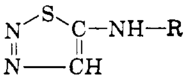
Table I. 5-(Substituted) Amino-1,2,3-thiadiazoles

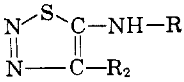


R^a	Yield, %^{d}	Crystalline^e form	M.p., °C.^{g}	Formula	N Calcd.	N Found	S Calcd.	S Found
C_6H_5	42.0	Grey needles	180	$C_8H_7N_3S$	23.71	23.80	18.09	17.80
$C_6H_5CH_2{}^b$	7.3	White needles	93–95	$C_9H_9N_3S$	22.19	22.21	16.75	16.52
$4\text{-}O_2NC_6H_4$	20.0	Tan powder	206–209	$C_8H_6N_4SO_2$	25.18	23.80	14.42	13.80
$4\text{-}CH_3OC_6H_4$	10.0	Colorless flakes^f	155–157	$C_9H_9N_3SO$	20.30	20.40	15.48	15.10
$4\text{-}ClC_6H_4$	10.0	Tan powder	173–175	$C_8H_6N_3SCl^h$	19.85	19.60	15.17	15.71
$4\text{-}BrC_6H_4$	13.0	Brown flakes	187–189	$C_8H_6N_3SBr^i$	16.40	16.15	12.50	12.77
$4\text{-}CH_3C_6H_4$	35.5	Yellow needles	172–174	$C_9H_9N_3S$	22.19	22.40	16.75	16.38
$4\text{-}(CH_3)_2NC_6H_4{}^c$	23.0	Green powder	168–170	$C_{10}H_{12}N_4S$	25.42	24.60	14.53	14.00
$C_{10}H_7{}^k$	20.0	Yellow needles	161–162	$C_{12}H_9N_3S$	18.50	18.35	13.55	14.26
$3\text{-}BrC_6H_4$	37.0	Tan scales	165–166	$C_8H_6N_3SBr^j$	16.40	16.80	12.50	12.85

[a] All are new compounds with exception of R = C_6H_5 (lit.,[5] m.p. 179–180°). [b] Product did not precipitate; ether was removed and residue recrystallized. [c] Product did not precipitate; ether was removed and product precipitated by benzene. [d] Represent first crop of crystals. [e] From ethanol. [f] From chloroform. [g] With decomposition except R = $C_6H_5CH_2$. [h] Cl: calcd., 16.78; found, 16.90. [i] Br: calcd., 31.17; found, 31.15. [j] Br: calcd., 31.17; found, 31.40. [k] α-Naphthyl.

Table II

Ultraviolet Absorption Spectra of 5-(Substituted) Amino-1,2,3-thiadiazoles



R_1	R_2	λ_{max}	Log ϵ_{max}	λ_{max}	Log ϵ_{max}	λ_{max}	Log ϵ_{max}
$C_6H_5CH_2$	H	240	4.54	266	4.48	296	4.53
3-Br—C_6H_4	H	246	4.21			314	4.34
						324	4.36
4-Cl—C_6H_4	H	258	3.94			310	4.26
						330	3.97
4-CH_3—C_6H_4	H	246	3.90			324	4.21
α-Naphthyl	H	232	4.47	236	4.27	334	4.21
				240	4.28		
$C_6H_5^-$	C_6H_5	236	4.05	242	3.89	316	3.49
				254	3.84		
				274	3.71		
$C_6H_5^-$	H	240	3.96	280	3.66	318	4.05
$4\text{-}CH_3OC_6H_4$	H	230	4.06			320	3.77
		240	4.03				
$4\text{-}BrC_6H_4$	H	252	3.93			320	4.24
$4\text{-}(CH_3)_2NC_6H_4$	H	260	4.34			324	4.17

Table III

Major Characteristic Infrared Frequencies of 5-(Substituted) Amino-1,2,3-thiadiazoles

Cm.$^{-1a}$	Assignment
3220 m	Bonded N—H stretching
1650–1590 v	N—H deformation
1560–1475 v^b	Ring stretching
1350–1280 v^d	C—N stretching
1265–1200 v	C—H in-plane deformation
1190–1175 v^d	C—H in-plane deformation
1150–950 v^d	Ring breathing
910–890 w	Ring breathing
705–670 w	C—H out-of-plane deformation

[a] Intensity: m, medium; w, weak; v, variable. [b] One or more bands. [c] Two bands. [d] At least one band.

