eral crystallizations of the crude product, prepared by the standard procedure, from Methyl Cellosolve gave an approximately 50–60% yield of gleaming red plates, m.p. 177–179°.

Anal. Calcd. for $C_{23}H_{25}N_5$: N, 18.9. Found: N, 18.6.

Preparation of the remainder of the dyes. 4′-Phenyl-4-dimethylaminoazobenzene,[12] m.p. 219–220° (1. xylene, 2. kerosene, 3. Methyl Cellosolve); 2-(4′-dimethylaminophenylazo)fluorene,[13] m.p. 227° (1, 2. Methyl Cellosolve, 3. acetone); 1-(4′-dimethylaminobenzeneazo)naphthalene,[14] m.p. 134–135° (1. heptane, 2,3. Methyl Cellosolve); 2-(4′-dimethylaminobenzeneazo)naphthalene,[15] m.p. 174° (1,2. heptane); and 2-(4′-dimethylaminophenylazo)-7-nitrofluorene, m.p. 270–271° (1,2. nitrobenzene) were prepared by the procedure used for the preparation of 4-dimethylamino-p-diazobenzene.

Ultraviolet-visible absorption spectra. The absorption spectra were determined with a Beckman Model DU Quartz spectrophotometer in the range of 325–800 mμ.

GAINESVILLE, FLA.

---

[12] W. Brode, J. Gould, and G. Wyman, *J. Am. Chem. Soc.*, **74**, 4641 (1952).

[13] A. Korczynski, G. Karlowska, and L. Kierzik, *Bull. soc. chim. France,* [4] **41**, 65 (1927).

[14] C. Bischoff, *Ber.*, **23**, 1908 (1890).

[15] H. Goldschmidt and B. Bardach, *Ber.*, **25**, 1347 (1892).

[CONTRIBUTION NO. 813 FROM THE CHEMISTRY LABORATORY OF INDIANA UNIVERSITY]

Reduction of Schiff Bases. II. Benzhydrylamines and Structurally Related Compounds[1a,b]

JOHN H. BILLMAN AND KWANG M. TAI

Received September 27, 1957

A new method has been developed for the preparation of secondary amines of the *N*-aryl substituted benzhydryl type and structurally related compounds by reduction of the corresponding Schiff bases with lithium aluminum hydride. In connection with this study, a series of Schiff bases has been prepared by a modification of procedures previously described. In preliminary studies, the optimum ratio of the lithium aluminum hydride to the Schiff bases has been found to be one hundred percent excess above the theoretical amount. The chlorine atoms present in the *N*-aryl group of the Schiff bases were not removed by the hydride. Acetyl and phenylurea derivatives and hydrochloride salts of the secondary amines were prepared. The *N*-aryl substituted anthrylidenimine failed to give the corresponding anthrylamines by this method. An explanation has been offered.

The present investigation was concerned with a new method for the preparation of secondary amines of the benzhydryl type, having the general formula $Ar_2CH\text{-}NHAr'$(II). The Ar_2 represents aryl groups which may be the same or different, or the aryl groups in fluorene and xanthene. Ar′ represents an aryl group.

Schiff bases, in general, form with little difficulty. However, those that were needed for the present work had to be made by an extension of the procedure of Reddelien[2,3] in which a catalyst such as fused zinc chloride or 48% hydrobromic acid was used.

$$Ar_2{=}O + H_2N{-}Ar' \xrightarrow[\text{HBr}]{\text{ZnCl}_2 \text{ or}} \underset{\text{I}}{Ar_2C{=}N{-}Ar'}$$

The two catalysts worked equally well but the Schiff bases prepared through the use of hydrobromic acid were easier to purify. In the experiments where 2,4-dichloroaniline was used the yield of Schiff base was lower than in other cases. 2,4,6-Trichloroaniline failed to react with the corresponding ketones probably due to excessive steric hindrance and the decreased basicity of the amine. The Schiff bases that were prepared are listed in Table I.

