7. R. A. Benkeser, J. A. Laugal, and A. Rappa, Tetrahedron Lett., 25, No. 20, 2089 (1984).
8. V. V. Bazyl'chik, T. I. Overchuk, and P. I. Fedorov, Method of Obtaining 1-Methoxycyclohexa-1,4-diene and Its Methyl Derivatives [in Russian], USSR Patent Application No. 4738223/04 (August 4, 1989).
9. R. A. Benkeser, M. L. Burrous, and J. J. Hazdra, J. Org. Chem., 86, No. 4, 1094 (1963).
10. G. Hilgetag and A. Martini, Weygand-Hilgetag's Preparative Organic Chemistry, Wylie, New York (1972).
11. F. Bohlmann, R. Zeisberg, and E. Klein, Org. Magn. Reson., 7, No. 9, 426 (1975).
12. C. Metge and J. Bertrand, Bull. Soc. Chim. Fr., No. 1-2, Pt. 2, 12 (1982).

MODIFIED OXIDATION OF (+)-3-CARENE BY POTASSIUM PERMANGANATE

G. A. Tolstikov, F. Z. Galin, V. K. Ignatyuk,
Yu. A. Kashina, and L. M. Zelenova

UDC 547.313+542.943

The oxidation of (+)-3-carene under the conditions of phase-transfer catalysis has been studied. It has been shown that when the reaction is performed in acetic acid the keto acids (IIa) and (IIIa) and (−)-3α-hydroxycaran-4-one (IV) are formed.

The synthesis of optically active pyrethroids from (+)-3-carene, which is a readily available product of wood chemistry is fairly urgent. In the development of our investigations in this direction we have studied the oxidative cleavage of (+)-3-carene under the action of $KMnO_4$ using phase-transfer catalysis.

It has been shown previously that the oxidation of (+)-3-carene by the action of $KMnO_4$ forms mainly neutral products [1], while the yield of caronic and homocaronic acids is insignificant [2, 3], while on the oxidation of (+)-3-carene with $KMnO_4$ in H_2O—AcOH keto acids are formed [4]. In recent years, definite advances have been achieved in the use of phase-transfer catalysis (PTC) for the oxidation of unsaturated compounds by $KMnO_4$ [5]. It appeared desirable to investigate the oxidation of (+)-3-carene by $KMnO_4$ under PTC conditions with the aim of obtaining the acids (II) and (III).

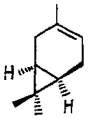
(+)-3-Carene was oxidized with $KMnO_4$ at room temperature under PTC conditions. In the benzene/Bu_4NBr, benzene/DB18C6, acetone/DB18C6, and water/DB18C6 systems the yield of acids was 8%, and of these caronic and homocaronic acids amounted to not more than 2%. The composition of the neutral fraction was practically the same as in the results published previously [1].

The oxidation of (+)-3-carene in the $KMnO_4$/AcOH/H_2O/Bu_4NBr system gave us 31% of neutral products and 50% of an acid fraction, the GLC analysis of which after esterification with CH_2N_2 showed the presence of 22.8% of the keto ester (IIb) and 23.3% of the keto ester (IIIb). When the Bu_4NBr was replaced by TEBAC, the yield of neutral products amounted to 48% and that of acid products to 38%. The amount of the keto ester (IIb) after the esterification of the acid fraction with CH_2N_2 was 3%, and that of the keto ester (IIIb) 36.6%. The oxidation of (+)-3-carene with $KMnO_4$/AcOH/H_2O gave 38.5% of neutral products of 35% of a mixture of acids the GLC analysis of which after esterification with CH_2N_2 showed the presence of 20.5% of the keto ester (IIb) and 60% of the keto ester (IIIb).

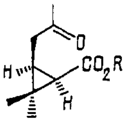
Thus, the use of phase-transfer catalysis substantially increases the yield of the acids (II) and (III) (see top of following page).

The products of neutral character also consisted of a mixture of substances in which the amount of the main substance (IV) was 76.5% on oxidation in the presence of Bu_4NBr, 40%

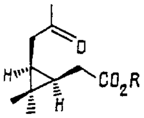
Institute of Organic Chemistry, Urals Branch, Russian Academy of Sciences, Ufa. Translated from Khimiya Prirodnykh Soedinenii, Nos. 3,4, pp. 338-340, May-August, 1992. Original article submitted October 14, 1991.



