statoil

TBP-distillation

Well: 31/6-5

FMT

STATOIL
EXPLORATION & PRODUCTION
LABORATORY

by

Hans Petter Rønningsen

September 1984 LAB 84.

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INTRODUCTION

This report presents the results of a true boiling point distillation, performed on stabilized oil from an FMT-sample from well 31/6-5 (depth 1571.5 m RKB), by West Lab A/S. A total composition of the sample has been calculated by using TBP-data above C_{10}, and GC-data (Statoil) from analysis of single flash liquid from the original FMT-sample below C_{10}. The high water content of the stabilized oil made GC-analysis impossible.

The water content was 6.0 % by volume. As it would be very difficult to remove this water without altering the light end of the oil, pour point, wax appearance point and viscosity were measured on samples containing water. Pour point and WAP seem to be reliable, compared to for instance 31/2-5 (P.p. -30^{o}C, WAP +13^{o}C; LAB. 84.232). The viscosity is, however much higher, and a part of the difference can certainly be attributed to the water content, as the viscosity of water-in-oil emulsions are higher than of pure oils. The viscosity is, however, still very high.

The sample was distilled in one step from room temperature to 151.3 ^{o}C at atmospheric pressure. It was fractionated from 88.6 ^{o}C (b.p. of n-C_{11} plus 0.5^{o}C) to 202.0^{o}C at 26.6 mbar reduced pressure. Because the C_{10} b.p. was passed by accident, the C_{10}- and C_{11}- fractions were taken as one fraction.

Table 1. Summary of some essential data of stabilized FMT-oil from 31/6-5.

	Oil	C_{10+}	C_{20+}
Density (15°C, g/cm^3)	0.904	0.920	0.948
Molecular weight (g/mole)	272	316	464
% by weight of oil	100	92.636	62.756
Water content (vol%)	6.0		
Sediment content (wt%)	0.3		
Wax content (wt%)	5.5 1)		
Pentane insolubles (wt%)	0.26		
Pour point, upper (°C)	-36 2)		
Wax appearance point (°C)	+15 2)		
Dynamic viscosity (mPa.s) 2)			
10°C	73.3		
20°C	42.1		
30°C	26.3		
40°C	17.7		

1) corrected for water content

2) analyses made on samples containing water

EXPERIMENTAL

The TBP distillation was performed according to modified ASTM D-2892 using a Kontens Martin MK IV-B fractionator system with a 24½ inches x 25 mm i.d. packed column (15 theoretical plates).

Fractions were collected according to boiling point ranges between successive n-alkanes as given by Katz and Firoozabadi (Journ. Petr. Tech., Nov. 1978, 1650).

For gas chromatograghic single component analysis below C_{10}, a Chrompack WCOT Cp Sil 5 column (25 m x 0.22 mm i.d., filmthickness 0.14 μm) was used with helium as carrier gas, split injection and FI-detector. The temperature was programmed from -5°C (2 min) to 40°C with 2°/min and from 40°C to 300°C with 8°/min.

For GC analysis of collected fractions to check fractions overlap, a Chrompack WCOT Cp Sil 5 CB column (25 m x 0.23 mm i.d., 0.11 μm filmthickness) was used with helium, split injection, FI-detector and temp. programming 4°/min from 10°C (4 min) to 300°C.

Molecular weights were determined by freezing point depression using a Cryette cryoscope with benzene as referance substance.

Densities were measured using a Paar DMA 46 frequency densiometer thermostatted at 15°C.

Dynamic viscosity was measured using a Contraves Rheomat 115 rotational viscosimeter equipped with a MS 0/115 measuring system.

A modification of UOP method 46-64 (Burger et.al.; Journ Petr. Tech., June 1981, 1075-1086) was used to determine wax content.

Pentane insolubles (asphalthenes) were determined by dilution of the oil 1:40 (vol/vol) with pentane and filtration.

Pour Point was measured according to ASTM method D-97 (1980).

Wax appearance point was measured optically with polarised light. The sample was heated at 70°C for 1 hour prior to temperature reduction.

The water content was determined by Dean Stark distillation and sediment content by a BS-test.

RESULTS

Table 2 gives compositional TBP-data and physical data of each fraction. Loss at the end the distillation was supposed to be column hold up material, and was added to the C_{20+} -fraction.

Table 3 gives calculated density of recovered distillate assuming ideal mixing behaviour:

$$S = \text{cumulative density} = \frac{\text{cumulative weight}}{\text{cumulative volume}}$$

Table 4 gives calculated molecular weight and densities assuming ideal mixing behaviour.

Table 5 gives weight distribution and calculated overlap between fraction. % by weight overlap is assumed to be equal to area % overlap in gas chromatograms.

Table 6 gives a detailed composition of the light end ($<C_{10}$). determined by GC-analysis of single flash liquid from FMT-sample. This table gives calculated molecular weights and densities of fraction without overlap, based on composition and the ideal mixture assumption. The C_{10} -fraction has also been corrected for overlap to the C_9-fraction.

Table 7 gives the content of some important cyclo-alkanes and aromatics, based on the same GC-analysis as table 6.

Table 2. Data from TBP distillation of stock tank condensate 31/6-5 FMT.

Fraction	Cut point (C,760 mmHg)	Actual head-temp.	% by weight of total oil	% by weight distilled
Gas	-	-	0.161	0.161
C 5	36.5	36.5	0.153	0.314
C 6	69.2	69.2	0.444	0.758
C 7	98.9	98.9	1.793	2.551
C 8	126.1	126.1	2.701	5.252
C 9	151.3	151.3	2.112	7.364
C 10+	> 151.3	> 151.3	92.636	100.000
C 10 + C 11	196.4	88.6	4.080	11.444
C 12	216.8	105.3	2.342	13.786
C 13	235.4	121.1	2.910	16.696
C 14	254.5	137.2	3.723	20.419
C 15	271.5	151.4	3.741	24.160
C 16	287.9	164.4	3.103	27.262
C 17	303.0	177.8	3.553	30.816
C 18	317.4	190.6	3.390	34.205
C 19	331.0	202.2	3.038	37.244
C 20+	> 331.0	> 202.2	62.756	100.000

Table 2 cont.

Fraction	Density (g/cm3)	% by volume of total oil	% by volume distilled
Gas	0.530	0.274	0.274
C 5	0.625	0.221	0.496
C 6	0.676	0.593	1.089
C 7	0.747	2.171	3.260
C 8	0.759	3.217	6.477
C 9	0.777	2.456	8.934
C 10+	0.920	91.085	100.019
C 10 + C 11	0.826	4.469	13.402
C 12	0.845	2.507	15.909
C 13	0.852	3.089	18.998
C 14	0.861	3.912	22.910
C 15	0.870	3.890	26.800
C 16	0.881	3.186	29.985
C 17	0.884	3.636	33.622
C 18	0.891	3.441	37.063
C 19	0.900	3.054	40.117
C 20+	0.948	59.883	100.000

Table 2 cont.

Fraction	Molecular weight	Mole%	Cumulative mole%
Gas	51.1	0.86	0.86
C 5	72.1	0.58	1.44
C 6	82.7	1.47	2.91
C 7	89.3	5.50	8.42
C 8	104.5	7.08	15.50
C 9	119.0	4.86	20.36
C 10+	316	80.33	100.69
C 10 + C 11	139	8.04	28.41
C 12	159	4.04	32.44
C 13	174	4.58	37.02
C 14	187	5.46	42.48
C 15	202	5.07	47.55
C 16	213	3.99	51.54
C 17	229	4.25	55.80
C 18	241	3.85	59.65
C 19	253	3.29	62.94
C 20+	464	37.06	100.00

Table 3. Cumulative weight and volume, % by volume distilled and calculated density S of recovered material.

S = Cum. weight/cum. volume

Fraction	Cum. weight	Cum. volume	S	% by volume distilled
Gas	2.750	5.181	0.531	0.274
C 5	5.363	9.356	0.573	0.496
C 6	12.948	20.563	0.630	1.089
C 7	43.576	61.564	0.708	3.260
C 8	89.714	122.313	0.733	6.477
C 9	125.792	168.696	0.746	8.934
C 10 + C 11	195.492	253.079	0.772	13.402
C 12	235.492	300.416	0.784	15.909
C 13	285.192	358.750	0.795	18.998
C 14	348.792	432.617	0.806	22.910
C 15	412.692	506.065	0.815	26.800
C 16	465.692	566.224	0.822	29.985
C 17	526.392	634.889	0.829	33.622
C 18	584.292	699.873	0.835	37.063
C 19	636.192	757.539	0.840	40.117

Table 4. Measured and calculated molecular weights and densities of condensate 31/6-5 FMT.

	Oil	C 10+	C 20+
Measured MW	272	316	464
Calculated MW using C10+ MW	272		
Calculated MW using C20+ MW	274	319	
Measured density	0.904	0.920	0.948
Calculated density using C10+ density	0.904		
Calculated density using C20+ density	0.905	0.920	

Table 5. Weight distribution and % by weight overlap between uncorrected fractions of condensate 31/6-5 FMT.