A survey of the literature showed that only a limited number of secondary amines of the aforementioned type (II) have been synthesized. In most instances the methods of preparation were rather inconvenient and gave poor yields or the author failed to report yields. At the time this work was started, no information had been published on the catalytic hydrogenation of these compounds. However, during the course of the investigation it was reported[4] that *N*-phenylbenzhydrylidenimine could be reduced catalytically but since no other compounds of this type were reduced it is impossible to draw any conclusions as to how general the procedure may be. Since none of the literature references gave evidence of a general preparative method for complex amines of the type under investigation, it was decided to try lithium aluminum hydride as the reducing agent which has been shown previously to reduce simpler Schiff bases.[5]

---

[1] (a) Taken in part from the Ph.D. thesis of Kwang M. Tai, Indiana University, 1953. (b) J. H. Billman and A. C. Diesing, *J. Org. Chem.*, **22**, 1068 (1957).

[2] G. Reddelien, *Ber.*, **43**, 2476 (1910).

[3] G. Reddelien, *Ber.*, **46**, 2718 (1913).

[4] I. H. Kaye, I. C. Kogon and C. L. Parris, *J. Am. Chem. Soc.*, **74**, 403 (1952).

[5] R. F. Nystrom and W. G. Brown, *J. Am. Chem. Soc.*, **70**, 3738 (1948). E. D. Bergmann, D. Lavie, and S. Pinchas, *J. Am. Chem. Soc.*, **73**, 5662 (1951). W. Stühmer and G. Messwarb, *Arch. Pharm.*, **286**, 19 (1953). R. N. Castle, D. L. Aldous, and M. Hall, *J. Am. Pharm. Assoc.*, **42**, 435

TABLE I

SCHIFF BASES

$Ar_2C{=}N{-}Ar'$

Product	Reactants (mole) Amine	Ketone	Reaction time (hr.)	Procedure[l]	Solvent for Recryst.	Yield, %	M.P., °C. (uncorr.)	Formula	N Analyses, % Calcd.	Found
1. benzhydrylidenimine										
N-Phenyl[a]	0.4	0.2	$4^{2}/_{3}$	A	Ethanol	81	113–114			
N-4-Methoxyphenyl[a]	0.4	0.2	$5^{1}/_{4}$	A[d]	Ethanol	78.5	75[j]	$C_{20}H_{17}NO$	4.88	5.02
N-Phenyl-*p*-methoxy[a]	0.4	0.2	6	A[d]	Methanol[e]	73	71–71.5			
	0.3	0.1	3	B	Methanol	72.4	71–71.5			
N-Phenyl-4,4′-dimethoxy[b]	0.3	0.1	$2^{1}/_{2}$	B	Methanol	76	93.5–94	$C_{21}H_{19}NO_2$	4.41	4.37
N-4-Chlorophenyl[a]	0.3	0.2	3	A[d]	Ethanol	80	92.5–93			
N-2,4-Dichlorophenyl-	0.3	0.2	$2^{1}/_{2}$	A[d]	Methanol	50.8	93.5–94	$C_{19}H_{13}Cl_2N$	4.30	4.45
N-2,4,6-Trichlorophenyl[c]	0.3	0.2	10	A, B						
N-1-Naphthyl[a]	0.3	0.2	8	A	Ethanol	74	136–136.5			
2. 9-fluorenylidenimine										
N-Phenyl[a]	0.3	0.2	2	B	Pet. ether[f]	75	88.5–90			
N-4-Methylphenyl[a]	0.3	0.2	$3^{1}/_{2}$	B	Ethanol	80.5	122.5–123			
N-4-Methoxyphenyl-	0.3	0.2	$4^{1}/_{2}$	B	Ethanol	76	135–136	$C_{20}H_{15}NO$	4.91	5.23
N-4-Chlorophenyl-	0.3	0.2	$3^{1}/_{2}$	B	Pet. ether[g]	71	147–147.5	$C_{19}H_{12}ClN$	4.84	5.04
N-2,4-Dichlorophenyl	0.3	0.2	$3^{1}/_{2}$	A	Ethanol	28	108–108.5	$C_{19}H_{11}Cl_2N$	4.32	4.47
	0.3	0.2	3	B	Ethanol	25	108–108.5			
N-2,4,6-Trichlorophenyl[c]	0.1	0.05	10	A, B						
3. 9-xanthydrylidenimine										
N-Phenyl[a]	0.8	0.4	12	B[h]	Pet. ether[f]	38	131–132[k]	$C_{19}H_{13}NO$	5.16	5.17
4. 9-anthrylidenimine										
N-Phenyl[a]	0.3	0.2	$3^{1}/_{2}$	A	[i]	74.3	202–203			
N-4-Methoxyphenyl-	0.3	0.2	3	A	[i]	70	164–165	$C_{21}H_{17}NO$	4.68	4.66
N-4-Chlorophenyl-	0.3	0.2	4	A	[i]	71.5	197.5–199	$C_{20}H_{14}ClN$	4.61	4.65
N-2,4-Dichlorophenyl-	0.3	0.2	4	A	[i]	49.5	146–147	$C_{20}H_{13}Cl_2N$	4.14	4.43

