quite the opposite of that which would be expected from current theories of sintering active metal areas by heat treatment. In the case of finely divided catalysts sintering must effect a reduction of surface and hence lessened activity. In the case of wires, the macrocrystalline one, whose sintered surface was obvious, was quite equal in activity to a crypto-crystalline one. This fact taken in conjunction with the remarkable activity at $-120°$ of the heat-treated wire shows that sintering is of no consequence, at least in the case of platinum wires.

Summary

1. A study of the hydrogen–oxygen reaction at low pressures on platinum wires has been made.

2. The reaction is not as simple as is commonly supposed. An excess of oxygen may react. This fact is here attributed to hydrogen peroxide formation from the elements.

3. The activity of platinum is variable even under carefully controlled conditions.

4. The rate of this reaction varies with the temperature difference between the wire and the wall of the containing vessel.

5. Flashing the wire at $900°$ in vacuum, hydrogen or oxygen induces super-activation which decays after some hours. A wire in the super-active condition causes an easily measurable rate of reaction at as low a temperature as $-120°$.

WILMINGTON, DELAWARE

ELECTRIC MOMENT AND MOLECULAR STRUCTURE. III. DOUBLE AND TRIPLE BONDS AND POLARITY IN AROMATIC HYDROCARBONS

BY C. P. SMYTH AND R. W. DORNTE

The electric moments of simple molecules containing double and triple bonds have been investigated with the object of determining the polarities of these bonds and their relations to structure[1] and these results, together with those of Errera for acetylene dihalides,[2] have been examined in the light of electronic theories of valence.[3] The need of further accurate measurements upon molecules in which ethylene and acetylene hydrogens are replaced by hydrocarbon groups has been evident for some time. An unusual opportunity for such measurements arose through the kindness of Professor Donald H. Andrews of the Johns Hopkins University, who

[1] Smyth and Zahn, THIS JOURNAL, 47, 2501 (1925).

[2] Errera, *Physik. Z.*, 27, 764 (1926).

[3] Smyth, THIS JOURNAL, 51, 2380 (1929); *Chem. Rev.*, 6, 549 (1929).

loaned us pure samples of the phenyl substituted ethylenes and acetylenes prepared in his laboratory by Dr. R. H. Smith. 1,1,1-Triphenylethane also from the Johns Hopkins laboratories has been measured in order to compare the effect of phenyl substitution in a saturated hydrocarbon with the effects in the unsaturated.

Method of Determination

The dielectric constants, ϵ, and densities, d, were measured with the apparatus used in previous work,[4] the former being determined at a wave length of 600 meters. All the determinations were made in solution in benzene, which appeared to be the best non-polar solvent for these substances, with the exception of those upon phenylacetylene, which was more soluble in heptane. The polarizations, P_2, of the polar components of the solutions were calculated by means of the equations

$$P_{12} = \frac{\epsilon - 1}{\epsilon + 2} \frac{c_1 M_1 + c_2 M_2}{d} \text{ and } P_2 = \frac{P_{12} - P_1}{c_2} + P_1$$

in which P_{12} is the polarization of the mixture, and c_1 and c_2, M_1 and M_2 and P_1 and P_2 are, respectively, the mole fractions, molecular weights and polarizations of the individual components. The values of P_2 have been plotted against those of c_2 and extrapolated to $c_2 = 0$ to obtain the values of P designated as P_∞. The values of P_∞ when plotted against $1/T$ should give a straight line, as required by the Debye equation, $P = a + b/T$, in which $a = P_E + P_A$, the sum of the electronic polarization, P_E, and the atomic, P_A, and $b = 4\pi N\mu^2/9k$, N being the Avogadro number, 6.061×10^{23}, μ, the electric moment, and k, the molecular gas constant, 1.372×10^{-16}. Unfortunately, the short temperature range within which benzene is liquid renders the location of the $P_\infty - 1/T$ curves inaccurate for these solutions. It has seemed best, therefore, to disregard P_A for these substances and use for P_E the molar refraction for the sodium D line, MR_D, which is slightly higher than P_E, a fact which partially compensates for the neglect of P_A. The pronounced variation of the polarizations of the substituted acetylenes with temperature made it possible to locate the $P_\infty - 1/T$ curves with seeming accuracy but with surprising values for a and b. However, instead of using the constant $(P_\infty - a)T = b$, it is safer to use the quantity $(P_\infty - MR_D)T$ at each temperature and calculate the moment from the relation, $\mu = 0.0127 \times 10^{-18} \sqrt{(P_\infty - MR_D)T}$, which follows from the preceding equation. The values of MR_D were determined experimentally—in the case of the solids, from measurements upon the solutions—and are listed in Table III in the "Obs." column. In the "Calcd." column are given the refractions calculated as the sum of the atomic refractions and those for the

