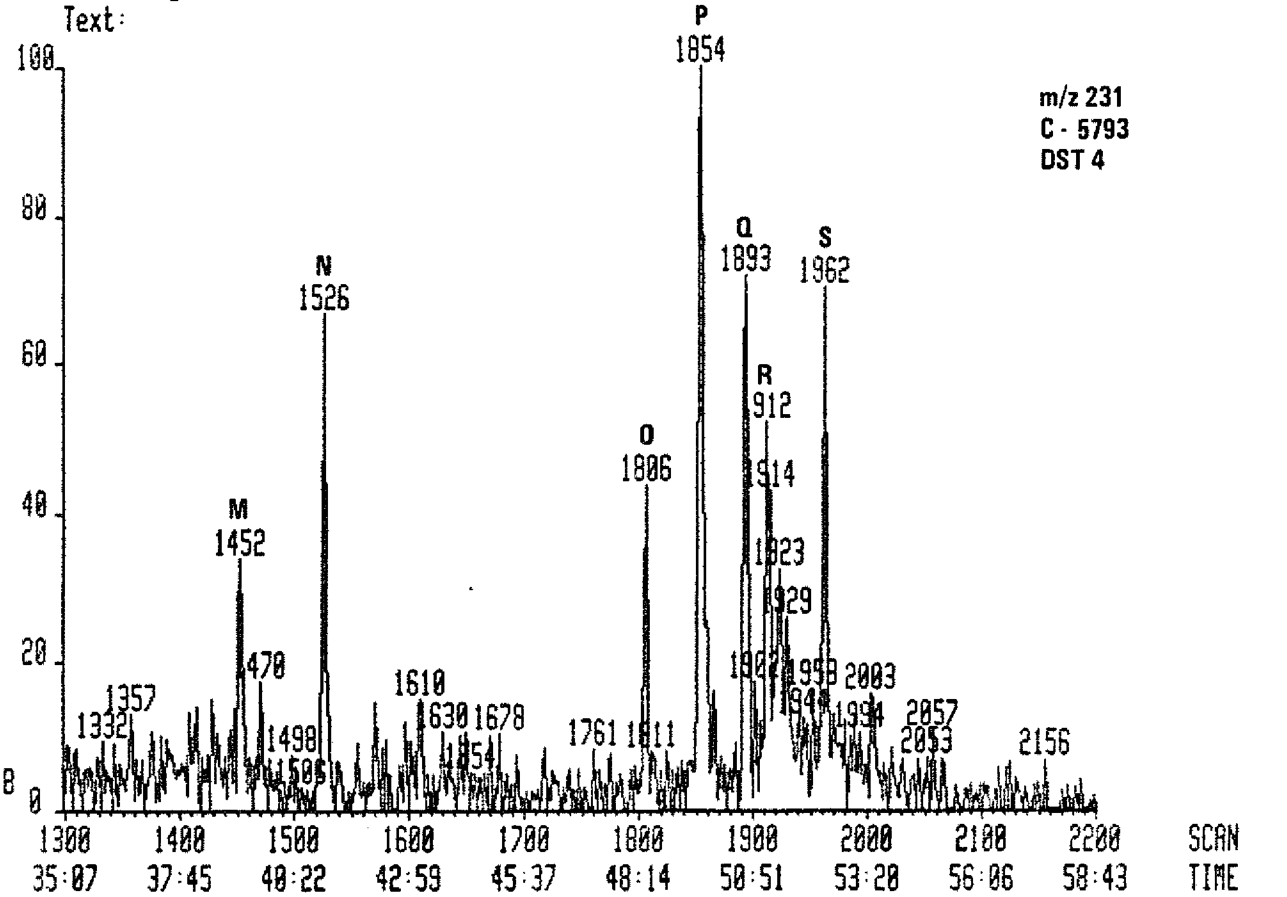


C5793ARO #600-1300 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : L1:198 L: 4053000
Text:



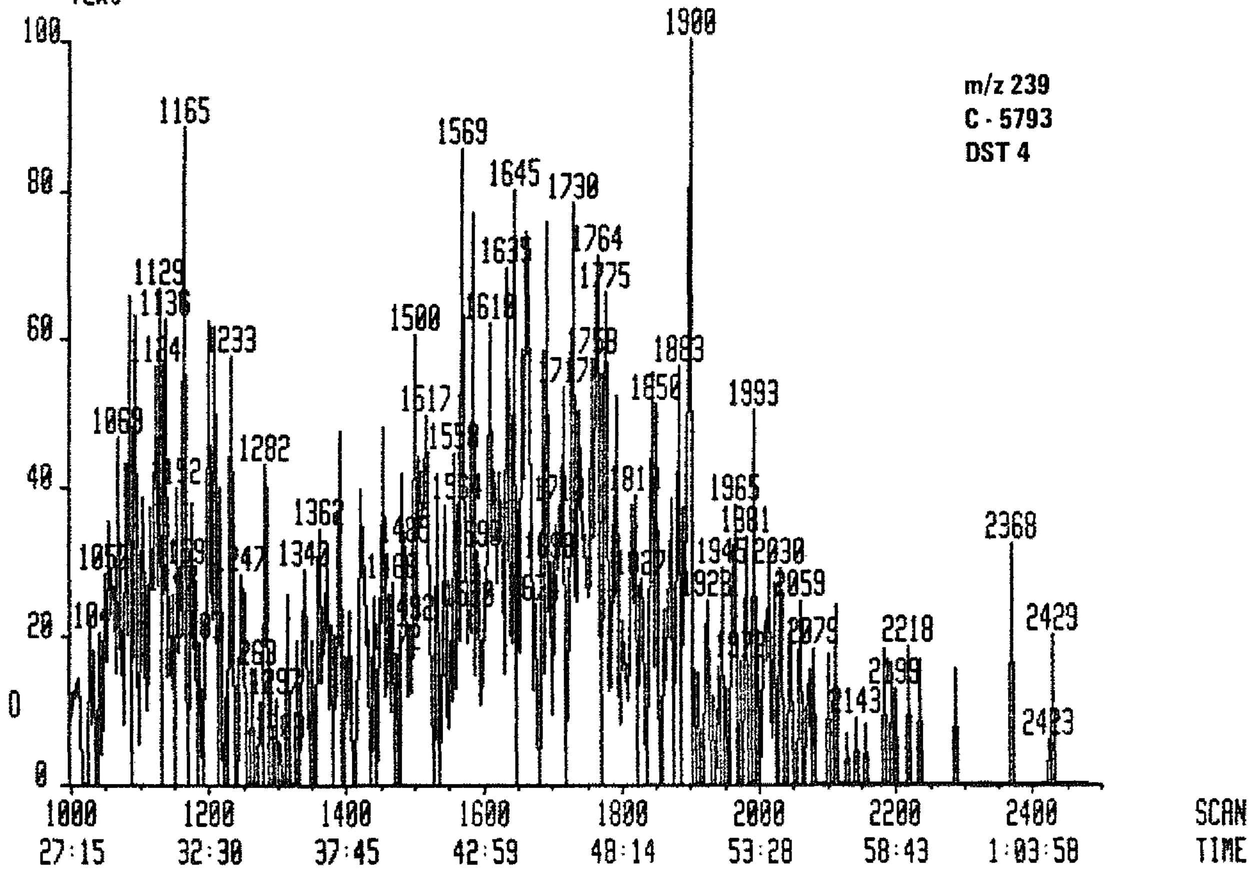

IKU
SINTEF-GRUPPEN
C5793ARO #600-1300 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : M1:212 M: 3407000
Text:
DMDBT
m/z 212
C - 5793
DST 4
1040
1083
1061
1054
1032
1100
859
922
869
897
942
946
959
965
998
1068
1125
1173
1209
1269
778
711
644
SCAN
TIME
600
700
800
900
1000
1100
1200
1300
16:46
19:23
22:01
24:38
27:15
29:53
32:30
35:07

C5793ARO #1300-2200 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : 81:231 B: 3166000
Text:

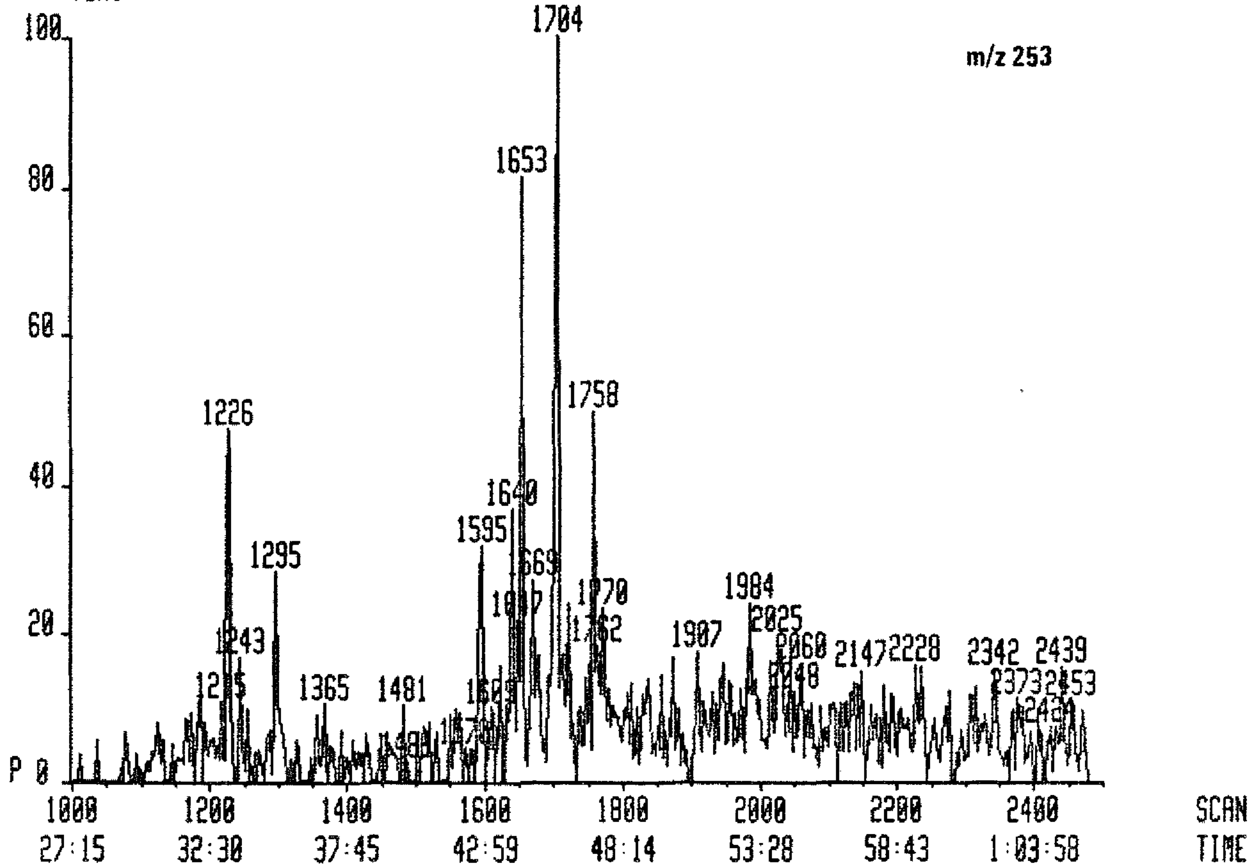


IKU SINTEF-GRUPPEN

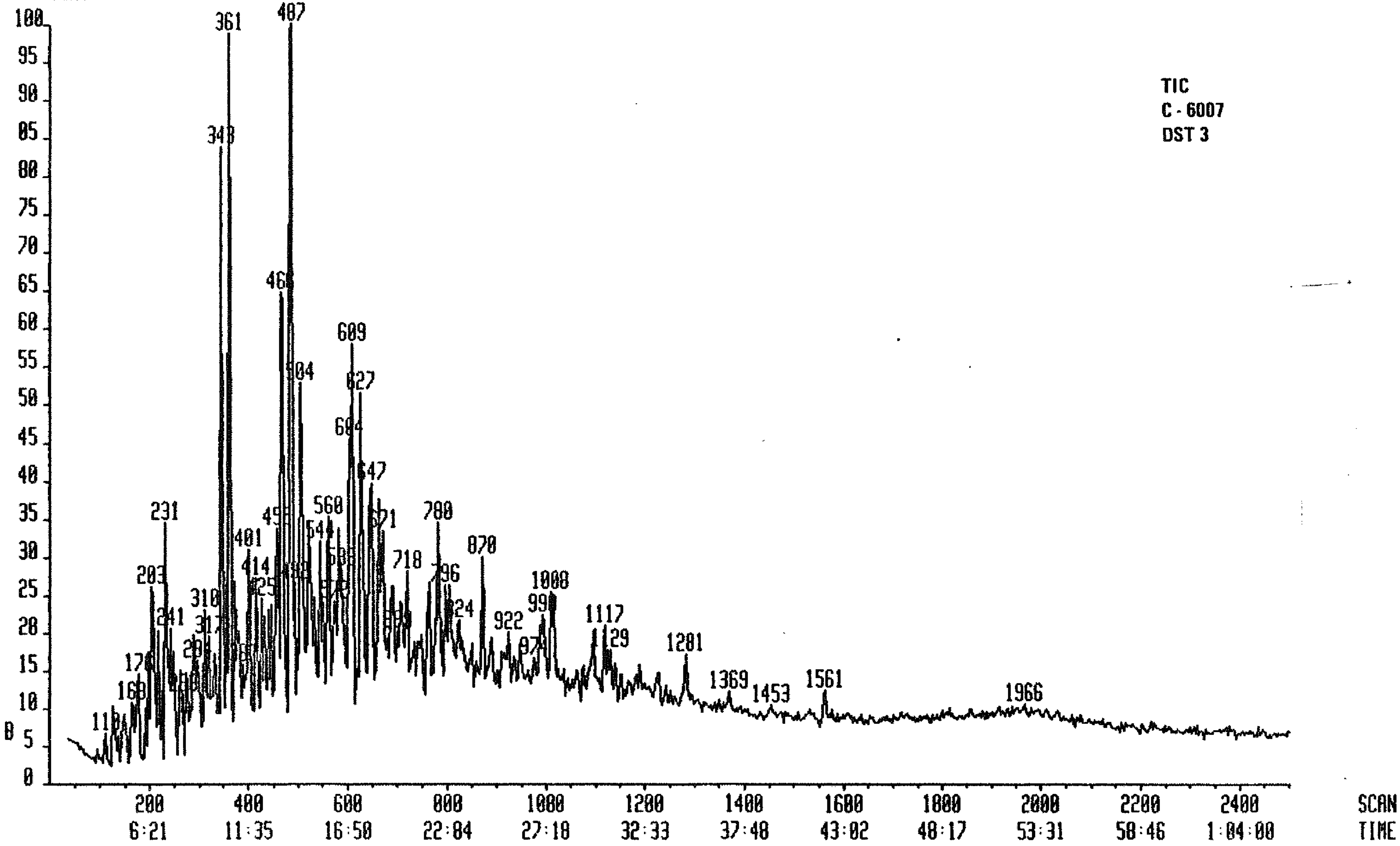
C5793ARO #1000-2470 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : 01:239 O: 535000
Text:



