cipitated. If placed in an Abderhalden dryer at 25° and 23 mm. (or 1 mm.), it continually lost weight and decomposed to a yellow glass-like mass. However, it was kept in a corked bottle for one week under normal conditions without any apparent change. The analysis of this product gave very unsatisfactory results, and the study of its properties will be continued.

Summary

1. In this paper are recorded some experimental results obtained by the further study of Biginelli's 2-keto-4-phenyl-5-carbethoxy-6-methyl-1,2,3,4-tetrahydropyrimidine.

2. The presence of the double bond in the 5,6-positions of the pyrimidine cycle is revealed by the action of bromine giving a characteristic dibromo derivative.

3. 2-Thio-4-phenyl-5-carbethoxy-6-methyl-1,2,3,4-tetrahydropyrimidine has been synthesized according to Hinkel, Hey and Samuel's method. We observed no evidence of the isomerization of this pyrimidine.

4. Alkylation of Biginelli's tetrahydropyrimidine is accomplished by interaction of this pyrimidine with phosphorus oxychloride followed by treatment with an alcoholate. The methyl compound obtained by this technique proved to be isomeric with the methylpyrimidine obtained by condensation of methylurea, benzaldehyde and ethyl acetoacetate. Both compounds are apparently N-methyl derivatives.

NEW HAVEN, CONNECTICUT

RECEIVED FEBRUARY 4, 1933
PUBLISHED JULY 6, 1933

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF IOWA STATE COLLEGE]

The Mechanism of the Wurtz–Fittig Reaction. The Direct Preparation of an Organosodium (Potassium) Compound from an RX Compound

BY HENRY GILMAN AND GEORGE F. WRIGHT

Introduction

Present evidence[1] indicates that the Wurtz–Fittig reaction involves free radicals

$$2RX + 2Na \longrightarrow 2R— + 2NaX \qquad (I)$$
$$2R— \longrightarrow R—R \qquad (II)$$

and the intermediate formation of organo-alkali compounds

$$RX + 2Na \longrightarrow RNa + NaX \qquad (III)$$
$$RNa + RX \longrightarrow R—R + NaX \qquad (IV)$$

Organometallic compounds are definitely formed from RX compounds and metals like lithium, beryllium, magnesium, zinc, etc. Indirect evidence for the intermediate formation of organosodium and organo-po-

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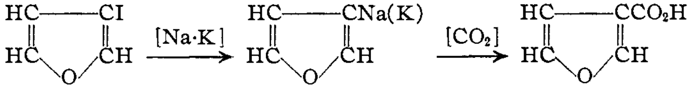
(1) Wooster, "Organo-alkali Compounds," *Chem. Rev.*, **11**, 1 (1932). An excellent recent review of the mechanism of the Wurtz–Fittig reaction is presented on pp. 79–83 and describes studies by Schorigin, Morton, Fuchs, Schlubach, Kirrmann, Goldschmidt, Ziegler, Schlenk, Kraus, Wooster, and Clarke and Bachmann.

tassium compounds has been obtained by treating the reaction mixture of RX compound and alkali metal with a reagent like carbon dioxide to isolate characteristic derivatives (like carboxylic acids) of the organo-alkali compounds. However, there appears to be no reported case of the *preparation* of an organo-alkali compound under the conditions of the Wurtz-Fittig reaction by the action of sodium or potassium or both, as an alloy, with an organic halide. Related reactions have been observed, such as the preparation of triarylmethyl-sodium compounds from the halides with sodium *amalgam* in ether, or sodium in *liquid ammonia*. Actually, sodium metal does not react with triarylmethyl halides in ether.[2]

The present work describes the preparation of an organosodium (potassium) compound from 3-iodofuran and sodium–potassium alloy. *Subsequent* to its preparation the organo-alkali compound was carbonated to give the known 3-furoic acid.



(V)

The preparation of the organo-alkali compound was largely made possible by the extraordinary inertness of the iodine in 3-iodofuran. 3-Iodofuran has not been brought into reaction with lithium or activated magnesium, and it is the only known compound with iodine attached to a doubly bonded carbon atom which has not formed a Grignard reagent. The relative inertness of the iodine is not confined to metals, but appears to be general with reagents that ordinarily undergo reaction with RX compounds. On the basis of the generally observed relative reactivities of halogens in organic halides, it appears probable that a compound like 3-fluorofuran would have a most inert halogen, and would be the type of halide to directly form an organocesium or organorubidium compound providing a nuclear hydrogen were not replaced by metal.[3]

It is possible that other RX compounds like triarylmethyl halides will form organo-alkali compounds with liquid sodium–potassium alloys, and that surface phenomena may be partly responsible for the absence of such compounds with sodium and potassium.

We are of the opinion that although both free radicals and organometallic compounds are involved in the Wurtz–Fittig reaction, the formation of free radicals is paramount in the sense that the organometallic compound derives in part, at least, from the combination of a free radical and the metal.[4,5]

(2) Schlenk and Marcus, *Ber.*, **47**, 1668 (1914) (footnote).

(3) Gilman and Wright, "Nuclear Substitution and Orientation of Furan Types," *Chem. Rev.*, **11**, 323 (1932). See also Karvonen, *Ber.*, **42**, 687 (1909), for the high inertness of iodine in β-iodoethyl ethyl ether.

(4) Gilman and Brown, *Rec. trav. chim.*, **50**, 184 (1931).

(5) Ziegler and Colonius, *Ann.*, **479**, 135 (1930), and Ziegler and Schäfer, *ibid.*, **479**, 50 (1930), have another interpretation.