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[4] Smyth, Morgan and Boyce, THIS JOURNAL, 50, 1536 (1928); Smyth and Morgan, *ibid.*, 50, 1547 (1928); Dornte and Smyth, *ibid.*, 52, 3546 (1930).

unsaturated bonds. The differences between the observed and the calculated values are given in the column under E. The refractive indices and densities of the two substances which could be measured pure in the liquid state are given in Table I. The values used for the polarizations, P_1, of benzene and heptane were those determined in previous measurements.[5]

When $P_\infty - MR_D$ is small, a small variation in P_∞ causes a large variation in μ. It has been pointed out[6] that, in such cases, neglect of P_A may lead to apparent values of μ as large as 0.4 or 0.5×10^{-18} when they are really zero. However, the values of P_A found for saturated hydrocarbons[6,7] are so small that their neglect is approximately compensated for by the failure to extrapolate MR to infinite wave length. The values found for ethylene, acetylene and benzene,[6] though small, are sufficient to suggest the possibility that considerable error may arise from the neglect of P_A in the substituted ethylenes and acetylenes, but the closeness of MR_D to P in the cases of phenylethylene and 1,1-diphenylethylene seems to indicate that the effect of P_A is slight. The values for the acetylenes lead to the impossible result, large negative values for P_A, which will be discussed later. The most serious error is that of P_∞, which is magnified by the necessity of working in dilute solution. It is greatest for the difficultly soluble tetraphenylethylene, which, in the one solution deemed worth measuring, gave an apparent value of P_2 lower than MR_D, the probable error being about equal to the difference. The accuracy of the moments is not sufficient to distinguish between a value of zero and one of 0.2×10^{-18}, but it is significant that two of the three substances for which an approximately zero moment is found have molecules which should be symmetrical, while the third, phenylethylene, has not a very unsymmetrical molecule. It seems probable that this latter substance may have a small moment.

Experimental Results

TABLE I

DIELECTRIC CONSTANTS AND DENSITIES OF BENZENE SOLUTIONS AND POLARIZATIONS OF POLAR COMPONENTS

Mole fr. of 2 =	1,1,1-Triphenylethane				Phenylethylene (n_D^{20} 1.54343; d_4^{20} 0.9046)			
t, °C.	0.0196	0.0317	0.0409	0.0726	0.0380	0.0524	0.0677	0.0836
			ϵ				ϵ	
10	2.324	2.337	2.342	2.371	2.305	2.308	2.311	2.311
30	2.283	2.296	2.301	2.330	2.266	2.270	2.273	2.275
50	2.241	2.254	2.260	2.290	2.226	2.226	2.232	2.232
70	2.199	2.208	2.216	2.246	2.180	2.180	2.187	2.184

[5] Smyth and Dornte, THIS JOURNAL, 53, 545 (1931).

[6] Smyth, ibid., 51, 2051 (1929).

[7] Smyth and Stoops, ibid., 50, 1883 (1928).

TABLE I　(*Continued*)

$\left(n^{20}_D \; 1.54333; \quad d^{20}_4 \; 0.9046\right)$

Mole fr. of 2 =	0.0196	0.0317	0.0409	0.0726	0.0380;	0.0524	0.0677	0.0836
t, °C.			d				d	
10	0.8998	0.9060	0.9106	0.9253	0.8901	0.8904	0.8908	0.8913
30	.8787	.8853	.8900	.9053	.8691	.8695	.8699	.8705
50	.8575	.8643	.8693	.8850	.8480	.8483	.8486	.8492
70	.8358	.8430	.8485	.8644	.8268	.8268	.8269	.8281

			P_2				P_2	
10	87.4	87.5	88.0	86.0	35.8	36.3	36.5	36.2
30	87.4	87.2	87.7	85.8	36.4	36.9	37.0	36.9
50	86.4	86.7	87.3	85.7	36.4	36.0	37.0	36.6
70	85.4	83.5	85.4	84.7	33.6	34.2	37.0	35.0