[a] Previously reported. [b] Previously mentioned but neither yield nor analytical data was given, A. Schonberg and W. Urban, *J. Chem. Soc.*, 530 (1935). [c] Only starting materials were isolated. [d] Reaction carried out under CO_2 atmosphere. [e] Compound was purified by fractional distillation (b.p. 191–195° at 6 mm.) before crystallization. [f] B.p. 30–60°. [g] B.p. 90–120°. [h] The residue, after removing chloroform and unreacted aniline, was triturated with low boiling pet. ether and extracted with ether; dry hydrogen chloride was then passed into the cold ethereal solution to separate the compound as its hydrochloride salt. The Schiff base was liberated by treating the salt with 20% NaOH solution. [i] Pet. ether (b.p. 90–120°) and benzene; the reaction mixture was treated with boiling benzene, and the benzene solution filtered. Crystallization was affected upon adding pet. ether to the filtrate and cooling. [j] Reported m.p. 70°, G. Reddelien, *Ber.*, **47,** 1360 (1914). [k] Reported m.p. 134–135°, C. Graebe and P. Röder, *Ber.*, **32,** 1688 (1899); 134.5°, A. Schonberg and W. Urban, *J. Chem. Soc.*, 530 (1935). [l] Procedure A employed hydrobromic acid as catalyst whereas procedure B employed zinc chloride as catalyst.

In general, it was found that lithium aluminum hydride was a good reducing agent for Schiff bases to produce amines of the *N*-aryl substituted benzhydryl type (II) as well as their structurally related compounds.

$$Ar_2C{=}N{-}Ar' + LiAlH_4 \longrightarrow \underset{\text{II}}{Ar_2CH{-}NH{-}Ar'}$$

Table II lists the amines that were prepared by this method.

Although no systematic study was made as to the effect of varying the molar ratio of lithium aluminum hydride, some preliminary experiments on the reduction of *N*-phenyl-9-fluorenylidenimine indicated that the optimum ratio of hydride to Schiff base was 0.5:1, which amounts to an excess of 100% of the hydride. The results are shown in Table III.

No reduction of *N*-phenyl-9-xanthydrylidenimine was observed when the reduction was carried out in diethyl ether even by varying the molar ratio of the hydride to a tenfold excess. However, by using tetrahydrofuran as a solvent and increasing the reaction temperature, the Schiff base was successfully reduced to the corresponding amine. In no instance were halogen atoms removed by the lithium aluminum hydride.

Although this method seemed to be general and suitable for the preparation of *N*-aryl substituted benzhydrylamines, fluorenylamines, and xanthydrylamines, it was not successful for the synthesis of secondary amines derived from *N*-arylanthrylidenimines. Both *N*-phenyl-9-anthrylidenimine and *N*-(4-methoxyphenyl)-9-anthrylidenimine were treated with varying amounts of hydride in diethyl ether and tetrahydrofuran but all modifications failed to give reduction. The failure of these Schiff bases to react with lithium aluminum hydride might be explained by considering the tautomeric nature of the parent compound, anthrone. The keto form of

---

(1953). B. Boothroyd and E. R. Clark, *J. Chem. Soc.*, 1499 (1953). A. H. Sommers and S. E. Aaland, *J. Org. Chem.*, **21,** 484 (1956). M. Mousseron, R. Jacquier, M. Mousseron-Canet and R. Zagdoun, *Bull. soc. chim. France*, [5] **19,** 1042 (1952). J. Thesing, *Ber.*, **87,** 507 (1954).