Fraction	% by weight of total oil	% by weight overlap between fractions *
Gas	0.161	-
C 5	0.153	-
C 6	0.444	0 : 100 : 0
C 7	1.793	0 : 100 : 0
C 8	2.701	0 : 100 : 0
C 9	2.112	0 : 100 : 0
C 10 + C 11	4.080	0 : 59 : 37 : 4
C 12	2.342	11 : 79 : 10
C 13	2.910	6 : 83 : 11
C 14	3.723	10 : 81 : 9
C 15	3.741	8 : 79 : 13
C 16	3.103	10 : 76 : 14
C 17	3.553	11 : 71 : 18
C 18	3.390	11 : 73 : 16
C 19	3.038	13 : 72 : 15

* Calculated on basis of area% from GC-reports
(respons factors have not been used)

Table 6 . Detailed composition of the light end of stock tank condensate 31/6-5 FMT.

Component	Weight%	Mole%	Vol%	MW	Density
Methane	0.000	0.00	0.000	16.04	0.2600
Ethane	0.014	0.13	0.035	30.07	0.3580
Propane	0.028	0.17	0.050	44.10	0.5076
i-butane	0.085	0.40	0.137	58.12	0.5633
n-butane	0.034	0.16	0.053	58.12	0.5847
2,2-dimethylpropane	0.004	0.02	0.006	72.15	0.5967
i-pentane	0.098	0.37	0.142	72.15	0.6246
n-pentane	0.051	0.19	0.073	72.15	0.6309
Hexanes total	0.444	1.47	0.593	82.7	0.676
Hexanes paraffines	0.363	1.15	0.496	86.2	0.662
Hexanes naphtenes	0.080	0.31	0.096	70.1	0.750