1,1-Diphenylethylene					*Trans*-1,2-diphenylethylene			
Mole fr. of 2 =	0.0303	0.0387	0.0479	0.0575	0.0196	0.0325	0.0376	0.0451
t, °C.			ϵ				ϵ	
10	2.329	2.335	2.342	2.352	2.324	2.335	2.341	2.343
30	2.287	2.292	2.300	2.310	2.281	2.293	2.299	2.303
50	2.242	2.246	2.257	2.267	2.238	2.250	2.256	2.260
70	2.197	2.202	2.208	2.217	2.195	2.204	2.212	2.213

			d				d	
10	0.8976	0.9001	0.9023	0.9049	0.8952	0.8989	0.9007	0.9014
30	.8767	.8790	.8816	.8843	.8737	.8779	.8795	.8817
50	.8551	.8577	.8605	.8633	.8523	.8565	.8583	.8604
70	.8335	.8362	.8391	.8421	.8308	.8351	.8369	.8395

			P_2				P_2	
10	65.6	65.1	65.0	64.9	67.9	67.0	67.0	66.5
30	64.9	64.6	64.6	64.7	66.9	66.6	66.8	65.6
50	63.3	62.6	64.1	64.3	66.0	65.8	66.3	65.2
70	61.0	61.1	61.2	61.7	63.9	63.3	65.1	62.7

Triphenylethylene				Tetraphenylethylene
Mole fr. of 2 =	0.0238	0.0350	0.0493	0.0645	0.0135
t, °C.			ϵ		ϵ
10	2.341	2.352	2.367	2.381	2.322
30	2.299	2.310	2.324	2.341	2.282
50	2.255	2.266	2.280	2.299	2.239
70	2.210	2.225	2.234	2.257	(2.192)

			d		d
10	0.9020	0.9074	0.9142	0.9210	0.8998
30	.8808	.8866	.8938	.9006	.8788
50	.8595	.8656	.8731	.8802	.8576
70	.8375	.8442	.8522	.8597	.8358

			P_2		P_2
10	94.8	92.1	90.6	89.8	110
30	94.1	91.7	90.1	90.0	111
50	92.6	90.8	89.2	89.6	108
70	91.0	90.5	87.2	89.2	(101)

TABLE I (*Concluded*)

Phenylacetylene (in Heptane)   Diphenylacetylene

Mole fr.	$(n_D^{20}$ 1.5492; d_4^{20} 0.9300)							
of 2 =	0.0269	0.0347	0.0641	0.0887	0.0132	0.0198	0.0285	0.0538
t, °C.			ϵ				ϵ	
10	1.957	1.962	1.983	2.002	2.333	2.337	2.347	2.368
30	1.928	1.933	1.954	1.969	2.291	2.299	2.306	2.327
50	1.897	1.900	1.922	1.933	2.245	2.258	2.260	2.284
70	1.864	1.866	1.885	1.897	2.201	2.212	2.216	2.240
			d				d	
10	0.6971	0.6988	0.7043	0.7088	0.8931	0.8953	0.8979	0.9049
30	.6801	.6818	.6870	.6917	.8718	.8741	.8766	.8842
50	.6626	.6644	.6695	.6741	.8503	.8525	.8552	.8631
70	.6447	.6466	.6515	.6560	.8284	.8307	.8337	.8416
			P_2				P_2	
10	48.5	46.8	45.9	46.2	85.0	77.1	73.9	69.4
30	47.8	46.5	46.2	45.1	84.9	79.1	74.6	70.5
50	46.0	43.4	45.4	43.5	80.4	80.2	72.6	69.5
70	42.1	39.3	42.4	41.8	77.5	77.2	71.2	68.9

TABLE II

VALUES OF $(P_\infty - MR_D)T$, $(P_\infty - a)T$, AND THE MOMENT

	$(C_6H_5)_3CCH_3$			$C_6H_5CH{=}CH_2$			$(C_6H_5)_2C{=}CH_2$		
T, °A.	P_∞	$(P_\infty - MR_D)T$	$\mu \times 10^{18}$	P_∞	$(P_\infty - MR_D)T$	$\mu \times 10^{18}$	P_∞	$(P_\infty - MR_D)T$	$\mu \times 10^{18}$
283	88.9	1440	0.48	36	0	0	68.8	2060	0.58
303	88.4	1390	.47	36	0	0	67.1	1700	.52
323	87.4	1160	.43	36	0	0	65.4	1260	.45
343	86.2	840	.38	36	0	0	63.7	760	.35

