15. Nectar from *Nicotiana affinis*, after dilution to about the threefold of the original volume, was fermented with *S. cerevisiae*. Two drops from the same flower were brought into two small platinum scales and herein the water was added. (The weighings were made with a torsion-balance, accurate to 0,1 mgr.). The two analyses, made separately gave as results 33,9 and 34,4 per cent. of sugar in the undiluted nectar; the sugar being calculated as hexose.

In studying the numbers published here, one will see, that on the whole the results obtained with the microsaccharimeter, were quite satisfactory. Add to this, that sugar determinations by chemical analysis too are of no great accuracy, whilst here we took only a few milligrammes of sugar. For the study of a large number of biological problems the accuracy that was reached here, certainly will be quite sufficient.

Laboratory for Microscopical Anatomy of the Technical Academy.

Delft, July 1915.

EXPLICATION OF PLATE.

Figure 1. Longitudinal section of the glass apparatus of the microsaccharimeter.
Figure 2. General view of the microsaccharimeter (the glass apparatus, fixed in the cork clamp).
Figure 3. Longitudinal section of the neck (enlarged) of the microsaccharimeter, filled with mercury, as for the 1th. reading.
Figure 4. Auxiliary apparatus, which may be used to place the mercury in the tube and the reservoir on the same level.

Chemistry. — *"Investigations on the Temperature-Coefficients of the Free Molecular Surface-Energy of Liquids between —80° and 1650° C."* **X.** *Measurements Relating to a Series of Aliphatic Compounds.* By Prof. F. M. JAEGER and Dr. JUL. KAHN.

§ **1.** For the purpose of comparison of the variations, which occur in the values of the molecular surface-energy of several derivatives of the aliphatic series, when simple substitutions have been made in them, it appeared necessary also to investigate in detail the surface-tension and its temperature-coefficient of the following compounds: *Ethyl-iodide, Ethylene-chloride, Ethylidene-chloride, Acetylene-tetrachloride, Acetylene-tetrabromide, Epichlorohydrine, Carbonbisulphide, Methylalcohol, Formic Acid, Mono-, Di-* and *Trichloroacetic Acid, Levulinic Acid, Nitromethane, Bromonitromethane, Capronitrile, Dimethylsuccinate, Diethylbromoisosuccinate,* and *Acetylacetone.*

In the following we publish the results of the measurements with these derivatives.

The determination of the specific gravity was made either by means of the pycnometer, or by means of volumeters especially constructed for that purpose, and which were previously accurately calibrated. If both these methods could not be applied, the determinations were made by the aid of a hydrostatic method, which some time ago was developed by the first-named of us originally for the purpose of measuring the densities of molten salts and liquid magmata at very high temperatures, and which will be described in detail on a future suitable occasion. By preliminary experiments and by comparison of the results thus obtained with those collected by other methods, the applicability and reliability of the method were proved and the degree of accuracy established; the last appeared to be no less than that reached by the usual way of measuring.

§ 2.

I.

Ethyl-Iodide: C_2H_5J.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg. pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg. pro cm².
	in mm. mercury of 0° C.	in Dynes			
−20°.5	1.427	1903.1	32.5	2.024	580.7
0	1.337	1782.7	30.4	1.979	551.4
20.4	1 238	1650.9	28.1	1.934	517.6
40.4	1.143	1524.8	25.9	1.895	483.6
64.8	1.023	1364.3	23.1	1.845	439.0

Molecular weight: **152.88.** Radius of the Capillary tube: 0.03489 cm. Depth: 0.1 mm.

This carefully purified liquid boils under a pressure of 760 mm at 72°.5 C; according to TIMMERMANS it solidifies at −110°.9 C. At the boilingpoint χ has the value: 22.3 Erg.

The temperature-coefficient of μ is between −20° and 0° C.: **1.43**; between 0° and 20°.4 C.: **1.65**; and between 20° and 65° C.: **1.84** Erg per degree: evidently therefore it gradually increases with rising temperature.

II.

Ethylene-chloride: $C_2H_4Cl_2$.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg pro cm².
	in mm mercury of 0° C.	in Dynes			
*—20°	1.176	1567.8	37.2	1.311	664.4
* 0	1.080	1439.8	34.1	1.283	617.9
29.9	0 961	1281 2	30.1	1.239	558.2
48	0.880	1173.8	27.5	1.213	517.2
58.9	0.831	1107.7	25 9	1.197	491.5
86	0.733	977.2	22.7	1.158	440.4

Molecular weight: **98.95.** Radius of the Capillary tube: 0.04839 cm.; in the observations indicated by *, the radius was: 0.04867 cm. Depth: 0.1 mm.

Under a pressure of 770 mm. the liquid boils constantly at 86° C. In solid carbondioxide and alcohol it crystallizes and melts at —31° C. At the boiling-point χ has the value: **23.6** Erg.

The density at 15° C. was: 1.2609; at 25° C.: 1.2463, at 50° C.: 1.2103. At $t°$ C.: $d_{4°} = 1.2826 - 0.001446\,t$.

The temperature-coefficient of μ has a mean value of: **2.16** Erg per degree.

III.

Ethylidene-chloride: $CH_3\ CHCl_2$.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg. pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg. pro cm².
	in mm. mercury of 0° C.	in Dynes			
—76°	1.144	1525.2	35.9	1.329	635.4
*—21	0.903	1203.9	28.3	1.240	524.5
* 0	0.819	1091.1	25.7	1.207	485.0
30.4	0.722	963.0	22.4	1.159	434.3
47 8	0.663	884.4	20.6	1.130	406 2
60.9	0.626	834.9	19.4	1.109	387.4

Molecular weight: **98.95** Radius of the Capillary tube: 0.04839 cm.; in the observations indicated by *, the radius was: 0 04867 cm. Depth 0.1 mm.

