curred at $x = 0.443$. Substitution in the appropriate equation (ref. 5b, equation 7) gives 0.1 for $K = ([Ni^{++}][N_2H_4])/([Ni(N_2H_4)^{++}])$. The stability constant of the dihydrazinate could not be determined because of the interfering absorption of the first complex in the same region. In addition precipitation prevented sufficiently high concentrations. The evidence is therefore only quantitative for the existence of the monohydrazine nickel(II) ion in solution.

DEPARTMENT OF CHEMISTRY
OREGON STATE COLLEGE
CORVALLIS, OREGON RECEIVED DECEMBER 26, 1950

Perfluorinated Grignard Derivatives

BY ALBERT L. HENNE AND WILLIAM C. FRANCIS

Since the recent disclosure by Haszeldine[1] that we had obtained perfluorinated Grignard derivatives, we have received repeated requests for experimental directions. The following general procedure, while not yet optimum, will permit others to proceed with practical results.

We have made our Grignard derivatives from iodides, $C_nF_{2n+1}I$, and most of the work was done with C_3F_7I. Contrary to a general impression, the formation of C_3F_7MgI is exceedingly easy; its stability is, however, so poor that complete decomposition occurs promptly at room temperature.

A clue to this behavior was obtained when the Grignard was prepared in an atmosphere of dry carbon dioxide. Under these conditions $C_3F_7CO_2H$ resulted in 6 to 10% yield. When the reaction was carried out in a nitrogen atmosphere and later carbonated, little or no acid was obtained. At 0°, the Grignard is still unstable, but it is possible to form it in ether solution at this temperature, drop it promptly into water or a slurry of Dry Ice in ether[2] and isolate C_3F_7H or $C_3F_7CO_2H$, respectively, in 5 to 7% yields. These experiments show that perfluorinated Grignard reagents exist as such, and appear to react normally.

If Grignard formation is carried out at about −80° in an ether solution of C_3F_7I containing a suspension of magnesium and Dry Ice, a 45% yield of $C_3F_7CO_2H$ is easily obtained, presumably improvable by refining the mechanical handling.

Reaction in a carbon dioxide atmosphere using the "extreme dilution" procedure usually applied to allylic halides appears promising, but at the present time the recommended procedure is the low-temperature reaction just described.

Pilot tests have shown that these procedures can be extended to reaction with the carbonyl function, and acetone gives the expected carbinol. More detailed information will be presented later.[3]

(1) R. N. Haszeldine, *Nature*, **167**, 139 (1951).

(2) A. S. Hussey, THIS JOURNAL, **73**, 1364 (1951).

(3) In a preprinted abstract for the New York Meeting of the A.C.S., September, 1951, Haszeldine states that perfluorinated Grignard Reagents appear to condense normally with a series of conventional functions (private communication).

DEPARTMENT OF CHEMISTRY
OHIO STATE UNIVERSITY
COLUMBUS, OHIO RECEIVED MAY 9, 1951

The Synthesis of 4-Chloro-3-indoleacetic Acid

BY CORWIN HANSCH AND JOHN C. GODFREY

4-Chloro-3-indoleacetic acid has been synthesized by the procedure of Snyder and Pilgrim[1] for assessment as a plant growth-regulator. This substance has been tested by the avena test as part of a program[2] to correlate plant growth activity with chemical structure. The compound was found by Dr. Robert Muir of the State University of Iowa to be active in promoting plant growth; his complete results will be published elsewhere. The starting point for the synthesis of the 4-substituted acid was 4-chloroindole[3] a generous sample of which was supplied by Dr. F. C. Uhle of Harvard University.

(1) H. R. Snyder and F. J. Pilgrim, THIS JOURNAL, **70**, 3770 (1948).

