131. *Addition of αβ-Unsaturated Alcohols to the Active Methylene Group. Part I. The Action of Ethyl Acetoacetate on Linalool and Geraniol.*

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Geraniol and linalool react with ethyl acetoacetate in the presence of a catalyst to produce the same compound—geranylacetone. This ketone was shown to be identical with that prepared by a known method.

The work to be described had its origin in an attempt to acetylate certain alcohols, use being made of the reversible nature of the acetoacetic ester condensation :

$$CH_3{\cdot}CO{\cdot}CH_2{\cdot}CO_2Et + ROH \rightleftharpoons CH_3{\cdot}CO_2R + CH_3{\cdot}CO_2Et \quad . \ . \ . \quad (1)$$

It was thought that by using a small quantity of an alkaline catalyst it might be possible to distil off the low-boiling ethyl acetate, thus forcing the equilibrium to the right. However, simple alcoholysis occurs,

$$CH_3{\cdot}CO{\cdot}CH_2{\cdot}CO_2Et + ROH \longrightarrow EtOH + CH_3{\cdot}CO{\cdot}CH_2{\cdot}CO_2R \quad . \ . \quad (2)$$

and only small amounts of ethyl acetate and acetone are formed. At a higher temperature, the high-boiling acetoacetic ester decomposes with formation of carbon dioxide and the ester $CH_3{\cdot}CO_2R$ of equation (1). With equimolecular quantities, a mixture of the alcohol ROH and the ester $CH_3{\cdot}CO_2R$ is obtained, containing about 50% of the ester. The proportion of ester can be increased by using an excess of ethyl acetoacetate.

This reaction, applied to linalool, appeared to follow the usual course, except that a lower temperature was required. The product resembled the expected geranyl acetate, but proved to be geranylacetone.

The course of the reaction—which bears a formal resemblance to the Michael condensation—appears to be determined by the presence of the allylic double bond. When this work was begun (1931) it was thought that geraniol would give a similar ketone :

$$CRMe(OH){\cdot}CH{:}CH_2 \longrightarrow CRMe{:}CH{\cdot}CH_2{\cdot}CH_2{\cdot}CO{\cdot}CH_3 \quad (I.)$$

$$CRMe{:}CH{\cdot}CH_2{\cdot}OH \longrightarrow CRMe(CH{:}CH_2){\cdot}CH_2{\cdot}CO{\cdot}CH_3 \quad (II.)$$

where $R = CMe_2{:}CH{\cdot}CH_2{\cdot}CH_2$.

No trace of (II) could be found in the product from geraniol and only (I) was obtained in small yield together with a large amount of geranyl acetate.

Linalool gave no linalyl or geranyl acetate but only the ketone and a small quantity of the acetate of an alcohol not identified. Geraniol also reacts according to equation (2), giving the acetoacetate, but linalool does not. Pyrolysis of the ester thus formed gives the acetate and the ketone. With linalool the addition and the decomposition appear to be simultaneous. Proof of this was obtained by maintaining the reactants at a constant temperature and determining the amount of carbon dioxide and ketone formed and the amount of decomposition of the ester.

The ketone from linalool was obtained pure by systematic fractionation. The ketone from geraniol, being present in small amount, gave more trouble and was eventually purified by regeneration from the semicarbazone. Both compounds were identified by the melting points of mixtures of their semicarbazones and that of the product prepared from geranyl chloride and ethyl acetoacetate (Foster and Cardwell, J., **1913**, **103**, 1338).

The yields from linalool and geraniol were 55% and 19% respectively, allowing for the recovered alcohol, and the product from the former was more thoroughly investigated. It was of uniform composition and its behaviour with semicarbazide showed that there was a sufficient amount of a related ketone present to depress the setting point of the semicarbazone markedly. On the other hand, the ketone from geraniol readily gave the pure semicarbazone in good yield. In order to test the uniformity of the ketone from linalool the product was thoroughly fractionated, but the boiling points of the fractions did not differ by more than 2°/2 mm. and other constants showed no significant variation. The setting points of the semicarbazones differed slightly, but from all the fractions the semicarbazone of (I) was the only product isolated. This suggests the absence of (II), since this compound should differ sufficiently from (I) in boiling point to enable a separation to be effected by fractional distillation.

