tube was established by dissolving an aliquot of the upper phase in alkaline methanol and reading the optical density at 255 mμ. Figure 1 shows the distribution pattern for a typical extract after 100 transfers. Two major constituents and at least one minor constituent are present with partition ratios of 0.9, 1.9 and 3.2. In addition, the tubes at each extremity of the distribution train contain mixtures of unidentified substances. A sample of pure humulone (*o*-phenylenediamine complex, m.p. 117°), after conversion to isohumulone either by the method of Windisch, *et al.*,[1] or by boiling in aqueous phosphate buffer of *p*H 5.2, yields a product conforming to the properties of isohumulone and also having a partition ratio of 1.9 when distributed using this solvent system. A search for the origin of the substance showing maximum concentration in tube 47 and a partition ratio of 0.92 revealed that this substance did not arise from lupulone, soft resins, hard resins or humulinone but was produced, together with isohumulone, by boiling the lead salt salt fraction of a hop extract.

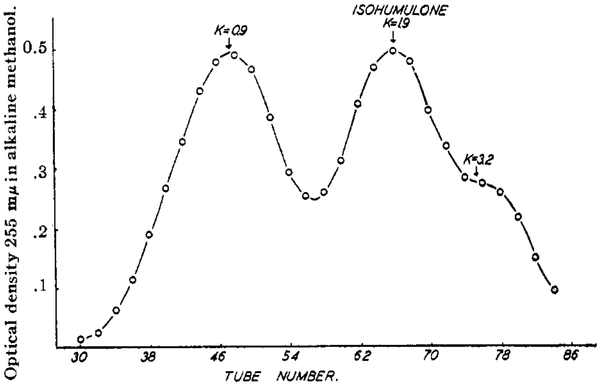

Fig. 1.—Distribution pattern for a beer extract: $n = 100$; solvent system, 2,2,4-trimethylpentane and phosphate–citrate buffer *p*H 4.9.

It was necessary therefore as a result of these observations to make a critical study of the lead salt fraction. Figure 2 shows the distribution pattern for the lead salt fraction of 1951 B. C. Bullion hops after 65 transfers using the system 2,2,4-trimethylpentane–phosphate buffer *p*H 8.5. The substance showing maximum concentration in tube 22 and a partition ratio of 0.53 is believed to be a new constituent of hops and has been assigned the name *cohumulone.* This substance was purified by repeated distributions using two solvent systems and high transfer numbers. The final product was a light-yellow oil at room temperature which formed a waxy solid on slight cooling. *Anal.* Calcd. for $C_{20}H_{32}O_5$: C, 69.23; H, 8.79; mol. wt., 364. Found: C, 69.1, 69.4, 69.4; H, 8.6, 8.8, 8.8; mol. wt. (by titration), 354. Cohumulone, like humulone, forms both a lead salt and an *o*-phenylenediamine complex but the solubility of the cohumulone product in each case is slightly greater than that of the humulone product. When boiled in phosphate buffer, *p*H 5.2, cohumulone is transformed to the new bitter substance of beer.

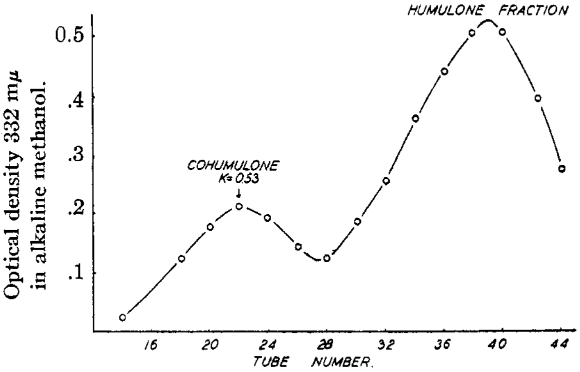

Fig. 2.—Distribution pattern for the lead salt fraction of a hop extract: $n = 65$; solvent system, 2,2,4-trimethylpentane and phosphate buffer *p*H 8.5; optical density units, mμ.