	$C_6H_5CH{=}CHC_6H_5$			$(C_6H_5)_2C{=}CHC_6H_5$		
T, °A.	P_∞	$(P_\infty - MR_D)T$	$\mu \times 10^{18}$	P_∞	$(P_\infty - MR_D)T$	$\mu \times 10^{18}$
283	69.0	1020	0.41	99.0	2490	0.63
303	67.5	330	0.23	97.4	2180	.59
323	66.4	0	0	95.8	1810	.54
343	65.0	0	0	94.8	1580	.51

	$C_6H_5C{\equiv}CH$				$C_6H_5C{\equiv}CC_6H_5$			
T, °A.	P_∞	$(P_\infty - MR_D)T$	$\mu \times 10^{18}$	$(P_\infty - a)T$	P_∞	$(P_\infty - MR_D)T$	$\mu \times 10^{18}$	$(P_\infty - a)T$
283	51.4	4670	0.87	8600	95.1	8780	1.19	18450
303	49.6	4450	.85	8670	91.8	8400	1.16	18750
323	47.8	4170	.82	8660	87.0	7400	1.09	18450
343	45.6	3670	.77	8440	83.2	6580	1.03	18300

$a = 21.0, b = 8610, \mu = 1.18 \times 10^{-18}$ $a = 29.9, b = 18430, \mu = 1.72 \times 10^{-18}$

TABLE III

REFRACTIONS AND ELECTRIC MOMENTS

	MR_D					MR_D			
	Obs.	Calcd.	E	$\mu \times 10^{18}$		Obs.	Calcd.	E	$\mu \times 10^{18}$
$(C_6H_5)_3CCH_3$	83.8	83.8	0	0.4	$(C_6H_5)_2C{=}CHC_6H_5$	90.2	83.3	6.9	0.6
$C_6H_5CH{=}CH_2$	36.3	35.1	1.2	0	$(C_6H_5)_2C{=}C(C_6H_5)_2$	115.1	107.4	7.7	0
$(C_6H_5)_2C{=}CH_2$	61.5	59.2	2.3	0.5	$C_6H_5C{\equiv}CH$	34.92	33.5	1.4	0.83
$C_6H_5CH{=}CHC_6H_5$	66.4	59.2	7.2	0	$C_6H_5C{\equiv}CC_6H_5$	64.1	57.6	6.5	1.12

Discussion of Results

It is interesting to compare the small moment .0.4 $\times$ 10^{-18} found for 1,1,1-triphenylethane with those of other phenyl substituted ethanes and also methanes. The moments of methane[8] and ethane[1] have been found to be zero. When one methane hydrogen is replaced by phenyl to form toluene,[9] a moment of 0.4 $\times$ 10^{-18} results. This moment is presumably the resultant, in part, at least, of small displacements of charges in the benzene ring. Because of the symmetry of the ring,[10] it probably acts in the direction of the line joining the ring to the methyl carbon, which lies in the plane of the ring. When a second methane hydrogen is replaced by a phenyl group to form diphenylmethane, a second doublet is introduced which, if the tetrahedral valence angles of the methane carbon are maintained, should give a slightly larger moment to the molecule. Estermann's[11] value 0.37 $\times$ 10^{-18} for diphenylmethane is not sufficiently accurate to show whether the moment is really larger or smaller than that of phenylmethane or toluene. This is shown by the fact that his measurements on diphenyl, which should have zero moment,[12] merely indicate the moment to be less than 0.4 $\times$ 10^{-18}. The application of the same arguments concerning structure to triphenylmethane leads to the conclusion that it should have the same moment as toluene, 0.4 $\times$ 10^{-18}, which has been found to be the case.[13] Actually, the well-known abnormal behavior of the triphenylmethyl radical would lead one to expect a displacement of the charges between the methane carbon and its one remaining hydrogen with resulting alteration of the moment. However, no such alteration is evidenced in the value for triphenylmethane, which is consistent with the absence of any regular differences in the moments of triphenylmethyl chloride and alcohol as compared to those of the normal and the tertiary butyl compounds.[5] As it has been shown[3,14] that a hydrogen attached to an aliphatic carbon in a hydrocarbon may be replaced by a methyl group without alteration of moment, the moment of 1,1,1-triphenylethane should be the same as that of triphenylmethane as actually observed.