Some Reactions of Fluorinated Cyclobutenes with Grignard Reagents

J. D. Park and R. Fontanelli[1]

Department of Chemistry, University of Colorado, Boulder, Colorado

Received April 20, 1962

In an attempt to find a simple method for introducing alkyl and aryl substituents into fluorocyclobutenes, our attention was turned to the reaction of Grignard reagents with these compounds. This had not been carried out previously.

The reaction of Grignard reagents with fluoroölefins, such as $CF_2{=}CCl_2$, $CF_2{=}CFCl$, and $CF_2Cl{-}CF{=}CF_2$, has already been described by Tarrant, *et al.*[2] These workers found that apparently addition first occurs across the double bond and the resulting adduct loses MgX_2 to give a new, longer chain fluoroölefin. The reaction goes with poor yield (10–20%) using aliphatic Grignard reagents and with better yields (30–70%) using aromatic Grignard reagents.

The preparation of some alkyl derivatives (mono- and dimethyl, mono- and dibutyl, and diphenyl) of perfluorocyclobutene, has been previously described by Dixon,[3] using the reaction with alkyllithium. This reaction, however, gives in poor yields (20–40%) only the diphenyl derivative with phenyllithium and a mixture of mono- and dialkyl derivatives (the latter predominating) with alkyllithium.

In this study, when the perfluorocyclobutene was treated with excess alkylmagnesium bromide under mild conditions, the monoalkyl derivatives in high yields (75–85%) (methyl excepted) had been obtained. Under stronger conditions, the monoalkyl derivatives with excess Grignard reagent gave comparable yields of the dialkyl derivatives. However, the reaction with phenylmagnesium bromide gave both the mono- and diphenyl derivatives (ratio 1:1) in a total yield of 80%.

Some reactions with vinyl- and perfluoroalkylmagnesium bromide have been attempted, but only high boiling polymeric materials were isolated.

When 1,2-dichloro-3,3,4,4-tetrafluorocyclobutene was treated with alkyl Grignards, the substitution of one vinylic chlorine took place quite readily. The substitution of the second vinylic chlorine, on the contrary, does not easily take place, even after refluxing the monoalkyl derivative for twenty-four hours in ether. This reaction has been carried out in a sealed Pyrex tube in ether under autogenous pressure, and only above 100° a reaction took place. The reaction products isolated were: starting material (25%), 1,2-diethyl-3,3,4,4-tetrafluorocyclobutene (16%) (this product was identical

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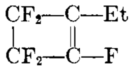
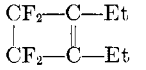
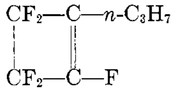
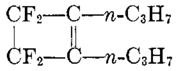
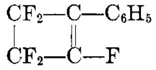
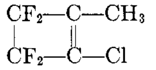
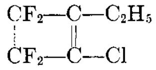
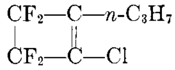
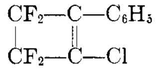
(1) Montecatini Industrial Research Fellow (1961–1962). Work done at the University of Colorado.

(2) P. Tarrant and D. A. Warner, *J. Am. Chem. Soc.*, **76**, 1624 (1954).

(3) S. Dixon, *J. Org. Chem.*, **21**, 400 (1956).