Experimental

4-Chlorogramine.—To 1.42 ml. of 25% aqueous dimethylamine cooled in an ice-bath was added 1 g. of cold acetic acid and 0.58 g. of cold 40% formalin. This solution was then poured onto 1.12 g. of 4-chloroindole, the beaker being rinsed with 1/3 ml. of water. The mixture was allowed to come to room temperature and after some shaking all of the chloroindole dissolved. This solution was allowed to stand overnight and then heated to 30–40° for 2 hours after which 1.35 g. of KOH in 10 ml. of water was added. The oil which separated crystallized quickly and after standing in an ice-bath 2 hours, the crystals were separated and dried. Dilution of the filtrate with the wash water caused more crystals to separate. Yield of crude chlorogramine was 1.4 g., m.p. 135–143°. After crystallization from acetone the m.p. was 147.6–148.4°.

Anal.[4] Calcd. for $C_{11}H_{13}N_2Cl$: C, 63.31; H, 6.24. Found: C, 63.40; H, 6.50.

The picrate was prepared in ethanol solution and recrystallized from the same solvent; m.p. 157.4–158.6°.

Anal. Calcd. for $C_{17}H_{16}N_5O_7Cl$: C, 46.63; H, 3.66. Found: C, 46.60; H, 4.10.

4-Chloro-3-indoleacetic Acid.—To 0.91 g. of potassium cyanide dissolved in 1.7 ml. of water and 5.4 ml. of 95% ethanol was added 0.57 g. of 4-chlorogramine. This mixture was heated under reflux for 98 hours and then diluted with 12 ml. of water. The resulting precipitate (presumably amide of 4-chloroindoleacetic acid) was removed by filtration (no free 4-chloroindoleacetic acid was obtained from this filtrate on acidification) and hydrolyzed by boiling with 2 *N* KOH for 4 hours. Acidification of the KOH solution caused a considerable precipitate of silicic acid and chloroindoleacetic acid. This precipitate and solution was evaporated to dryness and the residue extracted with ether. After evaporation of the ether the residue was crystallized from alcohol and ethylene chloride; yield 0.1 g., m.p. 179–180°.

Anal. Calcd. for $C_{10}H_8O_2NCl$: C, 57.28; H, 3.82. Found: C, 56.90; H, 4.30.

(2) C. Hansch and R. M. Muir, *Plant Physiol.*, **25**, 389 (1950).

(3) F. C. Uhle, THIS JOURNAL, **71**, 761 (1949).

(4) All analyses were made by C. F. Geiger of Chaffey College, Ontario, California.

DEPARTMENT OF CHEMISTRY
POMONA COLLEGE
CLAREMONT, CALIF. RECEIVED FEBRUARY 26, 1951

Preparation of N,N,N′,N′-Tetrasubstituted Diamines

BY THOMAS M. LAAKSO AND DELBERT D. REYNOLDS

Recent investigations in our laboratory required the use of certain N,N,N′,N′-tetrasubstituted diamines. A general method for their preparation is not described in the literature.

The method described here involves the reaction of glycol disulfonates with secondary amines as indicated by

$$RSO_2O{-}(CH_2)_x{-}OSO_2R + 4R'R''NH \longrightarrow \begin{matrix} R' \\ R'' \end{matrix}\!\!>\!N{-}(CH_2)_x{-}N\!<\!\!\begin{matrix} R' \\ R'' \end{matrix} + 2RSO_2OH{\cdot}HNR'R''$$