The presence of an isomeric ketone may be explained on other grounds: (1) The linalool used may be a mixture of two forms differing in the position of the end double bonds; (2) change in the position of the double bonds during the reaction; (3) formation of *cis*- and *trans*-isomers.

In view of these complications it was decided to investigate the reaction further, simpler compounds being used. This work will be reported in a later paper.

EXPERIMENTAL.

Materials.—Geraniol, from citronella oil, after purification by the calcium chloride method and fractional distillation, had $d_{4°}^{20°}$ 0·8765, $n_{D}^{20°}$ 1·4755, and absorbed 3·86 atoms of bromine per mol.

Linalool, from Bois de Rose oil, was fractionated, and the middle fractions bulked; $d_{4°}^{25°}$ 0·8652, $n_{D}^{20°}$ 1·4630, bromine absorption per mol. 3·78 atoms.

Geranyl chloride was prepared by Foster and Cardwell's method (*loc. cit.*) and by Tiemann's original method (*Ber.*, 1898, **31**, 832), both products giving the same derivatives. Geraniol (174 g.) was saturated with dry hydrogen chloride at 0° until the ester value showed 90% as chloride. The washed and distilled product gave a main fraction (92 g.), b. p. 79—80°/2·5 mm., $d_{4°}^{20°}$ 0·914, $n_{D}^{20°}$ 1·4765 (Found: Cl, 19·3. Calc.: Cl, 20·6%). On saponification with aqueous alkali both chlorides gave linalool and geraniol in approximately the same ratio, 1 : 3.

Geranylacetone.—A mixture of geranyl chloride (0·24 mol.), ethyl acetoacetate (0·31 mol.), potassium carbonate (0·29 mol.), and acetone (100 c.c.) was refluxed for 6 hours, water added, the solvent distilled off, and the oily layer boiled and stirred with dilute sodium hydroxide solution. The resulting oil gave on distillation 23 g. of a main fraction, b. p. 99—101°/4 mm., $n_{D}^{20°}$ 1·4683, 5 g. of which gave 6 g. of a semicarbazone, m. p. 95—96° after one crystallisation from *cyclo*hexane.

Linalool and Ethyl Acetoacetate.—The apparatus consisted of distillation flask, column and condenser, a separating funnel with side-arm acting as receiver. The distillate was run out through the tap and the gases were led off at the top and absorbed in N-sodium hydroxide in a 3-necked stirring flask with a mercury seal. A second flask was connected to ensure complete absorption.

Table I shows the course of the reaction; the quantities used were: linalool 0·8 mol., ester 0·82 mol., and 3 c.c. of 10% sodium ethoxide solution.

TABLE I.

Time, hours	3	5	7·5	9
Temp.	140°	170°	190°	210°
Total distillate, c.c.	17	30	45	57
Total CO_2, mol.	0·11	0·30	0·52	0·69

The total distillate (45·6 g.) contained 0·129 mol. of acetone and 0·825 mol. of alcohol.

The residue in the flask was washed and distilled, and the fractions checked by refractive index and oxime value, giving actual ketone as geranylacetone (Table II).

TABLE II.

Fraction.	Temp.	Press, mm.	Wt., g.	$n_{D}^{20°}$.	Ketone, g.	Fraction.	Temp.	Press, mm.	Wt., g.	$n_{D}^{20°}$.	Ketone, g.
1	62°	1·5	9	1·4720	0	6	89°	1·5	15·5	1·4732	10·7
2	64	,,	9	1·4671	0	7	95	2·0	25	1·4678	23·7
3	67	,,	19·5	1·4648	1·6	8	97	,,	16	1·4683	14·0
4	80	,,	9	1·4760	5·5	9	105	,,	2	1·4723	1·5
5	85	,,	12	1·4779	6·7	10	145	3·0	4	—	0

The yield of ketone (63·7 g.; 0·33 mol.) is 41% of the theoretical, calculated on the linalool.