Heptanes total	1.793	5.50	2.171	89.3	0.747
Heptanes paraffines	0.418	1.14	0.553	100.2	0.684
Heptanes naphtenes	1.372	4.35	1.616	86.5	0.768
Heptanes aromatics	0.003	0.01	0.003	78.1	0.884
Octanes total	2.701	7.08	3.217	104.5	0.759
Octanes paraffines	0.547	1.31	0.703	114.2	0.704
Octanes naphtenes	2.068	5.52	2.423	102.7	0.772
Octanes aromatics	0.086	0.26	0.089	92.1	0.871
Nonanes total	2.112	4.86	2.456	119.0	0.777
Nonanes paraffines	0.853	1.82	1.069	128.3	0.722
Nonanes naphtenes	0.769	1.77	0.879	118.8	0.791
Nonanes aromatics	0.491	1.27	0.509	106.2	0.872

Table 7 . Some important single compounds in stock tank condensate 31/6-5 FMT.

Component	Weight%	Mole%	Vol%	MW	Density
Methylcyclopentane	0.430	1.40	0.516	84.16	0.7534
Benzene	0.003	0.01	0.003	78.11	0.8842
Cyclohexane	0.683	2.22	0.789	84.16	0.7831
Methylcyclohexane	1.275	3.56	1.491	98.19	0.7737
Toluene	0.086	0.26	0.090	92.15	0.8669
m+p-xylene	0.246	0.63	0.257	106.17	0.8668
o-xylene	0.098	0.25	0.100	106.17	0.8844

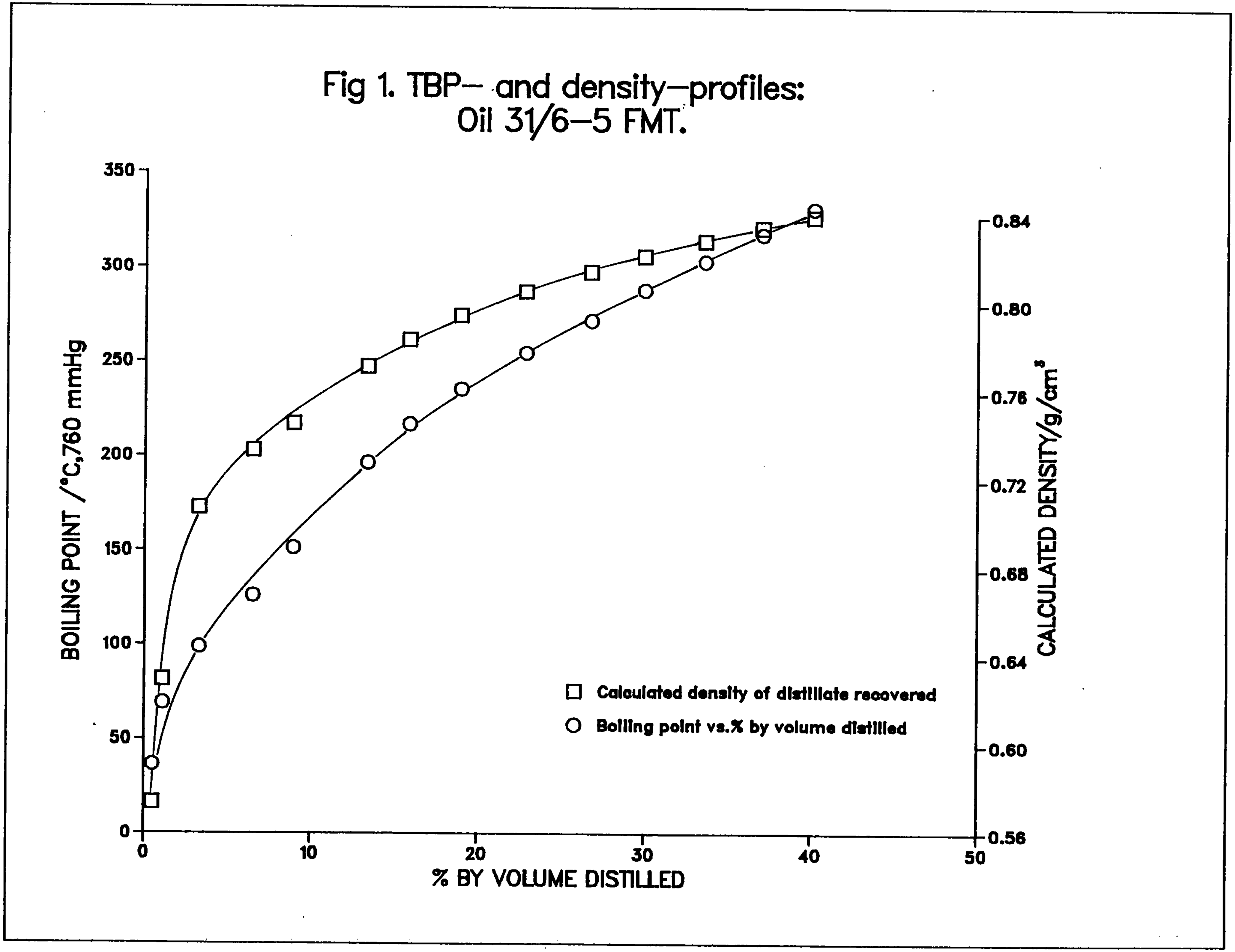
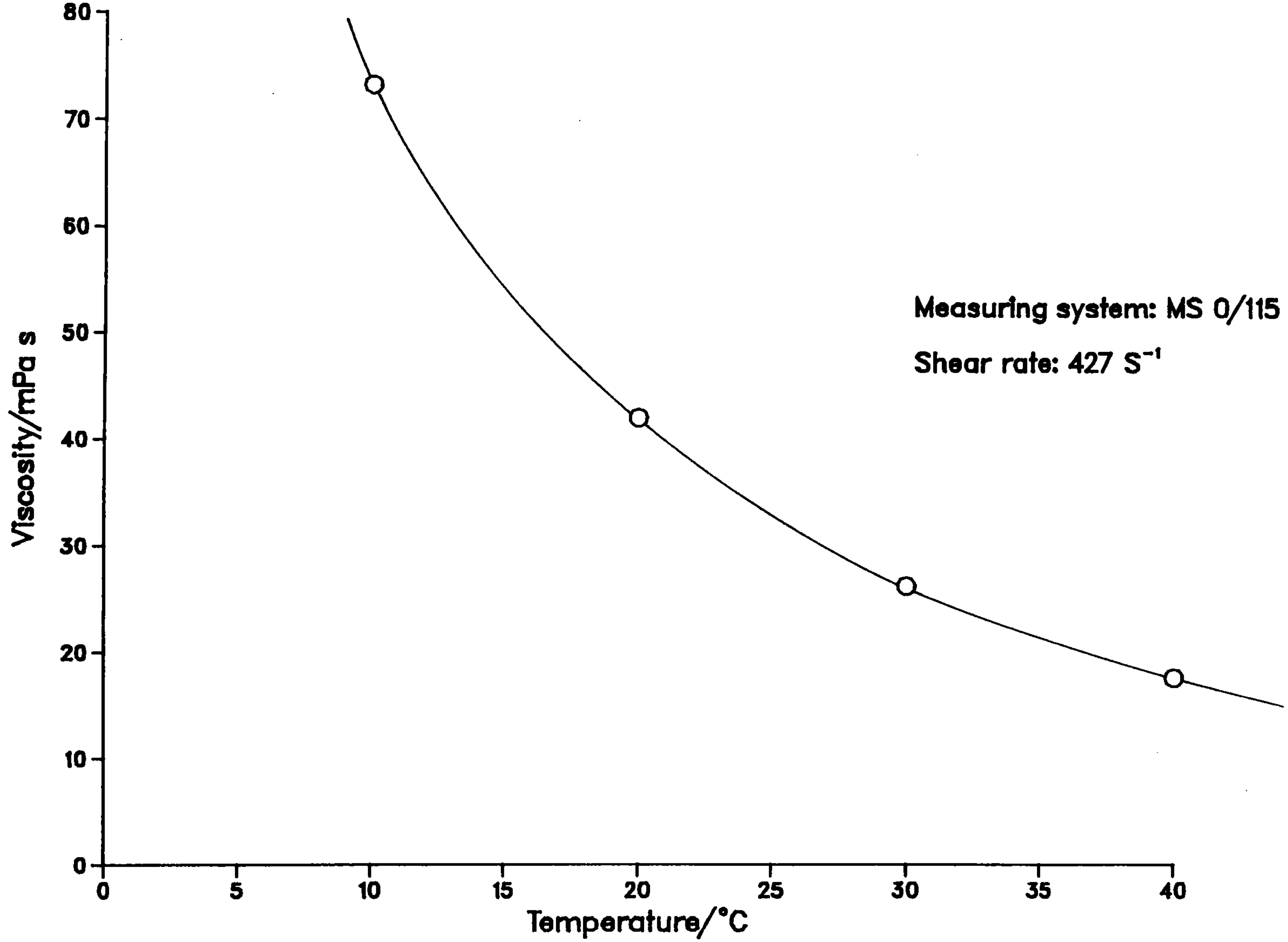
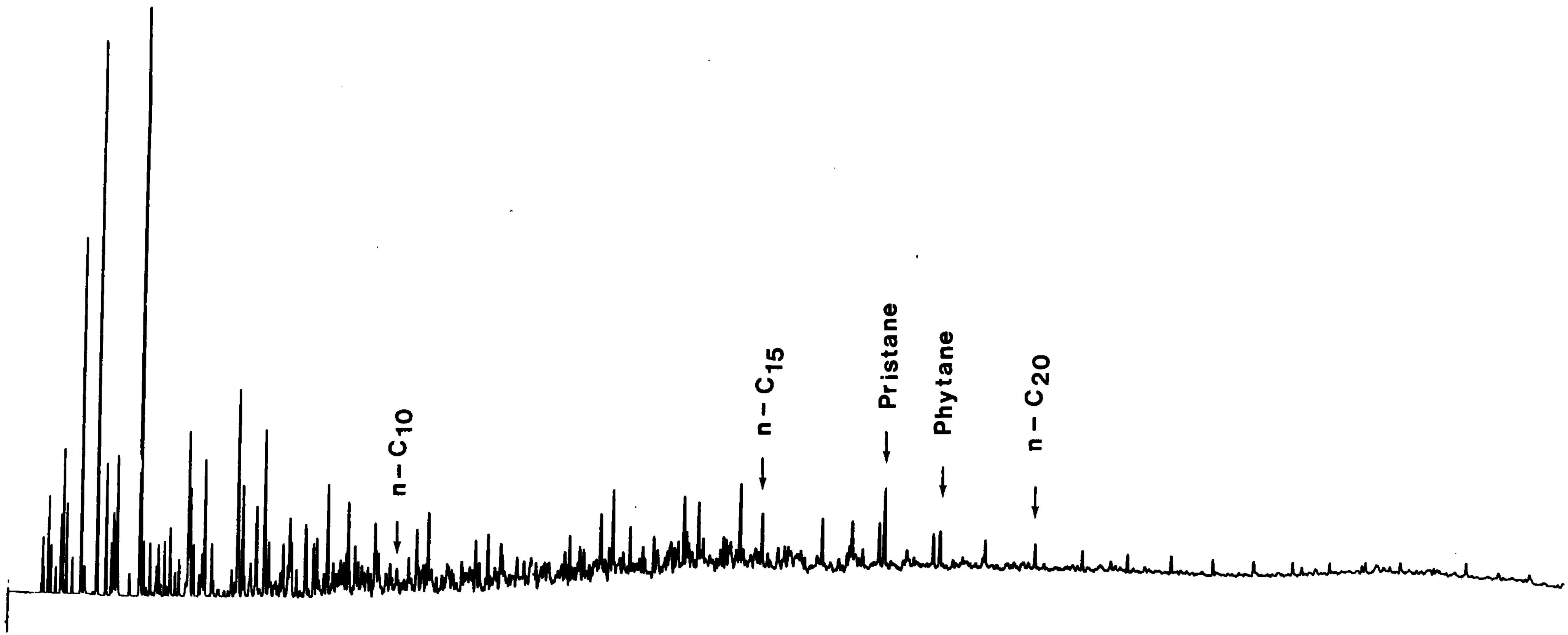