TABLE I
PHYSICAL PROPERTIES OF THE CYCLIC ETHERS

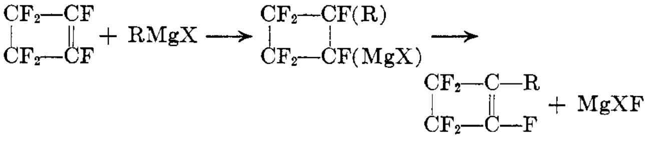
Compounds	Yield, %	B.p., °C./mm.	$d^{25}{}_4$	$n^{25}D$	Calcd. C	Calcd. H	Calcd. F	Calcd. Cl	Found C	Found H	Found F	Found Cl
	75	66–68/630	1.2421	1.3303	41.87	2.93	55.20		41.52	2.78	55.12	
	75	134–136/630 69–70/60	1.110	1.3735	52.74	5.53	41.72		53.03	5.78	41.62	
	83	86–88/630	1.199	1.3421	45.17	3.79	51.04		44.95	4.00	51.28	
	76	77/25	1.060	1.3908	57.13	6.71	36.15		57.28	6.59	36.01	
	80	67–68/15	1.354	1.4606	54.56	2.27	43.15		54.85	2.47	43.24	
	80	77–78/630	1.337	1.3602	36.03	1.73	43.54	20.32	36.00	1.92	43.39	20.61
	75	98/630	1.292	1.3723	38.21	2.67	40.30	18.81	38.46	2.65	40.21	19.02
	78	118/630	1.236	1.3795	41.50	3.49	37.51	17.50	41.53	3.70	37.71	17.41
	65	78–80/5	1.371	1.5012	50.77	2.13	32.12	14.99	51.00	2.50	32.31	14.49

to that already obtained from the reaction of 1-ethyl-2,3,3,4,4-pentafluorocyclobutene with ethylmagnesium bromide) and a difficultly separable mixture of five high boiling products that were partially resolved by vapor phase chromatography, but not identified. These may be a mixture of the triethyl derivatives formed from the substitution of the allylic fluorines.

What has been found in this study is in agreement with the base-catalyzed reactions of alcohols with perfluorocyclobutene and 1,2-dichloro-3,3,4,4-tetrafluorocyclobutene.[4,5]

Proof of Structure.—In the infrared spectra of the mono- and dialkyl derivatives of perfluorocyclobutene, there is evidence that the substitution of the vinylic fluorines took place. Thus, the double bond of perfluorocyclobutene absorbs at 1790 cm.$^{-1}$ and the monoalkyl derivatives exhibit a shift of the double bond absorption band to 1720–1730 cm.$^{-1}$. The dialkyl derivatives do not exhibit any absorption (or very weak at 1705 cm.$^{-1}$) as the tetrasubstituted double bond is perfectly symmetrical.

The reaction probably goes through the addition of the reagent (RMgX) to the double bond, and the intermediate product thus formed loses the magnesium halide giving the substituted olefin.



However, in the reaction of 1,2-dichloro-3,3,4,4-tetrafluorocyclobutene with Grignard reagents, the first step goes in the same way, but the displacement of the second chlorine is much more difficult because of the lesser tendency of chlorine to undergo mesomeric shift. In such a case, the vinylic chlorine atom shows the usual inertness toward displacement.

Experimental

1-Methyl-2,3,3,4,4-pentafluorocyclobutene (I).—In a 500-ml. three-neck flask fitted with a gas inlet tube, a stirrer, and a Dry Ice condenser connected to a bubbler, 250 ml. of 3 *M* ethereal solution of methylmagnesium bromide (0.75 mole) was introduced and cooled to 0°. A 50-g. sample (0.30 mole) of perfluorocyclobutene was bubbled into the ethereal solution in a period of 1 hr. and further maintained for 2 hr. at 0° and for another 20 hr. at room temperature. The reaction mixture was then warmed to gentle reflux of the ether for 4 hr. After cooling again to 0°, 150 ml. of 20% hydrochloric acid was dropped in very slowly to decompose the Grignard reagent. The decomposition is very exothermic and a strong evolution of methane occurred. The ethereal solution was separated and the aqueous layer extracted three times with ether. The combined extracts were washed with bicarbonate solution and dried over anhydrous sodium sulfate. Distillation yielded 11 g. (22%) of I; b.p. 44–45°/630 mm.; n^4D 1.3225; $d^4{}_4$ 1.377; molecular refraction: calcd. for $C_5H_3F_5$, 23.44; found, 22.92. Dixon[3] reports a boiling point of 50°/730 mm. for this compound.

The preparation of the other derivatives in general followed along similar lines. These reaction products and their properties are tabulated in Table I.