The liquid boils at 60°.9 C. under a pressure of 770 mm. At —80° C. it becomes turbid, but does not crystallize. According to TIMMERMANS the substance melts at —96°.6 C. At the boiling-point the value of χ is **19.4** Erg. pro cm² The density at 15° C. was: 1.1830; at $t°$ C.: $d_{4°} = 1.2069 - 0.0016\,t + 0.00000015\,t^2$.

The temperature-coefficient of μ decreases gradually with rise of temperature: between —76° and —21° C. it is: **2.00**; between —21° and 0° C.: **1.88**; between 0° and 30°.4 C.: **1.66**; between 30°.4 C. and 47°.8 C.: **1.61**; and between 47°.8 and 60°.9 C.: **1.43** Erg. per degree. The μ-t-curve is therefore a concave one.

IV.

Acetylene-tetrachloride: $C_2H_2Cl_4$.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg. pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg. pro cm².
	in mm. mercury of 0° C.	in Dynes			
*—21°	1.254	1672 4	39.4	1.657	856.2
* 0	1 171	1561.5	36.7	1 620	809.6
29.9	1.054	1405.2	32.7	1.570	736.6
47.4	0.983	1310.2	30.5	1.544	694.7
58.3	0.936	1248.2	29.0	1.526	665.8
87.1	0.834	1111.8	25.7	1.488	600.0
103.2	0 784	1045.7	24.1	1.468	567.7
117.7	0 725	967 1	22.2	1.452	526.8
127.8	0.694	925.8	21.2	1.440	505.9

Molecular weight. **167.86.**

Radius of the Capillary tube: 0.04839 cm.; with the measurements indicated by *, the radius was: 0 04867 cm
Depth: 0.1 mm.

The liquid boils at 146°.3 under 758 mm. mercury. In solid carbondioxide and alcohol it solidifies, and then melts at —50° C. At the boiling-point χ is about: 20.5 Erg. pro cm². The specific gravity at 25° C. is: 1.5779; at 50° C.: 1 5394; at 75° C.: 1.5042; at $t°$: $d_{4°} = 1.6197 - 0.001738\,t + 0.0000264\,t^2$.

The temperature-coefficient of μ is fairly constant; its mean value is **2.36** Erg. per degree

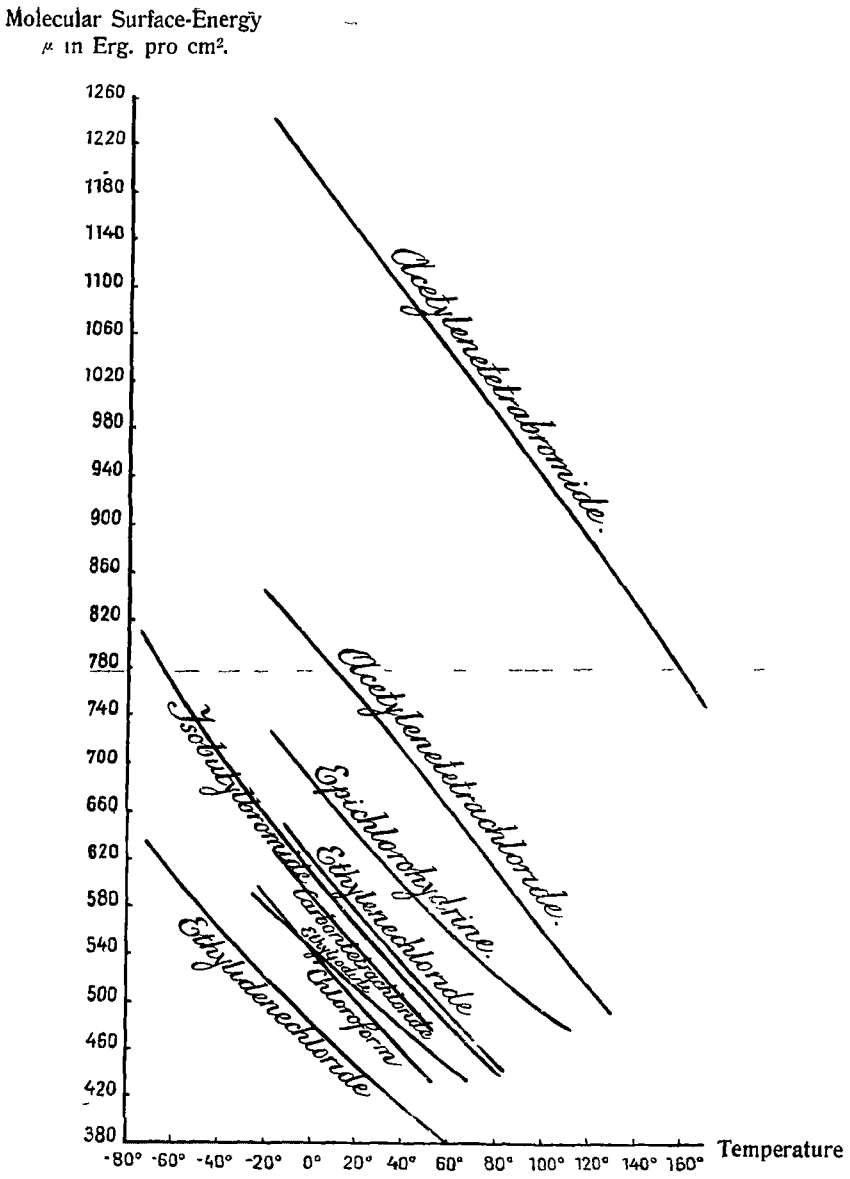
Molecular Surface-Energy
μ in Erg. pro cm².
1260
1220
1180
1140
1100
1060
1020
980
940
900
860
820
780
740
700
660
620
580
540
500
460
420
380
Acetylentetrabromide.
Acetylentetrachloride.
Epichlorhydrine.
Äthylenchlorid
Isobutylbromid
Tetrachlorkohlenstoff
Schwefelkohlenstoff
Chloroform
Äthylidenchlorid
-80° -60° -40° -20° 0° 20° 40° 60° 80° 100° 120° 140° 160°
Temperature

Fig. 1.