Cook and Harris[2] have reported the presence of humulinone in the lead salt fraction of Kent Golding and Worcester Fuggle hops. In the present investigation humulinone has been isolated from several varieties of Canadian and American hops. Purified humulinone from these sources distributes with a partition ratio of approximately 1 in a system of 2,2,4-trimethylpentane and 0.5 *M* monosodium phosphate adjusted to *p*H 3.2 with phosphoric acid. No humulinone, however, can be detected in these hops by distribution of either the lead salt fractions or the complete extracts. This evidence is supported by infrared and ultraviolet absorption spectra of humulinone, humulone and the lead salt fraction and permits us to conclude only that humulinone is not a natural constituent of hops but is an artifact in the method of isolation.

The second maximum in the distribution pattern, Fig. 2, is due predominantly to humulone but a theoretical curve for one substance cannot be fitted to this portion of the pattern. It is apparent, therefore, that a third component is present in the lead–salt fraction and it may be possible to accomplish its isolation by the use of a larger number of transfers or another solvent system.

[1] W. Windisch, P. Kolbach and R. Schleicher, *Wochschr. Brau.*, **44**, 453, 473, 485, 497 (1927).

[2] A. H. Cook and G. Harris, *J. Chem. Soc.*, 1873 (1950).

CANADIAN BREWERIES LIMITED
RESEARCH DIVISION
TORONTO, ONTARIO, CANADA

Derivatives of *o*-, *m*-, and *p*-Aminobenzotrifluoride. II. Azomethines Containing the Trifluoromethyl Group[1]

BY PAUL M. MAGINNITY AND JOHN L. EISENMANN

RECEIVED JUNE 30, 1952

A previous paper in this series[2] describes the preparation of a number of derivatives of the isomeric aminobenzotrifluorides, especially heterocyclic compounds. In conjunction with a study of certain azomethines being carried out in this Laboratory,[3] it was found desirable to prepare at

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[1] Parts of this paper were taken from a thesis submitted by John L. Eisenmann to the Graduate School of Boston College in partial fulfillment of the requirements for the degree of Master of Science.

[2] P. M. Maginnity and C. A. Gaulin, THIS JOURNAL, **73**, 3579 (1951).

[3] *Cf.* P. M. Maginnity and T. J. Gair, *ibid.*, **74**, 4958 (1952).