TABLE II

N-ARYLBENZHYDRYLAMINES AND RELATED COMPOUNDS

$Ar_2CH—NHAr'$

Secondary Amines	Reaction Time^{d} (min.)	Solvent for Recryst.	Yield, %	M.p., °C. (uncorr.)	Formula	*N* Analyses, % Calcd.	Found
A. benzhydrylamine							
N-Phenyl^{a}	50	Ethanol^{h}	77.1	57			
N-4-Methoxyphenyl^{a}	50	Ethanol^{h}	84.3	81			
N-Phenyl-*p*-methoxy-	70	^{i}	80	140–141^{p}	$C_{20}H_{20}ClNO^{p}$	4.29^{p}	4.60^{p}
N-Phenyl-4,4′-dimethoxy-	140	^{j}	86	^{j}	$C_{21}H_{21}NO_2$	4.40	4.51
N-4-Chlorophenyl-	80	^{k}	93.5	89.5–90	$C_{19}H_{16}ClN$	4.77	4.79
N-2,4-Dichlorophenyl	60^{e}	Ether^{l}	93.5	91.5–92	$C_{19}H_{15}Cl_2N$	4.28	4.40
N-1-Naphthyl^{b}	7 hrs.^{f}	Methanol^{l}	80.8	109.5–110	$C_{23}H_{19}N$	4.53	4.91
B. 9-flurorenylamine							
N-Phenyl^{a}	150	^{l,m}	94.2	121			
N-4-Methylphenyl^{a}	150	Ethanol^{l}	86.6	123.5–124			
N-4-Methoxylphenyl-	6 hr.^{f}	*n*-Butanol^{l}	72	134.5–135	$C_{20}H_{17}NO$	4.87	5.11
N-4-Chlorophenyl-	7 hrs.^{f}	*n*-Butanol^{l}	71	115–116	$C_{19}H_{14}ClN$	4.80	4.04
N-2,4-Dichlorophenyl	80^{g}	Ether^{l}	89	140–140.5	$C_{19}H_{13}Cl_2N$	4.29	4.42
C. 9-xanthydrylamine							
N-Phenyl^{c}	4 hr.	Pet. ether^{n}	70.6	97–97.5	$C_{19}H_{15}NO$	5.12	5.35

[a] Previously reported. [b] Previously mentioned, R. Cantarel, *Compt. rend.*, **226,** 931 (1948), but no melting point and analytical data were given. [c] The amine was prepared in tetrahydrofuran; no reduction of the corresponding Schiff base occurred in diethyl ether. [d] Including period of addition or extraction of the Schiff base. [e] The Schiff base was added as solid suspension in ether. [f] The Schiff base was added by extraction via Soxhlet setup. [g] The Schiff base was added as solid form. [h] Purified by fractionation under reduced pressure before crystallization. [i] A viscous colorless oil which failed to crystallize from various solvents; b.p. 187–189° (1 mm.). [j] A viscous colorless oil; b.p. 208–210° (1 mm.). [k] Recrystallized from ethanol acetone (4:1). [l] Crystallized without first purification by fractionation. [m] Recrystallized from pet. ether (b.p. 30–60°) 90–120°. [n] B.p. benzene (3:1). [p] Recorded for its hydrochloride.

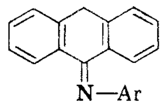
TABLE III

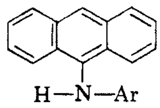
EFFECT OF VARYING THE RATIO OF LITHIUM ALUMINUM HYDRIDE TO THE SCHIFF BASE

Moles Schiff Base^{a}	$LiAlH_4$	Yield %
1	0.25	82.5
1	0.50	94.2
1	1.00	92.0
1	2.00	92.4

[a] N-Phenyl-9-fluorenylidenimine.

anthrone, in general, is indifferent to most reagents; whereas the enol form is highly reactive. When either form is dissolved in an organic solvent, tautomerization occurs and the material is slowly converted into an equilibrium mixture; the point of equilibrium being dependent upon the nature of the solvent and the temperature.[6] Furthermore, a basic medium and elevated temperatures favor the existence of the enolic form of anthrone. Likewise, the imino derivatives of anthrone should undergo a similar tautomeric shift under corresponding conditions.


III


IV

Since the Schiff bases were prepared in a basic medium (aniline) and the products later subjected to reduction with potentially basic lithium aluminum hydride at elevated temperatures, the equilibrium might be expected to shift completely to the amino form IV. On the other hand, the anthrone might first rearrange in the presence of the aniline to anthrol which would then react with the aniline to give form IV.

If the condensation products were in the form of structure III, reduction would certainly be expected in view of the results with the other Schiff bases. However, if they were in the form of structure IV, then reduction should not be expected since such a reduction would require an attack of a benzenoid system which is not accomplished by lithium aluminum hydride under ordinary conditions. In view of the experimental results, structure IV seems to be the favored form.