Fig 1. TBP- and density-profiles:
Oil 31/6-5 FMT.
BOILING POINT /°C,760 mmHg
350
300
250
200
150
100
50
0
0
10
20
30
40
50
% BY VOLUME DISTILLED
CALCULATED DENSITY/g/cm³
0.84
0.80
0.76
0.72
0.68
0.64
0.60
0.56
Calculated density of distillate recovered
Boiling point vs.% by volume distilled

FIG.2 VISCOSITY VS. TEMPERATURE OF OIL 31/6–5 FMT

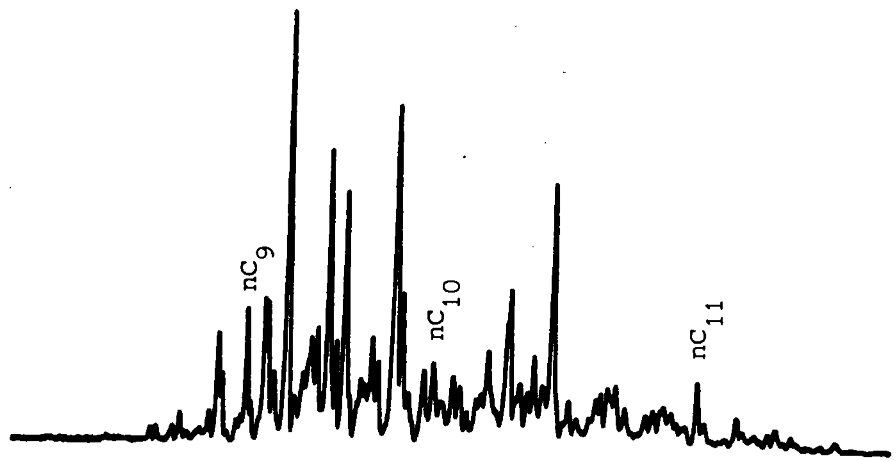


APPENDIX

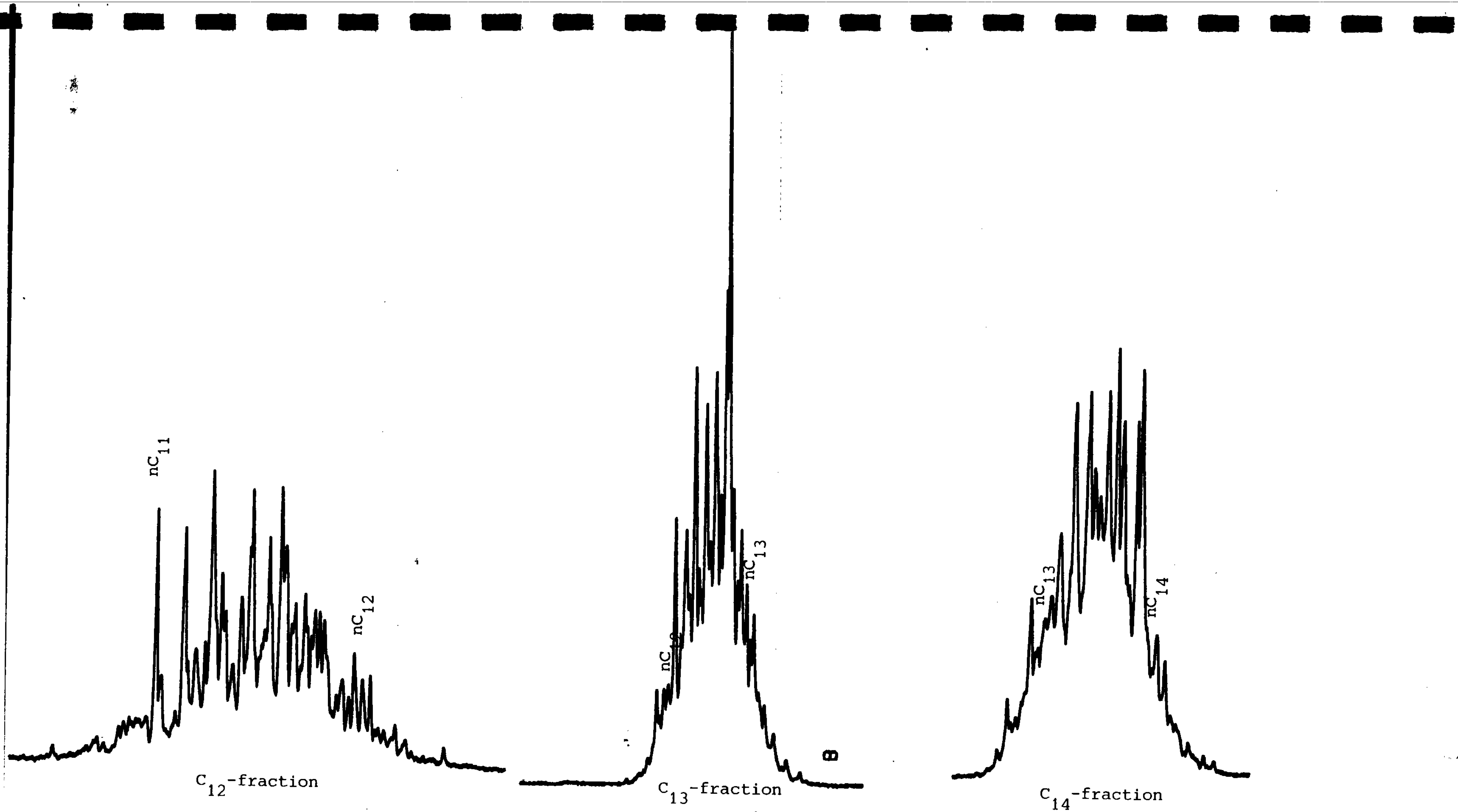


OIL 31/6-5 FMT

C_5 - C_9 fraction



C_{10} - C_{11} fraction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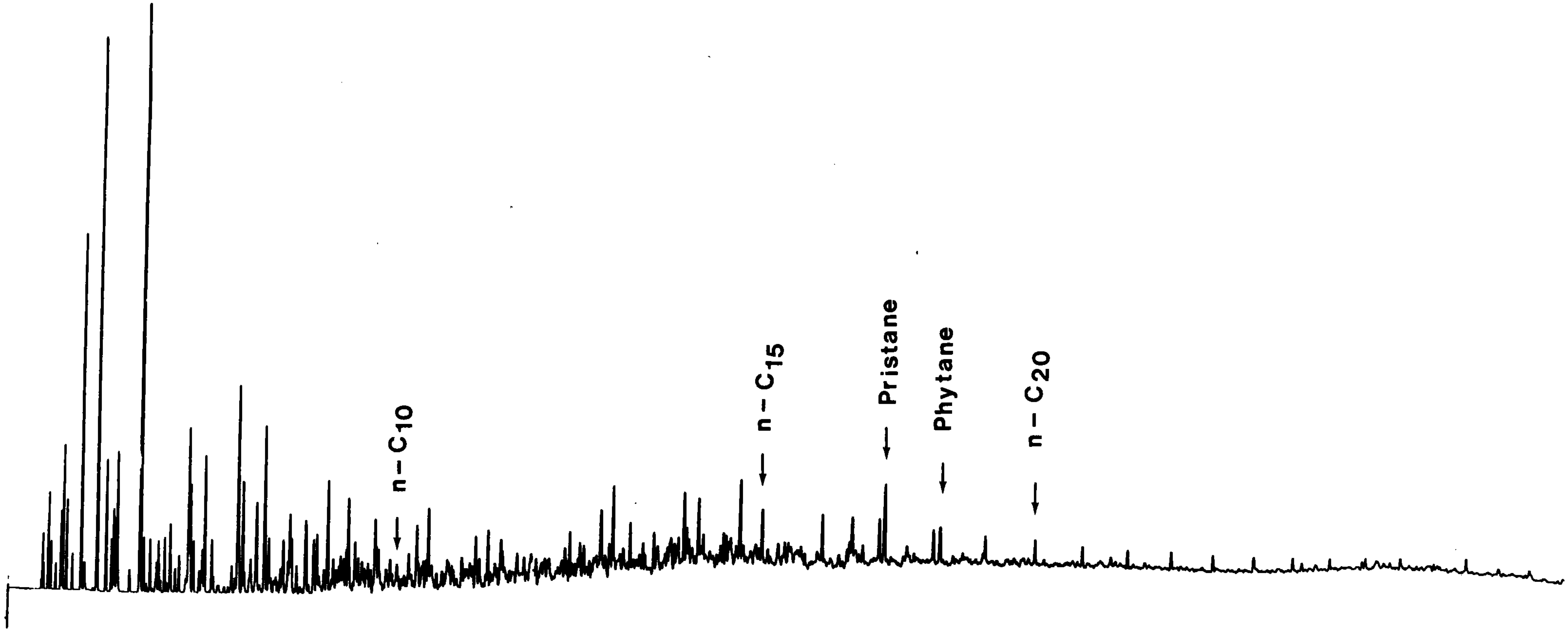
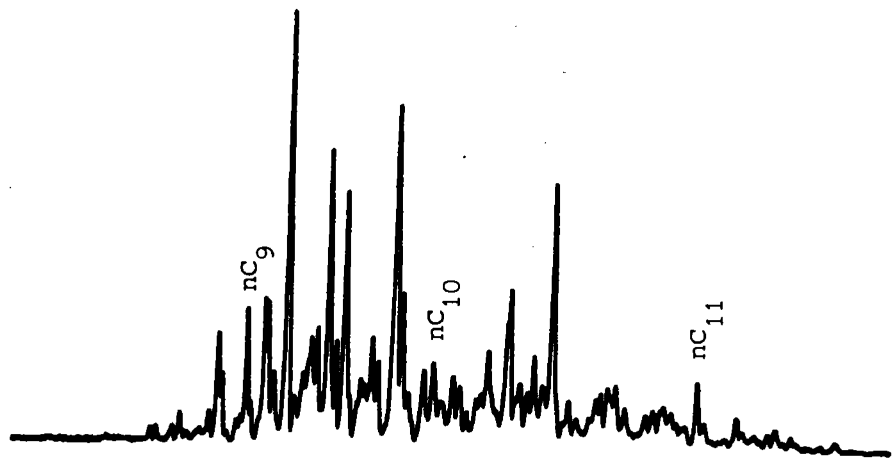
nC12
C12-fraction
nC12
nC13
C13-fraction
nC13
nC14
C14-fraction