I

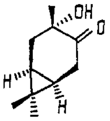


IIa,b



IIIa,b

a (R=H), b(R=CH_3)



IV

on oxidation in the presence of TEBAC, and 58.5% on oxidation without catalysts. By chromatography on silica gel, (−)-3α-hydroxycaran-4-one (IV) was isolated from the neutral products; its IR spectrum contained characteristic absorption bands at 1140, 1720, and 3200-3550 cm^{-1} of the stretching vibrations of C=O and OH groups. Singlet signals in the ^{13}C NMR spectrum at 72.65 and 214.76 ppm of the carbon atoms of C—OH and C=O groups, respectively, and also a singlet in the strong field (1.17 ppm) of the ^1H PMR spectrum of methyl protons (CH_3C-3) and the signals of methylene protons, assigned in the light of the spin-spin coupling constants, confirmed the structure as (−)-3α-hydroxycaran-4-one (IV). The oxidation of the ketone (IV) with $KMnO_4/AcOH/H_2O$ gave 65% of a mixture of acids containing 33% of the keto acid (IIa) and 32% of the keto acid (IIIa).

EXPERIMENTAL

The IR spectra of the substances were recorded on a UR-20 instrument (film). ^1H and ^{13}C NMR spectra were obtained on a Bruker AM-300 spectrometer (300 MHz) in the δ scale (ppm) with $CDCl_3$ as solvent and TMS as standard. Mass spectra were measured on an MKh-1320 instrument at an ionizing voltage of 70 eV. Specific rotations were measured in $CHCl_3$ on a Perkin—Elmer model 141 instrument. GLC analyses were performed on a Shimadzu GC-9A instrument (capillary, quartz, 0.2 mm × 25 m, PEG-20M, 100-180°C, 12 deg/min). Preparative liquid chromatography was conducted on columns filled with silica gel 40/100 μm (Czechoslovakia). Silufol plates were used for TLC.

Oxidation of (+)-3-carene. A flask fitted with an efficient mechanical stirrer, thermometer, and dropping funnel was charged with 31.6 g of $KMnO_4$, 180 ml of AcOH, 180 ml of water, and 2 g of Bu_4NBr. The contents of the flask were vigorously stirred and, with cooling (ice + water) 5.44 g of (+)-3-carene ($[\alpha]_D^{20}$ +16°) was added dropwise with the temperature in the flask being maintained at 22°C. Stirring was continued for another 1 h, and then 300 ml of water was added and the resulting precipitate was separated off on an ultracentrifuge of the MPW-300 type at 3700 rpm.

The precipitate was washed with acetone and was then treated twice with hot water. The acetone was driven off and, after alkalinization, the neutral fraction was extracted from the combined aqueous solution and then, after acidification to pH 3, the acids were extracted with ether and were then esterified with CH_2N_2. The neutral fraction and the esterified acid fraction were chromatographed on silica gel 40/100 μm in hexane—ether with a gradient increase in the amount of ether as eluent. Compounds (IIb) and (IIIb) were isolated from the acid fraction, and compound (IV) from the neutral fraction of the oxidation products.

Methyl (1R)-cis-(−)-2,2-Dimethyl-3-(2-oxopropyl)cyclopropanecarboxylate (IIb). R_f [ether—hexane (3:2)] 0.6, M^+ 184, $[\alpha]_D^{22}$ −32° (c 1.0) (lit. $[\alpha]_D^{25}$ −31° [5]). PMR spectrum 1.16 (s, 3H, CH_3), 1.22 (s, 3H, CH_3), 1.43 (ddd, 1H, H-3, $J_{3,1}$ = 8.5 Hz, $J_{3,4\alpha}$ = 7.0 Hz, $J_{3,4\beta}$ = 6.6 Hz), 1.58 (d, 1H, H-1, $J_{1,3}$ = 8.6 Hz), 2.15 (s, 3H, CH_3CO), 2.83 (dd, 1H, H-4β, $J_{4\beta 3}$ = 6.6 Hz, $J_{\beta,\alpha}$ = 16.4 Hz), 2.95 (dd, 1H, H-4α, $J_{4\alpha,3}$ = 7.44 Hz, $J_{\alpha,\beta}$ = 16.4 Hz), 3.62 (s, 3H, $COOCH_3$).

IR spectrum, cm^{-1}: 1130, 1700-1730, 1240 (C=O, $COOCH_3$), Mass spectrum, m/z: 184 (M^+), 169 $(M-CH_3)^+$, 166 $(M-H_2O)^+$, 153 $(M-CH_3O)^+$, 152 $(M-CH_3OH)^+$, 127 $(M-CH_2COCH_3)^+$, 114, 109, 99, 95, 59 $(CO_2CH_3)^+$, 73, 67, 55, 43 ($COCH_3$), 41. $C_{10}H_{16}O_3$. Calculated M 184.23.