V.

Acetylene-tetrabromide: $C_2H_2Br_4$.

Temperature in ° C.	Maximum Pressure H in mm. mercury of 0° C.	Maximum Pressure H in Dynes	Surface-tension χ in Erg pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg pro cm².
*—21°	1.698	2264.2	53.1	3.039	1246.1
* 0	1.624	2165.6	50.7	2.996	1201.2
30.4	1.510	2012.8	46.7	2.934	1122.0
47.6	1.445	1926.0	44.6	2.897	1080.5
59.6	1.398	1864.0	43.1	2.871	1050.5
87.2	1.296	1727.6	39.8	2 814	983.1
102.1	1.240	1653.2	38.0	2.780	946.3
117.8	1.178	1570.6	36.0	2:747	903.6
127.3	1.144	1525.1	34.9	2.736	878.4
154.1	1.042	1388.7	31.6	2.669	808.6
175.5	0.964	1285.4	29.1	2.620	753.8

Molecular weight: **345.46.** Radius of the Capillary tube: 0.04839 cm.; in the observations indicated by , it was : 0.04867 cm. Depth: 0.1 mm.

The bromide boils constantly at 132° under a pressure of 20 mm. In ice and salt it solidifies, after undercooling to —24° C., and melts at —3° C. On heating above 190° C. it is decomposed.

The density was at 50° C.: 2.8920; at 75° C.: 2.8390; at 100° C : 2.7852 At t C. in general: $d_{4°} = 2.9956 \quad 0.00204\,t - 0.00000064\,t^2$.

The temperature-coefficient of μ is fairly constant; its mean value is: **2.51** Erg. per degree.

VI.

Epichlorohydrine: $CH_2Cl.CH\overset{O}{\diagdown\diagup}CH_2$.

Temperature in ° C.	Maximum Pressure H in mm. mercury of 0° C.	Maximum Pressure H in Dynes	Surface-tension χ in Erg pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg pro cm².
*—21°	1.288	1717.7	41.0	1.228	731.2
* 0	1.196	1594.5	38.0	1.205	686.4
30.3	1.079	1438.3	34.0	1.170	626.3
46.5	1.014	1351.5	31.9	1.147	595.5
59.8	0.958	1277.1	30.1	1.131	567.1
86.2	0.865	1153.1	27.1	1.095	521.7
102.8	0.815	1087.0	25.5	1.071	498.2
117.5	0.772	1029.1	24.1	1.049	477.5

Molecular weight: **92.50.** Radius of the Capillary tube: 0.04839 cm.; in the measurements, indicated by *, the radius was: 0.04867 cm. Depth: 0.1 mm.

Under a pressure of 758 mm., the liquid boils at 117° C.; in a bath of solid carbondioxide and alcohol it crystallises, and melts then at —48° C. At the boilingpoint χ is about: 24.1 Erg.

The density at 20° C. was: 1.1812; at 50° C.: 1.1436; at 75° C.: 1.1101. At t° C.: $d_{4°} = 1{,}2046 - 0.00114\,t - 0.0000016\,t^2$.

The temperature-coefficient of μ is originally: **2.04** Erg; but from 86° C. upwards it decreases continually to **1.41** Erg per degree.

VII

Carbonbisulphide: CS_2

Temperature in ° C.	Maximum Pressure H in mm. mercury of 0° C.	Maximum Pressure H in Dynes.	Surface-tension χ in Erg pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg pro cm².
—72°	1.931	2574.4	44.3	1.398	636.5
—21	1.602	2146.0	36.8	1.323	548.6
0	1.483	1977.1	33.9	1.292	513.4
21.5	1.354	1805.1	30.9	1.262	475.3
40.9	1.245	1659.8	28.3	1.232	442.3

Molecular weight: **76.14.** Radius of the Capillary tube: 0.03489 cm. Depth: 0.1 mm.

The liquid was distilled several times, then shaken with mercury and again subjected to fractional distillation in an atmosphere of nitrogen after being completely dried. It boils at 46°.8 C. constantly; it solidifies (TIMMERMANS) at — 111°.6 C. At the boiling-point χ has the value: 27.3 Erg. The specific gravity at 0° C. was: 1.2921; at 20° C.: 1.261; at 46° C.: 1.226. In general at t C.: $d_{4°} = 1.2921 - 0.00147\,t$.

The temperature-coefficient of μ is constant; its value is **1.75** Erg per degree.

VIII.

Methylalcohol: CH_3OH.

Temperature in ° C.	Maximum Pressure H in mm. mercury of 0° C.	Maximum Pressure H in Dynes	Surface-tension χ in Erg pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg pro cm².
—75°	1.246	1661.2	29.8	0.878	327.8
—20	1.043	1391.8	24.9	0.828	284.8
0	0.986	1314.6	23.5	0.810	272.8
20.8	0.924	1232.0	22.0	0.792	259.2
35.3	0.882	1177.0	21.0	0.778	250.4
50.1	0.841	1121.2	20.0	0.765	241.2
65	0.794	1058.6	18.8	0.752	229.3

Molecular weight: **32.03.** Radius of Capillary tube: 0.03636 cm. Depth: 0.1 mm.

The alcohol was obtained in an anhydrous state by boiling with dry calcium-oxide for several days; then it was carefully distilled. Under a pressure of 752 mm. it boils at from 65.5 to 65°.8 C.; at this temperature the value of χ is: 18.7 Erg. It solidifies at —97.1 C. (TIMMERMANS). The specific gravity was calculated from the formula: $d_{4°} = 0.8102 - 0.000905\,t - 0.000000085\,t^2$.

The temperature-coefficient of μ is very small: as a mean value about **0.67** Erg per degree.

IX.