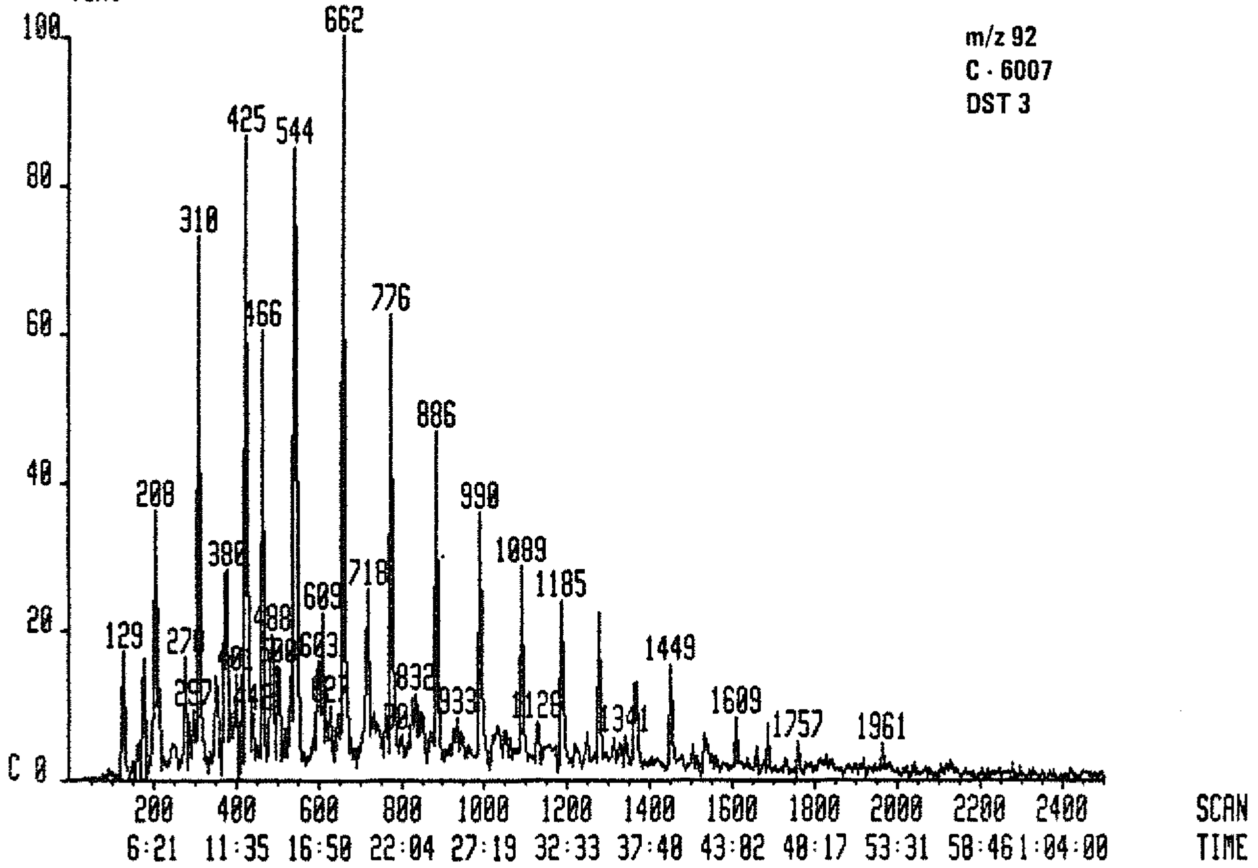
C5793ARO #1000-2470 2-MAR-87 14:52 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : P1:253 P: 2252000
Text:



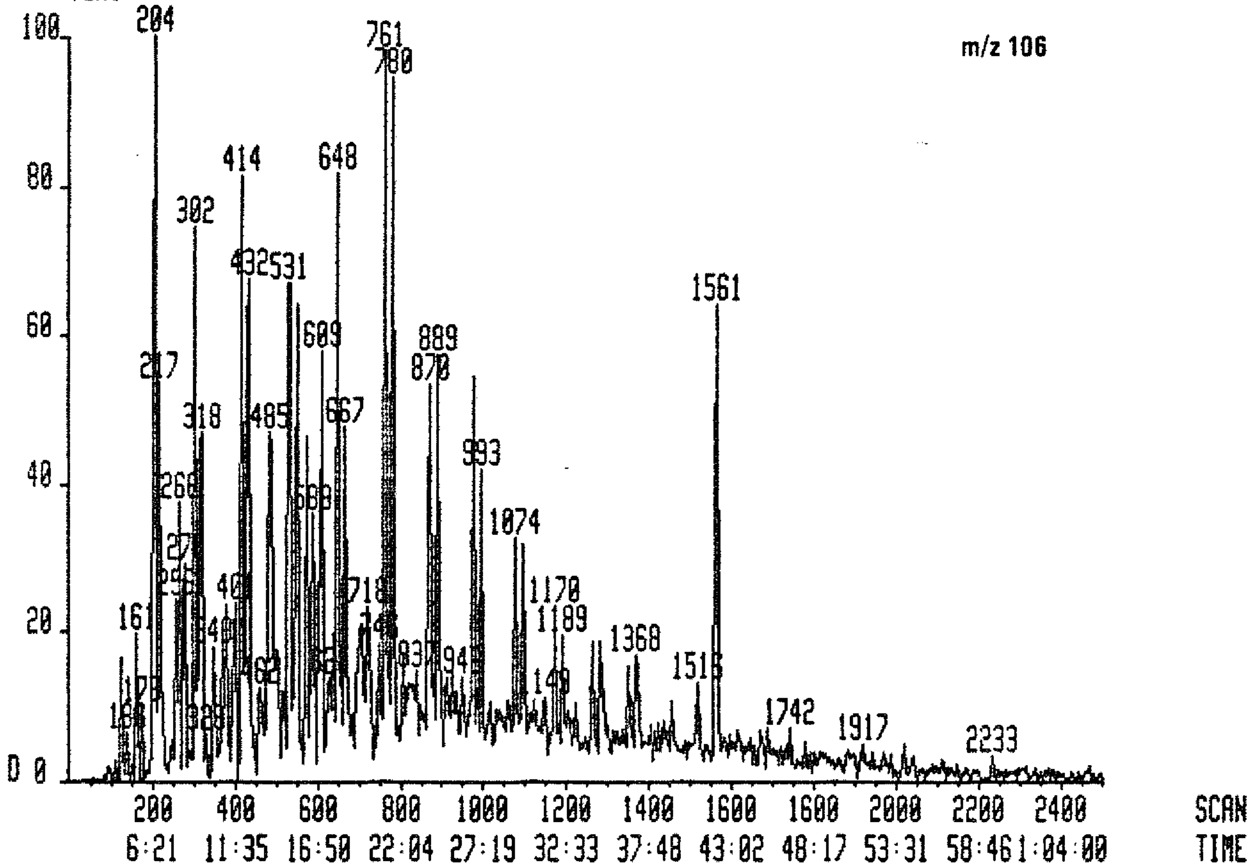
C6007ARO #1-2500 2-MAR-87 13:36 7070H acnt:IKU System:ARO70 IHP
Chromatogram Identifiers : 01:TIC 0: 374980992
Text:



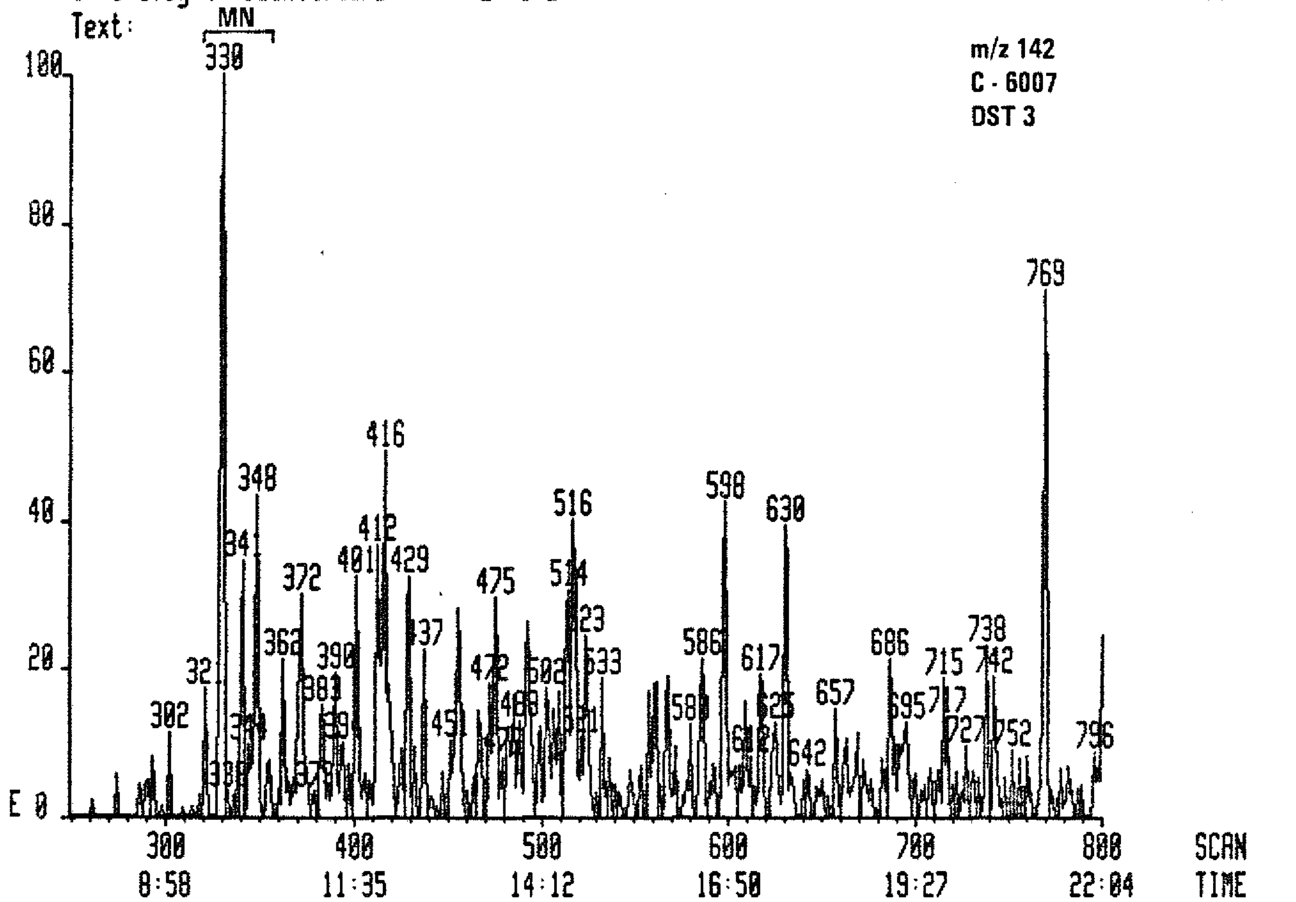
C6007ARO #1-2500 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : C1:92 C: 13017000
Text:



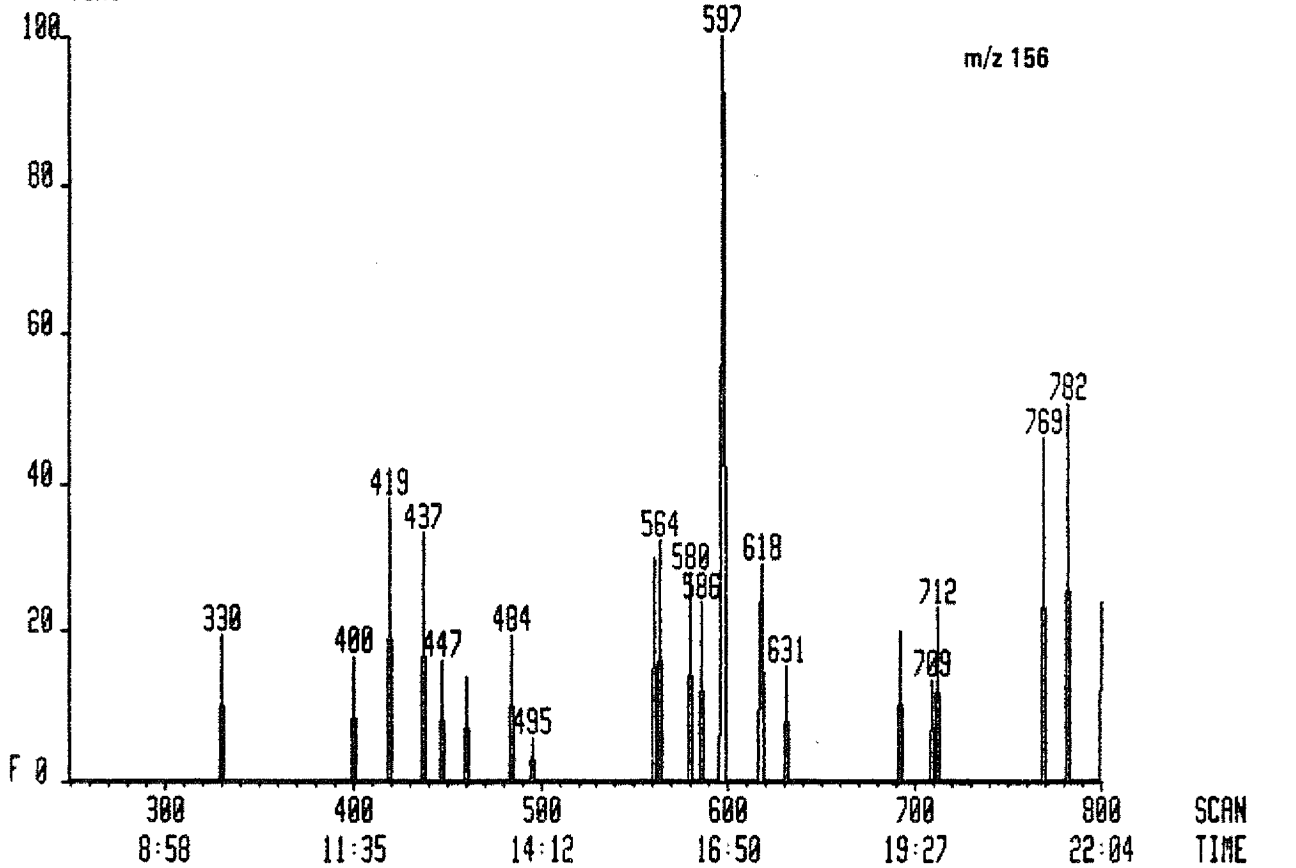
C6007ARO #1-2500 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : D1:106 D: 11377000
Text:

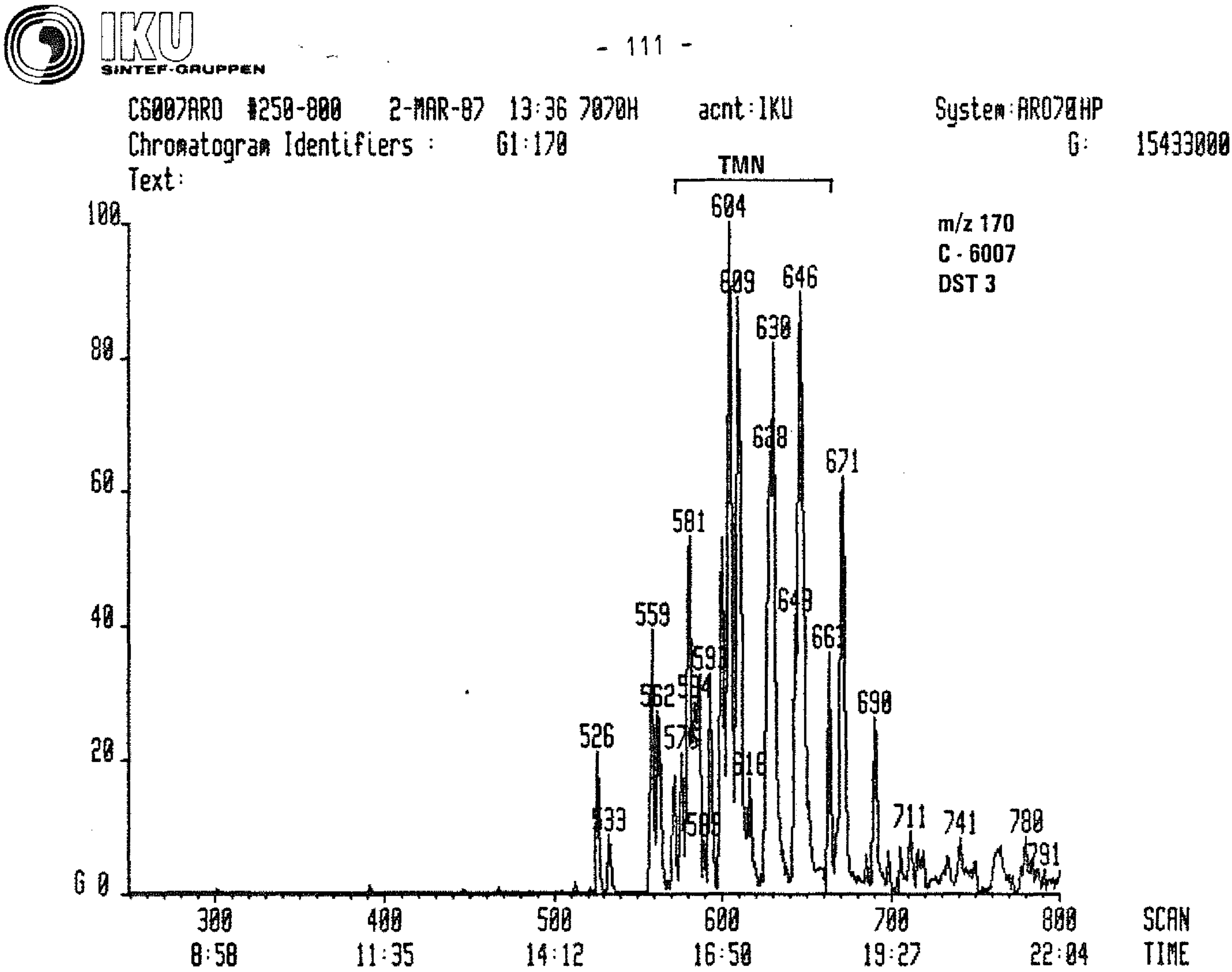


C6007ARO #250-800 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : E1:142 E: 3384000
Text:

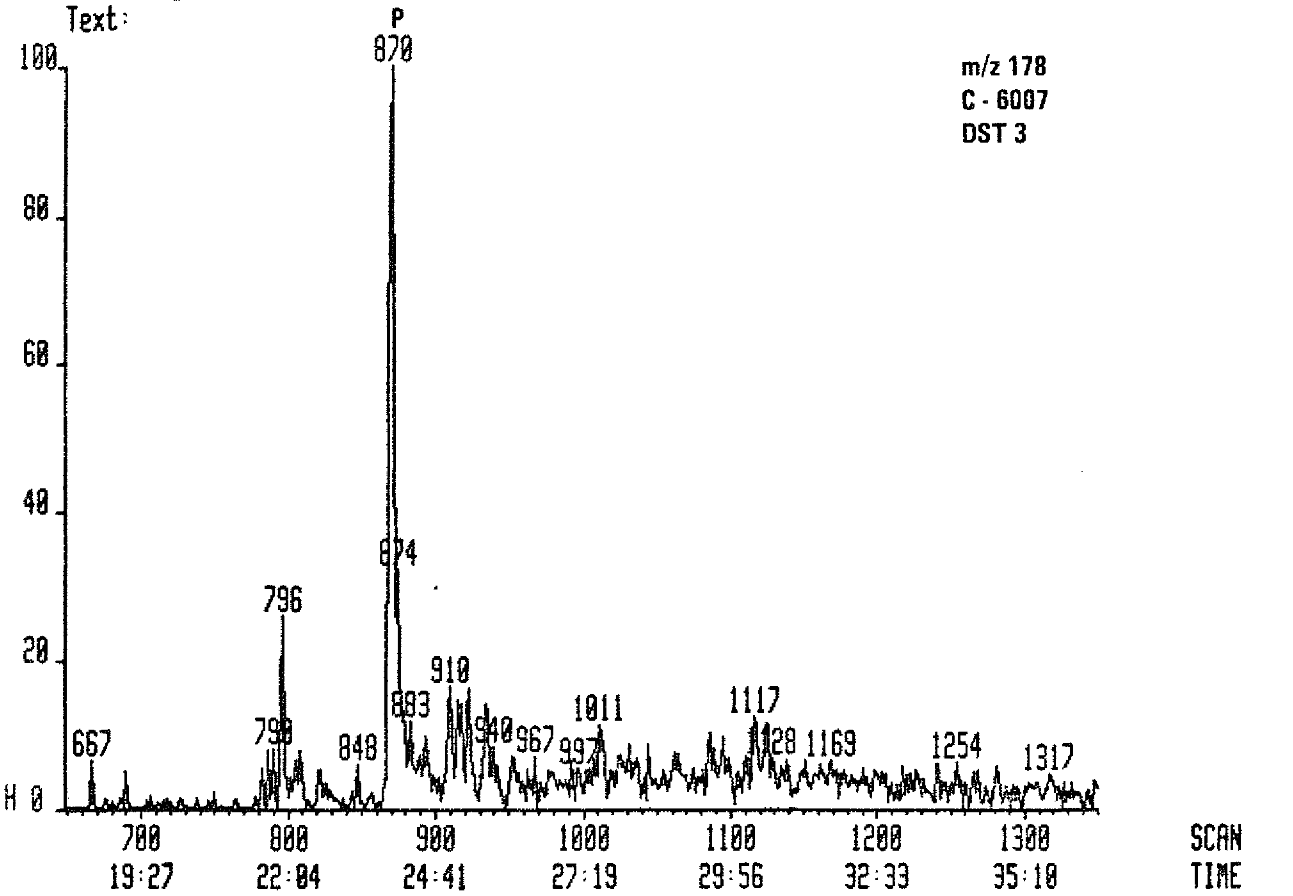


C6007ARO #250-800 2-MAR-87 13:38 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : F1:156 F: 447000
Text:

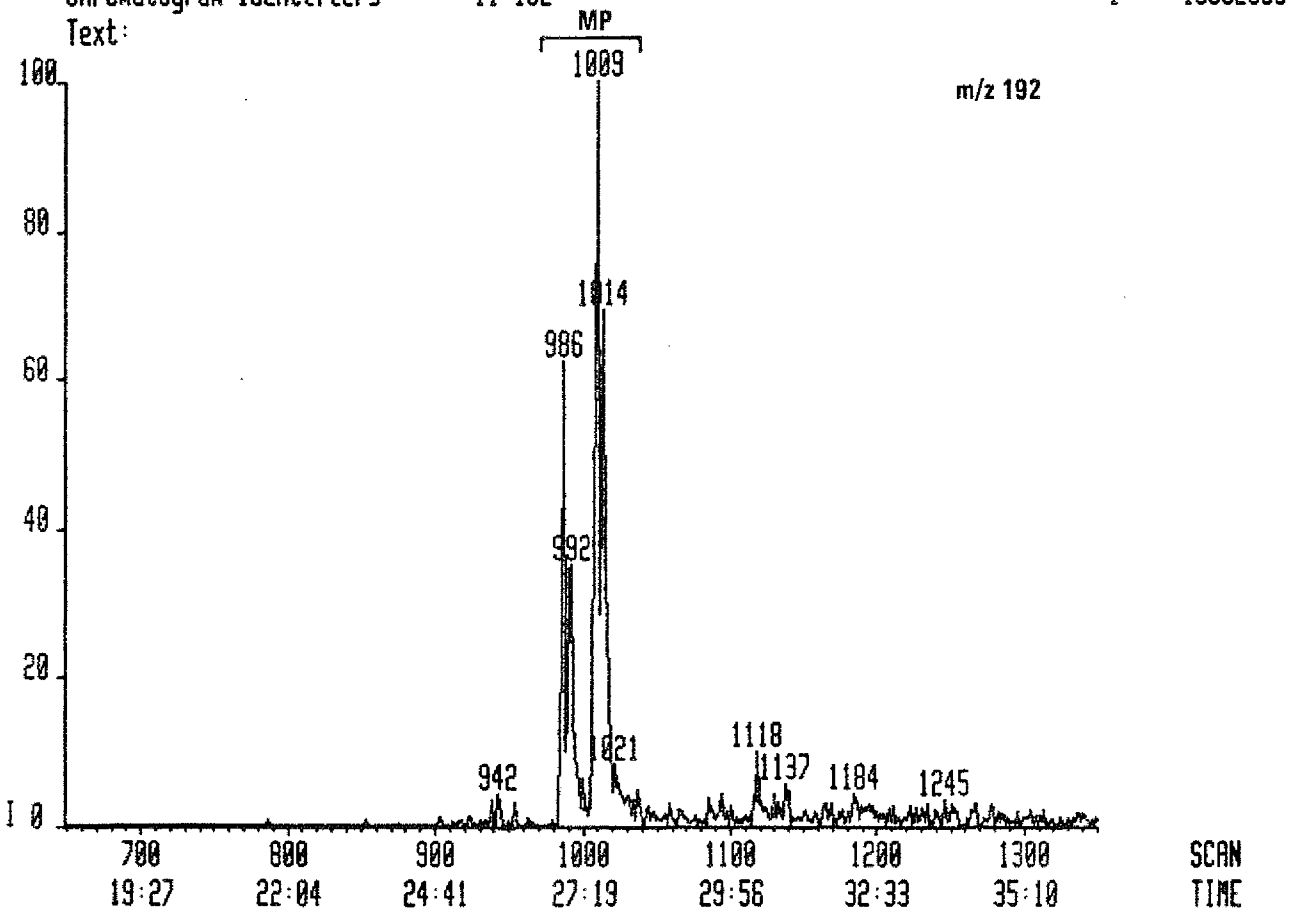



IKU
SINTEF-GRUPPEN
C6007ARO #250-800 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : G1:170 G: 15433000
Text:
TMN
m/z 170
C - 6007
DST 3
604
609
646
630
628
671
581
559
649
663
690
526
533
711
741
780
791
100
80
60
40
20
G 0
300
8:58
400
11:35
500
14:12
600
16:50
700
19:27
800
22:04
SCAN
TIME

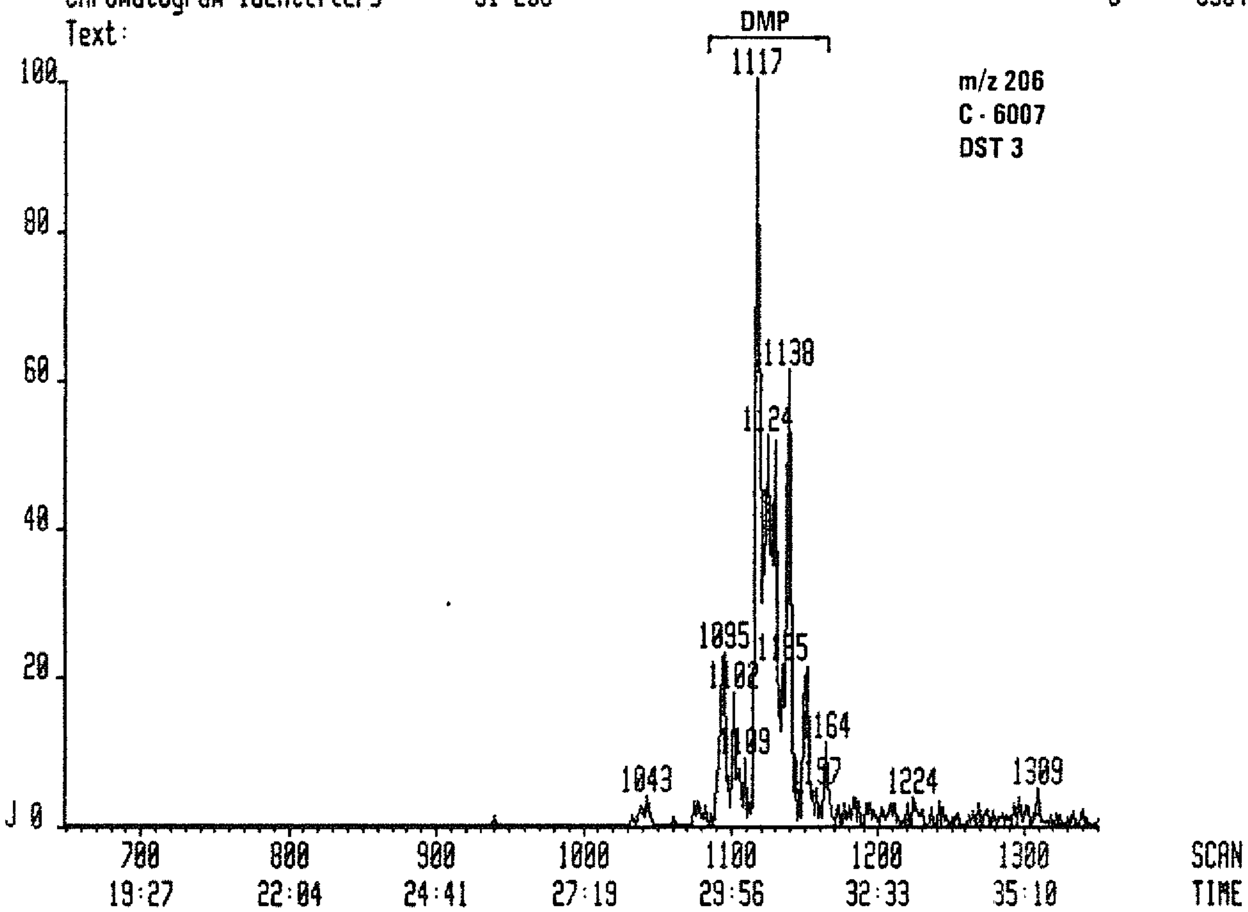
C6007ARO #650-1350 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : H1:178 H: 10402000
Text:



C6007ARO #650-1350 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : I1:192 I: 13662000
Text:



C6007ARO #650-1350 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : J1:206 J: 8504000
Text:



C6007ARO #600-1300 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : K1:184 K: 9136000
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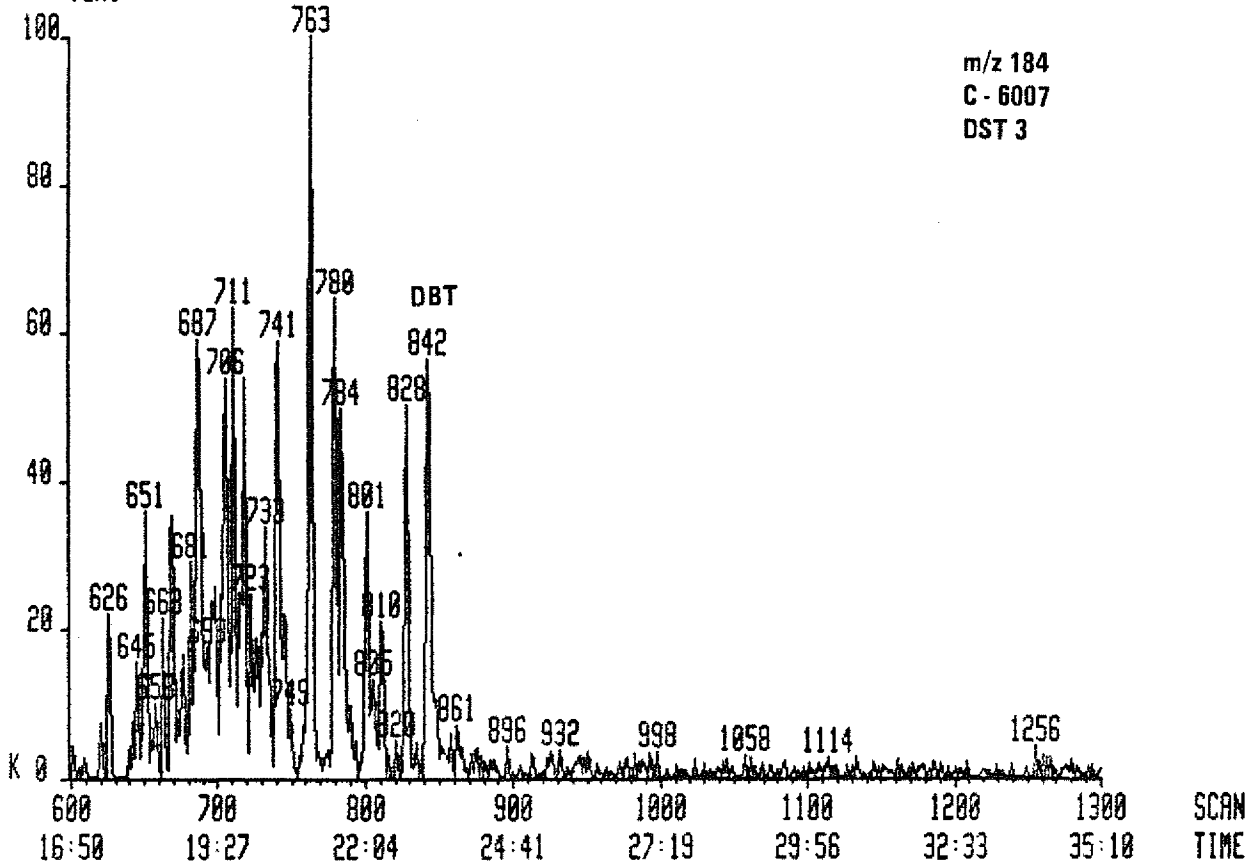