Reaction of 1-Ethyl-2-chloro-3,3,4,4-tetrafluorocyclobutene with Ethylmagnesium Bromide.—In a high pressure Pyrex tube fitted with a valve and a pressure gage, 100 ml. of a 3 *M* ethereal solution of ethylmagnesium bromide (0.3 mole) and 18.5 g. (0.1 mole) were introduced. The tube was then warmed to 100–110° for 30 hr. The formation of a grayish precipitate was noticed after a few hours and the pressure had increased to about 120 p.s.i.g. After cooling, the residual pressure was discharged and the content treated with 100 ml. of 20% hydrochloric acid. The ethereal layer was separated and the water layer extracted three times with ether. The combined extracts, washed with bicarbonate solution and dried over sodium sulfate, were distilled. After removal of the ether, 18 g. of a high boiling residue was obtained. Fractionation of the residue under reduced pressure yielded 6 g. of starting material, 4 g. of III (b.p. 68–75°/60 mm.) and 7 g. of a fraction distilling at 70–80°/0.5 mm. which upon vapor phase chromatography was resolved into five products which as yet have not been identified (column: silicon D/C/710, temp. = 200°).

---

[4] J. D. Park, M. L. Sharrah, and J. R. Lacher, *J. Am. Chem. Soc.*, **71**, 2337 (1949).

[5] J. D. Park, C. M. Snow, and J. R. Lacher, *ibid.*, **73**, 2342 (1951).

Acknowledgment.—The authors are indebted to Montecatini Industries of Milan, Italy, for making it possible for one of us (L.F.) to have a leave of absence and support to carry out this work at the University of Colorado.

A Direct Synthesis of 4-Azanaphthoquinones-1,2[1]

L. R. MORGAN, JR., AND R. J. SCHUNIOR

Department of Pharmacology, Louisiana State University, School of Medicine, New Orleans, Louisiana

AND J. H. BOYER

American Chemical Society, Petroleum Research Fund, Washington, District of Columbia

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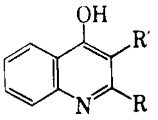
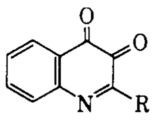
The difficulty encountered in the attempt to prepare azabenzoquinones[2] by the oxidation of hydroxy- and aminopyridones[3] suggested that fusion of a benzene ring to either an *o*- or *p*-azabenzoquinone might increase their stability. The reported synthesis and stability of 4-azanaphthoquinone-1,2 (IVa)[4] prompted an investigation of the chemistry of azanaphthoquinones. The present paper describes the preparation of two 4-azanaphthoquinones-1,2, IVa and IVb.



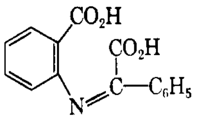


IVa. R = H
 b. R = CH_3

Ia. R = R′ = H
b. R = CH_3, R′ = H
c. R = C_6H_5, R′ = H

IIa. R = H, R′ = CHO
b. R = CH_3, R′ = CHO
c. R = C_6H_5, R′ = CHO

IIIa. R = H, R′ = OH
b. R = CH_3, R′ = OH
c. R = C_6H_5, R′ = OH



V

The synthesis of IVa and IVb now reported utilizes the extension of the Reimer–Tiemann reaction to hydroxyquinolines. This approach finds analogy in the observation of Bobranski[5] that 4-hydroxyquinoline and 4-hydroxyquinaldine are formylated with sodium hydroxide and chloroform. Unfortunately a rigid structure proof of the products was not provided in either case.

Formylation of Ia, b, c under Bobranski's conditions proceeded as desired with formation of 3-formyl-4-hydroxyquinolines, IIa,b,c, in good yields. 3,4-Dihydroxyquinoline (IIIa) and 3,4-dihydroxyquinaldine (IIIb) were obtained from Dakin oxidations of IIa and IIb with sodium hydroxide and hydrogen peroxide in satisfactory yields. Oxidation of IIIa and IIIb was accomplished with silver oxide and/or chromium trioxide. The products have been assigned the structure of 4-azanaphthoquinone-1,2 (IVa) and 3-methyl-4-azanaphthoquinone-1,2 (IVb), respectively. Condensation of the azaquinones with *o*-phenylenediamine gave the corresponding phenazines supporting the initial assignments of the formyl group in IIa and IIb.

In sharp contrast to the foregoing results, the Dakin oxidation of 2-phenyl-3-formyl-4-hydroxyquinoline (IIc) with sodium hydroxide and hydrogen peroxide to 2-phenyl-3,4-dihydroxyquinoline (IIIc) was unsuccessful. The major product was the anthranil of phenylglyoxylic acid (V) whose structure was confirmed by hydrolysis to phenylglyoxylic acid. Apparently in addition to the Dakin oxidation of the formyl group in IIc a Baeyer–Villiger transformation occurs with oxidation of an intermediate peroxide and ring fission. All attempts to stop the reaction at the dihydroxy stage were unsuccessful.