The fractions from several runs were collected according to ketone content and refractionated, giving: hydrocarbon (probably pinene), a trace; linalool, 30 g. (0·2 mol.); unknown ester (not quite free from ketone), 12 g.; geranylacetone, 45 g. (0·23 mol.). The above quantities refer to the average per run. No geraniol was found in any of the fractions.

The ester, b. p. 237—240° and 84—86°/1 mm., $n_D^{20^\circ}$ 1·4879, on saponification gave an alcohol, b. p. 82—85°/1·5 mm., $n_D^{20^\circ}$ 1·4747.

The constants for the ketone were : b. p. 244—246°/755 mm. and 101—102°/3 mm., $n_D^{20^\circ}$ 1·4671, $d_{4^\circ}^{20^\circ}$ 0·8685. Ketone (by oxime), 97·2% as geranylacetone (Found : C, 80·1; H, 11·0. Calc. : C, 80·4; H, 11·3%). The oxime, $n_D^{20^\circ}$ 1·4894, $d_{4^\circ}^{20^\circ}$ 0·9062, and the 2 : 4-dinitrophenylhydrazone were liquids. The semicarbazone (5·6 g.), m. p. 47°, from 5 g. of the ketone, after five crystallisations, gave 1·6 g., m. p. 96—97° alone or mixed with geranylacetonesemicarbazone.

Attempted separation of isomers. The ketone was fractionally distilled. Six equal fractions were collected, differing by not more than 2°/2 mm. in b. p. and 0·0005 in refractive index over the whole range. Fractions 1 and 6 gave semicarbazones, 5·2 g., m. p. 40°, and 5·6 g., m. p. 55°, respectively. The latter was obtained pure after four crystallisations, but the m. p. of the former could not be raised above 90—94°.

The following experiment was carried out to ascertain if the addition was preceded by alcoholysis and formation of the acetoacetic ester : Linalool and ethyl acetoacetate (0·15 mol. of each) were maintained at 157° for 2·5 hours. The carbon dioxide evolved was absorbed in baryta (Found, 0·027 mol.). Distillation of the residue gave no high-boiling material, showing the absence of the acetoacetate of linalool or geraniol. The amount of ketone formed (0·021 mol.) corresponds approximately to that formed in the larger runs.

Geraniol and Ethyl Acetoacetate.—Geraniol (0·57 mol.), ethyl acetoacetate (1 mol.), and sodium ethoxide (10% solution in alcohol, 3 c.c.) were heated to 200° during 2 hours; 60 c.c. of distillate were obtained, but no carbon dioxide was evolved. Further heating for 3 hours at 200° gave 13 c.c. of distillate and 0·72 mol. of carbon dioxide. The total distillate had $d_{4^\circ}^{20^\circ}$ 0·795 and contained 0·19 mol. of acetone and 1·02 mols. of alcohol. The residue was distilled :

Fraction.	Temp.	Press., mm.	Wt., g.	$n_D^{20^\circ}$.	Ketone, g.	Fraction.	Temp.	Press., mm.	Wt., g.	$n_D^{20^\circ}$.	Ketone, g.
1	80°	1·5	4	1·4782	0	5	85°	1·5	15	1·4755	5·4
2	80	,,	11	1·4744	0·7	6	110	,,	5	1·4778	2·0
3	81	,,	10	1·4753	1·3	7	125	,,	3	1·4858	—
4	82	,,	20	1·4761	4·4	8	145	2·0	5	1·5010	—

Residue, 38 g. of sticky resin.

The yield of ketone (13·8 g.; 0·07 mol.) was 12% of the theoretical, calculated on the geraniol. Fractions 3—6 were bulked and found to contain 25% of geranylacetone, 49% of geranyl acetate, and 23% of geraniol. After hydrolysis and distillation they gave 31 g. of geraniol and 15 g. of a fraction containing 35% of ketone. On repeated treatment with calcium chloride the latter gave 10 g. containing 45% of ketone. 5 G. of crude semicarbazone were obtained, which on treatment with hydrochloric acid gave 1·5 g. of an oil, $n_D^{20^\circ}$ 1·4678. The semicarbazone after two crystallisations had m. p. 96—97°, and mixed m. p. with geranylacetonesemicarbazone 95—97°.

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