Synthesis of 2-Hexyl-1-C^{13}-Thiophene

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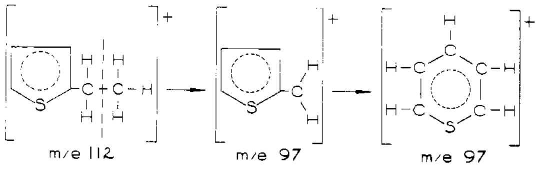
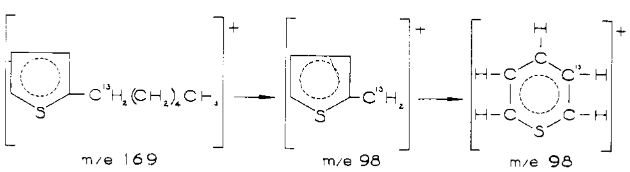
A SERIES of 2-alkyl- and 2,5-dialkylthiophenes, some which had not heretofore been synthesized, were prepared in this laboratory for use as reference standards in the possible identification of such type structures in petroleum. Pure samples of 2-ethyl- and 2-propylthiophene submitted have led to the identification of these substituted thiophenes in some samples of petroleum.

Mass spectral analysis of the monoalkylthiophenes indicated a 97 base peak regardless of the side chain length, suggesting that the bond between the alpha and beta carbon atoms was first broken. A similar rupture had been proven to occur when monoalkylbenzenes were subjected to mas spectrometry. Rylander, Meyerson, and Grubb (*6*) proposed the formation of the tropylium ion to account for the rupture of this bond and established the mechanism of breakdown using deuterated compounds. Foster (*1*) and other spectroscopists have postulated an intermediate ion similar to the tropylium ion; namely, a thiacyclohexatrienium ion, to account for the data obtained in the mass spectral analysis of alkylthiophenes. Kinney and Cook (*4*) have suggested further that in the case of the alkylthiophenes the alpha bonds to the ring carbons are strengthened by the presence of the aromatic electrons, while the beta bonds are thus weakened and hence should readily break. The breakdown and possible rearrangement of the 2-ethylthiophene are illustrated below.

In the case of 2,5-dialkylthiophenes the beta bond of the longest alkyl group fragments to form the base peak. For example, the base peak of 2-ethyl-5-propyl- and 2-ethyl-5-butylthiophene is 125.



The purpose of synthesizing a carbon-13 labeled alkylthiophene was to secure evidence of alpha, beta bond scission. A molecule having the alpha carbon to the ring enriched in carbon-13 was assumed to shed some light on the formation of the thiacyclohexatrienum ion which apparently gives rise to the 97 base peak. Consequently, a synthesis of 2-hexyl-1-C^{13}-thiophene was devised. Its mass spectral analysis gave rise to the anticipated 98 base peak (see structure below). Preliminary results seem to show that the C^{13} enters away from the S—C bond; that is, only C—C bonds are broken in the rearrangement. Apparently the C—C bond in the thiophene structure ruptures more readily than the C—S bond. Proof of this point can be ascertained from deuterated alkylthiophenes which are now being prepared.



The C^{13} enriched hexanoic acid was obtained from New England Nuclear Corp. and was used in the synthesis of a labeled acid chloride, ketone, and alkylthiophene. With the exception of the acid chloride, the mass spectral analysis of these labeled compounds is shown in Table I.

Table I. Mass Spectral Analysis of Some Labeled Compounds

Compound	Mass Ionization Voltage	Mole %	
		C^{12a}	C^{13}
Hexanoic-1-C^{13} acid	70.0	39.4	60.6
	13.0	39.5	60.5
	15.0	39.6	60.4
2-(Hexanoyl-1-C^{13})thiophene	70.0	40.6	59.4
	13.0	40.4	59.6
	15.0	40.3	59.7
2-(Hexyl-1-C^{13})thiophene	70.0	40.2	59.8
	13.0	39.6	60.4
	15.0	39.9	60.1

[a] Corrected for naturally occuring carbon-13 enrichment present at random in all other positions. Correction is 1.18% per carbon atom and 11.8% for these compounds.

EXPERIMENTAL

2-(Hexanoyl-1-C^{13}) chloride. Hexanoic acid (*5*), (7 grams, 0.06 mole) was placed in a 50-ml. three-necked round-bottomed flask, fitted with a condenser, mechanical stirrer, and dropping funnel. Thionyl chloride (9.6 grams, 0.08 mole) was added dropwise over a 1½-hour period. The reaction was stirred and heated at 80° to 85° C. for 3 more hours. Distillation of the reaction mixture gave 6.98 grams of product collected at 65° to 67° C. at 38 mm. pressure. This corresponded to an 87% yield.

2-(Hexanoyl-1-C^{13}) thiophene. Thiophene (*2*), (5.2 grams, 0.062 mole), hexanoyl-1-C^{13} chloride (6.98 grams, 0.052 mole), and 40 ml. of dry benzene were placed in a 100 ml. three-necked round-bottomed flask fitted with a mechanical stirrer, dropping funnel, and reflux condenser. The system was protected from atmospheric moisture by addition of drying tubes to the condenser and dropping funnel. Anhydrous stannic chloride (13.3 grams, 0.05 mole) was added dropwise over a 3-hour period, the temperature being kept at −5° to −10° C. The reaction mixture was stirred for an additional hour at room temperature, then hydrolyzed by slow addition of ice and dilute hydrochloric acid. The organic layer was separated from the aqueous layer which was then twice extracted with 40-ml. portions of ether. The organic layer and ether extracts were dried with magnesium sulfate. After filtration and removal of the solvent, vacuum distillation of the residue yielded 6.2 grams of the labeled ketone. The fraction boiling at 101° C./2 mm. pressure was collected. The yield realized was 65%.

2-Hexyl-1-C^{13}-thiophene. 2-Hexanoyl-1-C^{13}-thiophene (*3*) (6.2 grams, 0.034 mole), 9.6 ml. of hydrazine hydrate, and 20 ml. of diethylene glycol were placed in a 100 ml. three-necked, round-bottomed flask fitted with a mechanical stirrer, and condenser set up for distillation. During a

3-hour heating period 6.5 ml. of water was collected. The reaction mixture was then cooled and 6 grams of KOH pellets were added. The condenser was changed to a reflux position and the reaction mixture refluxed for 4 hours. On cooling, the mixture was diluted with 20 ml. of water. After separating the organic layer, the aqueous layer was twice extracted with 40-ml. portions of ether. The combined organic layer and extracts were washed with 5% HCl solution until the washings were acidic. After drying the organic material with magnesium sulfate, distillation yielded 4.2 grams of product boiling at 61 to 62° C./1.5 mm. pressure. This corresponded to a 75% conversion.

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