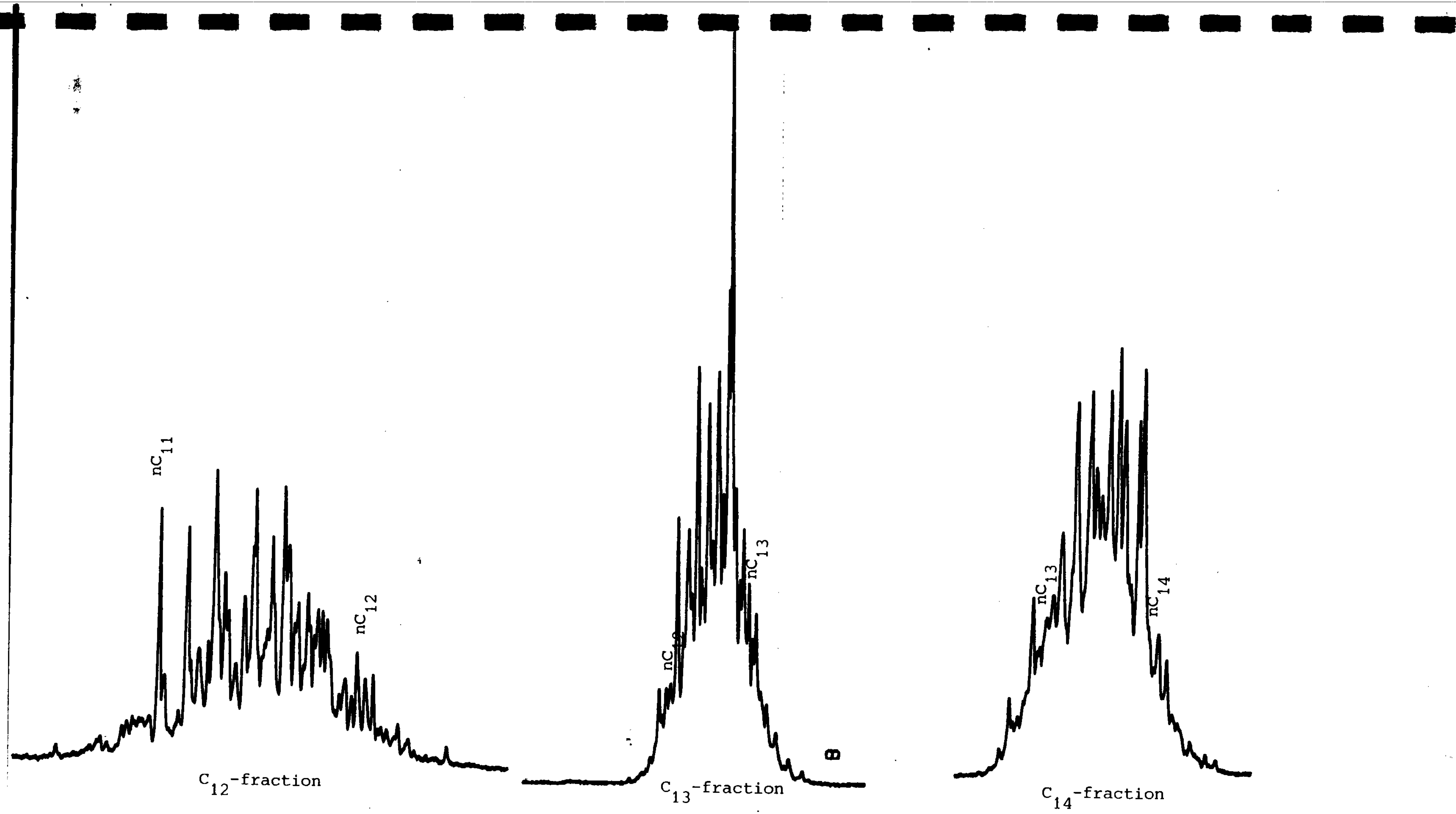


OIL 31/6-5 FMT

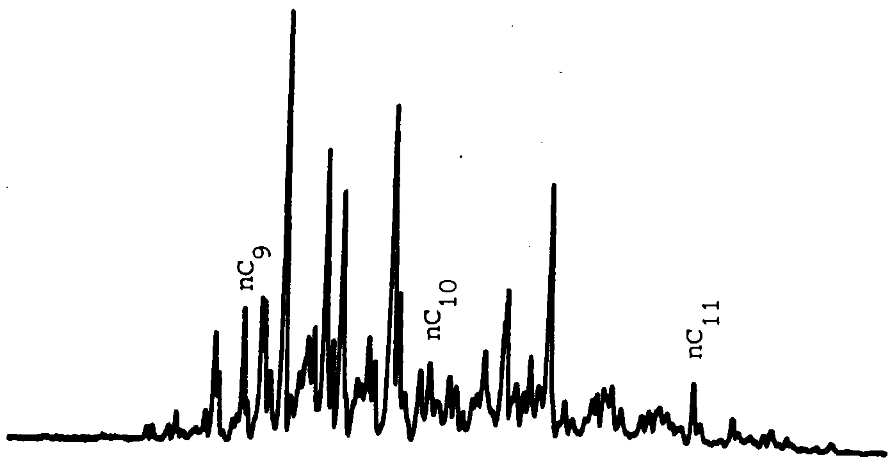
C_5 - C_9 fraction



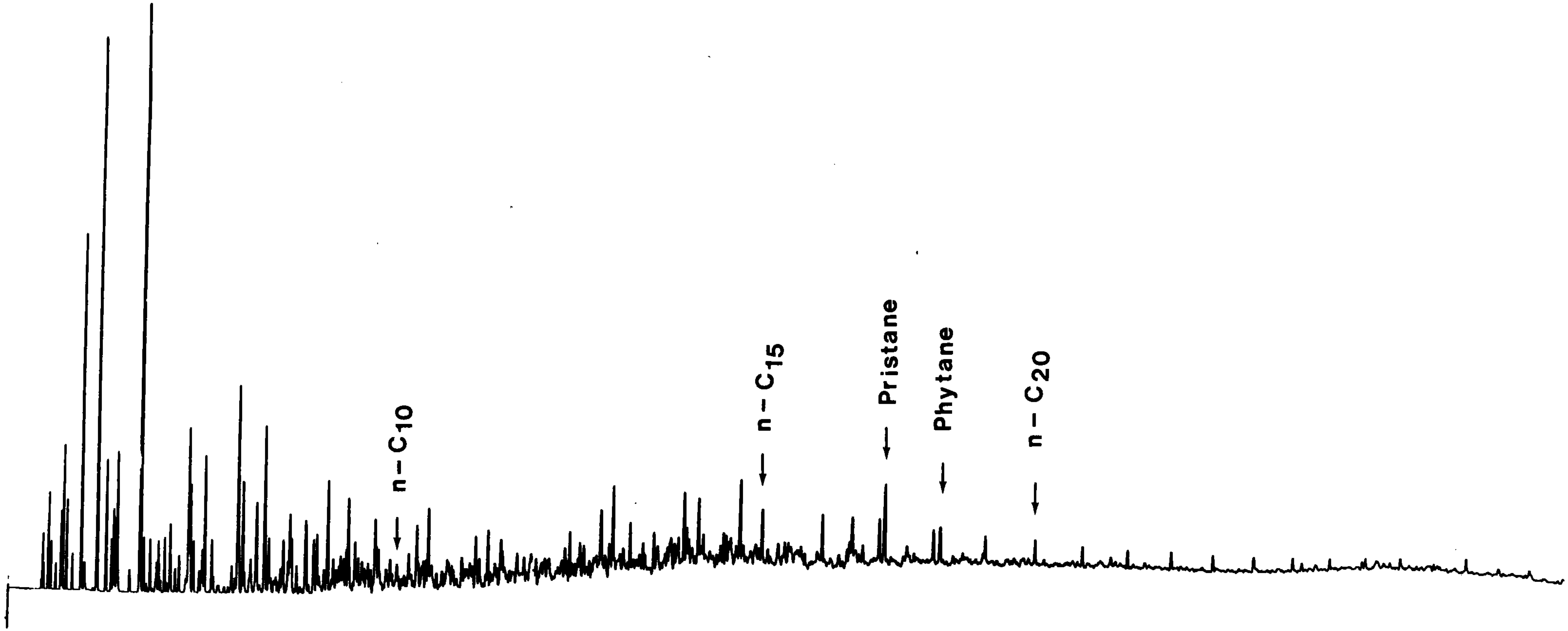
C_{10} - C_{11} fraction


nC11
nC12
C12-fraction
nC13
C13-fraction
nC13
nC14
C14-fraction

C_5 - C_9 fraction

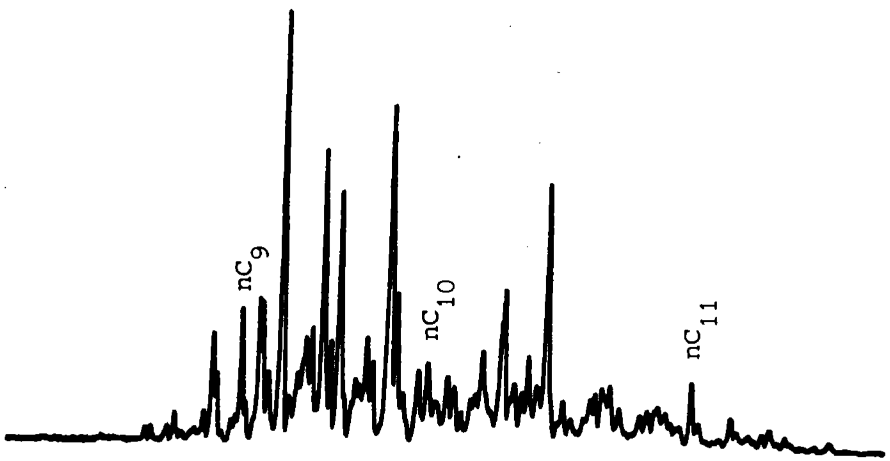


