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Convenient Syntheses of Some Analogs of the Sex Pheromone of Citrus Mealybug, Planococcus citri (Risso)

Liu Fu-Chu [a] , Li Wan-Xun [b] , Wang You-Chu [c] & Lin Jun [a]

[a] Department of Chemistry , Yunnan University , Kunming, 650091, P. R. China

[b] Yunnan Institute of Tobacco Industry , Xiaocaiyuan, Kunming, 650223, P. R. China

[c] Department of Chemistry , Kunming Teachers College , Kunming, 650031, P. R. China

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CONVENIENT SYNTHESES OF SOME ANALOGS OF THE SEX PHEROMONE OF CITRUS MEALYBUG, PLANOCOCCUS CITRI (RISSO)

Liu Fu-Chu[a]*, Li Wan-Xun[b], Wang You-Chu[c] and Lin Jun[a]

[a]Department of Chemistry, Yunnan University, Kunming, 650091, P. R. China
[b]Yunnan Institute of Tobacco Industry, Xiaocaiyuan, Kunming, 650223, P. R. China
[c]Department of Chemistry, Kunming Teachers College, Kunming, 650031, P. R. China

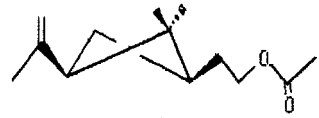
ABSTRACT A series of structural analogs(4a-h) of(+)-cis-(1R)-3-isopropenyl-2,2-dimethylcyclobutanemethanol acetate, the sex pheromone of citrus mealybug, Planococcus citri (Risso), was synthesized from(+) -α-pinene(I) via intermediate ,(+)-cis-(1R)-2,2- dimethyl-3- acetylcyclobutaneethanol(2).

The citrus mealybug, Planococcus citri (Risso), is a cosmopolitan pest, its sex pheromone was separated and identified as (+)-cis-(1R)-3-isopropenyl-2,2-dimethylcyclobutanemethanol acetate(I)[1]. For the synthesis of the *pheromone(I), a variety* of synthetic methods was reported[2-6]. Recently Dunkelblun et al.[7] found that the bio-activity of (+)-cis-(1R)-3-isopropenyl-2,2-dimethylcyclobutaneethanol acetate (4a), the structural analog of the pheromone (I),

* To whom correspondence should be addressed

was comparable to that of the pheromone(I), the analog (4a), however, was synthesized from (+)–cis–pinonaldehyde and no data was given.

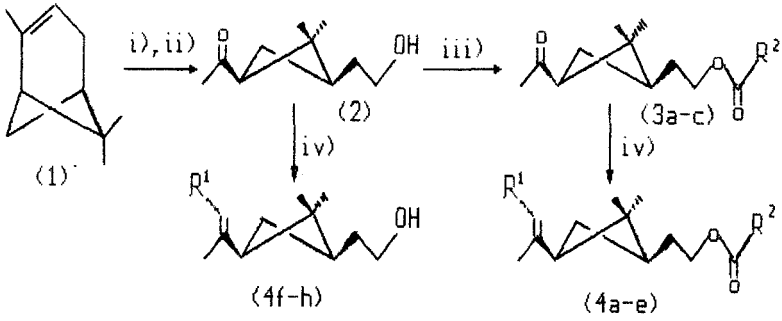
(I)



(4a)

In this paper, we presented a convenient method for the synthesis of the structural analog(4a) and some other analogs(4b–h) of the sex pheromone(I) from (+)–α–pinene via ozonization, incomplete sodium borohydride reduction, acylation and Wittig reaction as depicted in scheme.

Scheme



i) O_3 / isopropanol, 7 hr, iii) $R^2COOCOCH_3$(R^2COCl), 20 hr,

ii) $NaBH_4$ / NaOH–H_2O, 12 hr, iv) R^1Ph_3PBr(I) / NaH–DMSO, 7 hr.