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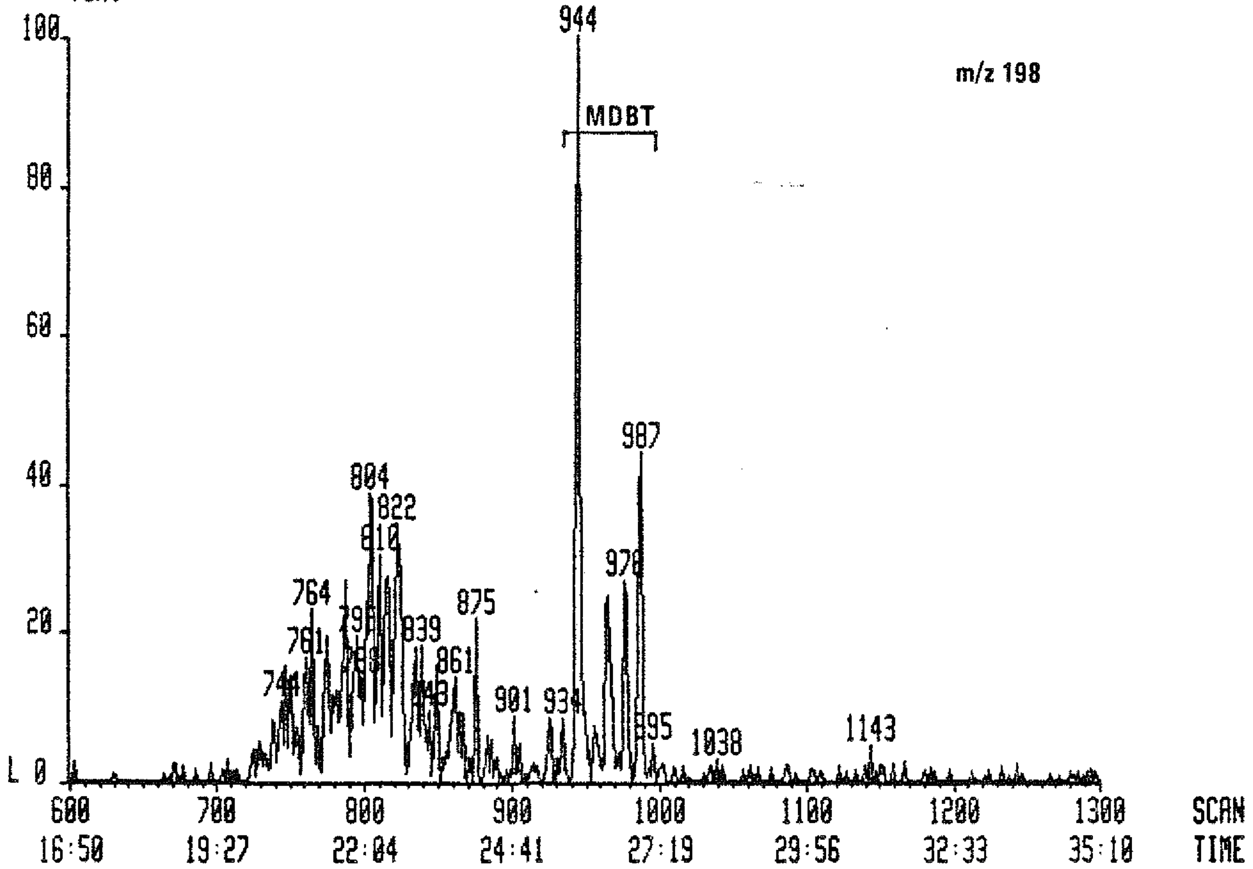
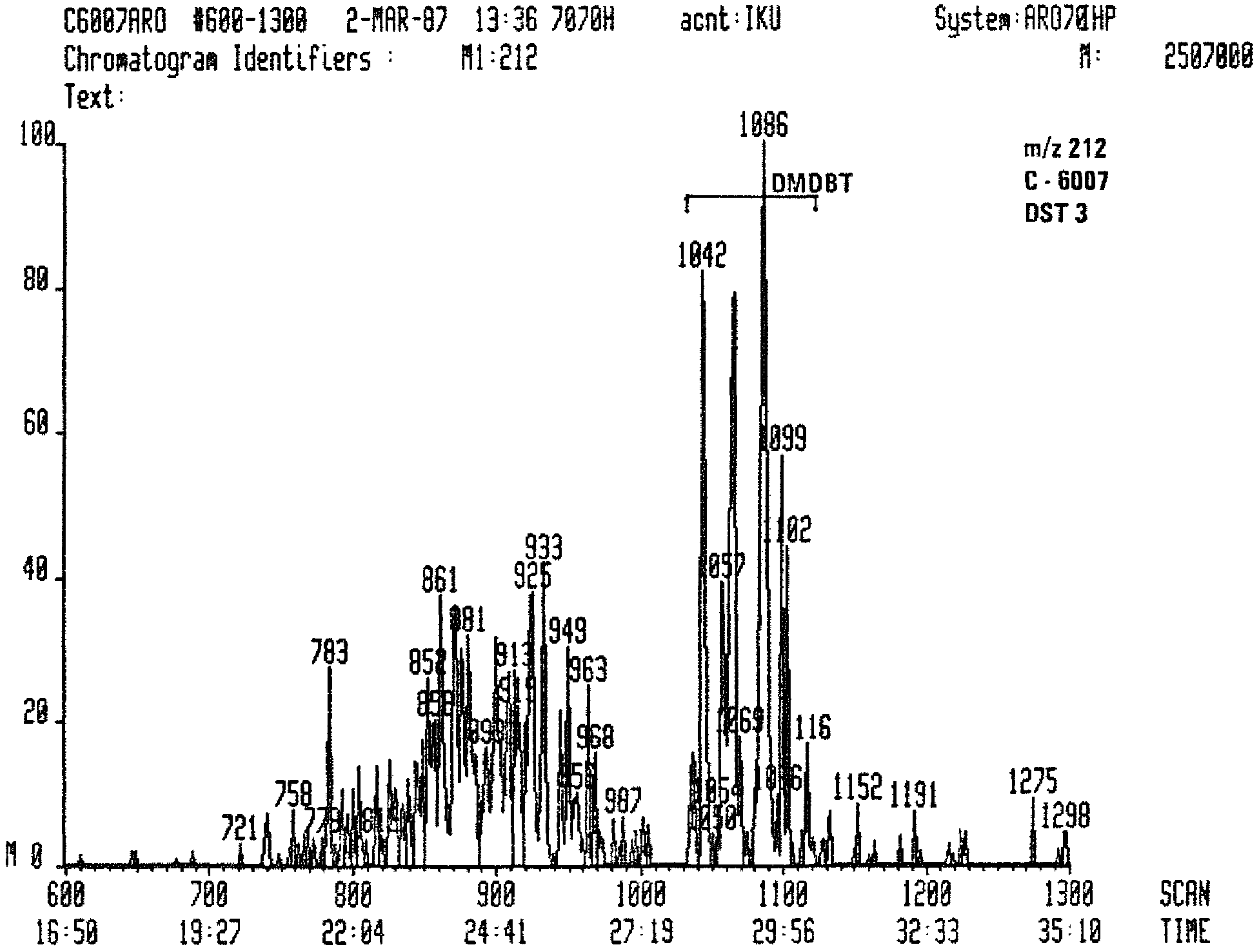
Chromatogram Identifiers : L1:198 L: 8791000.
Text:




C6007ARO #600-1300 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : M1:212 M: 2507000
Text:
m/z 212
C - 6007
DST 3
DMDBT
1086
1042
1099
1102
1057
933
925
861
881
949
783
852
913
963
968
758
721
987
1116
1152
1191
1275
1298
SCAN
TIME
600 700 800 900 1000 1100 1200 1300
16:50 19:27 22:04 24:41 27:19 29:56 32:33 35:10
0 20 40 60 80 100

C6007ARO #1300-2200 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : N1:231 N: 2732000
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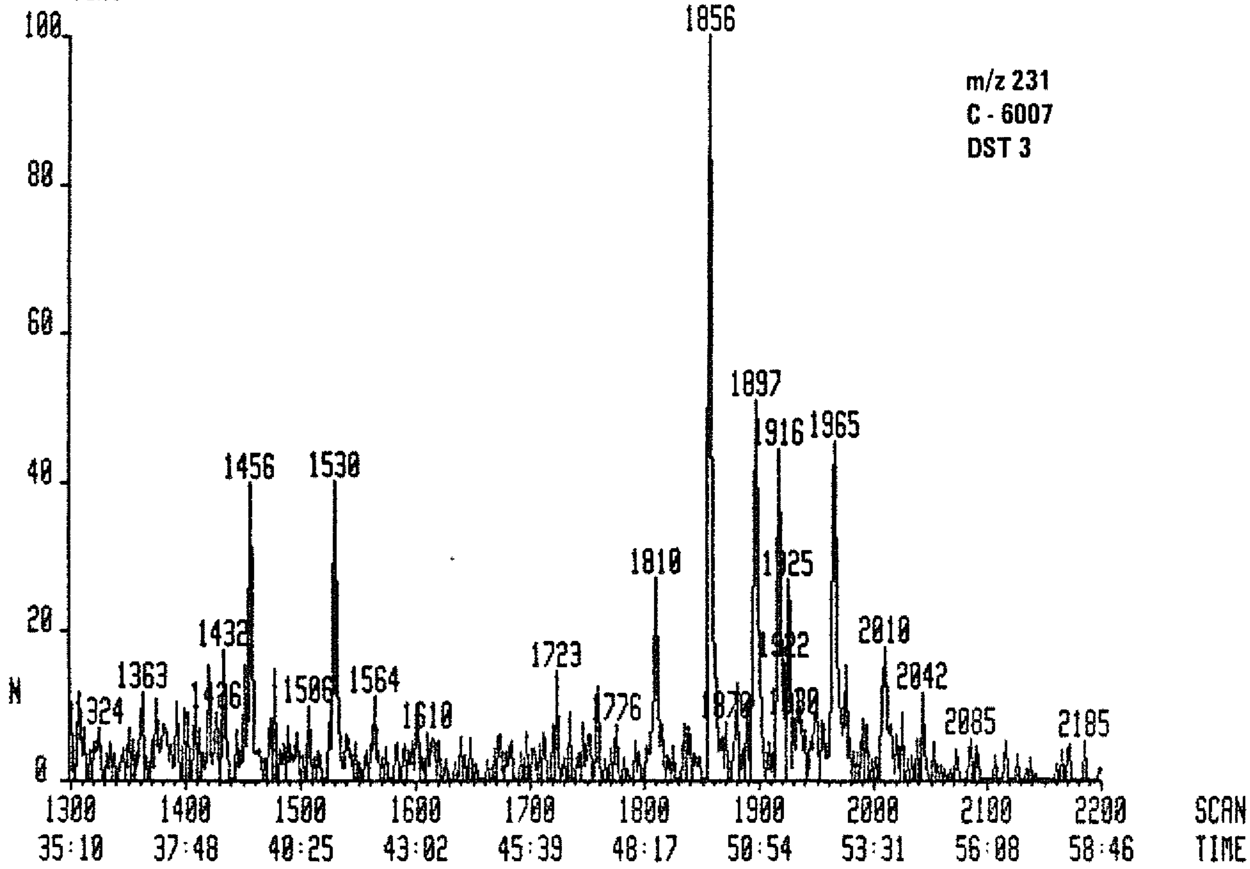
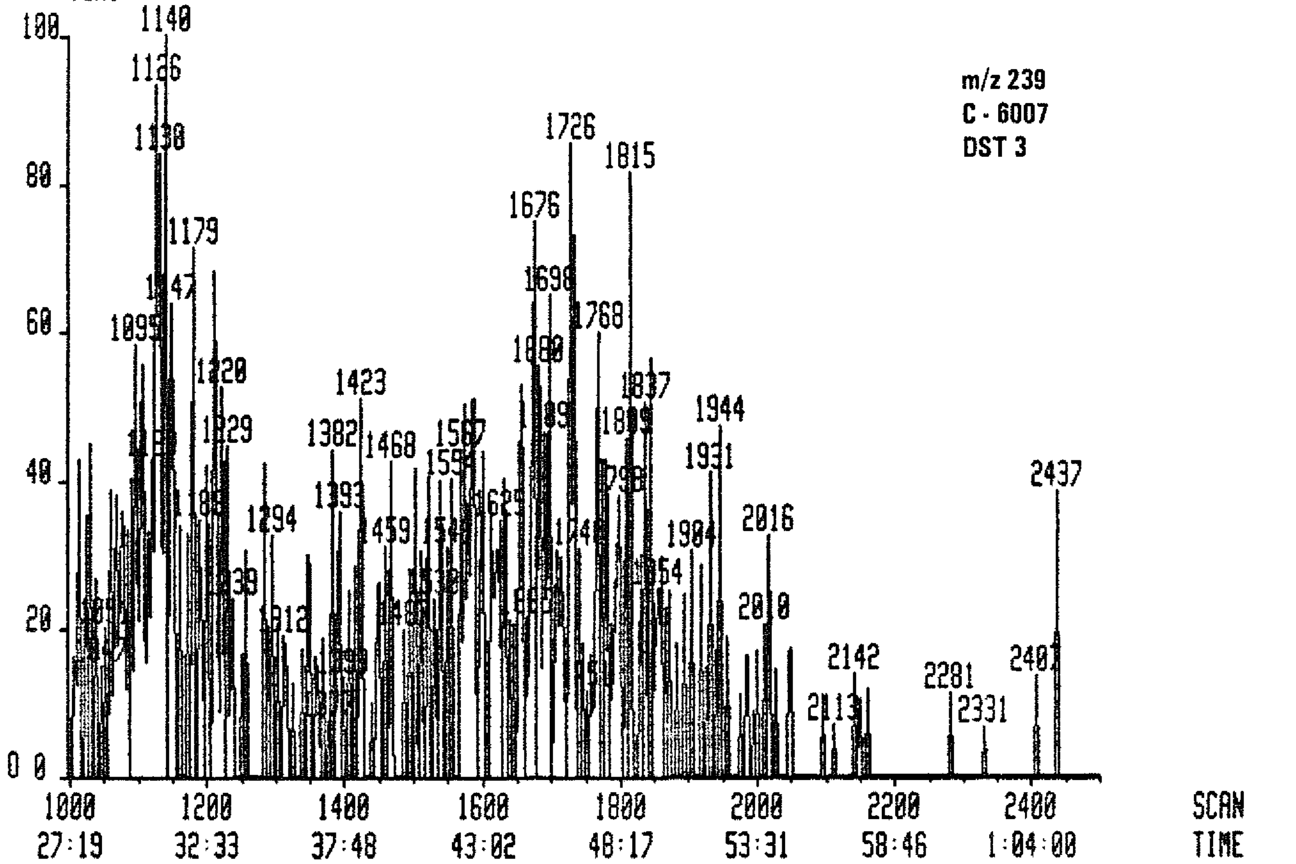
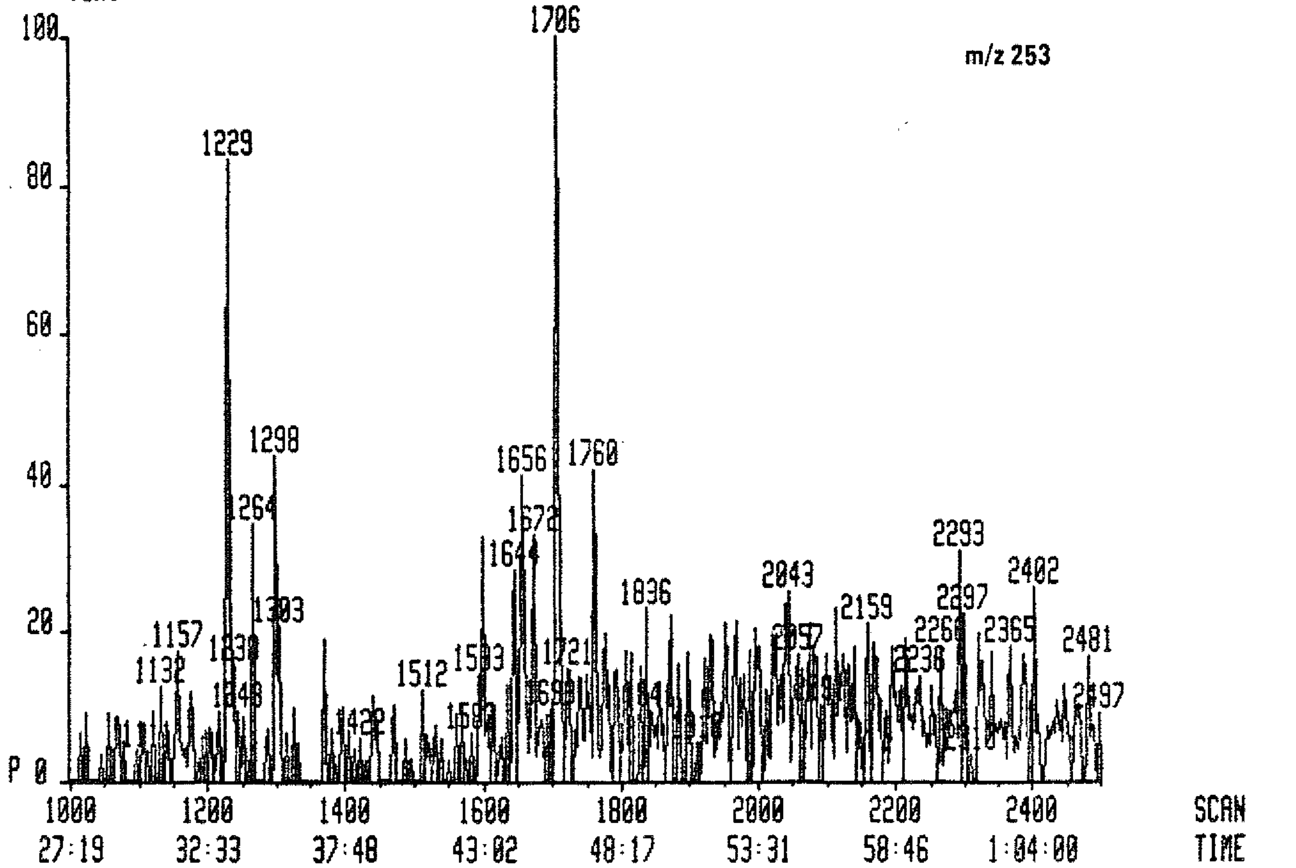