Formic Acid: *HCO.OH.*

Temperature in ° C.	Maximum Pressure *H*		Surface-tension χ in Erg pro cm².	Specific gravity d_{4°	Molecular Surface-energy μ in Erg pro cm²
	in mm. mercury of 0° C	in Dynes			
9.2°	1.596	2128.6	38.1	1.233	425.5
21.2	1.555	2073.7	37.2	1.218	418.8
35.3	1 510	2013.2	36.1	1.200	410.5
50.4	1.444	1925.1	34.5	1.181	396.5
64.8	1.386	1874.6	33 1	1 162	384.6
75.3	1.354	1787.6	32.0	1.149	374.6
90	1.263	1684.9	30.1	1.130	356.3
99.8	1.217	1622.5	29.0	1.117	346.0

Molecular weight: **46.02.** Radius of the Capillary tube: 0.03636 cm. Depth: **0.1** mm.

The acid solidifies below 0° C., and then melts again at + 6° C. It boils under a pressure of 762 mm. at 101° C ; at this temperature χ has the value: 28.8 Erg. The density was calculated from the equation: $d_{4^\circ} = 1.2441 - 0.001249\,t - 0.000000181\,t^2$.

The temperature-coefficient of μ is between 9° and 35°: **0.57** Erg.; between 35° and 75° C,: **0.90** Erg.; between 75° and 100° C.: **1.15** Erg. per degree.

X.

Monochloroacetic Acid: $CH_2Cl.COOH$.

Temperature in ° C	Maximum Pressure *H*		Surface-tension χ in Erg pro cm².	Specific gravity d_{4°	Molecular Surface-energy μ in Erg pro cm².
	in mm. mercury of 0° C.	in Dynes			
80.2°	1.072	1429.2	33.3	1.352	565.0
92	1.042	1389.8	32.4	1.339	553.3
118 5	0.970	1293.8	30.1	1.305	522 9
*136.2	0.932	1242.0	28.1	1.285	493.2
*149.4	0 883	1175.3	26.6	1.260	473.0
*176 3	0.784	1045.0	23.5	1.235	423.5

Molecular weight: **94.49** Radius of the Capillary tube: 0.04792 cm.; the measurements indicated with * were made with a tube whose radius was 0 04670 cm. Depth: 0.1 mm.

At a pressure of 20 mm. the acid boils constantly at 101° C. The melting-point was 62°.5 C. The density was at 75° C.: 1.3576; at 100° C.: 1.3261; at 125° C.: 1.2933. In general at t° C.: $d_{4^\circ} = 1.3878\ 0.001182\,(t-50^\circ) - 0\ 00000104\,(t-50^\circ)^2$

The temperaturecoefficient of μ increases gradually with rise of temperature: between 80° and 92° C.: **0.96**; between 92° and 118° C.: **1.14**; between 118° and 149° C.: **1.61**; and between 149° and 176° C.: **1.84** Erg per degree.

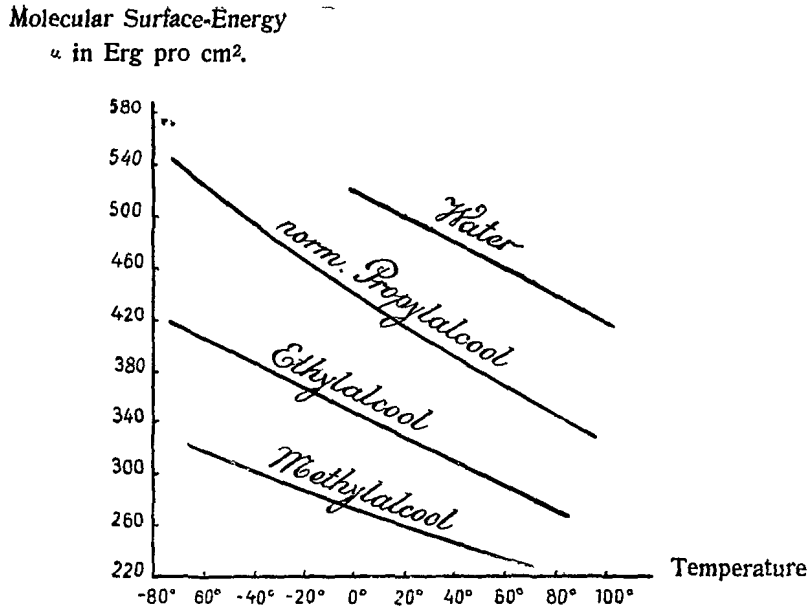
Molecular Surface-Energy
α in Erg pro cm².
580
540
500
460
420
380
340
300
260
220
Water
norm. Propylalcool
Ethylalcool
Methylalcool
Temperature
-80° 60° -40° -20° 0° 20° 40° 60° 80° 100°

Fig. 2.

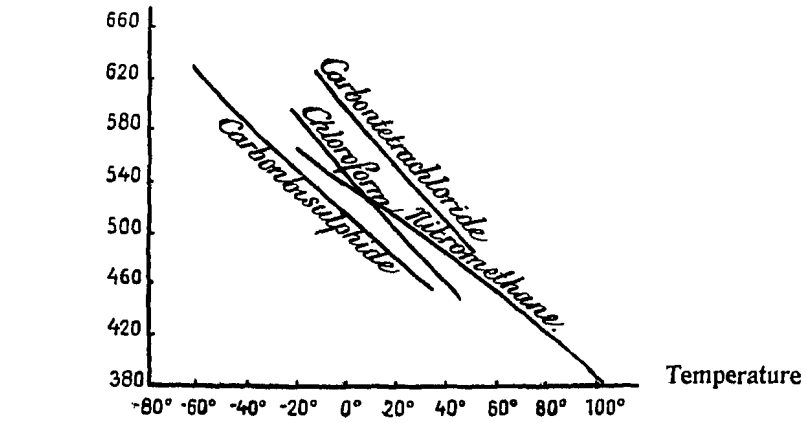
Molecular Surface-Energy
μ in Erg pro cm².
660
620
580
540
500
460
420
380
Carbontetrachloride
Chloroform
Nitromethane.
Carbonbisulphide
Temperature
-80° -60° -40° -20° 0° 20° 40° 60° 80° 100°

Fig. 3.