Experimental[6]

Preparation of the 4-Hydroxyquinolines (Ia–c).—4-Hydroxyquinaldine,[7] 2-phenyl-4-hydroxyquinoline,[8] and 4-hydroxyquinoline[9] were prepared according to the literature cited.

Preparation of the 3-Formyl-4-hydroxyquinolines (IIa–c).—3-Formyl-4-hydroxyquinoline[5] and 3-formyl-4-hydroxyquinaldine[10] were previously prepared.

A mixture of 2-phenyl-4-hydroxyquinoline (2.87 g., 0.013 mole), 2 g. of powdered sodium hydroxide, and 2 ml. of chloroform was heated at 50° for a few minutes and 3 ml. of water added. The slurry was gently refluxed for 6 hr. with 2 ml. of chloroform being added at 2-hr. intervals. The excess chloroform was removed *in vacuo* and the resulting slurry filtered. The dried solid was extracted twice with 20–30 ml. of hot water and the washings combined with the original filtrate. Acidification with glacial acetic acid afforded a yellow suspension which precipitated as a yellow sirup that solidified upon standing. Several recrystallizations from ethanol afforded yellow needles of 2-phenyl-3-formyl-4-hydroxyquinoline, m.p. 250–252°, 1.2 g. (37%).

Anal. Calcd. for $C_{16}H_{11}NO_2$: C, 77.09; H, 4.45; N, 5.63. Found: C, 77.27; H, 4.52; N, 5.57.

The aldehyde formed a 2,4-dinitrophenylhydrazone which recrystallized from ethyl acetate and ethanol as red needles, m.p. 275–277.5° dec.

Anal. Calcd. for $C_{22}H_{15}N_5O_5$: C, 61.54; H, 3.52; N, 16.31. Found: C, 61.27; H, 3.45; N, 16.41.

General Procedure for the Dakin Oxidation of 3-Formyl-4-hydroxyquinolines (IIa–b).—To a solution of 0.007 mole of the 3-formyl-4-hydroxyquinolines in 7 ml. of 1 *N* sodium hydroxide, 9.5 g. of 3% hydrogen peroxide was added in one portion and allowed to stand overnight at room temperature. A color change from deep orange to yellow was accompanied by an exothermic reaction. Upon cooling to room temperature the dihydroxyquinolines could be isolated.

3,4-Dihydroxyquinoline recrystallized from 95% ethanol as yellow microcrystals, m.p. 222–227° dec., 18% yield.

Anal. Calcd. for $C_9H_7NO_2$: C, 67.07; H, 4.38; N, 8.69. Found: C, 67.13; H, 4.21; N, 8.75.

3,4-Dihydroxyquinaldine recrystallized from 95% ethanol as a pale yellow powder, m.p. 275–281° dec., 49% yield.

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[1] Part of this work was carried out in the Department of Chemistry, Tulane University, New Orleans, La.

[2] In the present study, azaquinones designates nitrogen as a member of the quinone ring.

[3] J. H. Boyer and S. Kruger, *J. Am. Chem. Soc.*, **79**, 3552 (1957).

[4] M. Passerini, T. Bonciani, and N. Di Gioia, *Gazz. chim. ital.*, **61**, 959 (1931).

[5] B. Bobranski, *Chem. Ber.*, **69**, 1113 (1888).

[6] Semimicro analyses by Alfred Bernhardt Microanalytisches Laboratorium, Max Planck Institute, Mülheim (Ruhr), Germany. Melting points are uncorrected.

[7] G. A. Reynolds and C. R. Hauser, "Organic Syntheses," Coll. Vol. III, John Wiley and Sons, Inc., New York, N. Y., 1955, p. 593.

[8] R. C. Fuson and D. M. Burness, *J. Am. Chem. Soc.*, **61**, 2890 (1939).

[9] R. G. Gould, Jr., and W. A. Jacobs, *ibid.*, **61**, 2890 (1939).

[10] M. Conrad and L. Limpach, *Chem. Ber.*, **21**, 1965 (1888).