# CONTRIBUTION TO THE SYNTHESIS OF PERMETHRIN

## *New approach to 1,1-dichloro-4-methyl-1,3-pentadiene, novel 1,3- and 1,5-chlorine migrations*

L. TŐKE, I. BITTER, Z. BENDE, and É. KÁRPÁTI

Department of Organic Chemical Technology,
Technical University, H-1521 Budapest

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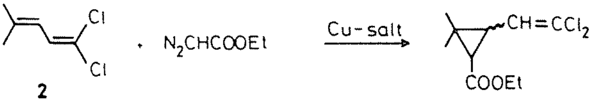
## Abstract

Several routes for the industrial synthesis of 1,1-dichloro-4-methyl-1,3-pentadiene as the key intermediate of permethrin insecticide have been developed. During the chlorination of 1,1,1-trichloro-4-methyl-pentene-3-ol new 1,3- and 1,5-rearrangements involving chlorine were observed. Radical species in the processes were detected by ESR spectroscopy and mechanisms of the rearrangements were rationalized.

## Introduction

Pyrethroids exhibit high degree of activity as insecticides while showing low mammalian toxicity. The most potent representatives belong to the derivatives of 2,2-dimethyl-3-(2,2-dihalovinyl)-cyclopropanecarboxylates which have greater photostability than the natural pyrethroids [1]. Since the discovery of permethrin (1-phenoxybenzyl-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate) great efforts have been made for developing a commercially feasible synthesis of the acid component of permethrin [2]. A simple approach was described by Farkas et al. starting from 1,1-dichloro-4-methyl-1,3-pentadiene (*2*) which was cyclopropanated by ethyl diazoacetate [3] (Scheme 1).



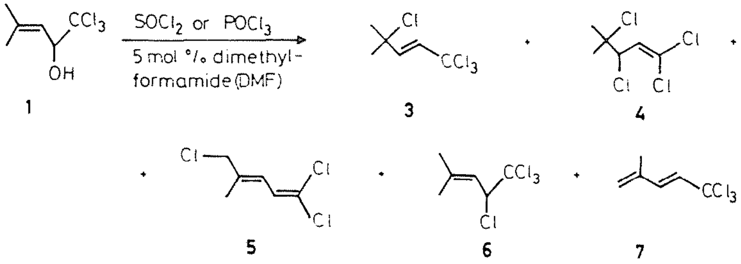
*Scheme 1*

The success of this procedure depends on the economic large scale production of *2*. From complex technological considerations we have chosen 1,1,1-trichloro-2-hydroxy-4-methyl-pentene-3 (*1*) as starting material since it is easily accessible by the reaction of inexpensive row-materials as chloral and isobutylene.

## Result and discussion

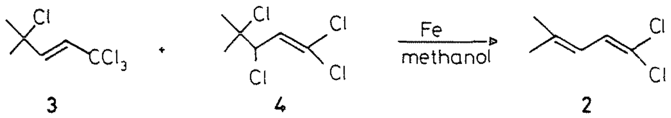
### I. Chlorination of 1,1,1-trichloro-2-hydroxy-4-methyl-pentene-3 (1)

In an attempt to replace the OH group by chlorine compound *1* was treated with inorganic acid chlorides ($SOCl_2$, $PCl_3$, $POCl_3$) resulting in formation of a mixture of polychloro compounds (Scheme 2) [4].



*Scheme 2*

The structure of the above compounds were unambiguously proved by GC-MS experiments [5] and *NMR* spectroscopic method. Compounds *3*, *4* and *5* were the major components while *6* and *7* were detected in a few percentage in the mixture. The product ratio was found to be very sensitive to the reaction conditions, mainly to the nature of the acid chloride. Using thionylchloride in ethylenechloride solvent at 80 °C, $(3+4):5=80:20$ ratio was achieved with a total yield of 93%. We succeeded in transforming this mixture to the title compound (*2*) by reductive dechlorination with iron powder in protic media. Thus compounds *3* and *4* were quantitatively converted to *2* while *5* remained unchanged. The yield reached 60% pure 1,3-diene (*2*) without 1,4-diene contamination [4] (Scheme 3).