C_{10} - C_{11} fraction

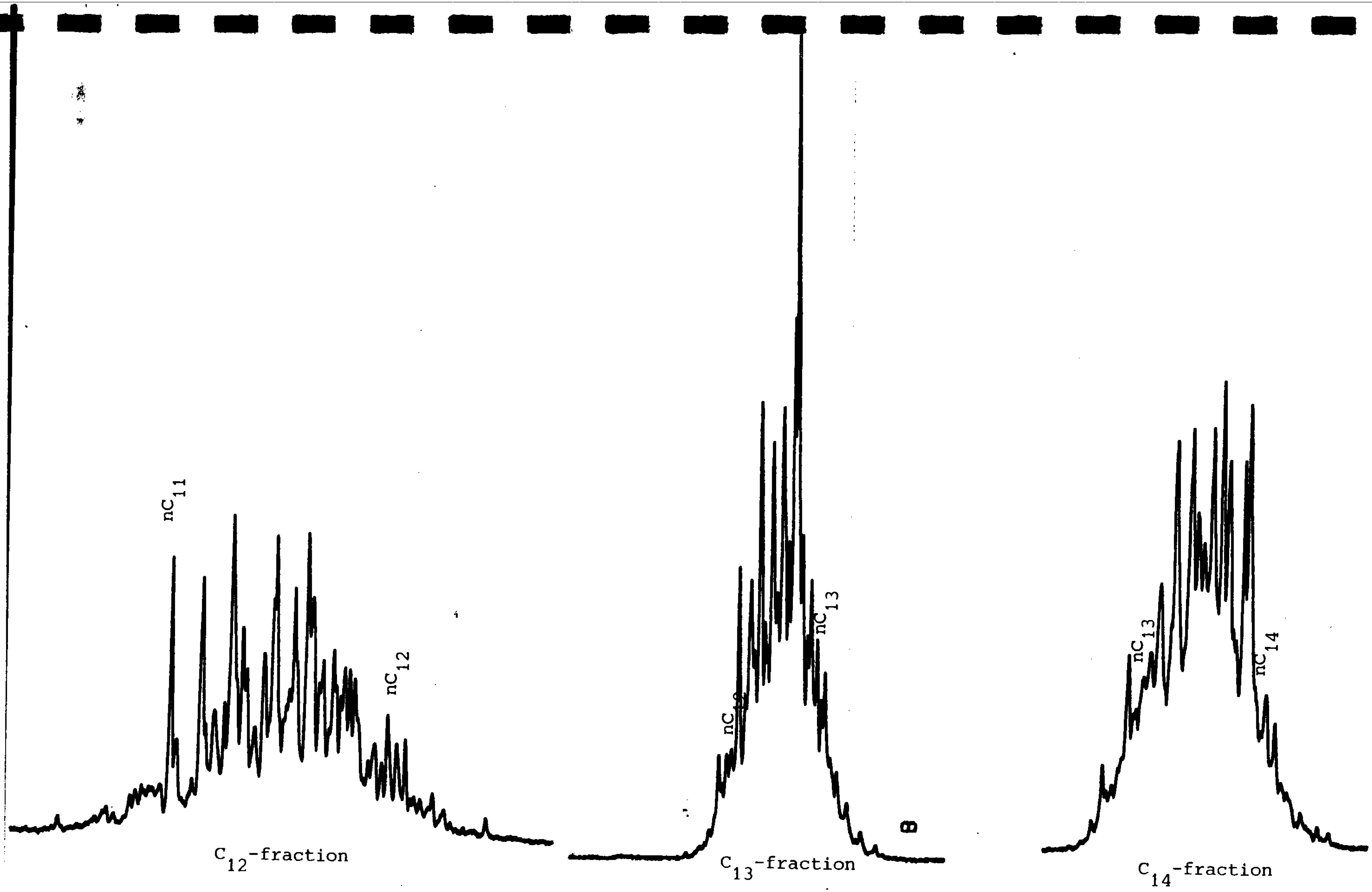


OIL 31/6 - 5 FMT

C_5 - C_9 fraction



C_{10} - C_{11} fraction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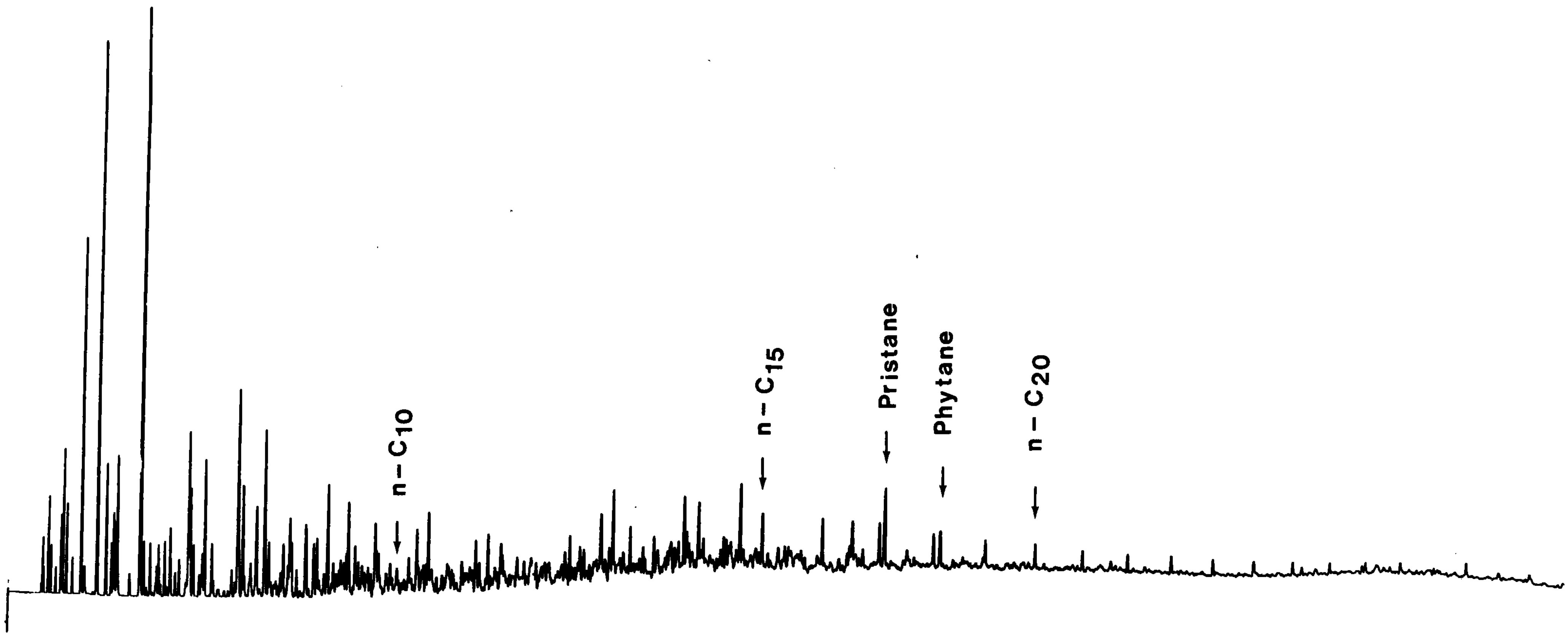
nC12
C12-fraction
nC13
C13-fraction
nC13
nC14
C14-fraction