Although all of these values for the substituted methanes and ethanes are inaccurate from the same causes as those to which the probably smaller uncertainties of the results in Table III are due, they show that electrical dissymmetry arises when an aliphatic hydrocarbon group is attached to a

[8] Sänger, *Physik. Z.*, **27**, 556 (1926); Riegger, *Ann. Physik*, **59**, 753 (1919).

[9] Williams, *Physik. Z.*, **29**, 174 (1928).

[10] Smyth and Morgan, THIS JOURNAL, **49**, 1030 (1927).

[11] Estermann, *Z. physik. Chem.*, [B] **1**, 134 (1928).

[12] Ref. 9, p. 271.

[13] Sack, *Ergebnisse Exakten Naturwissenschaften*, **8**, 307 (1929); Lautsch, *Z. physik. Chem.*, [B] **1**, 115 (1928).

[14] Smyth, THIS JOURNAL, **46**, 2151 (1924).

benzene ring, but give no evidence of a resultant displacement of charges in the bonds of these groups. This latter is in marked contrast to the considerable differences in chemical behavior observed.

Smyth and Zahn[1] have found zero moment for the ethylene molecule, but a moment of 0.37×10^{-18} for ethylethylene. This is in contrast to the absence of moment when the carbon chain of a paraffin is lengthened,[4] and is indistinguishable experimentally from the moment produced when a methyl or ethyl group is substituted for a hydrogen on a benzene ring. One would look for a moment in phenylethylene, but the experimental results indicate a zero value, although, as previously pointed out, their accuracy is not such as to preclude the possibility of a moment somewhat smaller than 0.4×10^{-18}. The dissymmetry in 1,1-diphenylethylene is sufficient to give rise to a moment of 0.5×10^{-18}, while, in the *trans*-1,2-diphenylethylene, the moment is zero as in the *trans*-acetylene dihalides investigated by Errera.[2] It is curious that the value found for triphenylethylene should be higher than that for the more unsymmetrical 1,1-diphenylethylene, but the difference is probably not significant. The value for the symmetrical tetraphenylethylene is apparently zero, as would be expected from its symmetry.

It was hoped at the beginning of this investigation that the substitution of a phenyl group for a hydrogen on a doubly-bonded carbon might have a marked effect upon the moment. However, although the exaltation of refraction usually found in conjugated systems given in the column under E in Table III shows a loosening of the electron binding,[15] no abnormal dissymmetry in the arrangement of the charges is apparent. In fact, there is no evidence of a measurable polarity inherent in the double bond itself and the attachment of hydrocarbon groups to it appears to have about the same effect upon the moment as a similar attachment to a benzene ring. The Kekulé formula for benzene has been indicated to be correct in so far as it places the carbons at the corners of a regular hexagon and the immediately attached atoms in the same plane.[10,16] In view of the mobile double bonds which this formula contains and of the fact that the benzene ring may take part in the formation of a conjugated system, it is suggestive that the substitution of a hydrocarbon group for a hydrogen on a doubly-bonded carbon gives rise to a moment of the same magnitude as that resulting from a similar substitution on a benzene carbon.

Judging from these results and the fact that acetylene has been found to have zero moment,[1] one would expect a small moment for phenylacetylene and a zero value for the seemingly symmetrical diphenylacetylene,

[15] Smyth, *Phil. Mag.*, **50**, 361 (1925).