	3a	3b	3c	4a	4b	4c	4d	4e	4f	4g	4h
R^1	–	–	–	Me	Pr	Et	Me	Et	Me	Et	Pr
R^2	Me	H	Et	Me	Me	H	Et	Et	–	–	–

For the synthesis of (2), Gora and co–workers[8] reported the method of the electroreductive ozonolysis of α–pinene(1) , however this method has some disadvantages. Consequently, (2) was usually obtained by the selective reduction of (+)–cis–pinonaldehyde[9–11]. we found that the ozonide of α–pinene(1) can directly be reduced to (2) by sodium borohydride through controlling the mole ration of α

–*pinene(1)to* $NaBH_4$with a satisfactory yield. On the configuration of (2), there was no discussion in lit[8]. However, reportedly the reductive ozonolysis of (+)–α–pinene gave 1R and cis configurational products.[6]

Experimental

All melting and boiling points were uncorrected. IR spectra were recorded on a Shimadzu 450S infrared spectrophotometer. ^{1}HNMR spectra were measured with FX–90 spectrometer(90MHz) using TMS as an internal standard and $CDCl_3$as a solvent. Mass spectra were made on a GC MS–QP1000 spectrometer. α–pinene ($[\alpha]_D^{20}$:+38 °) was redistilled before use. column chromatography silica gel 200–300mesh(Tsing Dao Oceanography Chemical Factory, China).

(+)–cis–(1R)–2,2–dimethyl–3–acetylcyclobutaneethanol(2):

A stream of 3.0% (v / v) ozonized oxygen was bubbled through a solution of α–pinene(1)(19g,140mmol) in isopropanol(150ml) at –2℃ until an aliquot test portion no longer decolorized a dilute solution of bromine in glacial acetic acid,the ozonide solution was then transferred to a flask with a magnetic stirrer, subsequently the aqueous solution of sodium borohydride(3. 2 g, 84mmol) and sodium hydroxide was added dropwise to the stirred ozonide mixture under ice–salt bath cooling, the reaction mixture was then stirred at room temperature for at least 10 hr, the isopropanol was removed by distillation under reduced pressure. The layer was separated and the aqueous layer was extracted with ether(3 × 20 ml),the combined organic layers were dried over anhydrous magnesium sulfate. Solvent removal and distillation under reduced pressure gave(2) (21. 3 g,89 .5%, b.p.147–148 ℃ (10mmHg, Lit[8] , 114–116℃ / 1.5Torr). semicarbazone, m.p. 180 –181℃ (lit[8], 184–185℃). IR (film): 3350(OH); 1700(CO); 1385, 1365[$C(CH_3)_2$]; 1050(C–O) cm^{-1}. ^{1}HNMR (δ,ppm): 0.86, 1.30 [2 s,3H each, $C(CH_3)_2$]; 1.01–1.12(m,3H,$CHCH_2CH$ and CH_2CHCH_2); 1. 43–1.64(m, 2H, CH_2CH_2O); 2.03(s,3H,CH_3CO); 2.92 (t,1H,CH_2CHCO); 3.38 (s 1H, OH); 3.56(t,2H,CH_2CH_2OH). MS((20ev,m / z):171(M^++1 ,4%); 126(15); 108(17); 98(15); 85(100); 83(49); 82(38); 71(17); 69(40); 57(23); 43(15).

(+)–cis–(1R)–2,2–dimethyl–3–acetylcyclobutaneethanol acetate(3a):

The acetylation of 2 (6.8 g, 40 mmol) with acetic anhydride (13.5 ml,142 mmol) in dry pyridine (3 ml) afforded 3a (7.9 g, 93%)as a colorless oil, b.p. 151–152℃ (9 mmHg).

(+)-cis-(1R)-2,2-dimethyl-3-acetylcyclobutaneethanol formate (3b):

2(8.6 g, 51 mmol) was added to a dry 50ml 3-necked flask equipped with a dropping funnel, reflux condenser, thermometer and magnetic stirrer, under stirring acetic-formic anhydride (6.2 g, 70 mmol) was added dropwise. After stirring about 12 hr at room temperature,solvent removal and distillation under reduced pressure gave a crude oil (3b) (9 g) b.p.129-131 ℃ (7 mmHg) . Further purification on column chromatography [silica gel, cyclohexane / EtOAc(2:1)] afforded 3b (4.5 g,45%).