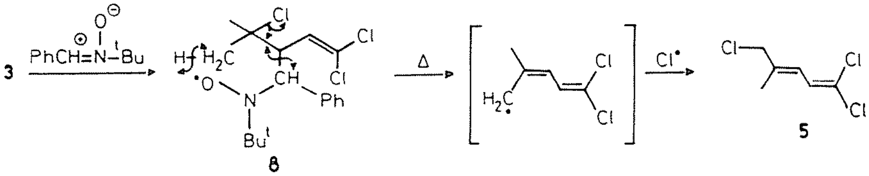
*Scheme 3*

### II. Investigation of 1,3- and 1,5-chlorine migration [6]

In order to give a reasonable explanation for the mechanism of the formation of compounds *3*, *4*, *5*, *6* and *7* during the chlorination of *1*, we investigated the mutual transformations of the individual products. Experiments were carried out in NMR and ESR tubes and the changes were monitored by the appropriate spectroscopic method.

## *1,3—Rearrangement of compound 3 to 4*

After 6h heating at 130—140 °C, compound *3* rearranged completely to *4*. This is an irreversible allylic rearrangement a few example of which is described in the literature without mechanistic details. We established that this process (*3* to *4*) takes place in radical way, by carrying out the transformation in *ESR* tube in the presence of N-t-butyl-α-phenylnitrone spin trap [7]. In the spectra at temperature range 90—140 °C intense lines were appearing with coupling constants $a_N = 14.65$ G and $a_H = 2.48$ G showing the formation of a spin adduct of possible structure *8* (Scheme 4).



*Scheme 4*

## *1,5—Rearrangement of compound 7 to 5*

The complete conversion of *7* to *5* takes place in about 8h at 70—75 °C but it proceeds at ambient temperature, too. From mechanistic point of view it was a very important observation that during the transformation not only the signals of the endproduct *5* could be seen but also those of an intermediate for which structure *9* was assigned by $^1$H NMR data (Fig. 1).

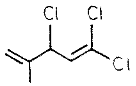


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*Fig. 1*

Transformation of *7* to *9* and to *5* is considered to be parallel processes giving new example for the kinetic and thermodynamic control. At the beginning of the reaction the ratio of compounds *9* to *5* is controlled by kinetic parameters, the rate constant for 1,3-chlorine shift leading to *9* was comparable to that of the 1,5-chlorine shift affording *5* but, being the process of the formation of *9* reversible, its proportion was continuously decreased transforming itself to the thermodynamically more stable *5*. Radical character of these processes could be proved again in the presence of spin trap nitrone.

The coupling constants in the ESR spectra indicated the formation of spin adduct with possible structure *10* (Fig. 2).

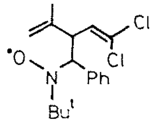

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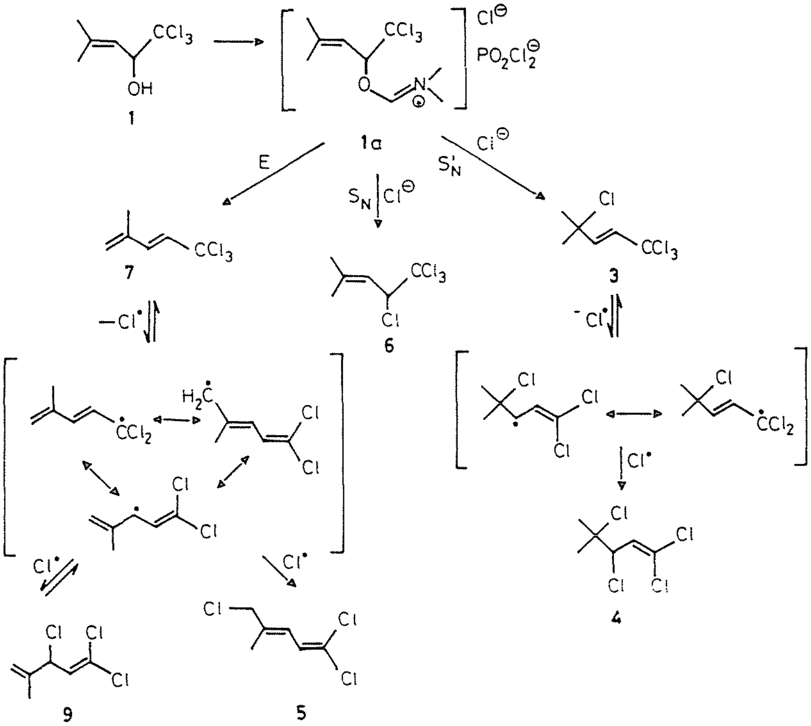
*Fig. 2*

To summarize all these observations we propose the mechanism shown in Scheme 5 for the reaction of *1* with inorganic acid chlorids.



*Scheme 5*

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Prof. Dr. László TŐKE
Dr. István BITTER
Zoltán BENDE
Dr. Éva KÁRPÁTI
H-1521 Budapest