XI.

Dichloroacetic Acid: $CHCl_2.COOH$.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg pro cm².	Specific gravity d_{4^0}	Molecular Surface-energy μ in Erg pro cm².
	in mm. mercury of 0° C.	in Dynes			
0°	1.228	1637.2	38.1	1.592	796.5
25.7	1.143	1523.4	35.5	1.557	726.5
41	1.096	1460.6	34.0	1.535	691.8
55.9	1.052	1402.3	32.6	1.515	655.3
80.2	0.980	1306.4	30.3	1.488	605.3
92	0.945	1260 5	29.2	1.444	571.8
117	0.905	1206.2	27.9	1.431	539.8
*136.6	0.842	1122.1	25.1	1.405	481.4
*149.3	0.803	1070.7	24.0	1.387	456.0
*176.2	0.719	959.3	21.4	1.349	400.6

Molecular weight: **128.95.** Radius of the Capillary tube: 0.04792 cm ; in the observations indicated by *, this radius was : 0.04670 cm. Depth: 0.1 mm

The acid boils at 192°.5 C. under a pressure of 763 mm.; on cooling it solidifies and melts again at + 10° C.

The density at 12° C. was. 1.5759; at 75° C.: 1.4891; at 100° C. 1.4547; t^0 C.: $d_{4^0} = 1.5924 - 0.001378\,t$. The temperature-coefficients of μ oscillates beyond a mean value of about **2.30** Erg per degree.

XII.

Trichloroacetic Acid: $CCl_3.COOH$.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg pro cm².	Specific gravity d_{4^0}	Molecular Surface-energy μ in Erg pro cm².
	in mm. mercury of 0° C.	in Dynes			
80°.2	0.902	1202.0	27.8	1.575	613.8
92	0.876	1168 6	27.0	1.556	601.0
117.5	0.814	1085.2	25.1	1.515	568.7
*136.5	0.784	1045.0	23.4	1.484	537.6
*149.2	0.746	994.6	22.2	1.465	514.4
*176.1	0.665	886.5	19.7	1.415	467.1
*196	0.607	809.2	17.8	1.378	429.6

Molecular weight: **163.40.** Radius of the Capillary tube: 0.04792 cm.; in the observations marked by *, the radius was: 0.04670 cm. Depth: 0.1 mm.

Under a pressure of 765 mm. the acid boils at 195.°5 C.; under 21 mm. at 107° C. The melting-point was 57°·5 C.

The specific gravity at 75° C. was: 1.5829; at 100° C.: 1.5451; at 125° C.: 1.5082; at t^0 C. $d_{4^0} = 1.6216 - 0.001566\,(t-50^0) - 0.00000072\,(t-50^0)^2$.

The temperature-coefficient of μ originally increases with rise of temperature: between 80° and 92° C.: **1.09**; between 92° and 117° C.: **1.27**; between 117° and 136° C.: **1.63**; afterwards it remains fairly constant at **1.82** Erg per degree.

XIII.

Levulinic Acid: $CH_3 . CO . CH_2 . CH_2 . COOH.$

Temperature in ° C.	Maximum Pressure H		Surface-tension χ' in Erg pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg pro cm².
	in mm. mercury of 0° C.	in Dynes			
25°.5	1.304	1738.2	39.7	1.135	868.1
41.1	1.268	1691.0	38.6	1.123	850.1
60.1	1.220	1626.6	37.1	1.109	823.9
81.5	1.166	1554.5	35.5	1.093	796.0
95.1	1.130	1506.4	34.4	1.083	776.1
115	1.082	1442.1	32.9	1.068	749.2

Molecular weight: **116.06.** Radius of the Capillary tube: 0.04660 cm
Depth: 0.1 mm.

Under atmospheric pressure the acid boils at 153°.5 C. Above 100° C. it is soon coloured yellowish and gets a special odour; the measurements were thus stopped because of the evident decomposition. The melting-point is 33° C. At 25° C. the density is: $d_{4°} = 1.1351$; at 50° C.: 1.1140; at 75° C.: 1.0924; at $t°$ in general: $d_{4°} = 1.1557 - 0.000814\,t - 0.0000004\,t^2$.

The temperature-coefficient of μ is almost constant and has the small mean value: **1.33** Erg per degree.

XIV.

Nitromethane: CH_3NO_2.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg pro cm².
	in mm. mercury of 0° C.	in Dynes			
*—21°.5	1.279	1705.4	40.6	1.199	557.6
* 0	1.202	1602.6	38.1	1.166	533.1
30.1	1.091	1454.8	34 3	1.123	492.1
46.3	1.026	1368.1	32.2	1.100	468.4
58.7	0.979	1306.0	30 8	1 086	451.9
86.2	0.868	1157.3	27.2	1.056	406.6
101.4	0.812	1082.9	25.4	1.040	383.6

Molecular weight: **61.03.** Radius of the Capillary tube: 0 04839 cm.; in the observations indicated by *, the radius was: 0.04867 cm.
Depth: 0.1 mm.

The nitromethane boils at 102° C. under a pressure of 760 mm. On cooling below —24° C. it solidifies and melts at —17° C.; according to WALDEN the melting point is —26°.5 C. At the boiling-point χ has the value: 25.3 Erg pro cm.² The specific gravity at 15 C. is: $d_{4°} = 1.1437$ at 25°: 1.1297; 50° C.: 1.0970; in general: $d_{4°} = 1.1657 - 0\,0015052\,t + 0.000002629\,t^2$.

