of the chemist in any program of preparedness and defense.

The subject-matter is assembled under the following chapter headings: I. The Soldier, II. Man-made Man-killers, III. Machines of Modern Warfare, IV. Crucibles of Death (warfare with toxic chemcials), and V. The Chemical Industry—America's First Line of Defense.

The book is not written for chemical or military experts, and such may find minor flaws here and there but, in the opinion of the reviewer, it fulfils creditably its mission of presenting the subject to the uninitiate in a form which he can assimilate with ease and satisfaction and which will equip him to follow more intelligently the war news of the day. If he is a military man, it will teach him something about chemistry. If he is a chemist, he will gain some useful elementary knowledge of military equipment and tactics.

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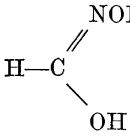
SPECIAL ARTICLES

A NEW CHEMICAL REACTION WITH THE NITROSYL RADICAL NOH[1]

MANY years ago I made the assumption that the nitrosyl radical, NOH, functions as the most important compound as far as the nitrogen in the synthesis of simple naturally occurring, carbon-nitrogen containing material is concerned.[2] It acts as a branching-point, leading to several series of compounds. The most important organic compounds synthesized by sunlight from KNO_2 and methyl alcohol or formaldehyde, which we have analyzed, are formhydroxamic acid,



, and formaldoxime, $CH_2=NOH$.

It was of special biochemical interest and importance to find other reactions involving nitrosyl. It was to be assumed that the strongly paramagnetic radical, NOH, would combine with inserted paramagnetic ethylene groupings which are present in the benzene ring and in many substituted benzene compounds.

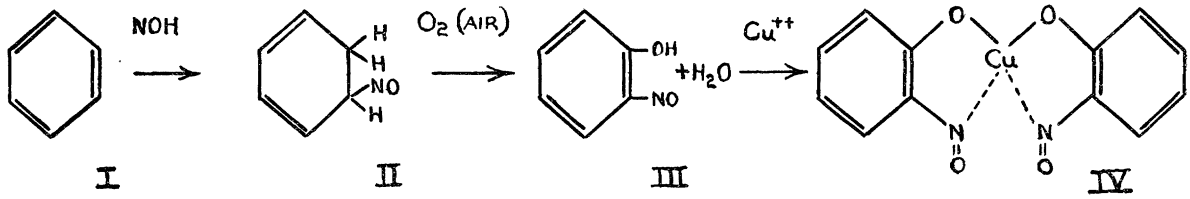
In this publication I will demonstrate that two groups, namely, NO and OH, can be substituted in benzene in a new, amazingly simple way at ordinary temperature. I will further try to elucidate the mechanism of the new chemical reaction with the radical NOH—a chemical process which will have a wide application in chemistry.

Exp. 1

0.5 g freshly prepared yellow cuprous hydroxide, CuOH, is suspended in 200 cc dist. water in which 0.5 g KNO_2 is dissolved (pH 9.9). Purest benzene is added and the solution well stirred. With dilute hydrochloric acid the pH is now adjusted to 2.5 and then 1 cc Merck's superoxol is added. The pale yellowish color changes immediately to pink and becomes deep red after longer stirring. The deep red *o*-nitrosophenol coppersalt (IV) forms *o*-nitrosophenol (III) on acidifying with HCl which can easily be extracted with petrol ether. The petrol ether solution is a beautiful green.

Exp. 2

0.5 g KNO_2 and 1 g cupric nitrate are dissolved in 200 cc dist. water (pH = 5.6). Purest benzene is now added



In my recent experiments with hydroxylamine-hydrochloride, copper ions and benzene,[3] nitrosophenol copper salt (IV) was easily formed by autoxydation of the reaction mixture or still better by adding hydrogen peroxide. This remarkable reaction has since been successfully applied by us to many aromatic hydrocarbons and to a great number of substituted benzene compounds, of which more will be said in another journal.

to the pale green solution and the whole mixture well stirred. On adding 1 cc Merck's superoxol the color remains green but becomes only a little darker. Now 0.5 g iso-ascorbic acid (or vitamin C) is added. The color immediately changes to pink and becomes deep red on further stirring (pH = 3.4), thus forming again *o*-nitrosophenol coppersalt (IV).

Exp. 3

0.5 g freshly prepared cuprous hydroxide is suspended in 200 cc dist. water in which 0.5 g benzene-sulfohydroxamic acid was dissolved (pH = 4.4). Purest benzene is added and the whole mixture well stirred. The pH is now adjusted to 2.9 by adding dilute hydrochloric acid. The solution quickly turns pink by autoxydation. By

[1] Part of the lecture presented at the A.A.A.S. symposium at Gibson Island, Maryland, July 22–26, 1940.

[2] Collected literature of the subject: Oskar Baudisch u. Lars A. Welo; *Chem. Rev.*, Vol. 15, no. 1, 1934.