TABLE I

SUBSTITUTED SCHIFF'S BASES ArCH=NR

Ar	R	M.p. (or B.p.), °C.[a]	Description	Formula	Nitrogen, % Calcd.	Nitrogen, % Found	Picrate[b] M.p., °C.	Nitrogen, % Calcd.	Nitrogen, % Found
			A. Solid compounds						
C_6H_5	*o*-CF_3	61–62	Lt. brown needles	$C_{14}H_{10}F_3N$	5.62	5.43			
C_6H_5	*m*-CF_3	66–67	White platelets	$C_{14}H_{10}F_3N$	5.62	5.67	124–126	11.71	11.85
C_6H_5	*p*-CF_3	65	White needles	$C_{14}H_{10}F_3N$	5.62	5.31	121.5–123	11.71	11.96
m-$CH_3C_6H_4$	*p*-CF_3	19–21	Lt. tan crystals	$C_{15}H_{12}F_3N$	5.32	5.31	138–139	11.38	11.43
p-$CH_3C_6H_4$	*p*-CF_3	114–115	White platelets	$C_{15}H_{12}F_3N$	5.32	5.32	159–160	11.38	11.49
p-C_6H_4CH=CH	*m*-CF_3	102.5–103	Lt. yellow platelets	$C_{16}H_{12}F_3N$	5.09	5.09	153.5–154.5	11.11	11.38
p-C_6H_4CH=CH	*p*-CF_3	98.5–101	Yellow crystals	$C_{16}H_{12}F_3N$	5.09	5.37	140–141	11.11	11.26
o-$CH_3OC_6H_4$[c]	*m*-CF_3	43–44	White needles	$C_{15}H_{12}F_3NO$	5.02	5.15	144.5–145.5	11.02	10.96
p-$CH_3OC_6H_4$[c]	*m*-CF_3	41–41.5	White platelets	$C_{16}H_{12}F_3NO$	5.02	5.06	181.5–183.5	11.02	10.91
p-$CH_3OC_6H_4$	*p*-CF_3	84.5–85.5	White crystals	$C_{15}H_{12}F_3NO$	5.02	5.08	183.5–185	11.02	11.20
2,3-$(CH_3O)_2C_6H_3$	*m*-CF_3	44.0–44.5	Fine white needles	$C_{16}H_{14}F_3NO_2$	4.53	4.52	95–96.5[d]	10.41	10.59
2,3-$(CH_3O)_2C_6H_3$	*p*-CF_3	87–88	Lt. tan crystals	$C_{16}H_{14}F_3NO_2$	4.53	4.26	133.5–135	10.41	10.21
3,4-$(CH_3O)_2C_6H_3$	*m*-CF_3	76–76.5	White crystals	$C_{16}H_{14}F_3NO_2$	4.53	4.27	159.5–161	10.41	10.30
3,4-$(CH_3O)_2C_6H_3$	*p*-CF_3	90–90.5	Lt. yellow crystals	$C_{16}H_{14}F_3NO_2$	4.53	4.05	188.5–189	10.41	10.35
m-$CF_3C_6H_4$	*o*-CF_3	50–50.5	White platelets	$C_{15}H_9F_6N$	4.42	4.51			
m-$CF_3C_6H_4$	*m*-CF_3	53.5–54	White needles	$C_{15}H_9F_6N$	4.42	4.50			
p-HOC_6H_4	*m*-CF_3	170–171	White needles	$C_{14}H_{10}F_3NO$	5.28	5.30	203.5–205	11.34	11.21
o-HOC_6H_4	*m*-CF_3	82–83	Lt. yellow platelets	$C_{14}H_{10}F_3NO$	5.28	5.37	144.5–145.5	11.34	11.29
m-$CF_3C_6H_4$	H	47–47.5	Pale brown prisms	$C_{14}H_{10}F_3N$	5.62	5.81	159–161	11.71	11.78
m-$CF_3C_6H_4$	*p*-CH_3	39.5–40	Fine white needles	$C_{15}H_{12}F_3N$	5.32	5.19	164–166	11.38	11.51
m-$CF_3C_6H_4$	*p*-OCH_3	41–41.5	White platelets	$C_{15}H_{12}F_3NO$	5.02	5.16	159–160 with dec.	11.02	11.13
m-$CF_3C_6H_4$	*p*-OH	79–81	Fine light brown needles	$C_{14}H_{10}F_3NO$	5.28	5.20	188–189.5 with dec.	11.34	11.19
			B. Liquid compounds						
m-$CH_3C_6H_4$	*o*-CF_3	134–135 at 8 mm.	Lt. yellow oil	$C_{15}H_{12}F_3N$	5.32	5.50			
m-$CH_3C_6H_4$	*m*-CF_3	208–210 at 43 mm.	Lt. yellow oil	$C_{15}H_{12}F_3N$	5.32	5.13	132–133	11.38	11.20
p-$CH_3C_6H_4$	*o*-CF_3	134–139 at 8 mm.	Lt. yellow oil	$C_{15}H_{12}F_3N$	5.32	5.43			
p-$CH_3C_6H_4$	*m*-CF_3	171–173 at 17 mm.	Lt. yellow oil	$C_{15}H_{12}F_3N$	5.32	5.47	153.5–154.5	11.38	11.41
p-C_6H_5CH=CH	*o*-CF_3	165–168 at 8 mm.	Viscous yellow oil	$C_{16}H_{12}F_3N$	5.09	5.37	132–133.5	11.11	11.32
p-$C_6H_5CH_2CH_2$	*o*-CF_3	220–228 at 8 mm.	Viscous orange oil	$C_{16}H_{14}F_3N$	5.05	4.82			
p-$C_6H_5CH_2CH_2$	*m*-CF_3	287–289 at 43 mm.	Viscous orange oil	$C_{16}H_{14}F_3N$	5.05	4.96	114.5–116.5[e]	11.07	11.24
o-$CH_3OC_6H_4$	*o*-CF_3	152–154 at 8 mm.	Lt. yellow oil	$C_{15}H_{12}F_3NO$	5.02	5.21	87–88	11.02	11.18
p-$CH_3OC_6H_4$	*o*-CF_3	158–162 at 8 mm.	Viscous orange oil	$C_{15}H_{12}F_3NO$	5.02	5.02			
2,3-$(CH_3O)_2C_6H_3$	*o*-CF_3	164–167 at 8 mm.	Lt. yellow oil	$C_{16}H_{14}F_3NO_2$	4.53	4.54			
3,4-$(CH_3O)_2C_6H_4$	*o*-CF_3	176–180 at 8 mm.	Yellow oil	$C_{16}H_{14}F_3NO_2$	4.53	4.28			

