companied by a vigorous evolution of carbon dioxide. Ether extraction yielded a dark partly crystallized oil which was oxidized to the bromo-dibasic acid by refluxing with 100 g. of potassium ferricyanide and 40 g. of potassium hydroxide in 600 cc. of water for four hours. Acidification and ether extraction gave the crude bromo-dibasic acid which was washed with chloroform and then sublimed under reduced pressure to yield 1 g. of pure 5-bromo-2,4-furandicarboxylic acid. There was no depression in a mixed melting point determination with an authentic specimen.[3] Additional confirmation of the identity of the 5-bromo-2,4-furandicarboxylic acid was secured by removal of the α-carboxyl group by the mercuric chloride procedure[4] to give the known 2-bromo-3-furoic acid[3] (mixed m. p.).

3-Isopropylfuran.—The 4-isopropyl-2-furoic acid (4 g.) was decarboxylated in accordance with Johnson's procedure by heating with quinoline and copper bronze at 220–240° until carbon dioxide evolution ceased. The yield of 3-isopropylfuran was 1.6 g.; b. p. 111–112°; d^{20}_{20} 0.8929; n^{20}_{D} 1.4369. Mercuration in the customary manner gave 3-isopropyl-2-furylmercuric chloride which melted at 90° after crystallization from an ethanol–water solution.

Anal. Calcd. for C_7H_9OClHg: Hg, 58.11. Found: Hg, 58.39.

The isomeric α-mercurial, 4-isopropyl-2-furylmercuric chloride, was prepared from 4-isopropyl-2-furoic acid, in accordance with the procedure for replacing an α-carboxyl group by a chloromercuri group,[4] and melted at 119–120°.

Anal. Calcd. for C_7H_9OClHg: Hg, 58.11. Found: Hg, 58.15.

The formation of these isomeric α-chloromercuri compounds from β-isopropylfuran compounds is additional confirmatory evidence for the 4-isopropyl-2-furfural. This follows from two facts: (1) a β-alkylated furan orients the chloromercuri group to a contiguous α-position; (2) an α-carboxyl group is preferentially and reliably replaced by a chloromercuri group.

Summary

The Friedel-Crafts reaction with 2-furfural and isopropyl chloride gives 4-isopropyl-2-furfural. This anomalous reaction is apparently the first unequivocal evidence of a β-substitution reaction of furan when an α-position is available.

AMES, IOWA RECEIVED MARCH 1, 1935

---

[3] THIS JOURNAL, **55**, 2903 (1933).

[4] *Ibid.*, **55**, 3302 (1933).

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF IOWA STATE COLLEGE]

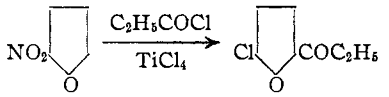
The Friedel–Crafts Reaction with Nitro Compounds

BY HENRY GILMAN, R. R. BURTNER, N. O. CALLOWAY AND J. A. V. TURCK, JR.

Introduction

Nitrobenzene has completely resisted acylation by means of the Friedel–Crafts reaction.[1] Furthermore, nitrobenzene is sometimes used as a medium in the Friedel–Crafts reaction. The alkylations of the negatively substituted ethyl 2-furoate and ethyl 5-bromo-2-furoate, described in the preceding paper, suggested the possibility of effecting a Friedel–Crafts reaction with an aromatic nucleus containing a nitro group. This appeared more reasonable when it was demonstrated that dimethyl 3,4-furandicarboxylate, which is rather resistant to nuclear substitution, could be acetylated by means of acetic anhydride and stannic chloride, a condensing agent used effectively in many Friedel–Crafts transformations.

The nitro compound first selected was 2-nitrofuran because of the greater ease of nuclear substitution reactions evidenced by furans. 2-Nitrofuran and propionyl chloride gave 5-chloro-2-furyl ethyl ketone.



The replacement of the nitro group by chlorine defeated an object of the experiment because there was no decisive way of determining whether such replacement preceded or was coincident with acylation. It was next shown in a corresponding experiment using ethyl 5-nitro-2-furoate in place of 2-nitrofuran that practically all of the nitro ester was recovered unchanged. This was not surprising from the point of view of furan chemistry because of the extreme difficulty of effecting β-substitution when both α-positions are occupied by relatively strong negative groups.

Nitrobenzene was next used. In the expectation that if a Friedel–Crafts reaction did occur it would take place slowly, a mixture of nitrobenzene, isobutyl bromide and aluminum chloride was set aside at room temperature for thirty days. The products isolated were almost equal quantities of *o*-chloroaniline and *p*-chloroaniline. Isopropyl bromide also gave a mixture of *o*-

---

[1] Stockhausen and Gattermann, *Ber.*, **25**, 3521 (1892). The more aromatic *o*-nitroanisole and *o*-nitrophenetole can be acylated.

and *p*-chloroanilines. Apparently, methyl bromide and ethyl bromide are without effect, for only nitrobenzene was recovered. Also, an alkyl halide higher than ethyl halide appears necessary to effect the reduction–chlorination reaction, for nitrobenzene with only aluminum chloride gave no significant quantity of product other than the initial nitrobenzene. Finally, the reaction with isobutyl bromide can be effected in a short period if heat be applied.

