STRUCTURE OF COMPOUNDS FORMED FROM THIOPHENE AND
2-METHYLTHIOPHENE UNDER THE CONDITIONS OF CHLOROMETHYLATION
IN PRESENCE OF ZINC CHLORIDE

Ya. L. Goldfarb and Ya. L. Danyushevsky

According to Blicke and Burckhalter [1], in the chloromethylation of thiophene with 40% formaldehyde and hydrochloric acid, not only 2-(chloromethyl) thiophene, but also 2,2'-methylenedithiophene (MDT) (1) is formed. The latter compound is obtained, though here as the main reaction product, also by reaction of thiophene with trioxane in presence of hydrofluoric acid [2]. In the reaction mixture obtained under these conditions a small amount of a compound of composition C_{14}H_{12}S_{2} can be isolated, and this is assigned [7] the structure of 2,5-di-2-thienylthiophene (DTT) (ID). 2,2'-Methylenedithiophene is obtained in higher yield by the condensation of 2-(chloromethyl) thiophene with 2-thienyllithium [3].

2,2'-Methylenedithiophene and 2,5-di-2-thienylthiophene are of interest as starting materials for the preparation of aliphatic compounds having a long carbon chain [4]. A simple method for the synthesis of MDT is described in the present paper; it is based on observations of Lock, who used zinc chloride as a condensing agent in the chloromethylation of benzene [5]. In presence of zinc chloride and hydrochloric acid, thiophene reacts with 35-37% formaldehyde solution at from −7° to 0° with formation of MDT in 50-55% yield. That the compound formed under these conditions is indeed 2,2'-methylenedithiophene (ID) is shown by the fact that, when formylated with N-methylformanilide in presence of phosphoryl chloride, it gives 5-(2-thienyl)-2-thiophenecarboxaldehyde, which can be converted into n-decyl alcohol by the action of Raney nickel. It is further confirmed by the fact that a mixture of the compound with the MDT obtained (see experimental part) by reduction of di-2-thienyl ketone [6] by a modified Kharasch method [7] melts without depression.

Apart from MDT, in our experiments we obtained a mixture of high-boiling products from which, as in the work with hydrofluoric acid (see above), we isolated a compound of composition C_{14}H_{12}S_{2}, m.p. 37.5-38.5°. From the way in which it was formed it was possible to assign the compound the structure (ID), but not as the only one permissible, as it was impossible to exclude the possibility of isomerization, associated with migration of the thienyl radical from the \( \alpha \)- to the \( \beta \)-position. Moreover, it must be remembered that in MDT (ID) which is probably an intermediate product in the formation of the substance of m.p. 37.5-38.5°, the \( \beta \)-position is activated by the thienyl radical attached to the \( \alpha \)-carbon atom of the ring. All this applies equally to the compound described as DTT (ID) by Cairns, McKusick, and Weinmayr [2], who assumed this structure without giving any data in its support.

As the most probable structure for the substance of m.p. 37.5-38.5° is \( \Pi \) (DTT), we decided to prepare it as follows, for comparison:
The ketone (III) is obtained in very low yield (10-12%). Attempts to improve the yield by the use of various condensing agents, change in the medium and the amount of stannic chloride, variations in the order of mixing the reactants, and alteration of temperature were not successful. Experiments on the acylation of MDT with 2-thiophencarboxylic acid in presence of phosphoric oxide were also unsuccessful; under these conditions the anhydride of the thiophencarboxylic acid was obtained instead of the expected ketone.

Of the two possible structures of the ketone, (III) and (IV), the second is not very probable, since, according to Hartough and Kosak [6], in the acylation of 2-alkylthiophenes, substitution of the acyl group in the 3-position does not occur to an appreciable extent. Reduction of the ketone (III) gave DTT (II), m.p. 37.5-38°, undepressed by admixture of the above-mentioned substance of composition C_{14}H_{12}S_{2}, isolated together with MDT in the chloromethylation of thiophene in presence of zinc chloride. The two dibromo derivatives, obtained from the reduction product of the ketone (III) and from the substance of m.p. 37.5-38.5°, were also found to be identical. These dibromo derivatives probably have the structure 2,5-bis(5-bromo-2-thienyl) thiophene.

It may, therefore, be considered as established that, under our chosen conditions of chloromethylation, the process proceeds mainly in the direction of the formation of 2- and 2,5-substituted thiophenes of structures (I) and (II). On hydrogenolysis in presence of Raney nickel, the DTT that we isolated from the mixture gave the hydrocarbon C_{34}H_{50}, which was identical in properties to n-tetradecane.

Under the above-described conditions, 2-methylthiophene gave a 60-66% yield of a compound of composition C_{14}H_{12}S_{2}, m.p. 38.5-39.5°, together with a high-boiling mixture of products that we did not investigate more closely. In this case also—owing to the presence of an activating group (methyl) in the original alkylthiophene and owing to other causes (see above)—the formation of structures other than (VI) must be admitted as a possibility. However, after synthesizing 2,2'-methylenebis[5-methylthiophene](VI) according to the scheme:

we convinced ourselves that this is identical with the compound of m.p. 38.5-39.5° mentioned above. Hence, under the given chloromethylation conditions, 2-methylthiophene reacts like thiophene, i.e., mainly in the free α-position. As we have stated, (II) and (VI) can be obtained by Kizhner reduction of the corresponding ketones. The yields of reduction products are quite satisfactory (50-65%). In view of these results, it became clear to us that the statement of the Swedish investigators Lofgren and Tegner [3] to the effect that di-2-thienyl ketone cannot be reduced by the Kizhner method is in error. Actually, in the reduction of this ketone, as also in the reduction of the ketones (III) and (V), we observed no departure from the usual course of reaction and obtained MDT in 65% yield.