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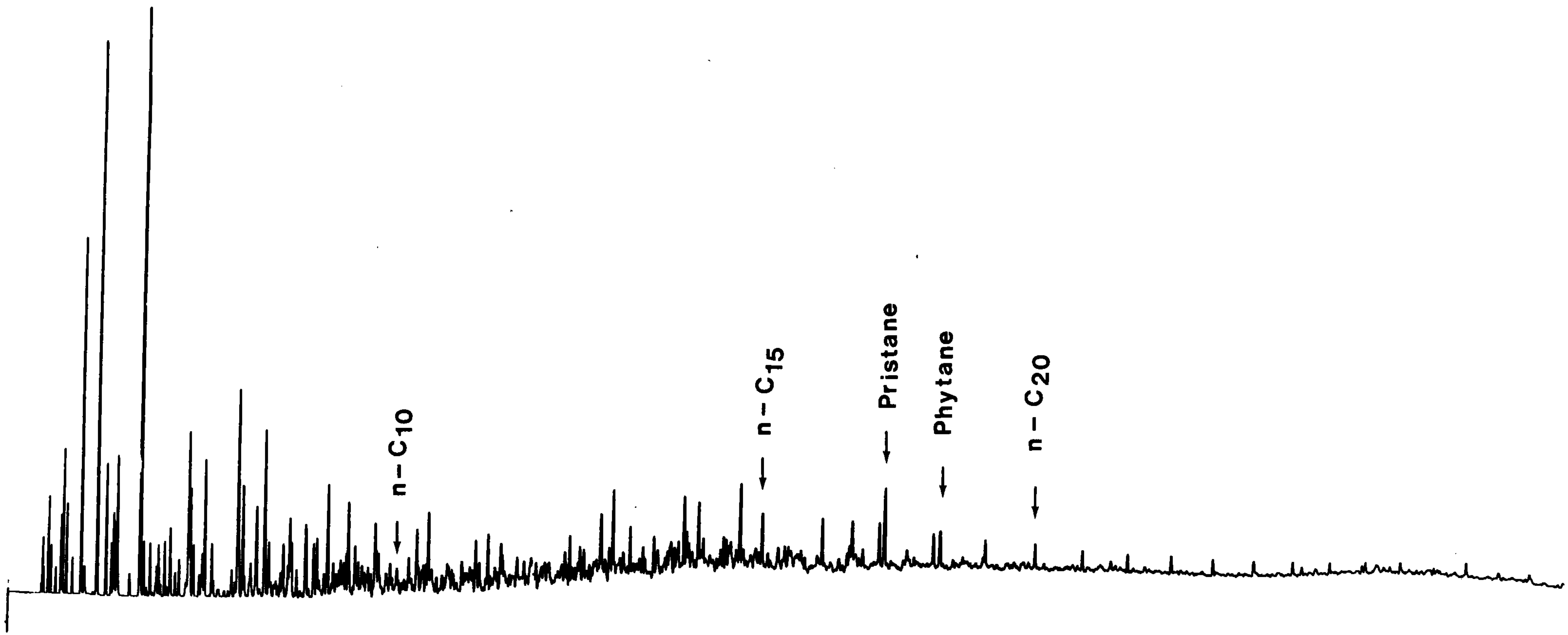
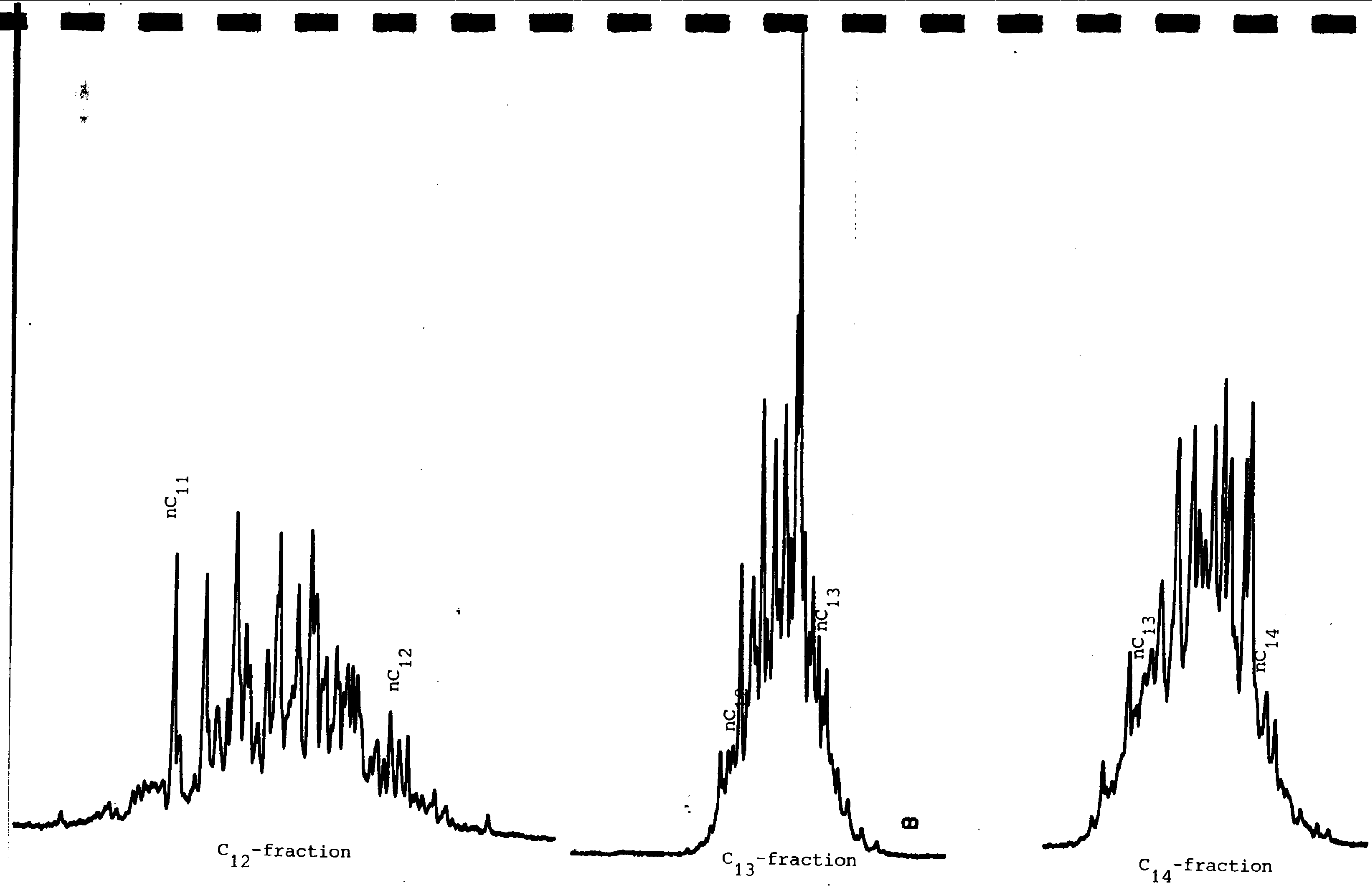
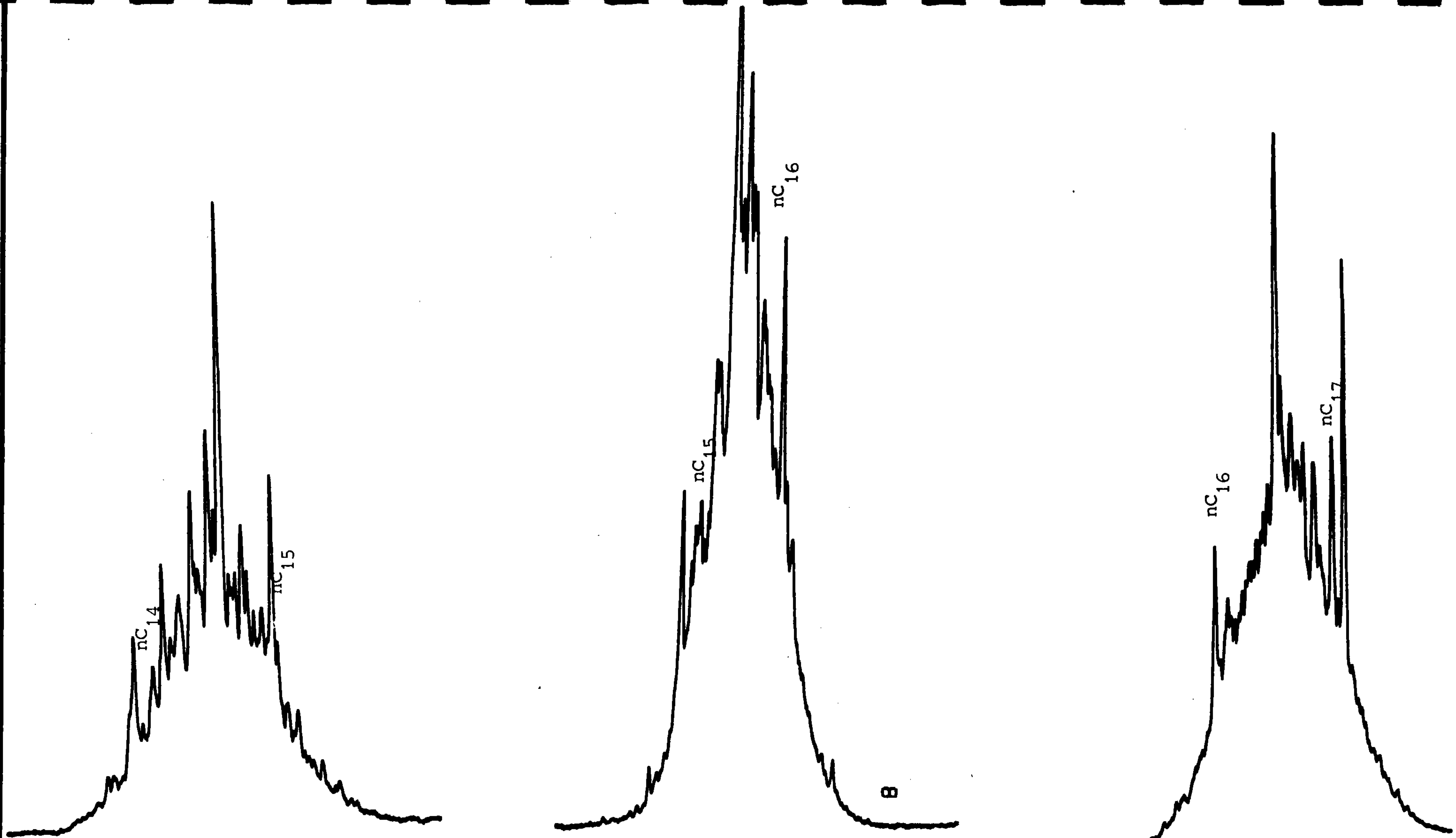


OIL 31/6-5 FMT



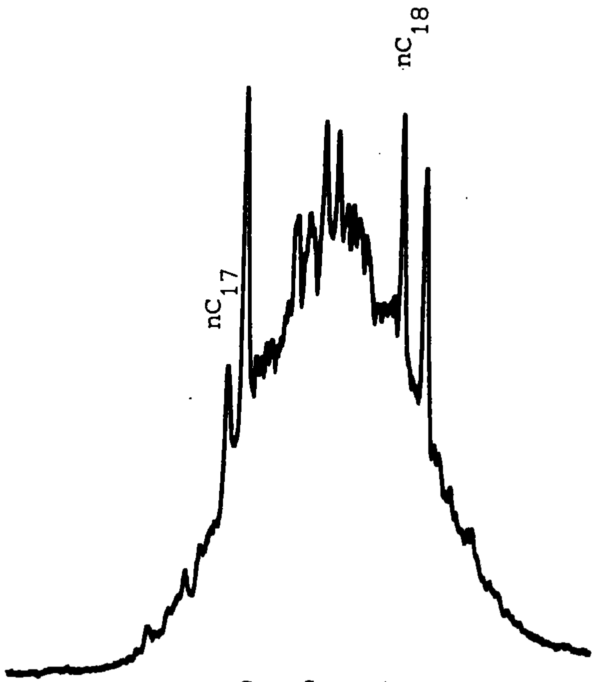
nC11
nC12
C12-fraction
nC13
C13-fraction
nC13
nC14
C14-fraction