Whereas most of the secondary amines involved in this work gave satisfactory acetyl and phenylurea derivatives, some of them failed to react with acetic anhydride, acetyl chloride, and phenyl isocyanate. Some of the amines likewise failed to form hydrochlorides. The derivatives that were prepared are listed in Tables IV, V, and VI.

EXPERIMENTAL

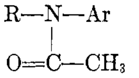
Schiff bases. The Schiff bases in Table I were prepared by modification of the methods described by Reddelien[2,3] in which the aromatic amine was allowed to react with the appropriate ketone, using a moisture trap to collect water as it formed. Fused zinc chloride or 48% hydrobromic acid was used as a catalyst. Several hours of heating, instead of 20–30 minutes, were required to collect approximately the

---

[6] L. F. Fieser and M. Fieser, *Organic Chemistry*, 3rd Ed., Reinhold Publishing Corp., New York (1956), p. 768.

TABLE IV

ACETYL DERIVATIVES OF *N*-ARYLBENZHYDRYLAMINES AND RELATED COMPOUNDS



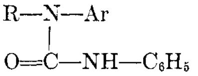
$R{-}N(C(=O){-}CH_3){-}Ar$

R—	Ar—	M.p., °C. (uncorr.)	Yield, %	Formula	*N* Analyses, % Calcd.	Found
Benzhydryl	Phenyl	84.5–85	98	$C_{21}H_{19}NO$	4.65	4.73
Benzhydryl	4-Methoxyphenyl	100.5–101	94	$C_{22}H_{21}NO_2$	4.22	4.35
Benzhydryl	4-Chlorophenyl	98–98.5	78	$C_{21}H_{18}ClNO$	4.17	4.17
Fluorenyl	Phenyl[a]	177–177.5	93	$C_{21}H_{17}NO$	4.68	4.65
Fluorenyl	4-Methylphenyl	160–161	95	$C_{22}H_{19}NO$	4.47	4.52
Fluorenyl	4-Methoxyphenyl	125–126	87	$C_{22}H_{19}NO_2$	4.25	4.39
Fluorenyl	4-Chlorophenyl	184–185	85	$C_{21}H_{16}ClNO$	4.19	4.35

[a] Previously reported, A. J. Hailwood and R. Robinson, *J. Chem. Soc.*, 1292 (1932).

TABLE V

PHENYLUREA DERIVATIVES OF *N*-ARYLBENZHYDRYLAMINES AND RELATED COMPOUNDS



$R{-}N(C(=O){-}NH{-}C_6H_5){-}Ar$

R—	Ar—	M.p., °C. (uncorr.)	Yield, %	Formula	*N* Analyses, % Calcd.	Found
Benzhydryl	Phenyl[a]	118–118.5	75	$C_{26}H_{22}N_2O$	7.40	7.50
Benzhydryl	4-Methoxyphenyl[a]	132–133	64	$C_{27}H_{24}N_2O_2$	6.86	6.84
Fluorenyl	Phenyl	165–165.5	55	$C_{26}N_{20}N_2O$	7.44	7.28
Fluorenyl	4-Methylphenyl	174.5–176	72	$C_{27}H_{22}N_2O$	7.17	7.18
Fluorenyl	4-Methoxyphenyl	177–178.5	68	$C_{27}H_{22}N_2O_2$	6.89	6.99
Fluorenyl	4-Chlorophenyl	170–171	78	$C_{26}H_{19}ClN_2O$	6.82	7.03
Xanthydryl	Phenyl	214–215	73	$C_{26}H_{20}N_2O_2$	7.14	7.07

[a] Previously reported, P. Grammaticakis, *Compt. rend.*, **210,** 716 (1940).