R may be alkyl, aryl, and so forth; R′ and R″ may

TABLE I

N,N,N′,N′-TETRASUBSTITUTED DIAMINES

Amine	Sulfonate derivative	Tertiary amine	M.p. or b.p., °C. (mm.)	Analyses, % Calcd.	Found	Yield
Dicyclohexyl	1,2-Di-(benzenesulfonoxy)-ethane	N,N,N′,N′-Tetracyclohexyl-ethylenediamine	M. 102–104	C, 80.4 H, 12.3 N, 7.2	80.5 12.2 7.0	85.9
Diethyl	1,2-Di-(benzenesulfonoxy)-ethane	N,N,N′,N′-Tetraethylethylene-diamine	B. 89 (31.5)	C, 70.0 H, 13.7 N, 16.3	70.3 14.1 16.7	55
Diisopropyl	1,3-Di-(*p*-toluenesulfonoxy)-propane	N,N,N′,N′-Tetraisopropyltri-methylenediamine	B. 83 (10.25)	C, 74.5 H, 14.0 N, 11.5	74.8 13.8 11.5	85.7
Diphenyl	1,3-Di-(*p*-toluenesulfonoxy)-propane	N,N,N′,N′-Tetraphenyltri-methylenediamine	B. 118–121 (0.3)	C, 85.7 H, 6.9 N, 7.4	85.3 7.0 7.0	64.8
Di-*n*-butyl	1,4-Di-(*p*-toluenesulfonoxy)-butane	N,N,N′,N′-Tetra-*n*-butyltetra-methylenediamine	B. 107–108 (1)	C, 77.0 H, 14.1 N, 9.0	77.1 14.0 9.2	77.5
Methylphenyl	1,4-Di-(*p*-toluenesulfonoxy)-butane	N,N′-Dimethyl,N,N′-diphenyl-tetramethylenediamine	M. 82–83	C, 80.6 H, 8.9 N, 10.5	80.2 8.8 10.8	24.3
Piperidine	1,5-Di-(methanesulfonoxy)-pentane	N,N′-Dipiperidylpenta-methylenediamine	B. 110 (0.5)	C, 75.6 H, 12.6 N, 11.7	75.4 12.7 11.9	25
Dibenzyl	1,5-Di-(methanesulfonoxy)-pentane	N,N,N′,N′-Tetrabenzylpenta-methylenediamine	B. 218–222 (0.6)	C, 85.7 H, 8.2 N, 6.1	86.0 7.8 6.0	10
Morpholine	2,5-Di-(benzenesulfonoxy)-hexane	2,5-(Dimorpholino)-hexane	B. 130–132 (0.3)	C, 65.1 H, 10.9 N, 10.8	64.7 10.6 11.0	66.5
Diethyl	β,β′-Di-(benzenesulfonoxy)-diethyl ether	β,β′-(Diethylamino)-diethyl ether	B. 69–70 (1)	C, 66.6 H, 12.9 N, 12.9	66.6 12.8 13.1	13
Diisopropyl	β,β′-Di-(benzenesulfonoxy)-diethyl ether	β,β′-(Diisopropylamino)-diethyl ether	B. 96.5 (0.5)	C, 70.5 N, 13.2 N, 10.4	70.9 13.2 10.3	49.2
Diisopropyl	1,3-Di-(*p*-toluenesulfonoxy)-butane	1 3-(Diisopropylamino)-butane	B. 85–87 (1)	C, 75.0 H, 14.0 N, 11.0	74.5 14.1 10.7	65

TABLE II

GLYCOL DISULFONATES

Glycol	Sulfonate derivative	M.p., °C.	Analyses, % Calcd.	Found	Yield, %
Ethylene glycol	1,2-Di-(benzenesulfonoxy)-ethane	48–50	C, 49.2 H, 4.1 S, 18.6	49.4 4.2 18.3	64.7
Propane-1,3-diol	1,3-Di-(*p*-toluenesulfonoxy)-propane	92–93	C, 53.2 H, 5.2 S, 16.8	52.9 5.2 16.5	69.4
Butane-1,4-diol	1,4-Di-(*p*-toluenesulfonoxy)-butane	81–82	C, 54.3 H, 5.5 S, 16.1	54.3 5.5 15.9	67
Pentane-1,5-diol	1,5-Di-(Methanesulfonoxy)-pentane	35–36	C, 32.4 H, 6.1 S, 24.6	32.3 6.1 24.2	82.7
Hexane-2,5-diol	2,5-Di-(benzenesulfonoxy)-hexane	104–105	C, 54.3 H, 5.5 S, 16.1	54.2 5.3 16.3	73.7
Diethylene glycol	β,β′-Di-(benzenesulfonoxy)-diethyl ether	38–39	C, 49.7 H, 4.6 S, 16.6	49.6 4.7 16.7	66.1
Butane-1,3-diol	1,3-Di-(*p*-toluenesulfonoxy)-butane	58–59	C, 54.3 H, 5.5 S, 16.1	54.6 5.5 16.4	77.0

