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ELECTROPHILIC ADDITION REACTIONS IN TERPENOID SYNTHESIS. IV.[1] C_4-OXYGENATED TERPENES BY WITTIG REARRANGEMENT OF ALLYLPENTADIENYL ETHERS

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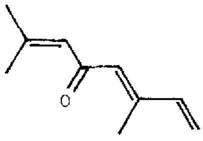
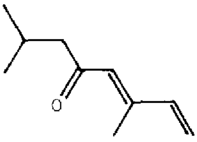
Benzylallyl and bisallyl ethers readily undergo Wittig rearrangements on treatment with base.[3] We have shown that benzyl and allyl ethers may be synthesized by electrophilic addition of benzylchloromethyl and allylchloromethyl ethers to suitable olefins.[1] In continuation of our studies on the synthesis of terpenoids from readily available starting materials,[4] we herewith report the construction of a C_4-oxygenated acyclic terpenoid[5] of type (1) by electrophilic addition of chloromethylmethallyl ether (5) to isoprene, followed by a Wittig rearrangement of the dehydrochlorinated condensation product. Due to the ease of polymerisation of chloromethylmethally ether (5), in the presence of Lewis acids, introductory experiments were carried out with allylchloromethyl ether (3).

The (E)- and (Z)-allylic chlorides (4),[6] obtained by $SnCl_4$-catalysed addition of allylchloromethyl ether (3) to isoprene, on dehydrochlorination gave a mixture of ethers (9) (τ_A 3.58; 10%), (10) (τ_A 3.26; 53%), and (11) (37%).[7] Treatment of the (Z)-ether (10) [containing 7% of ether (9)] with n-BuLi in THF (2 h at -90°) gave a mixture of products which were isolated severally by liquid chromatography[8] and were identified as hydrocarbon (18) (τ_A 3.73; 29%),[9] the (E)-alcohol (19) (τ_A 3.63; 27%), the alcohol (20) (33%), as well as unchanged (Z)-ether (10). On heating (benzene solution; 150°; 1h) the alcohol (20) rearranged[10] quantitatively to a mixture of the (E)- and (Z)-aldehydes (21) and (22) respectively (ratio 4:1). By employing KNH_2 as base, the formation of the hydrocarbon was avoided with a resultant increased yield in (E)-alcohol (19) (68%). Exposure to sunlight (15 h) of an ethereal solution of the (E)/(Z)-mixture of ethers (9) and (10) (ratio 1:9) containing iodine (1% by wt. of ethers) led to predominant formation of the (E)-isomer [(E)/(Z)-ratio 7:3]. Rearrangement by base of the latter mixture similarly gave (E)-alcohol (19) with no trace (< 1%) of the corresponding (Z)-alcohol. The Wittig rearrangement[11] of the (Z)-ether (10) is therefore accompanied by a (Z)- to (E)-stereomutation, which probably takes place during the radical dissociation recombination steps.[12] The formation of both alcohols (19) and (20) in the ^{n}BuLi induced rearrangement of ether (10), indicates the intermediacy of both ions (23) and (24). The origin of e.g. aldehyde (21) could also be explained by a 1,4-shift of the alkadienyl group in ion (24).[3,13] Under the experimental conditions, this possibility may be ruled out, since the aldehydes only formed on heating of the sigmatropic rearrangement product (20).

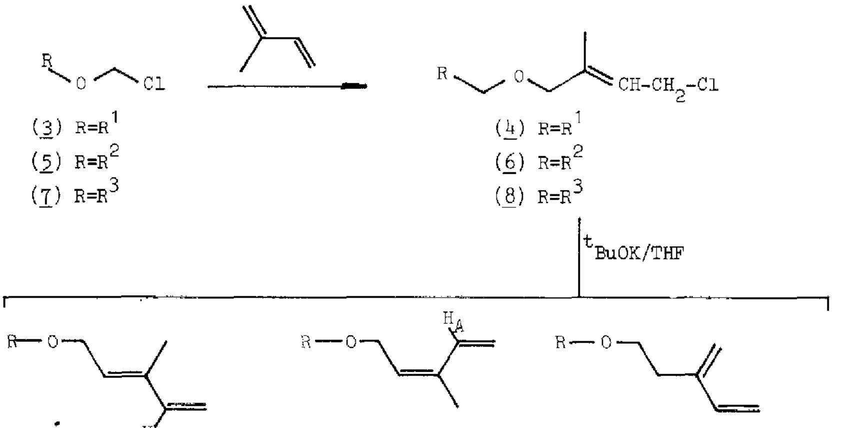


(1)



(2)