Attention should also be directed to the idea of "metal halyls" elaborated recently by Morton and Stevens.[6]

$$\mathrm{RBr} + \mathrm{Na} \longrightarrow \underset{\vdots}{\mathrm{R}}\cdots\mathrm{Br}\cdots\underset{\vdots}{\mathrm{Na}} \longrightarrow \mathrm{R}\cdots + \mathrm{NaBr}$$

This provides a free radical which can couple to give R·R or disproportionate or add metal to give an organometallic compound which in turn might undergo subsequent reaction with RX compound.

$$\mathrm{R}\text{—} + \mathrm{Na} \rightleftarrows \mathrm{RNa} \qquad \text{(VI)}$$

What may be supporting evidence for a general reaction like (VI) for the formation of organometallic compounds are some as yet unpublished studies by Professor F. Paneth and H. Loleit on the formation of dimethyl- and diethylberyllium from free radicals and beryllium. Hitherto, the excellent studies by Paneth and co-workers have shown the combination of free radicals with metals like mercury, lead and zinc to give less active organometallic compounds.

Experimental Part

The 3-iodofuran (4.84 g. or 0.025 mole) and 2 cc. of sodium–potassium alloy were sealed under 30 mm. pressure and allowed to stand for two weeks at room temperature. The two liquid phases changed to a gray solid. Using customary precautions for such operations, the contents of the tube were suspended in dry petroleum ether (b. p. 70–80°), chilled below 0°, and carbonated during stirring. The mixture was worked up in the usual manner, the excess alloy being amalgamated by the addition of mercury[7] prior to hydrolysis. The 3-furoic acid melted at 121° and showed no depression in a mixed melting point determination with an authentic specimen. Thirty-five per cent. of the 3-iodofuran was recovered. In addition, an as yet unidentified and quite insoluble solid was isolated. This may contain a polymer of di-3-furyl.

A second experiment was carried out and this also gave 3-furoic acid.

In order to remove the possibility that 3-furoic acid was formed during carbonation, the unused 3-iodofuran was removed by distillation at 10 mm. and the resulting mixture gave 3-furoic acid on carbonation.

When 3-iodofuran was heated with the alloy at 115° for twenty-four hours, and the unchanged iodide (75% of initial halide) removed by distillation at 10 mm., carbonation gave 0.5% of 3-furoic acid (on basis of reacted iodide), or about twice that obtained when the reaction was conducted at room temperature for two weeks. The results of this experiment were also checked.

The authors are grateful to Grover M. Ford for assistance.

Summary

3-Iodofuran reacts with sodium–potassium alloy to give 3-furylsodium (potassium) which was *subsequently* carbonated to give 3-furoic acid. This is apparently the first reported case of the preparation of an organosodium or organopotassium compound from the direct reaction of an RX compound and the metal, and is offered as supporting evidence for

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(6) Morton and Stevens, THIS JOURNAL, **54**, 1919 (1932).

(7) Ziegler and Schnell, *Ann.*, **437**, 241 (1924).

that mechanism of the Wurtz–Fittig reaction which postulates the intermediate formation of organometallic compounds.

AMES, IOWA RECEIVED FEBRUARY 4, 1933
PUBLISHED JULY 6, 1933

[COMMUNICATION FROM THE CHEMICAL LABORATORY OF THE JOHNS HOPKINS UNIVERSITY]

The Grignard Reaction in the Synthesis of Ketones. III. The Preparation and Characterization of a Series of Mono- and Dichlorodesoxybenzoins

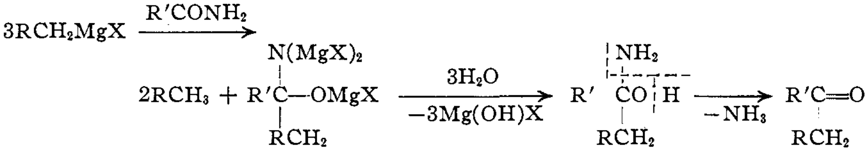
BY SANFORD S. JENKINS

In previous work,[1] which was contained in Article I of this series, the Grignard reaction was applied to the synthesis of a number of desoxybenzoins. The method, which consists in the reaction of primary benzamides with benzylmagnesium halides, was found to be entirely satisfactory when three to four equivalents of the Grignard reagent with one equivalent of the amide were heated for sufficiently long periods of time. In Article II[2] the preparation of a series of eight mono and di ortho and para chlorodesoxy ketones was set forth.

The purpose of the present article is to describe the synthesis of the remaining members (the meta chloro derivatives) of this series (see Table I).

In order to confirm further the assigned structures, the method previously adopted[1,2] was employed in the present work. The compounds were oximated and, under the conditions of the experiments, all of the ketones produced single oximes, which, when rearranged in the Beckmann manner, gave anilides whose structures were established by comparison with anilides of known configuration. The oximes were all of the *anti* benzyl type.

Since the maximum yields of ketones were always obtained when at least three equivalents of the Grignard reagents to one equivalent of the amides were employed it appears that the reaction should be represented as



$$3RCH_2MgX \xrightarrow{R'CONH_2} 2RCH_3 + R'\overset{N(MgX)_2}{\underset{RCH_2}{C}}{-}OMgX \xrightarrow[-3Mg(OH)X]{3H_2O} R'\overset{NH_2}{\underset{RCH_2}{CO}}H \xrightarrow{-NH_3} R'\underset{RCH_2}{C}{=}O$$

Before this explanation of the reaction can be definitely accepted, however, further confirmatory evidence must be obtained. This question is being studied at present and will be discussed in a future report.

The Grignard method of preparing ketones should be of value in work of structure dealing with compounds of the desoxy class and especially in the synthesis of the ortho and meta substituted phenyl types such as

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(1) Jenkins, THIS JOURNAL, **55**, 703 (1933).

(2) Jenkins and Richardson, *ibid.*, **55**, 1618 (1933).