The temperature-coefficient of μ evidently increases with rising temperature; between —21° and 0° it is: **1.14**; between 0° and 59°: **1.38**; between 59° and 101° C.: **1 58**; being thus appreciably under EÖTVÖS' normal-value of **2.2** Erg.

XV.

Bromonitromethane $CH_2(NO_2)Br$.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg pro cm².
	in mm. mercury of 0° C.	in Dynes	
—18°.5	1.512	2015.9	48.3
0	1 431	1907.2	45 7
25.7	1.337	1782.1	42.7
40.5	1.280	1707.0	40.9
55.5	1.227	1636.1	39.2
80	1 139	1519.2	36.4
92.2	1.105	1473.2	35.3
116	1.002	1335.6	32.0
*135 8	0.919	1224.8	28.6

Molecular weight: **139.99.** Radius of the Capillary tube: 0.04792 cm; with the observations indicated by *, the radius was: R=0.04670 cm. Depth: 0.1 mm.

Under a pressure of 765 mm. the liquid boils at 152°.5 C.; in a bath of solid carbondioxide and alcohol it soon solidifies into a hard mass of crystals, melting at – 28° C.

XVI.

Capronitrile: $C_5H_{11}CN$.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg pro cm².	Specific gravity $d_{4°}$	Molecular Surface-energy μ in Erg pro cm².
	in mm. mercury of 0° C.	in Dynes			
*—22°	0.903	1204.1	28.7	0.854	673.6
* 0	0.854	1138.3	27.1	0.835	645.6
29.9	0.781	1041.5	24.6	0.810	598.1
47.9	0.735	979.5	23.1	0.793	569.6
59.7	0.704	938.2	22.1	0.782	550.0
86	0.635	847.3	19.9	0.757	506.1
101.8	0.592	789.4	18.5	0.740	477.7
117.5	0.555	739.8	17.3	0.723	453.7
127.4	0.530	706.7	16.5	0.713	436.8
151.8	0.465	619.9	14.4	0.684	391.9

Molecular weight: **97.10.** Radius of the Capillary tube: 0.04839 cm.; in the measurements indicated by *, the radius was: 0.04867 cm. Depth: 0.1 mm.

This very ill-smelling liquid boils constantly at 157° C. under a pressure of 762 mm. In solid carbondioxide and alcohol, it solidifies and melts again at —45° C.

The density is at 24° C.: 0.8147; at 50° C: 0.7914; at 75° C.: 0.7675. At t° C.: $d_{4°} = 0.8347 - 0.000806\,t - 0.0000012\,t^2$.

The temperature-coefficient of μ has between 0° and 127° C. a mean value of about 1.63 Erg per degree, and above the last temperature a somewhat greater value: 1.84 Erg.

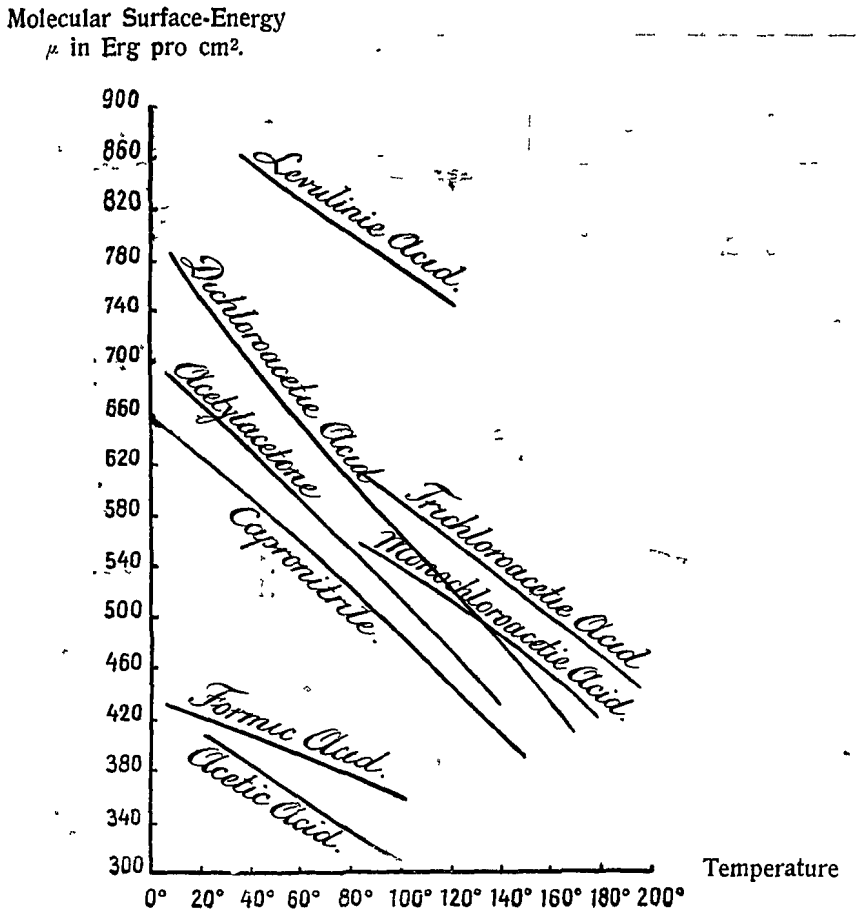

Fig. 4.

XVII.

Dimethyl-Succinate: $CH_3O . CO . CH_2 . CH_2 . CO . OCH_3$.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg pro cm².	Specific gravity d_{4^0}	Molecular Surface-energy μ in Erg pro cm².
	in mm. mercury of 0° C.	in Dynes			
25°.2	1.123	1497.2	34.1	1.115	879.6
40.4	1.085	1446.5	33.1	1.097	863.1
54	1.015	1353.2	30.9	1.082	813.2
75.9	0.932	1242.5	28.3	1.058	756.0
95	0.870	1160.6	26.4	1.032	717.0
116	0.806	1069.5	24.3	1.014	667.8
135	0.745	993.6	22.5	0.995	626.2
150	0.694	925.0	20.9	0.980	587 6
176.2	0.585	779.9	17.5	0.955	500.5

Molecular weight: **146.08.** Radius of the Capillary tube: 0.04670 cm. Depth: 0.1 mm.