$R^1 = -CH_2-CH=CH_2$
$R^2 = -CH_2-C(CH_3)=CH_2$
$R^3 = {}^{i}Bu$



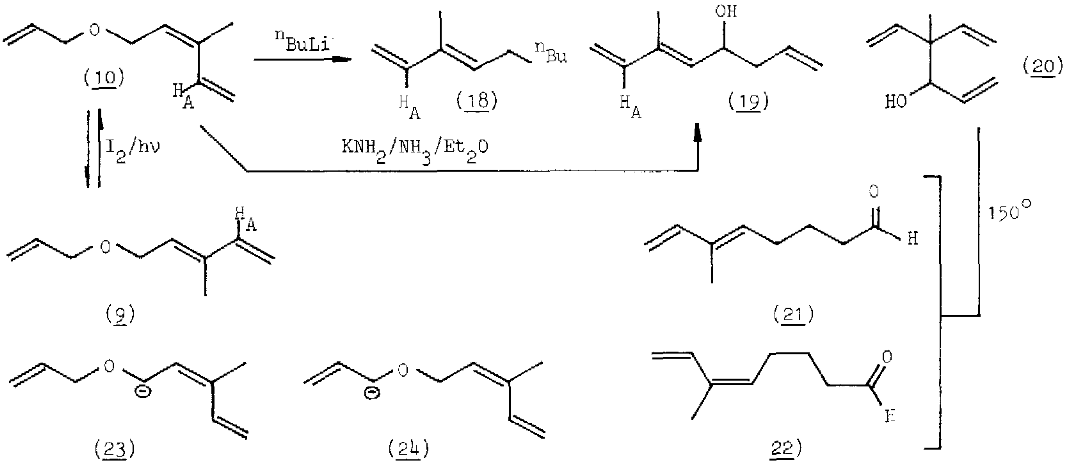
(3) R=R^1
(5) R=R^2
(7) R=R^3

(4) R=R^1
(6) R=R^2
(8) R=R^3

(9) R=R^1
(12) R=R^2
(15) R=R^3

(10) R=R^1
(13) R=R^2
(16) R=R^3

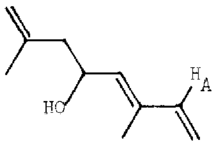
(11) R=R^1
(14) R=R^2
(17) R=R^3



(10) (18) (19) (20)

(9) (21)

(23) (24) 22)



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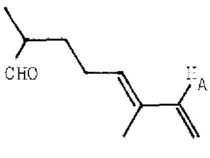

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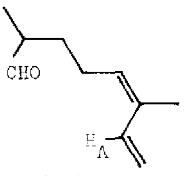

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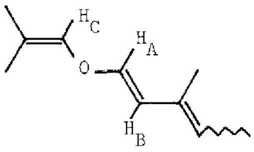
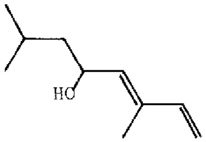


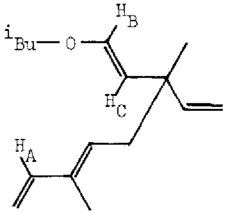
(28)

Similarly the corresponding (E)- and (Z)-ethers (12) and (13) were rearranged to the (E)-alcohol (25) and the aldehydes (26) and (27). Concentrates of ether (13) [containing (E)-ether (12) (18%)] on treatment with n-BuLi (THF, -90°) gave, after distillation and isolation by preparative glc, the diene (18) (42%), the (E)-alcohol (25) (τ_A 3.60; 36%), and the (E)-aldehyde (26) (τ_A 3.63; 14%; only traces of the (Z)-isomer (27) was observed). By effecting the rearrangement of ether (13) [containing 12% of ether (12)] with KNH_2/NH_3, the alcohol (25) (50%), the aldehyde (26) (13%) and the bis-vinylether (28) [τ_A 3.53; τ_B 4.25, J_{AB} 12.5 Hz; τ_C 3.99 (m)] were obtained.14) Separation of the individual components was effected by preparative glc at elevated temperature (7.63 m x 6 mm, 20% SP 1000 on Chromosorb WAW-DMCS, 60-80 mesh; temp. 100 ⟶ 135° @ 0.5°/min., N_2 80 ml/min.) and consequently aldehyde (26), with traces of aldehyde (27) (τ_A 3.26) was isolated directly.

In conclusion it should be mentioned that the attempted synthesis of tagetol (29), a reduction product of tagetone (2),8) by rearrangement of ethers (15) and (16) failed. Treatment of the (Z)-ether (16) with n-BuLi (THF; -75°) generated the required anion, which did not rearrange but attacked unchanged ether (16) to give the formal displacement product (30) (27%; τ_A 3.70; τ_B 3.92; τ_C 5.36, J_{BC} 13.0 Hz) as well as the diene (18) (57%), resulting from decomposition of ether (16) by the n-BuLi. With t-BuOK in DMSO, the (E)-vinyl ether (31) (τ_A 3.66; τ_B 4.59, J_{AB} 12.5 Hz) was obtained.14)



(29)



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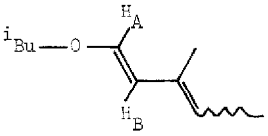

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6. Apart from compounds (5) and (6), all new compounds gave satisfactory combustion analyses. The spectral properties of all compounds are in accord with the assigned structures. Ethers (9) - (17) were isolated severally by preparative glc. Concentrates of these ethers were prepared by fractional distillation.
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