Methyl (1R)-cis-(−)-2,2-Dimethyl-3-(2-oxopropyl)cyclopropylacetate (IIIb). R_f 0.3, M^+ 198, $[\alpha]_D^{20}$ −18° (c 1.0) (lit. $[\alpha]_D^{20}$ − 20.2° (c 16.6) [7]). PMR spectrum: 0.92 (s, 3H, CH_3), 0.93-1.07 (m, 2H, H-1, H-3), 1.12 (s, 3H, CH_3); 2.17 (s, 3H, CH_3CO), 2.25 (dd, 2H, CH_2CO_2, $J_{\alpha,\beta}$ = 11.5 Hz, $J_{\alpha,1}$ = 7.0 Hz, $J_{\beta,1}$ = 7.4 Hz), 2.37 (dd, 2H, CH_2Ac, J = 6.4 Hz, three lines), 3.67 (s, 3H, $COOCH_3$). Mass spectrum, m/z: 198 (M^+), maximum ion 43 $(COCH_3)^+$, $C_{11}H_{18}O_3$. Calculated M 198.25.

(−)-3α-Hydroxycaran-4-one (IV). $[\alpha]_D^{20}$ −107° (c 1.0) (lit. $[\alpha]_D$ −148.2° [8]). PMR spectrum: 0.89 (s, 3H, CH_3), 1.03 (s, 3H, CH_3), 1.17 (s, 3H, CH_3 C-3), 1.16-1.4 (m, 2H, H-1, H-6), 1.56 (dd, 1H, H-5α, $J_{\alpha,\beta}$ = 15.8 Hz, $J_{a,b}$ = 5.7 Hz), 2.22 (dd, 1H, H-2α, $J_{\alpha,\beta}$ = 17 Hz, $J_{\alpha,1}$ = 2.6 Hz), 2.35 (dd, 1H, H-5β, $J_{\beta,\alpha}$ = 15.8 Hz, $J_{\beta,1}$ = 9.1 Hz), 2.87 (dd, 1H, H-2β, $J_{\beta,\alpha}$ = 17 Hz, $J_{\beta,1}$ = 9.0 Hz). IR spectrum, cm^{-1}: 1140 (C—O), 1720 (C═O), 3200-3550 br. s (OH).

^{13}C spectrum: 34.07 (t, CH_2-5), 35.32 (t, CH_2-2), 72.65 (s, C-3), 214.76 (s, C═O). Mass spectrum, m/z: 168 (M^+), 151 $(M{-}OH)^+$, 150 $(M{-}H_2O)^+$, 141.140 $(M{-}CO)^+$, 139.126 $(M{-}COCH_2)^+$, $(M{-}C_3H_6)^+$, 125 $(M{-}COCH_3)^+$, 123, 111, 109, 107, 82, 67, 59, 55, maximum ion: 43 $(COCH_3)^3$, $C_{10}H_{16}O_2$. Calculated M 168.23.

Oxidation of (−)-3α-Hydroxycaran-4-one (IV). With vigorous stirring and maintenance of the temperature at 20°C, 0.14 g of 3-hydroxycaran-4-one was added to a solution of 0.63 g of $KMnO_4$, 4.5 ml of AcOH, and 4.5 ml of H_2O, and then stirring was continued for 1 h and the reaction mixture was worked up as described above. This gave 0.09 g (65%) of an acid which was esterified with an ethereal solution of CH_2N_2.

LITERATURE CITED

1. W. D. F. Burns, M. S. Carson, W. Cocker, and P. V. Shannon, J. Chem. Soc. C., 24, 3073-3084 (1968).
2. J. K. Simonsen and M. G. Ran, J. Chem. Soc., 117, 570-578 (1920); J. Chem. Soc., 121, 2292-2299 (1922).
3. J. L. Simonsen and M. G. Ran, J. Chem. Soc., 123, 549-560 (1923).
4. Indian Patent No. 154,394 (1984). Chem. Abstr., 104, 207,483 (1986).
5. A. J. Fatiadi, Synthesis, No. 2, 93-96 (1987).
6. K. Mandal, D. P. Borude, R. Armugasamy, N. R. Soni, D. C. Jawalkar, S. W. Mahajan, K. R. Ratnam, and A. D. Goghare, Tetrahedron, 42, 5715-5728 (1986).
7. R. Sobti and S. Dev., Tetrahedron, 30, 2927-2929 (1974).
8. H. Schmidt, P. Richter, and M. Mühlstadt, Chem. Ber., 96, 2636 (1963).