be the same or different, alkyl, aryl, cyclic, and so forth. This process has a broad application, since, for a given disulfonate, a large number of secondary amines may be chosen. Moreover, the availability of the glycol disulfonates is being greatly increased by the ever-increasing number of glycols which are appearing on the market.

Table I lists the amines synthesized by this method and Table II contains the glycol disulfonates which were prepared as intermediates.

Experimental

General Procedure for the Preparation of Glycol Disulfonates.—The anhydrous glycol (1 mole) is dissolved in 3 to 5 volumes of anhydrous pyridine and the appropriate sulfonyl chloride (2 moles) is added to this well-stirred solution. The temperature is maintained between 5 and 15°. After the reaction is completed, the reaction mixture is stirred into three times its volume of finely crushed ice. The crystalline product which separates is washed with ice-water and then dried. It is purified by recrystallization from ethanol.

General Procedure for the Preparation of N,N,N',N'-Tetrasubstituted Diamines.—A glycol disulfonate is refluxed with 20 equivalents of anhydrous secondary amine under anhydrous conditions, with stirring, for approximately 20 hours. The secondary amine is fractionally distilled, after which an excess of 40% sodium hydroxide solution is added. The oil layer is separated and the water layer extracted with ether. The oil and ether extracts are combined and dried over anhydrous potassium carbonate. After distillation of the ether, the residual oil is fractionated under reduced pressure through a glass-packed column using a variable take-off stillhead.

RESEARCH LABORATORY
EASTMAN KODAK COMPANY
ROCHESTER, NEW YORK RECEIVED MARCH 22, 1951

On the Preparation of Xanthurenic Acid

BY ALEXANDER D. MEBANE AND WILLIAM OROSHNIK

Xanthurenic acid was first synthesized by Musajo and Minchilli,[1] who reported a melting point of 283–285° (dec.) "with fast heating." Subsequent preparations[2,3,4] have resulted in melting points varying from 250°[3] (in spite of correct elementary analyses) to as high as 289°.[4] When the synthesis was carried out in this Laboratory, a product of m.p. 255° was obtained, although all intermediates had been carefully purified. The explanation was found to lie in incomplete ether-fission under the conditions specified by Musajo and Minchilli; more exhaustive treatment with hydriodic acid raised the melting point to 294°. A subsequent examination of two of the above-mentioned preparations showed the 250° specimen[3] to contain 8.3% of methoxyl, corresponding to 58 mole per cent. of the 8-methyl ether; the 289° specimen,[4] on the other hand, proved to contain only 3.3 mole per cent. of the methyl ether.

Reprecipitation of methoxyl-free material was ineffective in freeing it of inorganic contaminants. None of the common organic solvents permitted recrystallization, but dilute hydrochloric acid proved to be quite satisfactory, giving a chloride-free crystalline product decomposing at 297°.

(1) L. Musajo and M. Minchilli, *Ber.*, **74B**, 1842 (1941).

(2) E. C. Miller and C. A. Baumann, *J. Biol. Chem.*, **157**, 554 (1945); **159**, 174 (1945).

(3) C. C. Porter, I. Clark and R. H. Silber, *ibid.*, **167**, 575 (1947). A sample of this material was kindly made available to us by Dr. Silber.

(4) F. Rosen, J. W. Huff and W. A. Perlzweig, *J. Nutrition*, **33**, 561 (1947). The melting point was not reported in the original publication.