[3] *Naturwissenschaften*, 27: 768–9, 1939; *Chem. Abstracts*, 34: 1976, 1940.

adding 1 cc Merck's superoxol a deep red color immediately appears. After one hour stirring, the red solution is acidified with dil. HCl and extracted with petrol ether. The now deep green petrol ether contains pure *o*-nitrosophenol. The aqueous layer remains deep red. It contains coppersalt of *o*-nitrosophenol sulfinic acid (see exp. 4).

Exp. 4 (without benzene)

0.5 g cuprous hydroxide is suspended in 200 cc dist. water in which 0.5 g benzene sulfo-hydroxamic acid was dissolved (pH = 4.4). The pH is now adjusted to 2.9. After putting 1 cc Merck's superoxol in the well-agitated solution, the brownish liquid turns deep red with a violet tint. After one hour, the liquid is acidified with HCl and shaken with petrol ether. Nothing goes into the petrol ether and it remains colorless. With ether, however, the *o*-nitrosophenol sulfinic acid can be extracted. The yellowish green ether solution gives characteristic colors with many metals, just like the free *o*-nitrosophenol. Deep red copper, green ferrous, greyish brown cobalt, red nickel and red mercury salts are formed.

From the four experiments described, one can notice that the radical, nitrosyl, has been formed in three different ways—(1) oxidation of $NH_2OH \cdot HCl$ with cupric ions, forming cuprous ions; (2) reduction of HNO_2 with cuprous ions; (3) NOH released from benzenesulfo-hydroxamic acid by adding copper ions plus H_2O_2.

In experiment 3, the NOH is partly captured by the benzene present in the reaction mixture and, therefore, *o*-nitrosophenol copper besides red *o*-nitrosophenol sulfinic acid copper is formed. On acidifying, the *o*-nitrosophenol goes easily into petrol ether while the free *o*-nitrosophenol sulfinic acid is only soluble in ether or ethylacetate.

In experiment 4, the NO and OH substitute hydrogen atoms in the benzene ring of the formed sulfinic acid (the exact position of the chelate NO–OH grouping will be later determined).

Without going into detail here as to the mechanism of the reaction, I assume that primarily both NOH and benzene (toluene, ethylbenzene, xylene, etc.) are coordinately linked to the cuprous ion and thus activated by rearrangement of the the electronic system. The whole reaction occurs, so to say, in the inner sphere of the Werner copper complex, which might be a cuprous or a cuprous-cupric complex. However, only the cuprous central atom of the complex seems to be able to link benzene coordinately. On oxidation to the cupric form it is again released. The reaction between the activated benzene and nitrosyl could be written schematically in the following way:

Compound II is autoxidizable and forms Compound III. The cuprous-cupric complex is stable only in a small range of pH (2.1–4), and in this pH range the best results are obtained. Addition of small amounts of acetone or acetonylacetone to the reaction mixture prevents the formation of *o*-nitrosophenol from benzene entirely. By using the new reaction, we have already synthesized about sixty new *o*-nitrosophenol compounds, all of which show the characteristic of the chelate grouping, ortho NO–OH, towards metals. At the same time many interesting properties are developed by the different substitutes in the benzene ring in different (*o.m.p.*) positions of which we will have more to say in another paper.

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THE FUNCTIONS OF DIPHOSPHOTHIAMINE (PHOSPHORYLATED VITAMIN B_1)

IN 1937, Lohmann and Schuster[1] identified *cocarboxylase* as diphosphothiamine. This important discovery, coupled with the work of Peters and his collaborators[2] on the necessity of vitamin B_1 for oxidation of pyruvate by the brain of avitaminotic pigeons, brought one more vitamin within the group of enzyme components. Soon after Lohmann's discovery, Lipmann[3] demonstrated that diphosphothiamine is one of the components of α-ketonoxidase, and Barron and Lyman[4] found that diphosphothiamine acted in animal tissues and bacteria as a catalyst not only for the decarboxylation and oxidation of pyruvate, but also for its dismutation.

The mechanism of this catalysis is still unexplained. It does not seem to be a reversible oxidation-reduction system, as riboflavine and nicotinic acid derivatives were shown to be, although such a theory was suggested by Lipmann.[5] In fact, a comparative study of the rates of reduction and reoxidation of thiamine and diphosphothiamine has shown that the vitamin becomes with phosphorylation more resistant to the action of reducing and oxidizing agents (Barron and Lyman[6]). Nor does it seem to act according to Langenbeck's theory,[7] for Stern and Melnick[8] have presented evidence against a "Langenbeck cycle" involving the amino groups in the pyrimidine ring. The multiple catalytic functions of diphosphothiamine suggest the possibility that it acts by forming the integral part of the activating protein of the enzyme systems concerned with the activation of pyruvate. Once the pyruvate is activated, it may react with catalysts for its oxidation, reduction, dismutation or condensation. This hypothesis need not postulate reversible oxida-

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