Under a pressure of 25 mm the liquid boils at 103°.5 C.; the melting-point of the crystals is 18°.2 C. The specific gravity at 25° C. was: 1 1149; at 50° C.: 1.0865; at 75° C.: 1.0589; at t^0 in general. $d_{4^0} = 1.1441 - 0.001184\,t + 0.00000064\,t^2$.

The temperature-coefficient of μ is fairly constant up to 150° C. its mean value being: **2.32** Erg. per degree. Above 150° however it increases rapidly, perhaps caused by a beginning decomposition.

XVIII.

Diethyl-Bromoisosuccinate: $CH_3 . CBr(CO . OC_2H_5)_2$.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg pro cm².	Specific gravity $d_{4°}$	Mol Su ener Erg
	in mm mercury of 0° C.	in Dynes			
—21°	1.155	1539.8	35.0	1.377	11
0	1.079	1439.0	32.7	1.350	10
25.1	1.005	1340.5	30.4	1.318	10
40.3	0.960	1280.5	29.0	1.300	9
52.8	0.918	1223.9	27.8	1.284	9
75.5	0.861	1147.7	26.0	1.257	8
95.4	0.809	1079.2	24.4	1.232	8
114	0.752	1002.6	22.6	1.211	7
134.1	0.698	930.6	20.9	1.189	7
152	0.652	869.4	19.5	1.169	7
176	0.581	775.1	17.3	1.144	6
197	0.499	665.3	14.7	1.121	5

Molecular weight: **253.03.** Radius of the Capillary tube: 0.046
Depth: 0.1 mm.

Under a pressure of 13 mm. the liquid boils at 122° C. At —79° becomes turbid and very viscous, but does not solidify. Above 176° a decomposition sets in, and the χ-t-curve then rapidly falls towards the The specific gravity at 25° C. is: 1.3183; at 50° C.: 1.2875; at 75° C.: At $t°$ in general it is calculated from: $d_{4°} = 1.3499 - 0.00128\,t + 0.0000$

The temperature-coefficient of μ is fairly constant up to 176°; its value is about: **2.54** Erg. per degree.

XIX.

Acetylacetone: $CH_3 . CO . CH_2 . CO . CH_3$.

Temperature in ° C.	Maximum Pressure H		Surface-tension χ in Erg pro cm².	Specific gravity $d_{4°}$	Mol Su ener Erg
	in mm. mercury of 0° C.	in Dynes			
—21°	1.124	1498.9	34.2	1.020	7
0	1.041	1387.7	31.6	0.998	6
25.2	0.956	1274.5	29.2	0.972	6
40.5	0.912	1216.3	27.7	0.957	6
5 .5	0.867	1156.3	26.3	0.943	5
7 1	0.805	1073.3	24.4	0.923	5
94 8	0.752	1002.6	22.7	0.906	5
1	0 6 7	916.5	20.7	0.889	4
35	0 6 3	830.6	18.7	0.873	4

Molecular weight: **00.06.** Radius of the Capillary tube: 0.046
Dep h: 0.1 mm.

Under a pressure of 755 mm. the liquid boils at 137 .5 C. In a b solid carbondioxide and alcohol it crystallizes; the crystals melt at — At 25° C. the specific gravity is: 0.9721; at 50° C.: 0.9475; at 75° C.: At $t°$ C.: $d_{4°} = 0.9979 - 0.001056\,t + 0.00000096\,t^2$.

The μ-t-curve has a peculiar shape, which is probably connected wi transformation of the keto $\rightleftarrows$ enol-equilibrium: between —21° and is: 2.17 Erg., and decreases between 54° and 76° to **1.60**; afterwa increases gradually to **2.06** Erg.