TABLE VI

HYDROCHLORIDES OF *N*-ARYLBENZHYDRYLAMINES AND RELATED COMPOUNDS

$R{-}NH{-}AR{\cdot}HCl$

R—	Ar—	M.p., °C. (uncorr.)	Formula	*N* Analysis, % Calcd.	Found
Benzhydryl	Phenyl[a]	201–203[e]	$C_{19}H_{18}ClN$	4.73	
Benzhydryl	4-Methoxyphenyl[b]	191–192[e]	$C_{20}H_{20}ClNO$	4.29	4.62
4-Methoxybenzhydryl	Phenyl	140–141[e]	$C_{20}H_{20}ClNO$	4.29	4.60
Benzhydryl	4-Chlorophenyl	176–178	$C_{19}H_{17}Cl_2N$	4.24	4.41
Fluorenyl	Phenyl	222–223.5[c]	$C_{19}H_{16}ClN$	4.77	4.77
Fluorenyl	4-Methylphenyl	217–219[c]	$C_{20}H_{18}ClN$	4.55	4.94
Fluorenyl	4-Methoxyphenyl	214.5–216.5	$C_{20}H_{18}ClNO$	4.32	4.45
Fluorenyl	4-Chlorophenyl	192–193	$C_{19}H_{15}Cl_2N$	4.27	4.38
Xanthydryl	Phenyl[c]	248–251[d]	$C_{19}H_{16}ClNO$	4.52	4.62

[a] Reported m.p. 194°, H. Staudinger, E. Anthes, and F. Pfenninger, *Ber.*, **49,** 1928 (1916); and 202.5°, A. Skita, *Ber.*, **48,** 1685 (1915). [b] Reported m.p. 187°, M. Busch and A. Rinck, *Ber.*, **38,** 1761 (1905); and 194°, P. Grammaticakis, *Compt. rend.*, **210,** 716 (1940). [c] Color changed to greenish after drying. [d] Started to sinter at 148°. [e] Melted with decomposition.

theoretical amount of water. Because of the difference in time of heating, the yields of the Schiff bases obtained in this work were 10 to 20% higher than those given by Reddelien. The yields of several Schiff bases prepared by both methods are listed in Table VII.

A number of comparisons of the fused zinc chloride and 48% hydrobromic acid procedures were made and it was found that the crude yields were roughly the same. However, it was found that the hydrobromic acid method gave products that were easier to purify and thus gave slightly higher yields of pure products.

Secondary amines. Stock solutions of the lithium aluminum hydride were prepared and standardized according to the procedure of Finholt, Bond, and Schlesinger.[10]

In a typical preparation of the secondary amines, 25 ml.

---

(7) G. Reddelien, *Ber.*, **48,** 1462 (1915).

(8) G. Reddelien, *Ber.*, **47,** 1360 (1914).

(9) E. Bergmann, L. Engel, and H. Meyer, *Ber.*, **65,** 446 (1932).

(10) A. E. Finholt, A. C. Bond, and H. I. Schlesinger, *J. Am. Chem. Soc.*, **69,** 1199 (1947).

TABLE VII

COMPARISON OF YIELDS OF SCHIFF BASES

Schiff Bases	Yield, % Method 1[a]	Yield, % Method 2[b]	References
N-Phenylbenzhydrylidenimine	81	71	(7)
N-p-Methoxyphenylbenzhydrylidenimine	78.5	56	(8)
N-*p*-Chlorophenylbenzhydrylidenimine	80	59	(9)
N-α-Naphthylbenzhydrylidenimine	74	66	(3)
N-Phenyl-9-florenylidenimine	75	56	(2)

[a] Modified method. [b] Reddelien's method, see refs. (2) and (3).

of a one-molar stock solution of lithium aluminum hydride (0.025 mole) diluted with 200 ml. of absolute ether was refluxed in a 1-liter, three-necked flask equipped with a dropping funnel, a mercury-sealed stirrer, and a reflux condenser. A solution of 13 g. (0.05 mole) of *N*-phenylbenzhydrylidenimine in 100 ml. of absolute ether was added dropwise at a rate to maintain gentle refluxing. The addition required 20 min. and the solution was refluxed for an additional 30 min. During this time, the yellow color of the solution gradually faded and finally became nearly colorless. The complex formed and the excess of hydride were decomposed by careful addition of water with cooling of the flask in an ice bath. Through the top of the condenser, enough ordinary ether was added to compensate for the amount which had been entrained by the evolved hydrogen. This was followed by the addition of 100 ml. of 20% sodium potassium tartrate and 40 ml. of 10% sodium hydroxide, which caused most of the precipitate to dissolve. The contents of the flask were then transferred to a separatory funnel and the ether layer separated. After the ether solution had been dried over sodium hydroxide pellets, the ether was evaporated, leaving an oily residue which was fractionally distilled. The material that distilled at 178–182° under 2 mm. pressure was collected as a pale yellow oil. For isolation of the product in crystalline form, the oily mass was dissolved in 125 ml. of boiling absolute ethanol and the hot solution filtered. The filtrate was allowed to cool slowly, and then chilled at 0° for 24 hr. The precipitate which crystallized was collected and washed twice with 5-ml. portions of cold ethanol. The filtrate and washings were evaporated to a volume about one half that of the original filtrate, and a second crop of crystals was obtained upon cooling. The crude product weighed 10.6 g., and melted at 54–56°. Two recrystallizations from absolute ethanol gave 10.1 g. (77.1%) of colorless crystals, melting at 57°. The melting point agrees with that previously described.[11–13]