A simplified version of the Musajo–Minchilli synthesis which embodies these improvements is described below.[5]

Experimental

Commercial sodium salt of oxalacetic ester (49 g.) was shaken with 300 ml. of ether and 400 ml. of ice-cold 5% sulfuric acid until all had dissolved, and the aqueous layer was reextracted with ether. The combined extracts, after drying over anhydrous $MgSO_4$, were concentrated at 20 mm. The residue (38 g., 0.2 *M*) was heated in a boiling water-bath with 25 g. (0.2 *M*) of *o*-anisidine for 90 minutes, after which the water that had separated was evaporated at 20 mm.

The resulting orange sirup was stirred with 1 liter of mineral oil while heating to 240° in an electric mantle. After five minutes at 240–250°, the flask was cooled with an air blast. When the temperature had fallen to 60°, the solution was decanted from precipitated tar, diluted with 2 liters of petroleum ether, and stored for several days in the refrigerator. Tan-colored crystals of crude ethyl xanthurenate 8-methyl ether (23 g.) were obtained. Recrystallization of this material (from toluene, with ligroin) was undesirable for practical purposes, since the best crops were the later and smaller ones (colorless needles, m.p. 100–101°).

The crude ether-ester was dissolved in 350 ml. of 57% hydriodic acid (freshly distilled from hypophosphorous acid; b.p. 126–128°), and the liquid was distilled slowly at atmospheric pressure under an 8" Vigreux column until the stillhead temperature had reached 110° (3 hours). The HI was then distilled off to near-dryness at 20 mm. and the residue taken up in water, made alkaline with bicarbonate, filtered, and acidified to *p*H 3 with dilute HCl in the presence of a little bisulfite. After chilling, the xanthurenic acid was filtered off with water washes and sucked as dry as possible: sulfur-yellow, non-crystalline.

The damp filter cake was dissolved, by boiling, in a mixture of 400 ml. of concd. HCl and 500 ml. of distilled water, and filtered hot with a little Norit and SuperCel, washing with 70 ml. of the hot solvent. To the filtrate was added 2400 ml. of boiling-hot distilled water, and the solution was allowed to stand overnight. Filtration, with water and then acetone washes, furnished 14.5 g. (35% based on *o*-anisidine) of crystalline xanthurenic acid; small, imperfectly-rhombic ochre-yellow flakes.

Anal. Calcd. for $C_{10}H_7NO_4$: C, 58.54; H, 3.44; N, 6.83. Found: C, 58.59, 58.34; H, 3.52, 3.67; N, 6.61, 6.66; methoxyl, none; ash, none; Cl^-, none; Fe, none.

The melting point is quite sensitive to the rate of heating. If the temperature was brought rapidly to 270° and thereafter raised 5° per minute, decomposition occurred at 297°.

At *p*H 6.95, the ultraviolet absorption spectrum of xanthurenic acid in water shows two smooth peaks: $\lambda_{max.}$ 243 mμ, ε 30,000; $\lambda_{max.}$ 342 mμ, ε 6,500.

Acknowledgments.—We are indebted to Mr. Robert A. Mallory for checking this procedure, and to Mr. Joseph Grodsky for the microanalyses.

(5) A paper by A. Furst and C. J. Olsen (*J. Org. Chem.*, **16**, 412 (1951)), which appeared after this note had been submitted, describes more extensive improvements in this preparation. The melting point of 284° for crystalline material reported by Furst and Olsen is presumably due to a difference in heating rate.

ORTHO RESEARCH FOUNDATION
RARITAN, NEW JERSEY RECEIVED MARCH 19, 1951

The Activity Coefficients of the Alkaline Earth and Magnesium Perchlorates from Freezing Point Data

BY DAN E. NICHOLSON[1] AND W. A. FELSING

In a previous article,[2] experimental data were presented in which the freezing points for aqueous solutions of barium, strontium, calcium and magnesium perchlorates had been used to calculate the

(1) Materials Chemistry Division, Oak Ridge National Laboratory.

(2) D. E. Nicholson with W. A. Felsing, THIS JOURNAL, **72**, 4496 (1950).