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INTRAMOLECULAR CYCLIZATION OF UNSATURATED ACYL CHLORIDES BY TRIBUTYLTIN HYDRIDE

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Tributyltin hydride reduction of acyl chlorides to the corresponding aldehydes has been proposed to proceed by a free radical chain mechanism involving an intermediary acyl radical[1-4]. Also, it has been observed that an alkenyl radical possessing a double or triple bond in position 5 or 6, generated by tributyltin hydride reduction of the corresponding unsaturated halides[5-7], or by some other reactions[8], undergoes intramolecular cyclization affording five- and/or six-membered hydrocarbon rings.

We wish to report reductive intramolecular homolytic cyclization of the unsaturated acyl chlorides, having a double bond in the position 5 or 6, by means of tributyltin hydride. These reactions afforded as the main reaction products the corresponding cyclohexanone derivatives. We found that reduction of 5-hexenoyl chloride (1) gave cyclohexanone itself in 36% yield (eq. 1), while menthone was isolated in the reduction of citronelloyl chloride (2) in 43% yield (eq. 2)[9].

(1)

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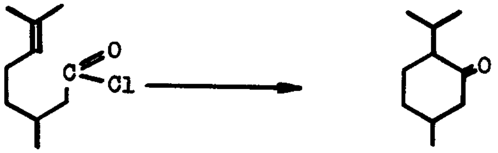


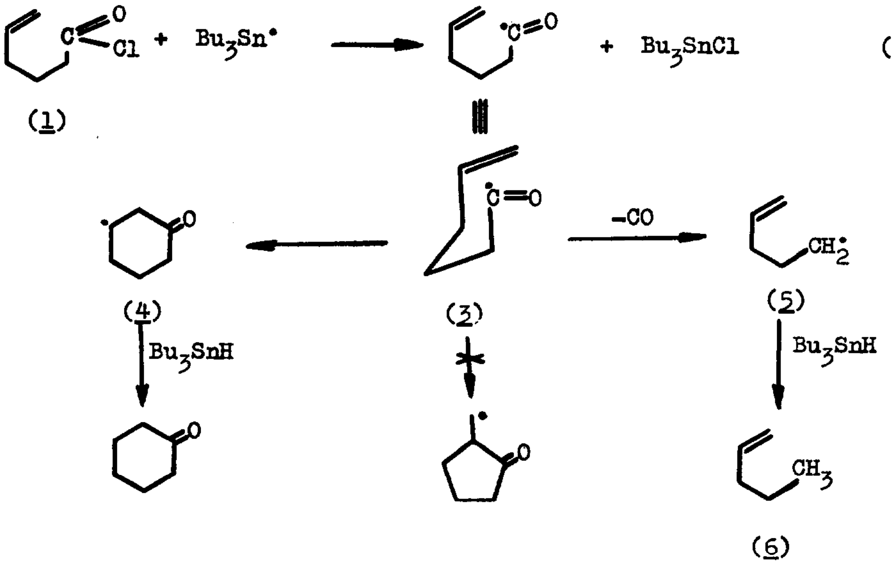
(2)

(2)

The reaction products were isolated from the reaction mixtures by GLC and identified by IR, NMR and mass spectra and as 2,4-dinitrophenylhydrazones.

Initiation step of this free radical cyclization involves generation of tributyltin radical, arising by hydrogen abstraction from tributyltin hydride by a free radical initiator (AIBN)(eq. 3)[1,5,9]. In the propagation step tin radical abstracts a chlorine atom from the acyl chloride (1), affording acyl radical (3) (eq. 4)[1-3]. Possessing an olefinic bond in the position 5 or 6, acyl radical (3) preferably undergoes to the intramolecular addition onto suitably situated double bond giving alicyclic radical (4)[10,11]. The reaction further proceeds with hydrogen abstraction from tributyltin hydride by the alicyclic radical (4) with the formation of the cyclic ketone and another organotin radical. Decarbonylation of the acyl radical (3), as the competing reaction to the intramolecular acyl radical addition, takes place to a considerable extent, affording alkenyl radical (5) which is stabilized by hydrogen abstraction from tin hydride giving unsaturated hydrocarbon (6)[1,3,12]. In the reduction of the citronelloyl chloride, 2,6-dimethyl-2-heptene has been isolated as the decarbonylation product, in 27% yield.

$$Bu_3SnH \quad + \quad In^{\bullet} \longrightarrow Bu_3Sn^{\bullet} \quad + \quad InH \qquad (3)$$



(4)

Other possible competing reactions of acyl radical (3), as described by Kuivila[1,2], are the hydrogen abstraction from tributyltin hydride leading to the corresponding aldehyde, and its addition onto the C=O bond forming an ester[1-4]. However, in the reduction of the unsaturated acyl chlorides, these two competing reactions take place only at very low extent.

Although there are two possibilities for the intramolecular addition of 5-hexenoyl acyl radical (3) which should lead to either cyclopentanone or cyclohexanone rings, while citronelloyl acyl radical (having an olefinic double bond in the position 6) should give six- and/or seven-membered cyclic ketones, in both cases no other products than the more stable cyclohexanones are formed. Obviously, intramolecular addition of acyl radical proceeds in such a way to generate the more stable six-membered cyclic radical (4), i.e. cyclization of acyl radical (3) producing six-membered cyclic ketone is a process under thermodynamic control.

Other possibilities of intramolecular addition of acyl radicals are under investigation.

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