Reductions in a Friedel–Crafts reaction are well known. Of particular significance is the study by Freund[2] wherein it was shown that aluminum chloride serves to condense nitrobenzene and benzene, and to reduce the nitro group to an amino group, to give *p*-aminobiphenyl. The second phenyl group undoubtedly was supplied by benzene and not by the original nitrobenzene, for Kliegl and Huber[3] in a corresponding reaction between nitrobenzene and toluene obtained 4-amino-4′-methylbiphenyl, and from *o*-nitrotoluene and toluene there was secured 4-amino-3,4′-dimethylbiphenyl. The reduction reaction appears not to be general, for α-nitronaphthalene did not undergo a reduction–condensation reaction with benzene.[2] It has been suggested[3] that the reduction–condensation reaction may proceed through the intermediate formation of arylhydroxylamines. It is possible that the source of the hydrogen or its equivalent may be different in the two types of reactions: that for the reduction–condensation reaction deriving from the condensation, and that for the reduction–chlorination reaction being associated in some manner with the higher branched alkyl halide.

Experimental Part

Acetylation of Dimethyl 3,4-Furandicarboxylate.—From 9.2 g. (0.05 mole) of dimethyl 3,4-furandicarboxylate (prepared in accordance with the directions of Reichstein and co-workers[4]), 5.1 g. (0.05 mole) of acetic anhydride, 39 g. (0.15 mole) of stannic chloride and 100 cc. of dry, thiophene-free benzene there was obtained 2 g. of dimethyl 2-aceto-3,4-furandicarboxylate melting at 108°.

Anal. Calcd. for $C_{10}H_{10}O_4$: C, 53.07; H, 4.47. Found: C, 52.82 and 52.63; H, 4.20 and 4.15.

No attempts were made to alkylate the dibasic ester.

2-Nitrofuran and Propionyl Chloride.—From 8 g. (0.07 mole) of 2-nitrofuran, 6.5 g. (0.07 mole) of propionyl chloride, 13.3 g. (0.07 mole) of titanium tetrachloride and 100 cc. of carbon disulfide there was obtained 2 g. of 5-chloro-2-furyl ethyl ketone melting at 55° after crystallization from an aqueous ethanol solution.

Anal. Calcd. for $C_7H_7O_2Cl$: Cl, 22.4. Found: Cl 22.9.

The compound prepared in this manner was shown, by the method of mixed melting points, to be identical with the product obtained from 2-chlorofuran,[5] propionic anhydride and stannic chloride in benzene.

From an experiment carried out with methyl 5-nitro-2-furoate under corresponding conditions (with the replacement of a three-hour period of refluxing for a like period at room temperature), 94% of the nitro ester was recovered.

Nitrobenzene, Alkyl Halides and Aluminum Chloride.—Aluminum chloride (133 g. or 1.0 mole) was added to a solution of 68 g. (0.5 mole) of isobutyl bromide in 492 g. (4 moles) of nitrobenzene. Because of the evolution of heat, the mixture was initially cooled by tap water. The reaction mixture, contained in a flask provided with a drying tube with calcium chloride, was set aside for thirty days at room temperature. Subsequent to hydrolysis by cracked ice, the mixture was made acid by the addition of hydrochloric acid and extracted with ether to remove the nitrobenzene. An excess of sodium hydroxide was added to the aqueous solution, which was then extracted with ether. After removing the ether, there was isolated 10 g. of *o*-chloroaniline and 8 g. of *p*-chloroaniline. The chloroanilines were separately identified by quantitative analysis and by mixed melting point determinations with authentic specimens of the acetyl derivatives, picrates and picramides. The experiment was checked. Steam distillation was also used as a means of removing the nitrobenzene.

From an experiment in which the mixture was heated at 65–75° with stirring for six and one-half hours and then allowed to stand for three days at room temperature, there was isolated 11 g. of *o*-chloroaniline and 4.5 g. of *p*-chloroaniline.

In a corresponding experiment using isopropyl bromide, 1.5 g. of a mixture of *o*- and *p*-chloroanilines was obtained. Separation and identification of the chloroanilines was effected, in this case, by diazotization of the mixture and coupling with β-naphthol. The lesser solubility of the *o*-chlorophenylazo-β-naphthol in methanol made it possible to effect a separation from the isomeric *p*-derivative.

Due care was exercised in the experiments with methyl bromide and ethyl bromide to avoid loss of these volatile halides during the extensive period in which reaction was attempted.

Summary

2-Nitrofuran, propionyl chloride and titanium chloride give 5-chloro-2-furyl ethyl ketone.

Nitrobenzene undergoes a reduction–chlorination reaction with isopropyl bromide (or isobutyl bromide) and aluminum chloride to give *o*-chloroaniline and *p*-chloroaniline.

AMES, IOWA RECEIVED MARCH 1, 1935

---

[2] Freund, *Monatsh.*, **17**, 395 (1896).

[3] Kliegl and Huber, *Ber.*, **53**, 1646 (1920). See, also, Königs and Nef, *ibid.*, **19**, 2431 (1886), and Drechsler, *Monatsh.*, **35**, 533 (1914).

[4] Reichstein, *et al.*, *Helv. Chim. Acta.*, **15**, 268 (1932).

[5] Shepard, Winslow and Johnson, THIS JOURNAL, **52**, 2083 (1930).