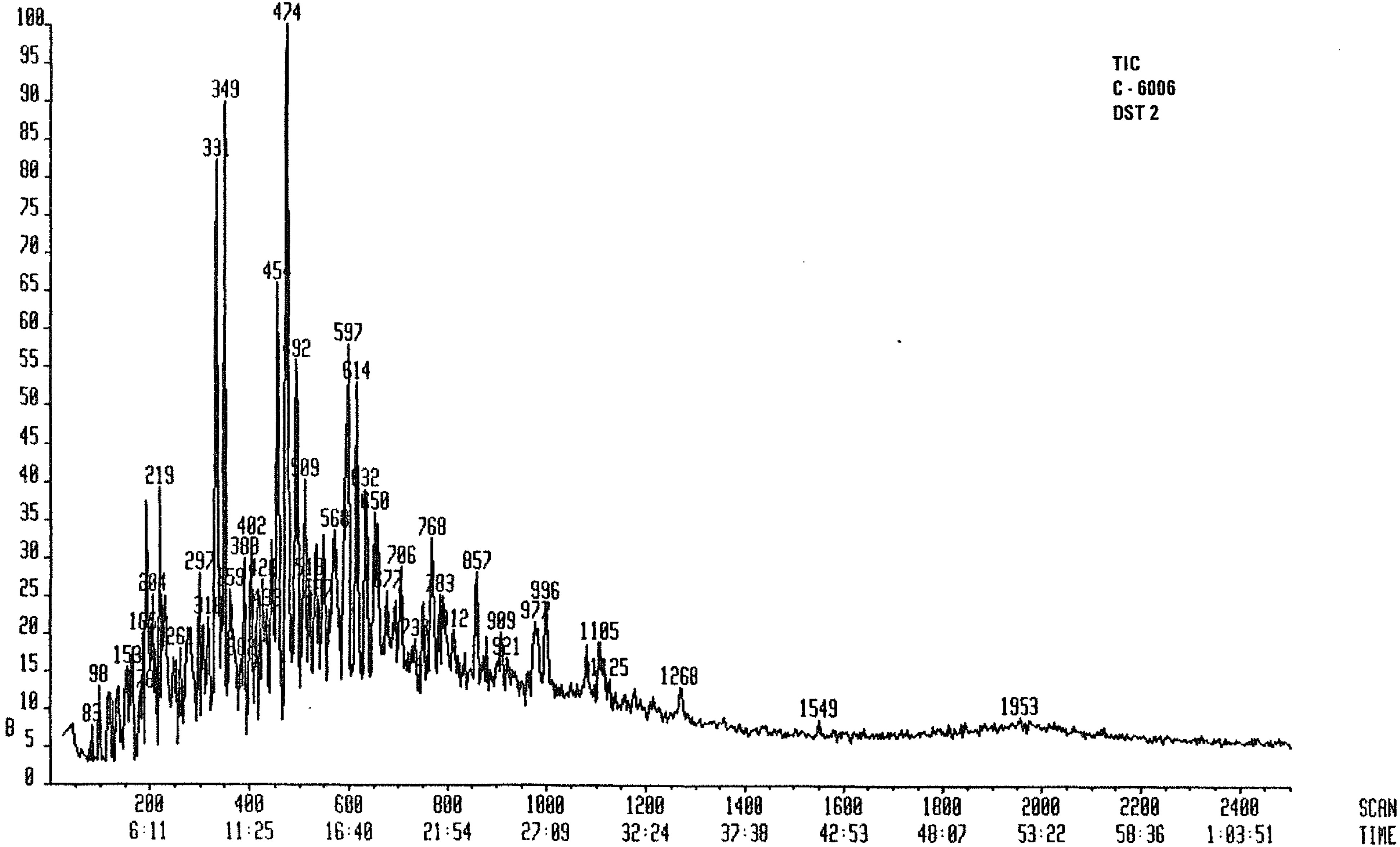
C6007ARO #1000-2500 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : 01:239 0: 400000
Text:



C6007ARO #1000-2500 2-MAR-87 13:36 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : P1:253 P: 1443000
Text:

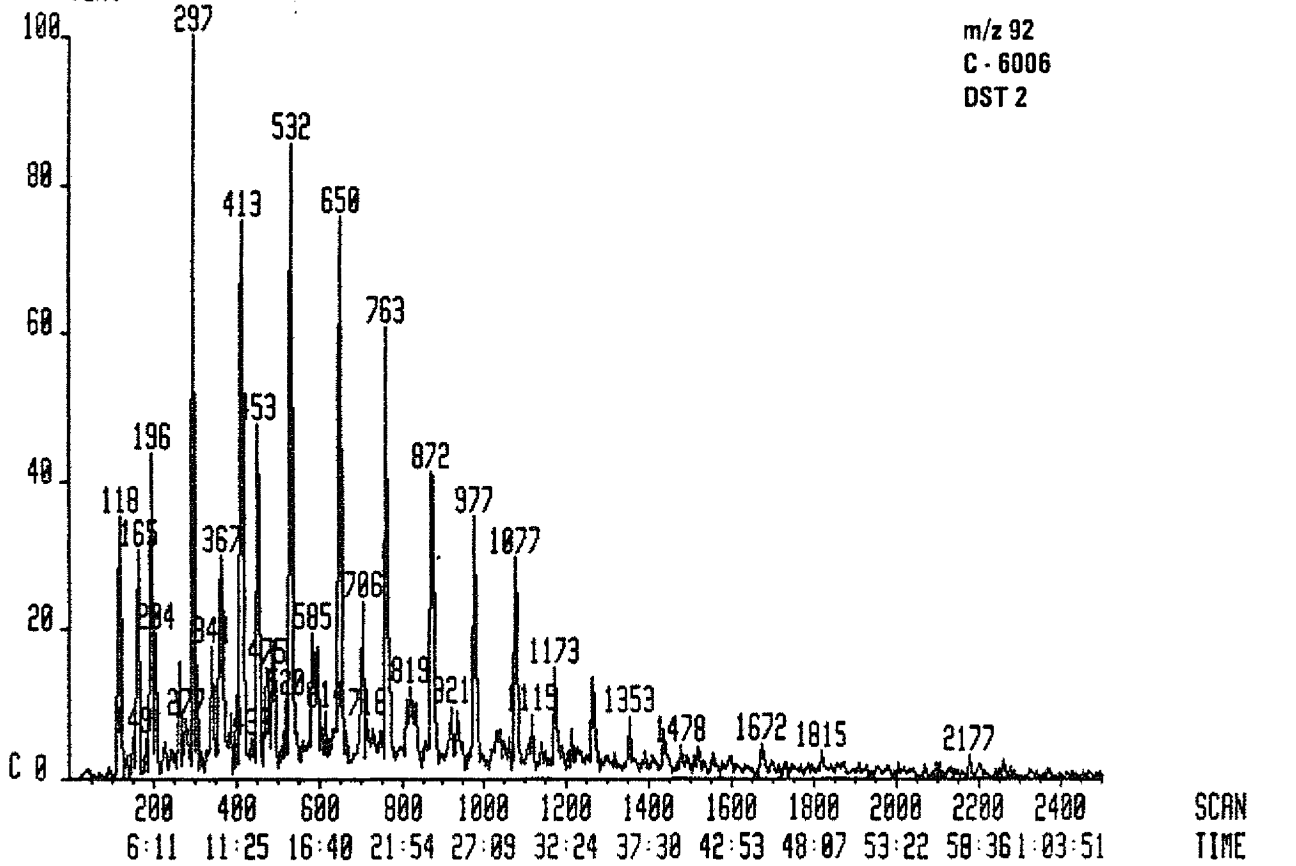


C6006AR01 #1-2500 2-MAR-87 12:10 7070H acnt:IKU System:AR070 IHP
Chromatogram Identifiers : B1:TIC B: 373556000
Text:



IKU
SINTEF-GRUPPEN

C6006AR01 #1-2500 2-MAR-87 12:18 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : C1:92 C: 14134000
Text:



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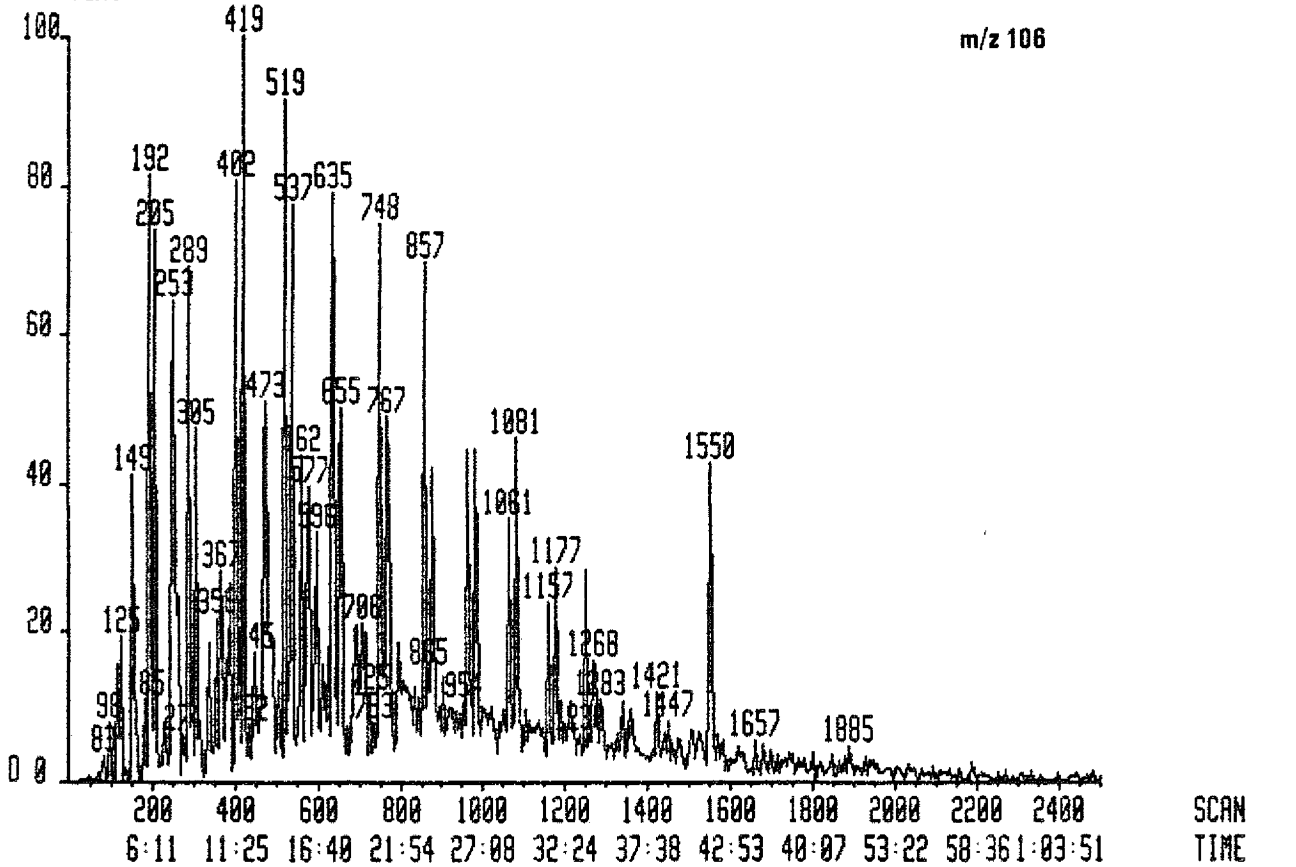
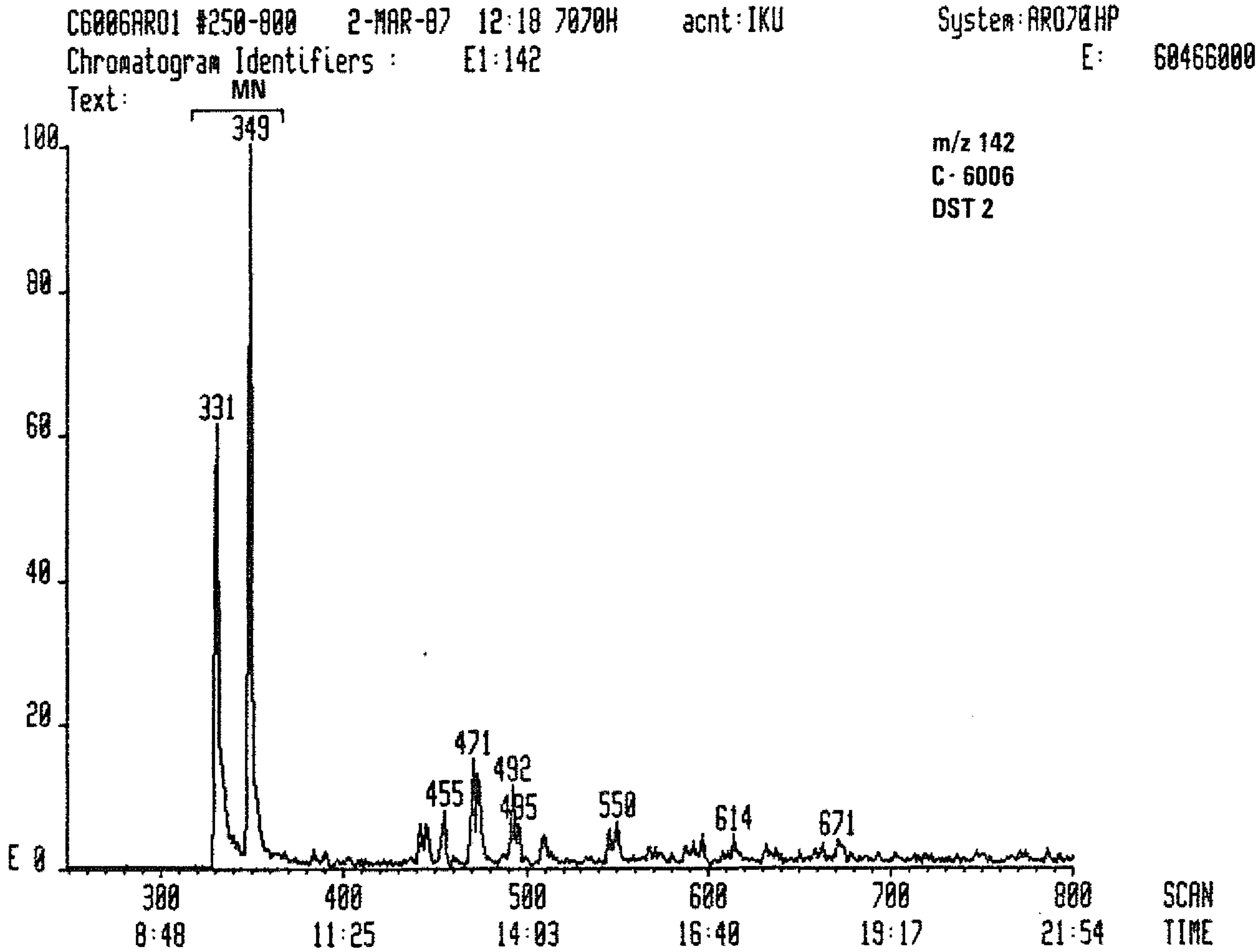
Chromatogram Identifiers : D1:106 D: 11255000
Text:




C6006AR01 #250-800 2-MAR-87 12:18 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : E1:142
E: 60466000
Text:
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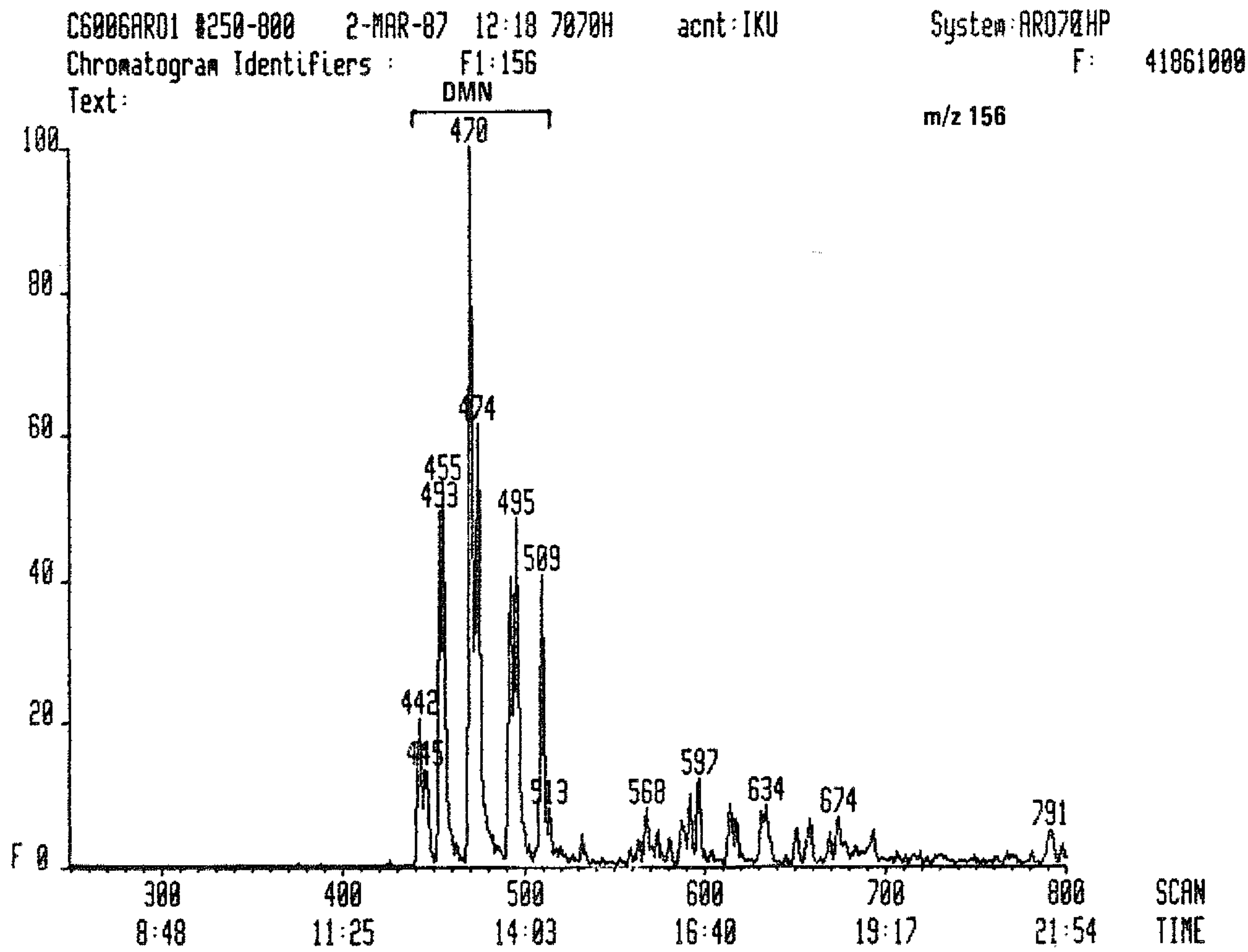
331
471
492
455
495
550
614
671
m/z 142
C-6006
DST 2
SCAN
TIME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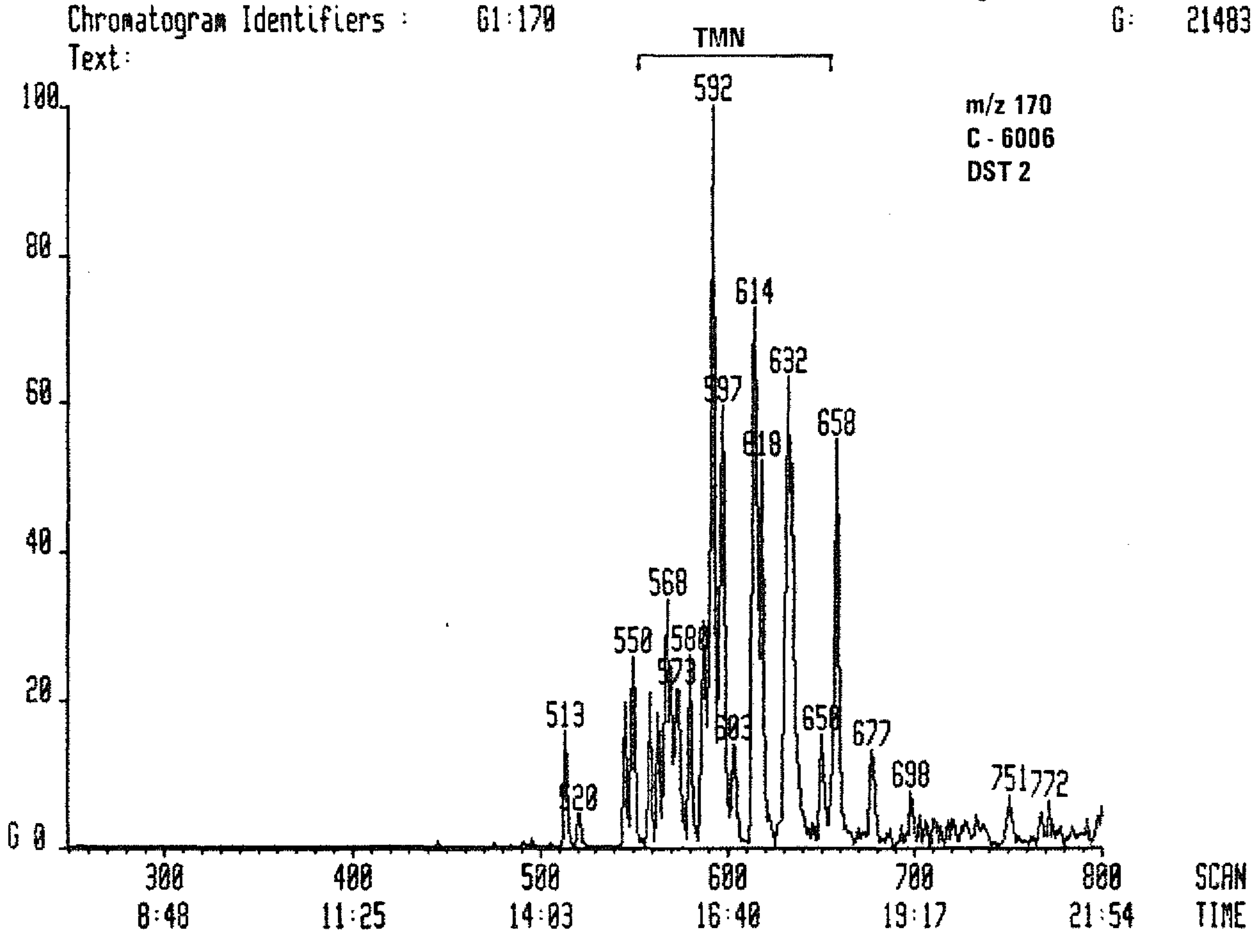
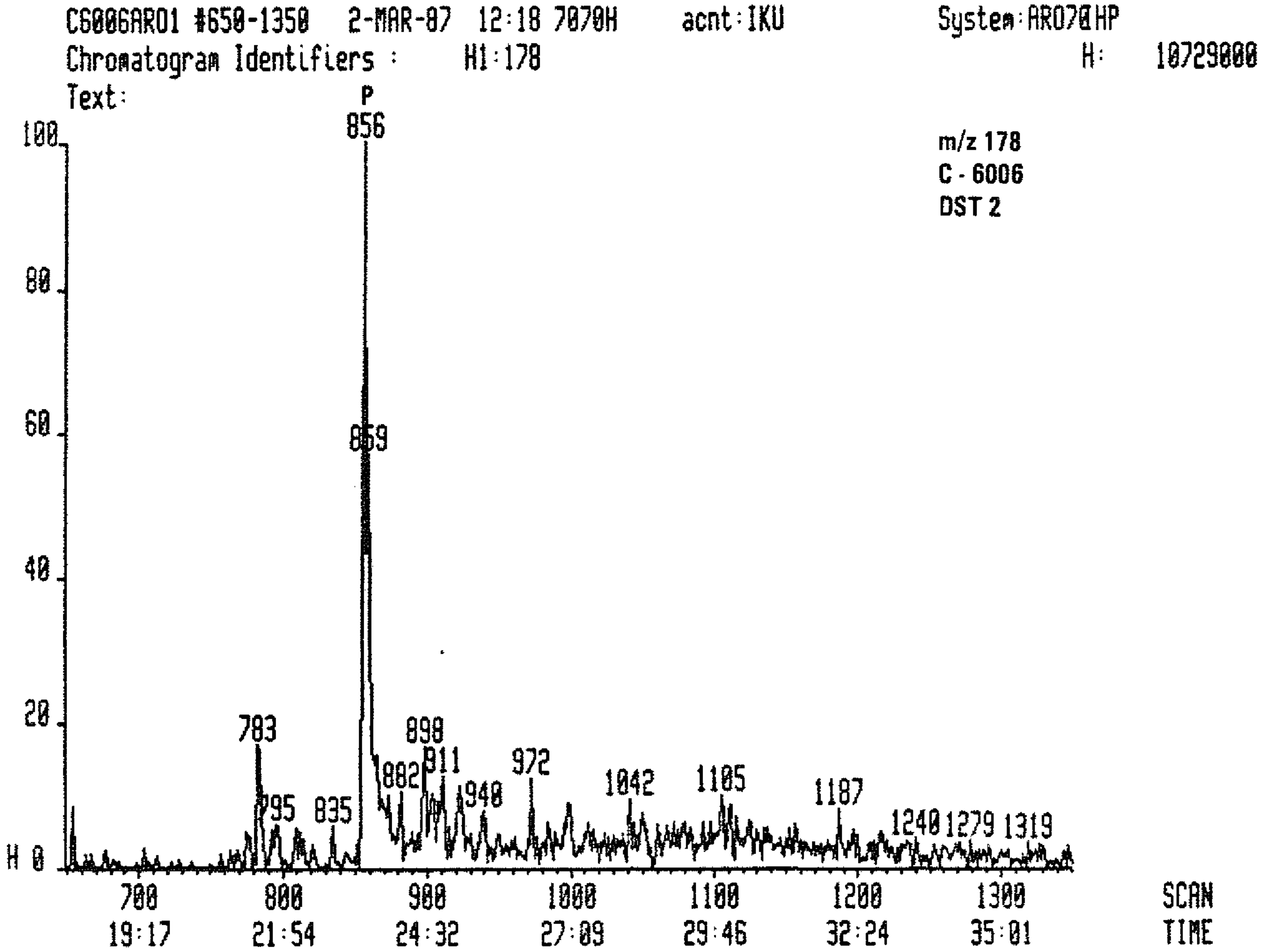
Chromatogram Identifiers : F1:156
F: 41861000
Text:
DMN
470
m/z 156
474
455
453
495
509
442
445
513
568
597
634
674
791
SCAN
TIME

C6006AR01 #250-800 2-MAR-87 12:18 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : G1:170 G: 21483000
Text:




C6006AR01 #650-1350 2-MAR-87 12:18 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : H1:178 H: 10729000
Text:
P
856
m/z 178
C - 6006
DST 2
859
783
898
911
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835
972
940
1042
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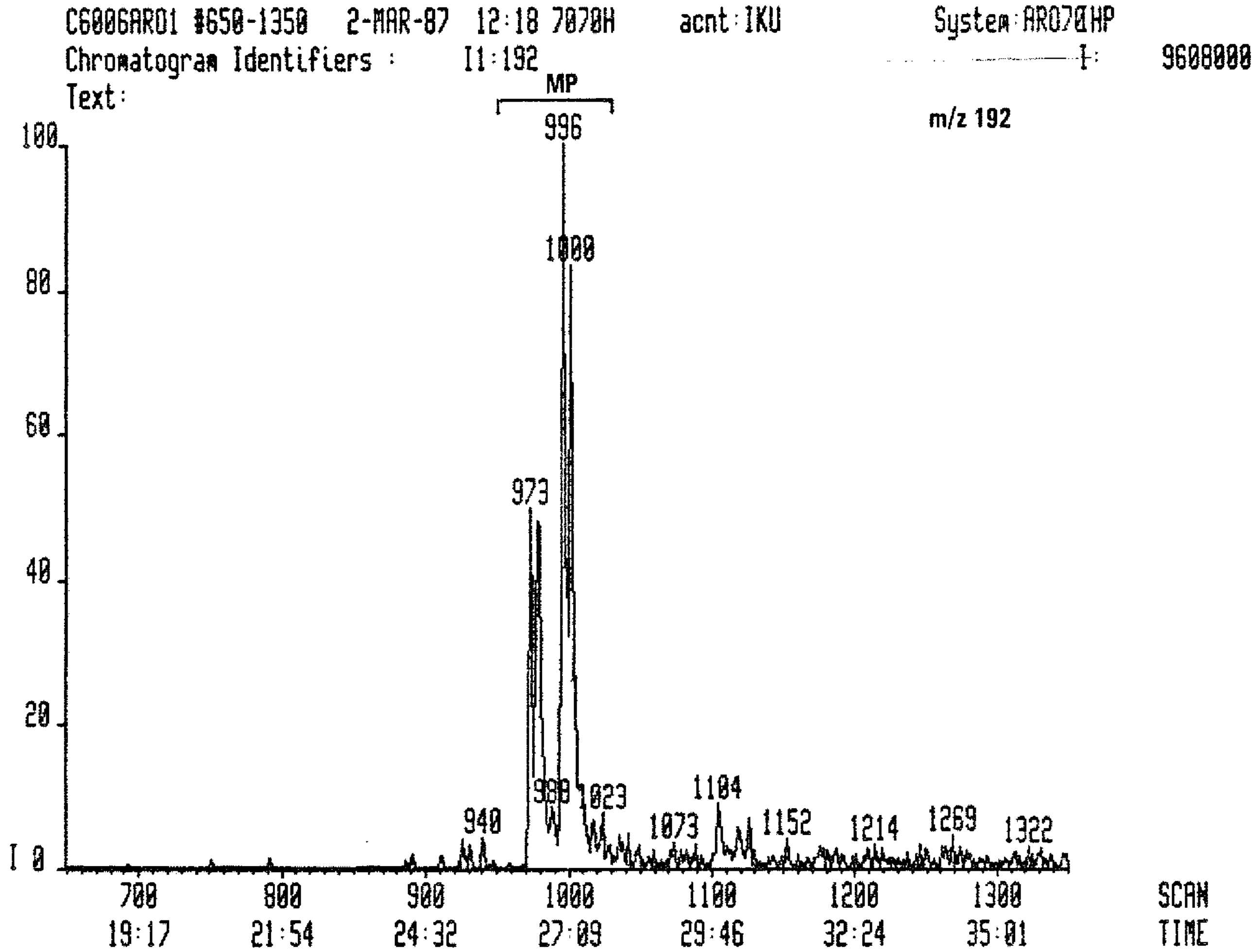
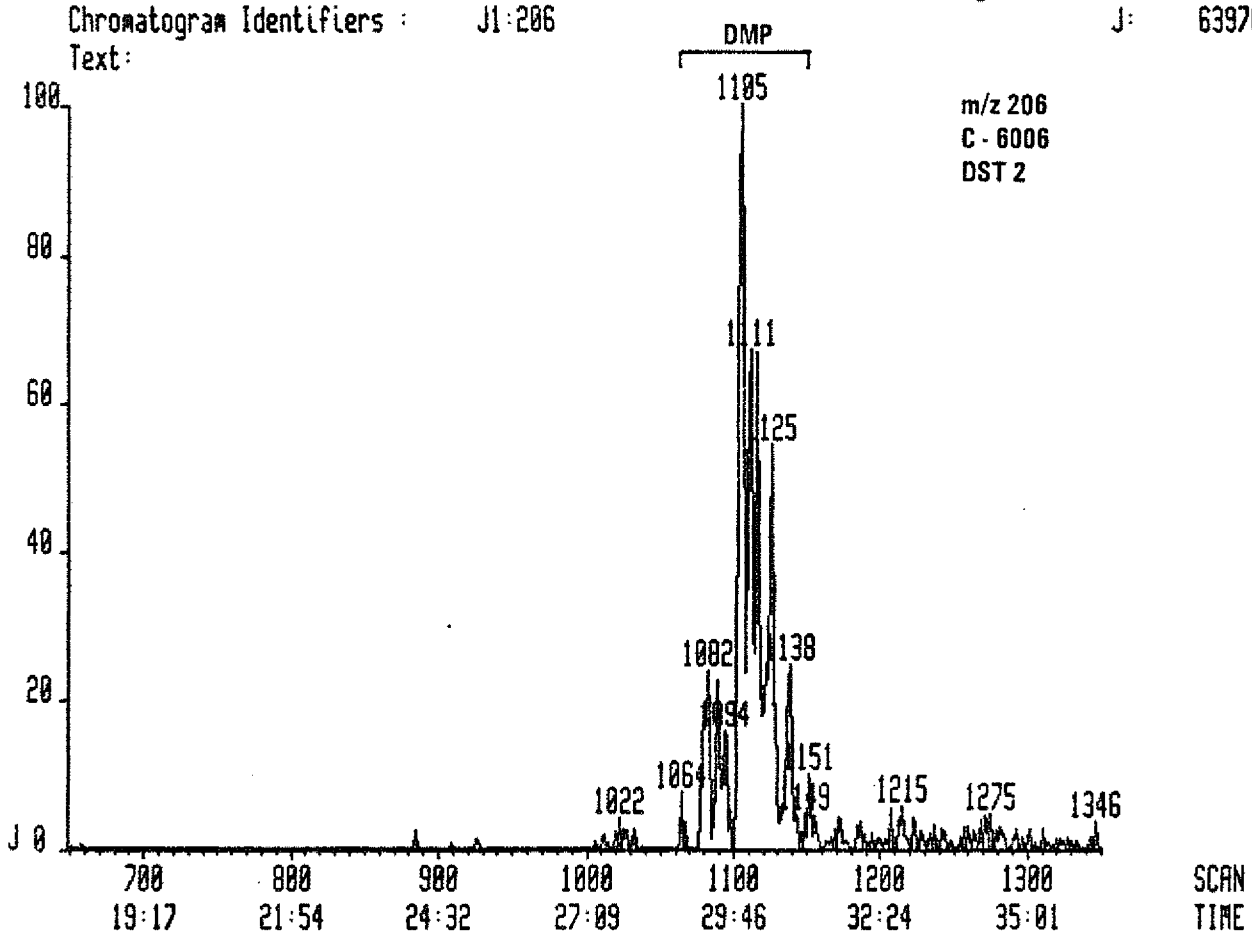
1187
1240
1279
1319
SCAN
TIME