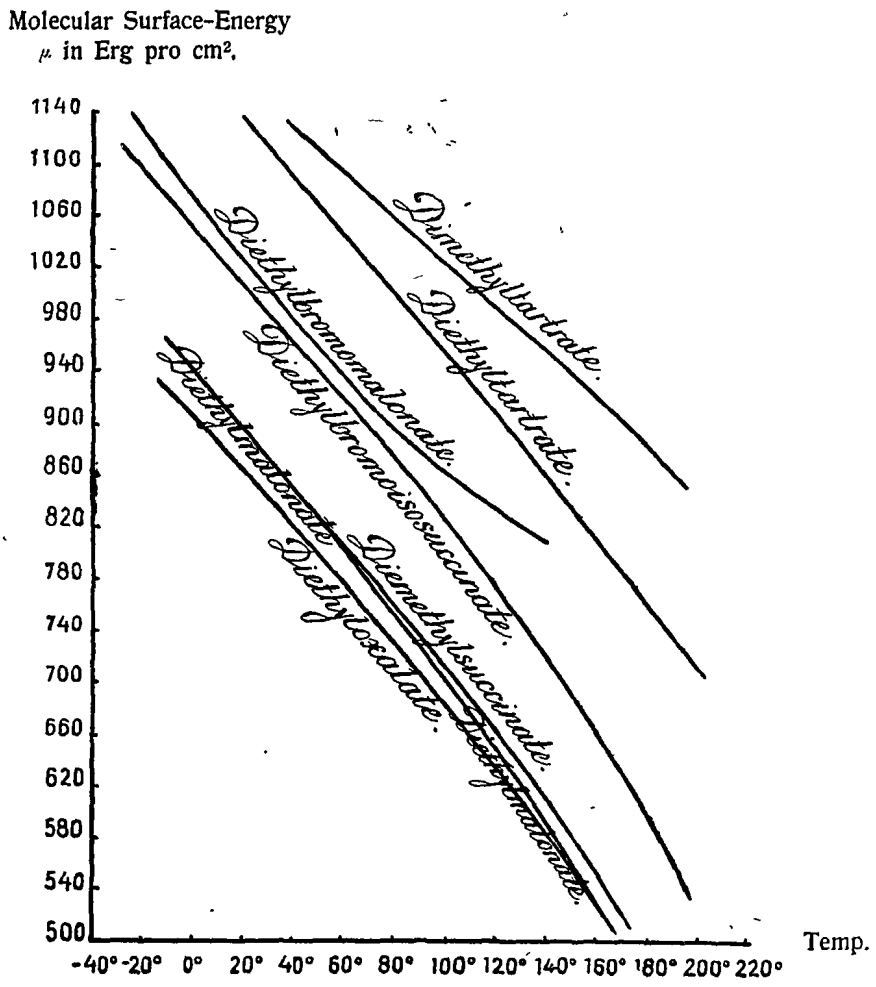

Fig. 5.

§ 3. The results reviewed in Tables 1—19 and graphically reproduced in Fig. 1—5, give rise to the following general remarks.

In general the shape of the μ-t-curves, as determined by the values of the temperature-coefficients of μ, appears to be quite analogous in the case of derivatives of similar constitution: it is so in the case of all halogen-derivatives of the hydrocarbons (Fig. 1), in the case of the alcohols and water (Fig. 2), and in that of the neutral ethers of two-basic acids (Fig. 5).

In the case of *ethylene-*, and of *ethylidene-chloride* (Fig. 1), the different situation of the two chlorine-atoms in their molecules, appears in these cases to cause an appreciable difference of the values of μ at corresponding temperatures: thus such isomerides evidently do not possess the same surface-energy, as has been occasionally suspected by previous authors (FEUSTEL). With the increase of the atomic weight of the halogen (cf. *acetylene-tetrabromide* and *-tetra-*

chloride) the surface-energy μ also increases. Substitution of hydrogen-atoms by the negative oxygen-atom has in the same way a magnifying influence on the original values of μ.

In the case of the *alcohols* (fig. 2) the values of μ, and also those of the temperature-coefficient of μ, increase regularly with the increase of the alkyl-radical; *water* however has evidently a special place.

In the case of *Acetic* and *Monochloro-*, and *Trichloroacetic Acids*, μ increases regularly with the content of halogen, while $\frac{\partial \mu}{\partial t}$ in these cases is quite analogous. *Dichloroacetic Acid* however shows a much larger temperature-coefficient, as a consequence of which the values of μ below 126° C. appear to be *greater*, above 126° however to be *smaller* than in the case of monochloroacetic acid. It must be mentioned also as a remarkable fact that the μ-t-curve for *Formic Acid* is entirely situated *above* that for Acetic Acid, while at the same time the value of $\frac{\partial \mu}{\partial t}$ for the formic acid appears to be unusually *small*. The special and diverging character of the formic acid shows itself in a most striking way in this fact too.

Diethylmalonate and *Dimethylsuccinate* (fig. 5) show within a rather considerable temperature-range, almost the same values of μ; furthermore a comparison of the μ-t-curves of *dimethylsuccinate* and *dimethyltartrate* clearly demonstrates the strongly magnifying power of the substitution of two hydrogen-atoms by the typically negative hydroxyl-groups. This increase of the molecular surface-energy by the substitution of *negative* elements of radicals into the original molecules, according to these data and those formerly published seems to be a quite *general* phenomenon.

With respect to the temperature-coefficients $\frac{\partial \mu}{\partial t}$ themselves, it may be remarked that in the case of the halogen-derivatives of the hydrocarbons they seem to be not unappreciably variable with the temperature as e.g. in *ethylidenechloride*, and *ethylidenechloride*, and also in the case of the *symmetrical* compounds: *ethylenechloride*, and *tetrachloro-*, resp. *tetrabromoacetylene*, they may be considered to be *constant*, while they furthermore appear to increase regularly with the augmenting content of the halogen:

For $C_2H_4Cl_2$: 2,16 Erg per degree.
For $C_2H_2Cl_4$: 2,36 Erg per degree.
For $C_2H_2Br_4$: 2,51 Erg per degree.

In the case of the *alcohols* and *water*, the values of $\frac{\partial \mu}{\partial t}$ are remarkably small; also in the case of the *alcohols* a regular increase with growing molecular weight is observable:

While in the case of *water* the value of $\frac{\partial \mu}{\partial t}$ is 1,0 Erg per degree,

it is for CH_3OH: 0,67 Erg per degree.
for C_2H_5OH: 0,94 Erg per degree.
and for C_3H_7OH. 1,10 Erg per degree.

On later occasions other regularities of this kind will be pointed out.

Groningen, Holland, June 1915.

Laboratory for Physical and Inorganic Chemistry of the University.

Chemistry. — "*Investigations on the Temperature-Coefficients of the free Molecular Surface-Energy of Liquids between* — 80° *and* 1650° *C.*" **XI.** *The Surface-Tension of homologous Triglycerides of the fatty Acids.* By Prof. F. M. JAEGER and Dr. JUL. KAHN.

§ **1.** In the following we give the measurements made with the neutral ethers of glycerol and the fatty acids. The information about the surface-energy of the simple fats and its temperature-coefficient must be considered of high importance for practical reasons, because it allows conclusions to be made about the corresponding values for the natural fats, those being mixtures of the simple fats. The temperature-coefficient of μ appears furthermore to have very exceptional values for some of these derivatives which may be considered as a fact in many respects also of interest from a theoretical point of view.

Finally we give here again some measurements of the specific surface-energy χ and its temperature-coefficient, for natural butter and for margarine, which measurements were made with the purpose of finding out, if a reliable criterion could perhaps be obtained for the discrimination of pure natural butter from that which had been adulterated by vegetable fats. Although the temperature-coefficient of χ in the case of margarine evidently differs from that for natural butter, we think these differences too slight to found