[a] All melting points (corrected) determined on a calibrated Fisher–Johns melting point apparatus. [b] Picrates were recrystallized from glacial acetic unless otherwise noted. [c] These compounds prepared by L. P. Paradis. [d] Recrystallized from ethanol. [e] Recrystallized from benzene.

this time a new series of fluorinated azomethines from the three fluorine substituted toluidines.

In the present work, thirty-three new azomethines were prepared, each containing the trifluoromethyl group. The methods for their preparation in general followed those described for analogous compounds containing the methyl group in place of the trifluoromethyl group.[4–7] Table I summarizes the data obtained for the fluorinated azomethines.

Experimental

o- and m-Aminobenzotrifluoride.—The ortho isomer was prepared from the commercially available (Hooker) meta compound by methods previously described.[2,8]

***p*-Aminobenzotrifluoride** was prepared by a procedure based on that of Jones.[2,8] It was previously noted that when the original method of Jones was used, the reaction was often violent and the crude *p*-nitrobenzal bromide was quite irritating to the skin. When smaller quantities were brominated over longer periods of time, according to the following procedure, the reaction became less violent and yields were increased.

Forty-eight grams of *p*-nitrotoluene was brominated at 190–200° as described by Jones, the *p*-nitrotoluene being stirred rapidly while 140 g. of bromine was added over a period of 4–5 hours. To avoid contact with the irritating crude products, the reaction mass was not poured into a dish but allowed to cool in the flask. About 500 ml. of hot petroleum ether was added to the solid material in the flask and stirred with additional heating until all but a black residue had dissolved. Evaporation of the solvent to one-half of its volume and cooling of the remainder to 0° produced a precipitate of crystalline *p*-nitrobenzal bromide. The crude product thus obtained was further brominated as described by Jones. The yield of pure *p*-nitrobenzotribromide was 90.3 g. by this method, corresponding to a yield of 68% (from *p*-nitrotoluene), compared to 58% by Jones' original method.

***m*-Trifluoromethylbenzaldehyde.**[9]—*m*-Aminobenzotrifluoride was diazotized and converted into *m*-trifluoromethylbenzonitrile (b.p. 94–95° at 30 mm.) by the method described in "Organic Syntheses."[10] The nitrile (14.9 g.) was reduced to the aldehyde by the method of Stephen,[11,12] producing 10.9 g. (78%) of *m*-trifluoromethylbenzaldehyde, b.p. 93–94° at 52 mm.

Preparation of Azomethines.—The following procedure is based on those developed for syntheses of the corresponding non-fluorinated bases (*cf.* references 4–7). Equal weights (usually 1.5 to 2.5 g.) of the amine and aldehyde were mixed in a test-tube or small flask and heated either in an oil-bath or on a hot-plate until the reaction ceased. The reaction was considered completed when the gently boiling solution no longer expelled water and began to reflux smoothly on the sides of the vessel, the time for this generally being from 10–15 minutes. When this point was reached, the solution was allowed to cool slightly and was then poured into about 50 g. of an ice–water mixture. If the compound solidified, it was separated and recrystallized

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(4) C. K. Tinkler, *J. Chem. Soc.*, **103**, 885 (1913).