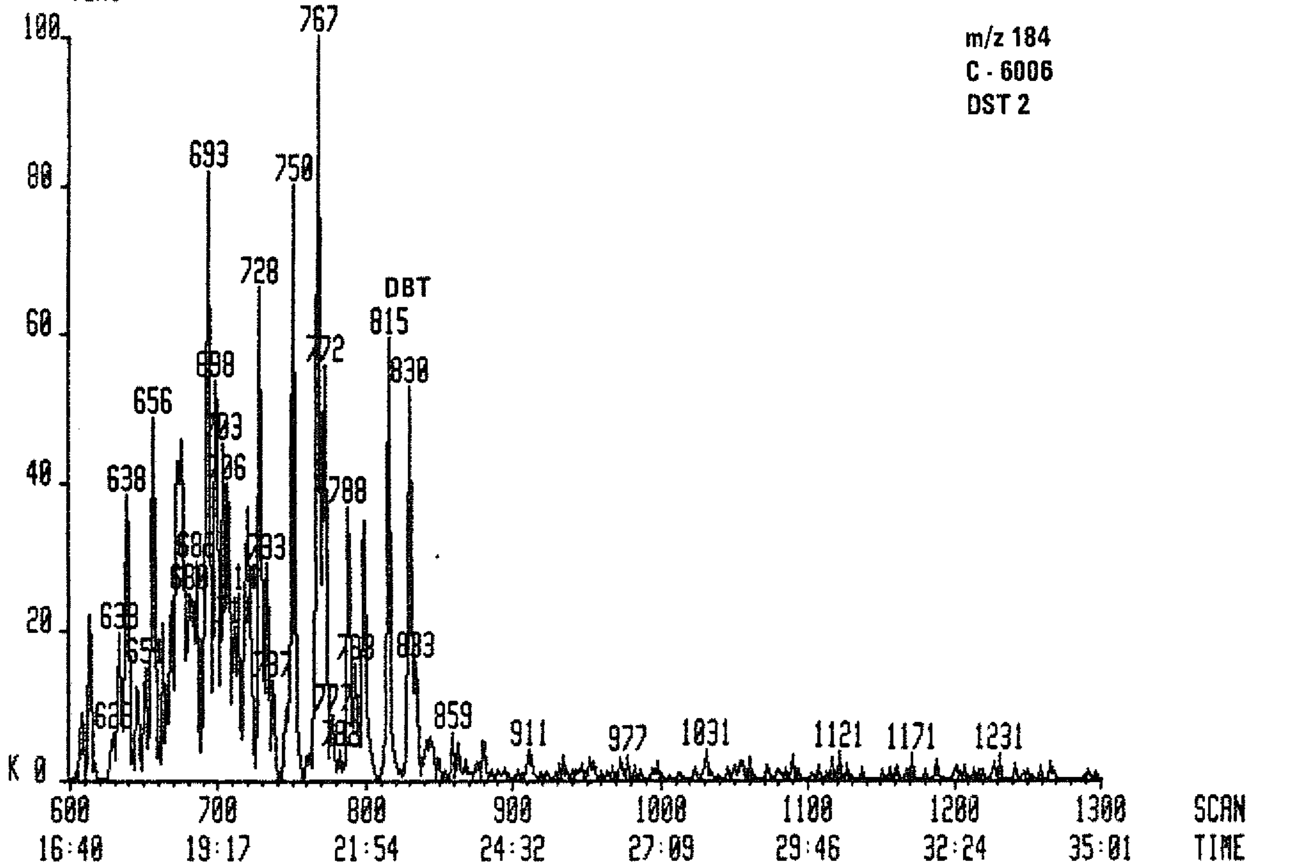

C6006AR01 #650-1350 2-MAR-87 12:18 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : I1:192 I: 9608000
Text:
MP
996
m/z 192
1000
973
940
1023
1073
1104
1152
1214
1269
1322
SCAN
TIME

C6006AR01 #650-1350   2-MAR-87 12:18 7070H   acnt:IKU   System:AR070HP
Chromatogram Identifiers :   J1:206   J: 6397000
Text:

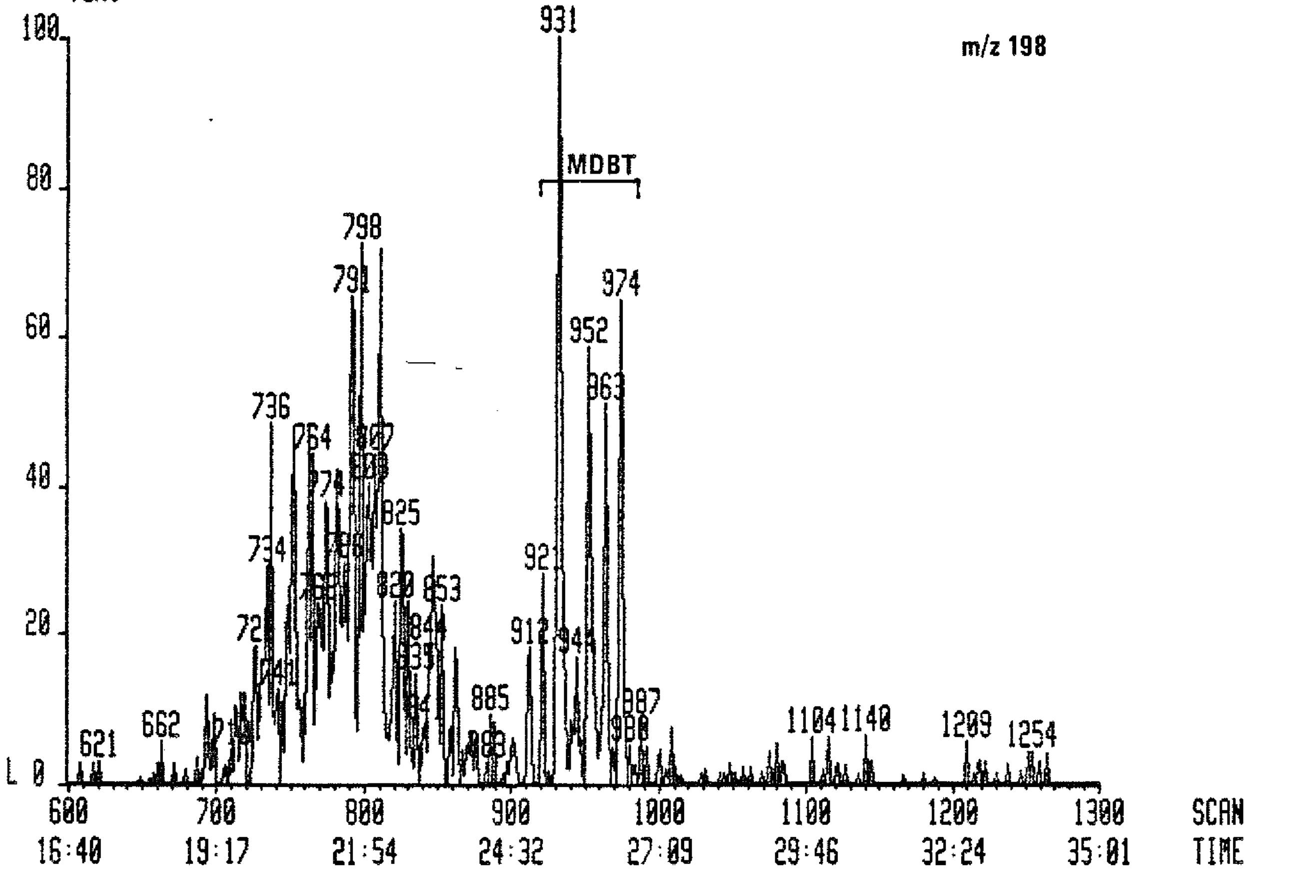


IKU SINTEF-GRUPPEN

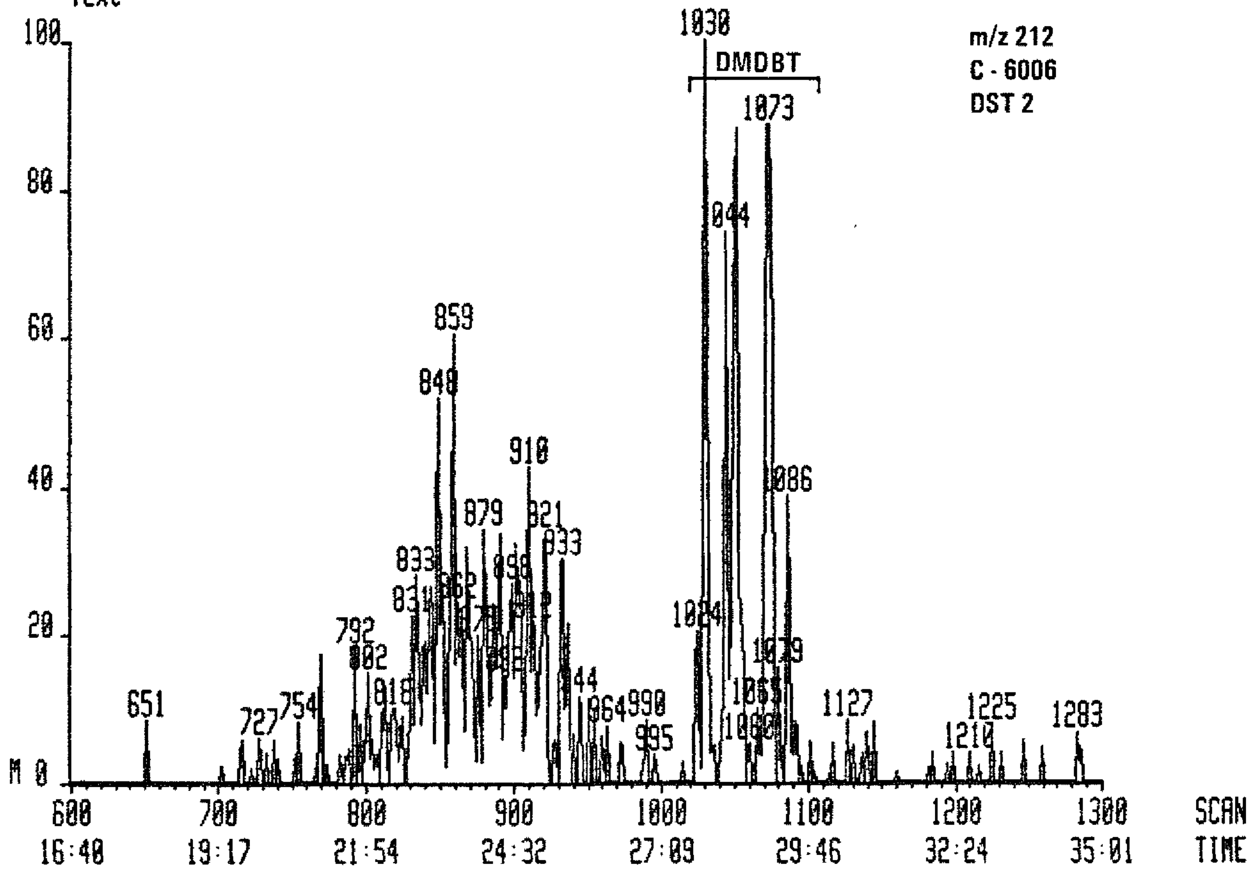
C6006AR01 #600-1300 2-MAR-87 12:18 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : K1:184 K: 8079000
Text:



C6006AR01 #600-1300 2-MAR-87 12:18 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : L1:198 L: 3702000
Text:



C6006AR01 #600-1300 2-MAR-87 12:18 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : M1:212 M: 2269000
Text:



IKU SINTEF-GRUPPEN

C6006AA01 #1300-2200 2-MAR-87 12:18 7070H acnt:IKU System:AR070HP
Chromatogram Identifiers : N1:231 N: 2723000
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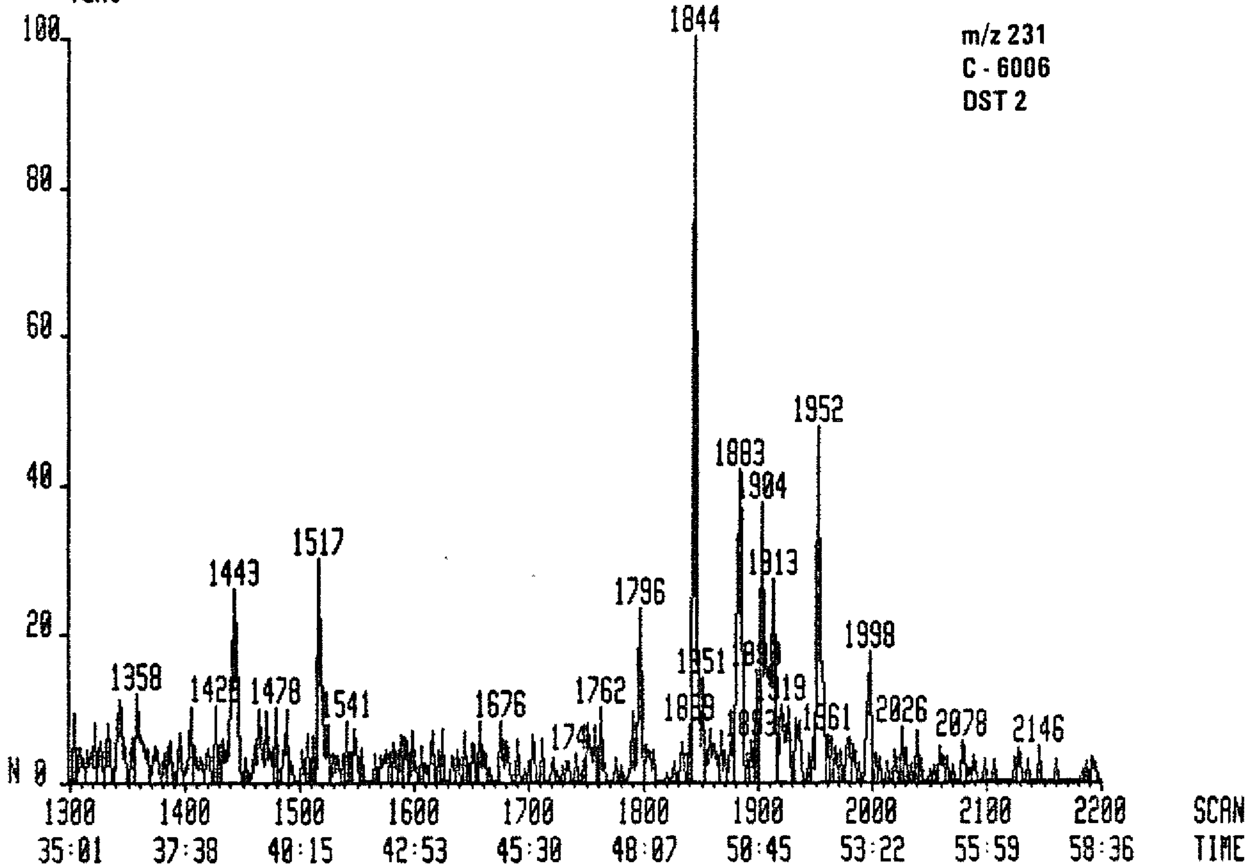
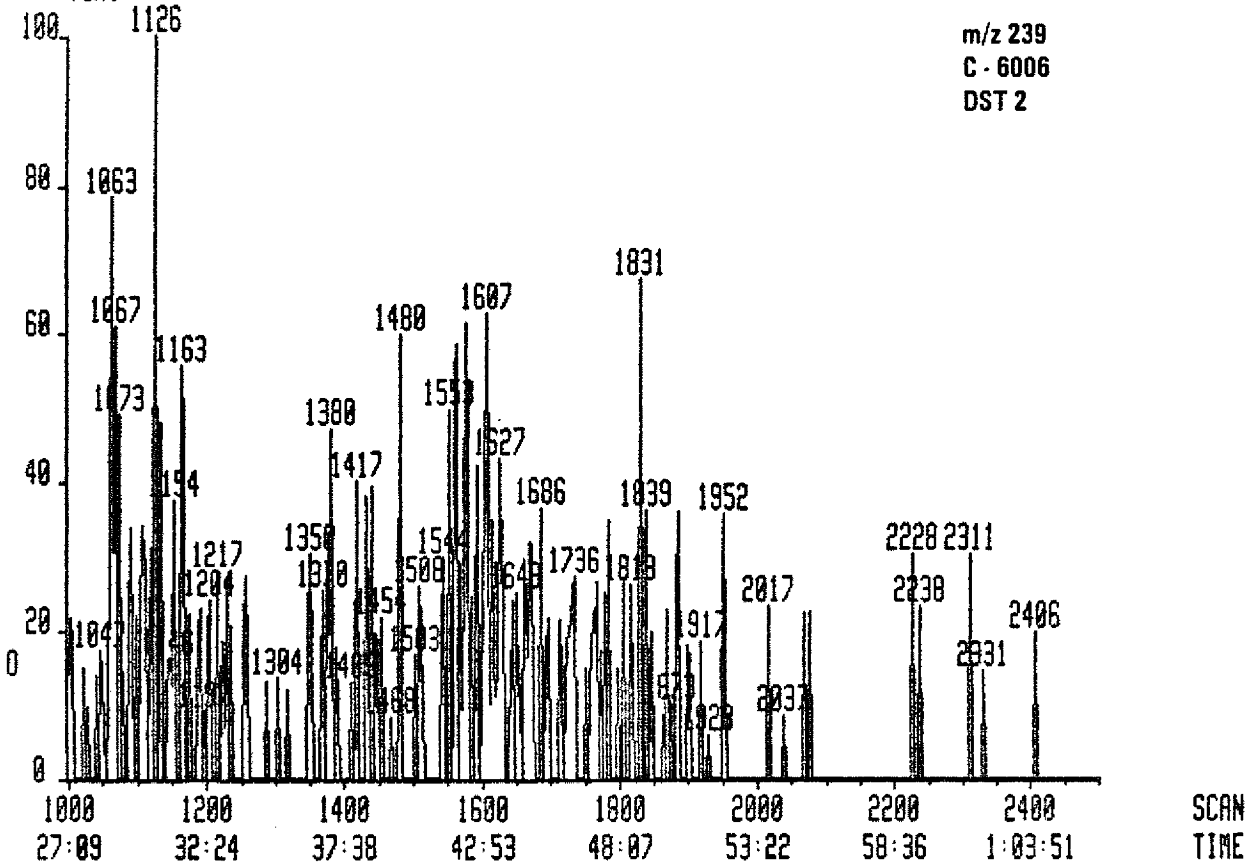


C6006AR01 #1000-2500 2-MAR-87 12:18 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : 01:239 O: 421000
Text:



C6006AR01 #1000-2500 2-MAR-87 12:18 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : P1:253 P: 825000
Text:

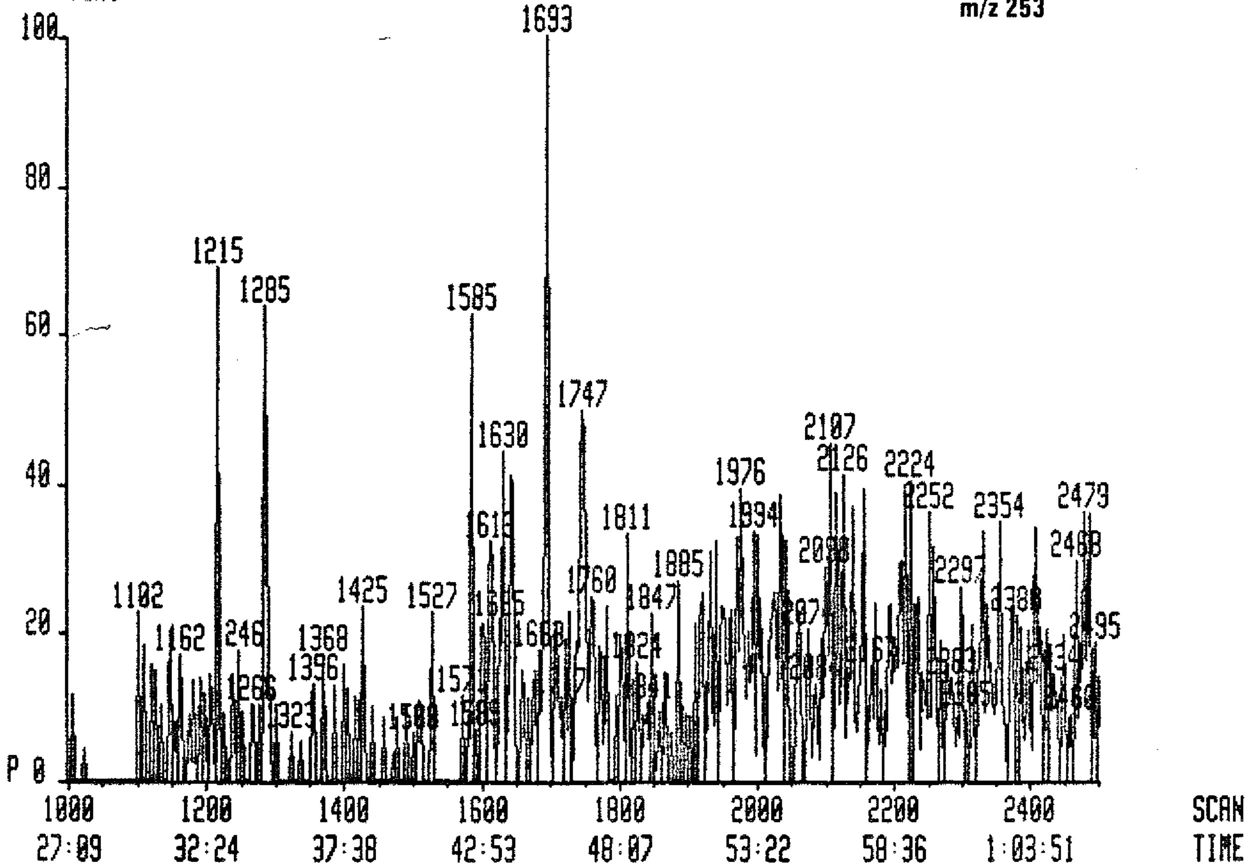
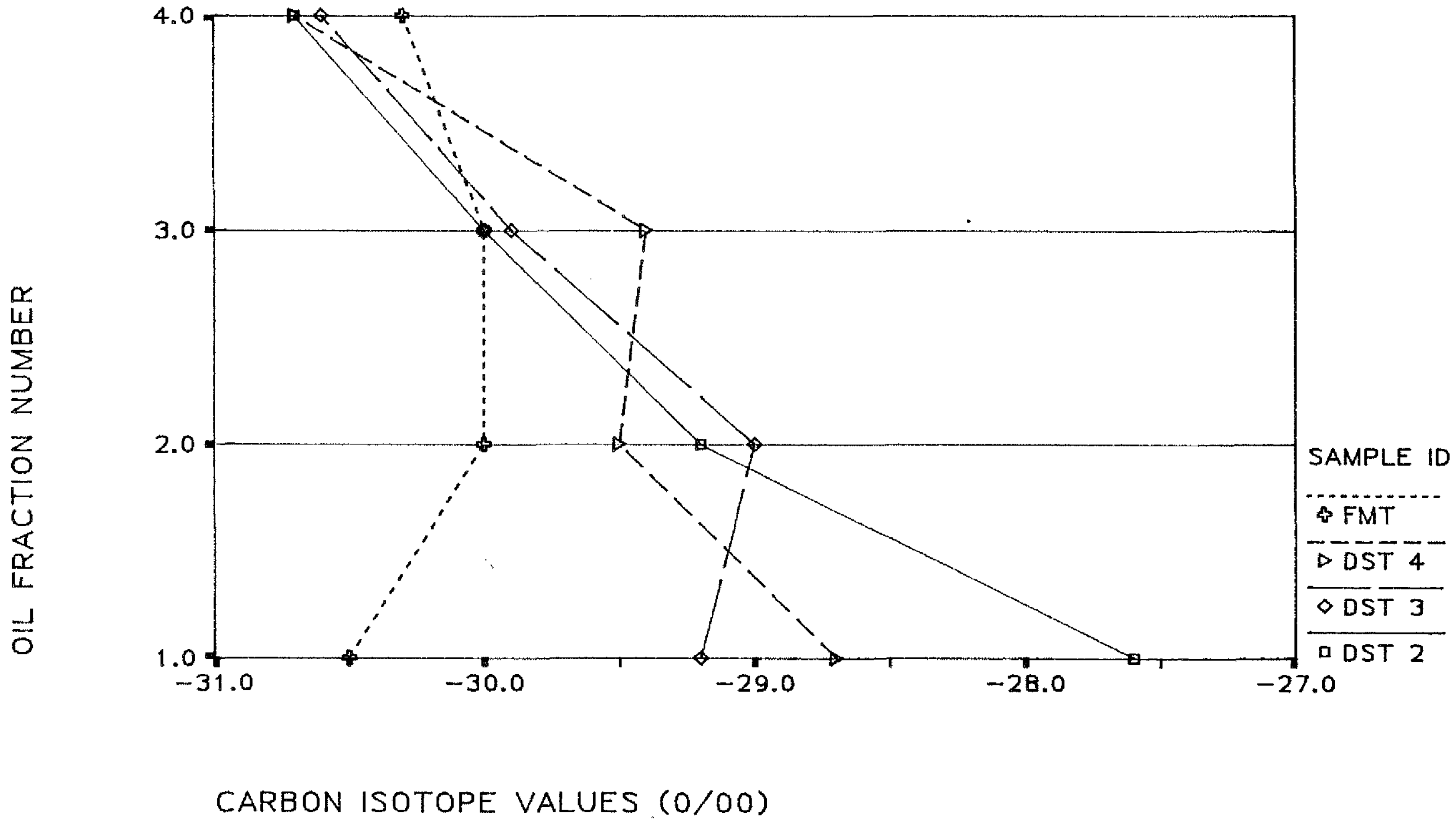


Figure 15: CARBON ISOTOPE PROFILES FOR OIL FRACTIONS FROM 34/7-10



EXTRACT FRACTIONS: 1=NSO;2=ASPHALTENES;3=AROMATICS;4=SATURATES.

APPENDIX

Molecular ratios from terpane and sterane mass chromatograms applied as maturity and source characteristic parameters

Geochemical fossils or biological marker components are characteristic of the type of organic matter present at the time the sediments were deposited. The biological isomers of these components undergo changes due to increased maturity in particular, but also to a certain degree caused by migration and weathering processes.

Source characteristic parameters

In the m/z 191 mass chromatograms which represent the terpanes, the hopanes and moretanes are the major components in most extracts and oils. Of the hopanes the C_{27} and C_{29}-C_{35} homologs are ubiquitous, while the C_{28} bisnorhopane is believed to be typical of certain types of source rocks. This is also the case for the component, probably gammacerane, sometimes seen to coelute with the 22S isomer of the C_{31} 17α(H)-hopanes (H). In the sterane mass chromatograms, m/z 217 and m/z 218, the molecular weight distribution of the C_{27}-C_{29} regular steranes is believed to be representative of the original input of organic matter. The highest molecular weight compounds, the C_{29} steranes, represent organic matter of terrestrial origin, while the lower molecular weight analogs originate from more marine type environments.

Maturity dependent parameters

The biological isomers of the hopanes, the 17β(H), 21β(H)-hopanes, undergo structural changes during the maturation process. The isomerisation reactions are thought to be produced via the 17β(H), 21α(H)-hopanes (moretanes) to the most stable 17α(H), 21β(H)-hopanes. At equilibrium 100% of the 17α(H)-hopanes are seen. The ratio αβ/αβ+βα is used to describe this reaction. In the extended hopanes ($\geq C_{31}$), the thermally stable S configurations at C-22 become increasingly more abundant as compared to the biologically preferred R configurations at increased maturity level. The equilibrium ratio is approximately 60% of the 22S configuration. Another ratio that is known to change with maturity is the Tm/Ts (Seifert et al., 1978) of the C_{27} hopanes. The maturable 18α(H)-trisnorneohopane (Tm) is reduced in intensity relative to the more stable

17α(H)-trisnorneohopane (Ts), causing the Tm/Ts to decrease at increased maturity. This ratio is also believed to be source dependant, and this should be born in mind when applying the ratio for maturity comparison. The amount of tricyclic terpanes is also to a certain extent seen to be maturity dependant.

Two isomerisation reactions taking place in the steranes are most commonly applied for maturity assignments from the m/z 217 mass chromatograms. The biologically preferred 14α(H), 17α(H)-isomers of the regular steranes is transformed to the thermally stable 14β(H), 17β(H)-steranes, the %ββ approaching 75% at equilibrium. An equilibrium concentration of 50% is seen of the stable S configuration at C-20 as opposed to the 100% of the biological 20R epimer (Mackenzie et al., 1980). The abundance of rearranged steranes increased with increasing maturity.

One of the reactions taking place at an early stage of diagenesis is the aromatisation of steranes, leading to the formation of mono- and tri-aromatic analogs. This process is measured as the abundance of tri-aromatic relative to mono-aromatic compounds (% tri/tri + mono) in the m/z 231 and 253 mass chromatograms, respectively. In addition the degree of side chain cracking, as $\%C_{20}/C_{26,\ 27}$ and $\%C_{21}/C_{28,29}$ respectively, is applied. These cracking processes are also taking place during early diagenesis, and are used for maturity assignment together with the previously mentioned ratios.

Migration and weathering

The effect on the geochemical fossils of migration and weathering, is less apparent than the maturity induced changes. Migration is believed to cause an increase in the relative amounts of rearranged and 14β(H), 17β(H) regular steranes (Seifert and Moldowan, 1978, 1981). Severe biological alteration leads to the formation of desmethyl-hopanes (Seifert and Moldowan, 1979).