[16] Williams, *Chem. Rev.*, **6**, 589 (1929); Lonsdale, *Proc. Roy. Soc.* (London), **123A**, 494 (1929); Hendricks, *Chem. Rev.*, **7**, 431 (1929).

instead of which Table III shows a considerable moment for phenyl-acetylene and a larger one for diphenylacetylene.   In Table II, the values of $(P_\infty - MR_D)T$ and the values of the moment calculated from them, instead of being constant as they should be, have a tendency to fall off with rising temperature.   With all the substances except the substituted acetylenes, the change in polarization is so small that the change in $(P_\infty - MR_D)T$ and μ, although relatively large, cannot be regarded as definitely significant.   However, the polarizations of the acetylenes vary more with temperature.   If P_∞ is plotted against $1/T$, a straight line results from which are obtained the values of a, b and μ shown at the bottom of the data for each of the two substances in Table II.   The constancy of the values for $(P_\infty - a)T = b$ testifies to the linearity of the curves and the seeming consistency of the results.   It must be remembered, however, that $a = P_E + P_A$.   The values found for a are much lower than those in Table III for MR_D, which is approximately equal to P_E, and, accordingly, lead to large negative values for P_A, which are impossible.   It seems best, therefore, to disregard the value of μ calculated from b and use the mean of the values calculated from $(P_\infty - MR_D)T$ as an approximate indication of the moment.

Evidence of a tautomerism for acetylene and its derivatives, HC≡CH ⇌ H_2C=C, was obtained by Nef[17] and later investigators,[18] but Biltz has criticized this evidence and argued against the supposition of the acetylidene form.[19]   It is evident that the second structure containing bivalent carbon is unsymmetrical and should possess a considerable moment.   The zero moment found for acetylene does not preclude the possibility of the existence of a small fraction of the molecules in the unsymmetrical form, the number of these molecules being too small to have a detectable effect upon the dielectric constant.   It would appear that the replacement of a hydrogen by a phenyl group increases the tendency to give the unsymmetrical form, which is still further increased in diphenylacetylene, the behavior being analogous to that of the halogen-substituted acetylenes.   The observed moment would thus be the effective mean of those of the two forms.   As change in temperature would shift the tautomeric equilibrium, the apparent falling off of moment with rising temperature could be explained by increase in the proportion of the symmetrical form.   The uncertainty connected with the temperature variation of the moments weakens it as evidence of the tautomeric equilibrium, but the considerable size of the moments found definitely requires the existence of an unsymmetrical molecule in mono- and diphenylacetylene.

[17] Nef, *Ann.*, 298, 332 (1897).

[18] Lawrie, *Am. Chem. J.*, 36, 487 (1906); Ingold, *J. Chem. Soc.*, 125, 1528 (1924).

[19] Biltz, *Ber.*, 46, 143 (1913).

Summary

The dielectric constants and densities of dilute solutions of the phenyl substituted ethylenes and acetylenes have been measured between 10 and 70°, the molar refractions of the substances have been determined and the data used to calculate the electric moments of the molecules.

The phenyl substituted ethylenes have small or zero moments according to the symmetry of their arrangement about the double bond, showing that there is no measurable polarity inherent in the bond itself. The replacement of a hydrogen on a doubly-bonded carbon by a hydrocarbon group gives rise to a moment of the same magnitude as that which results from a similar replacement in benzene.

The considerable moment found for phenylacetylene and the still larger value for diphenylacetylene, acetylene itself having no moment, give evidence of unsymmetrical molecules and may be explained in terms of a tautomeric equilibrium between a symmetrical form and an unsymmetrical containing bivalent carbon as proposed ·by Nef, the shift of equilibrium with temperature perhaps causing the temperature variation of the moment observed.

PRINCETON, NEW JERSEY

THE EFFECT OF AN ELECTRIC FIELD ON FLAMES AND THEIR PROPAGATION[1]

BY BERNARD LEWIS[2]

The knowledge that flames conduct electricity goes back many years. As early as 1801, Volta showed that the leaves of a gold-leaf electroscope diverge when burning charcoal is brought in contact with the knob. Many researches followed for the purpose of measuring the electrical conductivity of flames. It was found that the gases which emerge from the flame are conductive for some time afterward and furthermore, that this property of conduction can be lessened or removed by passing the gases through an electric field of appropriate strength. Complete accounts of these early researches are to be found in Wiedermann's "Elektricität,"[3] in a paper by de Hemptinne,[4] and in the "Handbuch der Experimentalphysik."[5]

[1] Published by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.)

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[3] Wiedermann, "Elektricität," Vol. 4B, Chapter 4, 1898.

[4] De Hemptinne, Z. physik. Chem., 12, 244–274 (1893).

[5] "Die Elektrischen Eigenschaften der Flamme," by H. Becker, Vol. 13, 1929.