(5) T. C. James and C. W. Judd, *ibid.*, **105**, 1427 (1914).

(6) A. Senier and F. G. Shepheard, *ibid.*, **95**, 443, 1943 (1909).

(7) Steinhart, *Ann.*, **241**, 338 (1888).

(8) R. G. Jones, THIS JOURNAL, **69**, 2346 (1947).

(9) This work was carried out by Mr. Leo P. Paradis, student at Boston College.

(10) H. T. Clarke and R. R. Read, "Organic Syntheses," Coll. Vol. I, John Wiley and Sons, Inc., New York, N. Y., 1941, p. 514.

(11) H. Stephen, *J. Chem. Soc.*, **127**, 1874 (1925).

(12) J. W. Williams, THIS JOURNAL, **61**, 2248 (1939).

from ethanol. If the substance remained liquid (generally a heavy oil), it was extracted with ether, the extract dried over magnesium sulfate, and warmed to remove the solvent. The resulting residue was distilled under diminished pressure.

Picrates.—The picrates of the azomethines were prepared by adding a saturated solution of picric acid in either ethanol or benzene to a solution of about 0.2 g. of the base in the same solvent. The crude picrates were recrystallized from glacial acetic acid (except as noted in the table).

DEPARTMENT OF CHEMISTRY
BOSTON COLLEGE
CHESTNUT HILL, MASSACHUSETTS

Correlation of Cl^{35} Nuclear Quadrupole Coupling Frequencies with Hammett's Sigma[1]

BY HARLAN C. MEAL

RECEIVED SEPTEMBER 4, 1952

The nuclear quadrupole resonance frequency for Cl^{35} has been measured for some chlorobenzene derivatives with a frequency modulated superregenerative spectrometer[2] (Table I). Signals too weak to be detected with frequency modulation and oscilloscope display were observed using magnetic field modulation, phase-sensitive detection and pen recording. Temperature dependences of the frequencies were determined (Fig. 1) and extrapolated to absolute zero. These, together with the data of Dean and Pound similarly extrapolated, have been plotted against Hammett's substituent parameter sigma[3] (Fig. 2). Limits of error assigned are the mean deviations given by Hammett or arbitrarily taken to be 0.1 unit for sigma; for the frequencies the expected maximum error in the extrapolation is used. Where crystallographically non-equivalent chlorines give rise to multiple lines the frequencies of the several lines are plotted.

TABLE I

CL^{35} NUCLEAR QUADRUPOLE INTERACTION FREQUENCIES OBSERVED IN VARIOUS SUBSTITUTED CHLOROBENZENE COMPOUNDS

Substituent	Cl^{35} frequency at 196°K.	77°K.	0°K. (extrapolated)	σ
o-NO$_2$	36.997 mc.[a]	37.260 mc.	37.47 mc.	+2.030
o-CF$_3$[b]	35.633			
o-Cl	35.496[a]	35.824	35.97	+1.260
	35.424[a]	35.755	35.92	
	35.278[a]	35.755	35.97	
	35.215[a]	35.580	35.75	
m-NO$_2$	35.225[a]	35.457	35.60	+0.710
m-COOH	35.053	35.227	35.26	+ .355
m-CF$_3$	34.632	35.073	35.23	+ .42[c]
m-Cl	34.732[a]	35.030	35.20	+ .373
	34.724[a]	35.030	35.20	
	34.523[a]	34.875	35.09	
	34.503[a]	34.809	34.96	
p-OH	34.672[a]	34.945[a]	35.19	− .317
	34.434[a]	34.700[a]	34.82	
m-N=C=O[b]	34.653			
p-OCH$_3$	34.433	34.753	34.94	− .268
o-N=C=O[b]	34.415			
None	34.026[a]	34.622[a]	34.90	0.00
p-Cl	34.562[a]	34.779[a]	34.88	+ .227
p-COOH	34.471	34.673	34.78	+ .728
p-COCH$_3$	34.327	34.618	34.73	+ .874
p-CHO	34.381	34.607	34.67	+1.126
	34.403	34.623	34.68	
p-CH$_2$Cl	34.303	34.567	34.69	+0.025
	32.840	33.754	34.24	
p-OC$_2$H$_5$	34.180	34.381	34.44	− .25
p-NH$_2$	33.974[a]	34.146[a]	34.20	− .660
p-CH=CHCOOH	34.227		34.40	+ .619
Benzyl chloride	32.417	33.630	34.14	