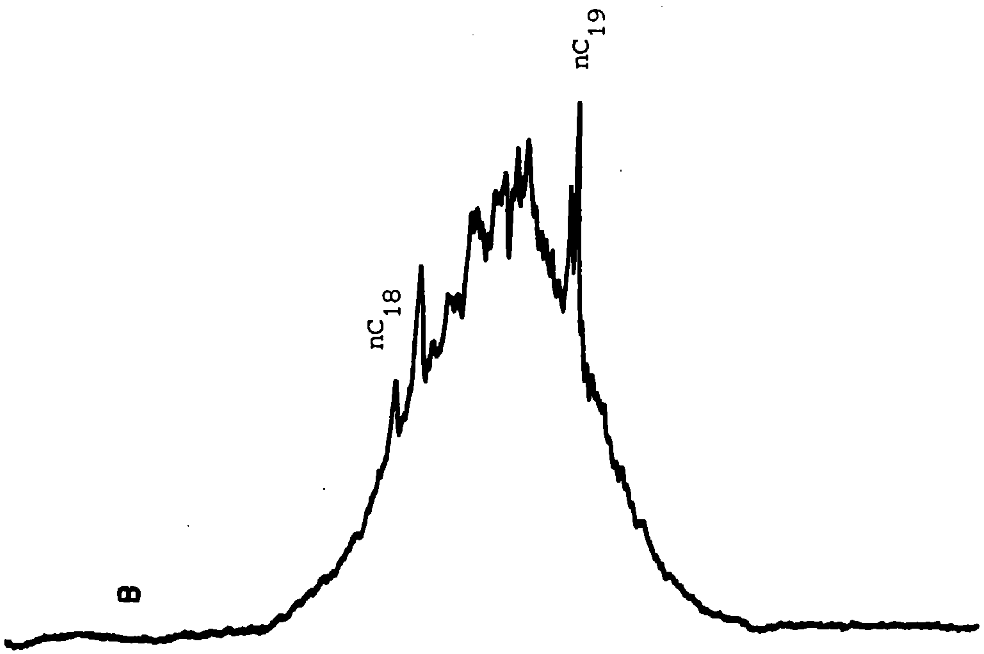
C_{15}-fraction

C_{16}-fraction

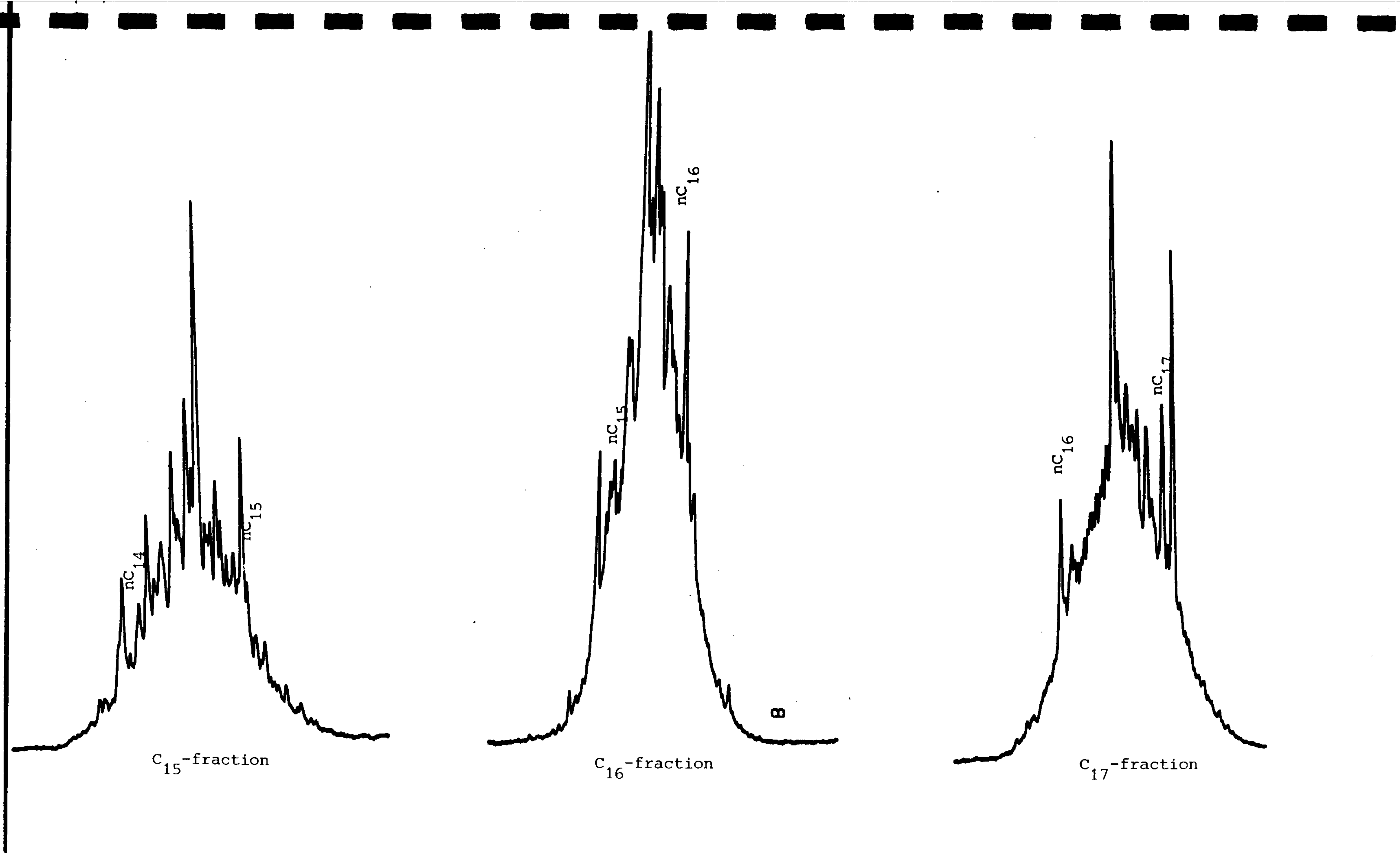
C_{17}-fraction



C_{18}-fraction



C_{19}-fraction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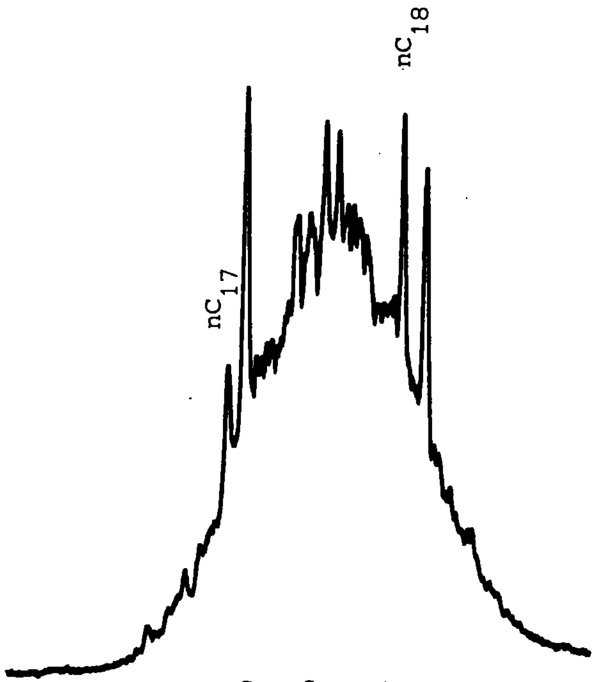
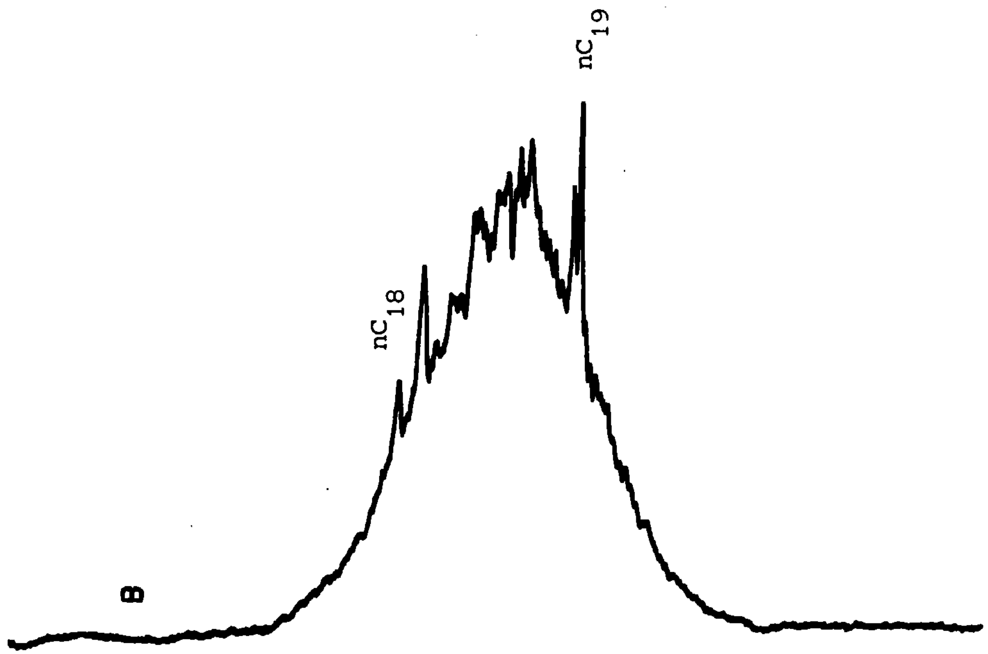
nC15
C15-fraction
nC15
nC16
B
C16-fraction
nC16
nC17
C17-fraction



C_{18}-fraction



C_{19}-fraction