(+)-cis-(1R)-2,2-dimethyl-3-acetylcyclobutaneethanol propionate(3c):

The propionylation of 2 (5.8 g, 34 mmol) with propionyl chloride (5.0 g,54 mmol) and redistilled xylidene(5.5 ml) in ether (20 ml) gave a crude oil (3c) (6.9 g), b.p. 149-152℃ (6 mmHg). Further purification on column chromatography[silica el, cyclohexane / EtOAc (2:1)]afforded 3c (3.2 g, 41.6%).

General Procedure[12]for the Synthesis of Analogs (4a-h):

In a dry 50ml 3-necked flask equipped with reflux condenser ,thermometer and magnetic stirrer, urder nitrogen a solution of sodium hydride (0.48 g, 16 mmol, 80% in paraffin) in dry DMSO(20 ml) was treated at 50-60℃ until sodium hydride was completely dissolved, the corresponding phosphonium halide[13]was then added and stirred for 2 hr at 60℃ . after cooling to room temperature, 3a-c (14 mmol) and 2 (14 mmol) was added to the above mixture, respectively, and stirred for 5 hr at 60-70℃ . the mixture was then poured into water (20 ml) and stirred for 15 min, after extraction with ether (3 × 50 ml) , the combined ethereal layers were washed with water and dried over anhydrous sodium sulphate. Solvent removal gave yellow oils, purification on column chromatography[silica gel, cyclohexane / EtOAc (5:1)] afforded colorless oils (4a-h).

(+)-cis-(1R)-3-isopropenyl-2,2-dimethylcyclobutaneethanol acetate(4a):

3a(3.0 g,14 mmol) and $MePh_3PI$ (6.1 g,15 mmol) was converted into 4a(0.6 g,21%). IR(film): 3050(=CH_2); 1738(CO); 1650(C=C); 1368[C(CH_3)$_2$]; 1245 (CH_3COO); 885(C=CH_2) cm^{-1}. ^{1}HNMR (δ,ppm): 0.88, 1.06[2s, 3H each, C(CH_3)$_2$]; 1.04-1.14(m,2H, $CHCH_2CH$); 1.24-1.31(m, 1H, CH_2CHCH_2); 1.48-1.77 (m,2H, CH_2CH_2O); 1.99(s,3H, CH_3C=C); 1.80-1.90(m, 1H, =C-$CHCH_2$); 2.02(s,3H, CH_3CO); 3.85-4.00(t,2H, CH_2CH_2O); 4.56-4.85(m,2H, C=CH_2). MS(70ev,m / z): 150(M^+-CH_3COOH,1%); 96(4); 95(2); 82(100); 81(9); 68(6); 67(32); 54(1); 43(70).

(+)-cis-(1R)-3-(1-methyl-1-butenyl)-2,2-dimethylcyclobutaneethanol acetate(4b):

3a(3.0 g,14 mmol) and n-$PrPh_3PBr$ (5.7g, 15mmol) was converted into 4b (0.3 g,17.8%).IR (film): 3010(=CH); 1733(CO); 1650(C=C); 1365[$C(CH_3)_2$]; 1244 (CH_3COO); 816(C=CH)cm^{-1}. ^{1}HNMR (δ,ppm): 0.74,1.16[2s,3H each,$C(CH_3)_2$]; 0.89-0.92(t,3H, CH_3CH_2); 1.17-1.27(m,2H, $CHCH_2CH$);1.42-1.46(m,1H, CH_2CHCH_2); 1.56(s,3H, $CH_3C=CH$); 1.61-1.68(m,2H, CH_2CH_2O); 1.78-1.90(m,2H, $CH_3CH_2C=CH$); 2.03(s, 3H, CH_3CO); 2.14-2.38(m, 1H, $CHC=CH$); 3.92-4.08(t,2H, CH_2CH_2O); 4.92-5.43(m, 1H, $CH=C$). MS(70ev, m / z): 124(M^+-CH_3COOH- $CH_2=CH-CH=CH_2$, 6%); 123(2); 96(28); 95(6);82(100); 81(12); 54(2); 43(10).