[a] Data from Dean and Pound (private communication).
[b] Observations not yet complete, also, no σ-values available.
[c] J. D. Roberts, R. L. Webb and E. A. McElhill, THIS JOURNAL, **72**, 408 (1950).

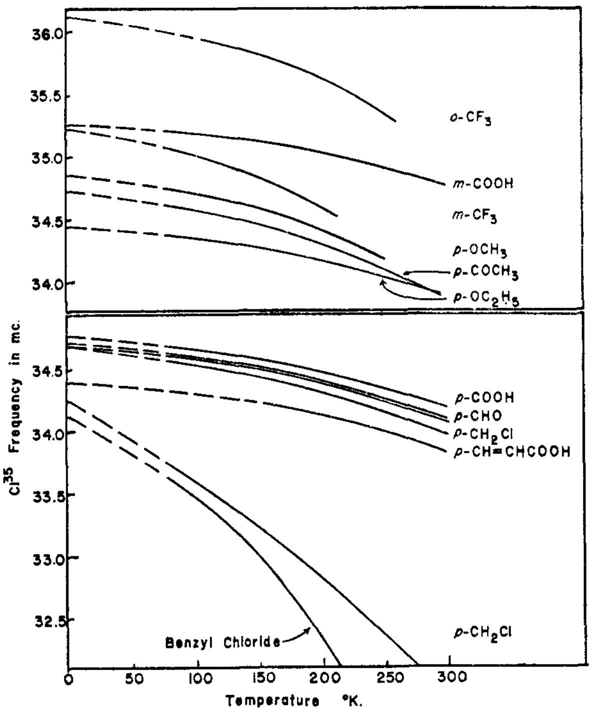

Fig. 1.

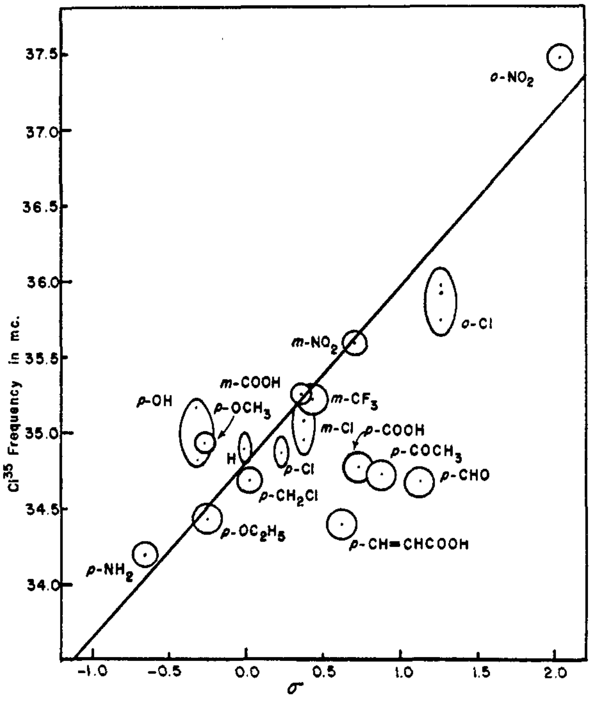

Fig. 2.

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(1) The research reported in this paper was made possible by support extended Harvard University by the ONR under Contract N5ori 76, Task Order V.

(2) C. Dean and R. V. Pound, *J. Chem. Phys.*, **20**, 195 (1952).

(3) L. P. Hammett, "Physical Organic Chemistry," McGraw-Hill Book Co., Inc., New York, N. Y., 1940, Chap. VII.