Acetyl derivatives of N-arylbenzhydrylamines and related compounds (*Table IV*). One gram of the amine and a four- to fivefold excess of acetic anhydride were mixed and heated under gentle reflux for 15 to 30 min. After being cooled, the reaction mixture was poured into 30–40 moles of cold water. The aqueous mixture was then neutralized by careful addition of solid sodium carbonate. The mixture was cooled, and the insoluble acetamide was collected, washed, and dried in a vacuum desiccator. Recrystallization was effected from water-ethanol mixtures or from cyclohexane-benzene mixtures.

Phenylurea derivatives of N-arylbenzhydrylamines and related compounds (*Table VI*). A slight excess of phenyl isocyanate was added to a solution of 1 or 2 g. of the amine in 10–20 ml. of petroleum ether (b.p. 90–120°). If the amine was only slightly soluble, heating was necessary to bring it into solution. The mixture was boiled at a gentle reflux for about 5 min., and then allowed to cool. When the precipitate did not form even after the wall of the container had been rubbed, the heating was repeated, two times if necessary. The solid product was collected and extracted with 10–20 ml. of boiling petroleum ether (b.p. 90–120°), and the solution was filtered and cooled. If the phenylurea did not crystallize, the filtrate was concentrated. The crystals were collected, dried, and the melting point determined. If the latter was not sharp, petroleum ether (b.p. 60–120°) or 95% of ethanol was used for recrystallization.

Hydrochlorides of N-arylbenzhydrylamines and related compounds (*Table VII*). The hydrochlorides were prepared by dissolving one gram of the amine in 15–30 ml. of absolute ether and passing dry hydrogen chloride through this solution for 5 to 15 min. The precipitate which formed was collected and dried over phosphorus pentoxide. The amine hydrochlorides were recrystallized from an ether-ethanol mixture. All of the salts obtained were white, solid, and nonhygroscopic. The yields in all cases were over 95%.

BLOOMINGTON, IND.

---

(11) W. Schlenk, J. Appenrodt, H. Michael, and A. Thal, *Ber.*, **47**, 473 (1914).

(12) M. Busch and A. Rinck, *Ber.*, **38**, 1761 (1905).

(13) P. Grammaticakis, *Comp. rend.*, **210**, 716 (1940).

[CONTRIBUTION FROM THE RADIUM INSTITUTE OF THE UNIVERSITY OF PARIS]

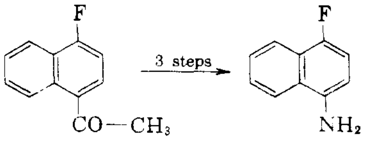
Some Nitrogen Derivatives of 1-Fluoronaphthalene

N. P. BUU-HOÏ, N. D. XUONG, AND V. Q. YEN

Received September 9, 1957

4-Fluoro-1-naphthylamine has been synthesized from 4-fluoro-1-acetonaphthone, and used for the preparation of a number of fluorinated *N,N'*-diarylthioureas of interest as potential antiviral agents. Various nitrogen-containing heterocyclic derivatives of 1-fluoronaphthalene have also been prepared from various 4-fluoro-1-acylnaphthalenes, for biological testing.

A number of aryl derivatives of thiourea bearing nuclear fluorine substituents, especially 4-chloro-4′-fluorothiocarbanilide, have been found to possess chemotherapeutic activity against influenza virus,[1] and these observations prompted the preparation of similar compounds derived from the 4-fluoro-1-naphthyl radical. 4-Fluoro-1-naphthylamine (II),



I II

---

(1) N. P. Buu-Hoï, P. Gley, N. D. Xuong, and A. Bouffanais, *Compt. rend.*, **238**, 2582 (1954); N.P. Buu-Hoï, P. Gley, A. Bouffanais, N. D. Xuong, and N. H. Nam, *Experientia*, **12**, 73 (1956).