(+)-cis-(1R)-3-(1-methyl-1-propenyl)-2,2-dimethylcyclobutaneethanol formate(4c):

3b(2.8 g,14 mmol) and $EtPh_3PBr$(5. 8 g, 15. 6 mmol) was converted into 4c(0.5 g,17.0%).IR (film):3010(=CH); 1725(CO);1677(C=C); 1369[$C(CH_3)2$; 1181(HCOO); 838(C=C)cm^{-1}. ^{1}HNMR(δ, ppm): 0.92, 1.09[2s, 3H each, $C(CH_3)_2$]; 1.04-1.18(m, 2H,$CHCH_2CH$); 1.15-1.29(m,1H, CH_2CHCH_2); 1.40-1.52(m,2H,CH_2CH_2O); 1.62 (d,3H, $CH_3CH=C$); 1.94(s,3H,$CH=C-CH_3$); 1.99-2.38(m,1H,$=CCHCH_2$); 3.97-4.12(t,2H, CH_2CH_2O); 4.56-5.02(m,1H,$CH_3CH=C$); 7.94(s,1H,CHO). MS (70ev,m / z): 164(M^+-HCOOH,1%); 110(1); 109(2); 82(100); 81(4);54(1).

(+)-cis-(1R)-3-isopropenyl-2,2-dimethylcyclobutaneethanol propionate(4d):

3c(3.2 g,14 mmol)and $MePh_3PI$(6.1 g, 15 mmol) was converted into 4b(0.7 g,22.3%).IR (film):3050(=CH); 1737(CO); 1645(C=C); 1365[$C(CH_3)_2$]; 1190 (C_2H_5COO); 886(C=CH_2)cm^{-1}. ^{1}HNMR (δ,ppm):0.79,1.22[2s,3H each, $C(CH_3)_2$]; 0.93-1.27(m ,5H, CH_3CH_2CO and $CHCH_2CH$); 1.66(s,3H, $CH_3C=CH_2$); 1.44-1.60 (m,3H,$CHCH_2CH_2O$); 2.14-2.61(m,3H,CHCHC= and CH_3CH_2CO); 3.91-4.05 (t,2H,CH_2CH_2O); 4,52-4.75(m,2H,$C=CH_2$); MS(70ev,m / z): 150(M^+-C_2H_5COOH, 2%); 96(13); 95(11); 82(100); 81(23); 68(11); 67(49); 57(55); 54(4).

(+)-cis-(1R)-3-(1-methyl-1-propenyl)-2,2-dimethylcyclobutaneethanol propionate(4e):

3c(3.2 g,14 mmol) and $EtPh_3PBr$(5.6 g,15 mmol) was converted into 4e(0.6 g,18%).IR (film):3030(=CH); 1737(CO); 1650(C=C); 1367[$C(CH_3)_2$]; 1190

(C_2H_5COO); 805(C=CH)cm^{-1}. ^{1}HNMR (δ,ppm): 0.81,1.17[2s,3H each, $C(CH_3)_2$]; 0.96(t,3H, CH_3CH_2CO); 1.25(m,3H, CH_2CHCH_2); 1.45–1.57 (m,2H, CH_2CH_2O); 1.63(s,3H,$CH_3C=CH$); 1.89,1.96(dd,3H, $CH_3CH=C$); 2.11–2.40(q,2H, CH_3CH_2CO); 2.14–2.31(t,1H,$CH_2CHC=$); 3.88–4.02(t,2H,CH_2CH_2O); 4.57–4.88(m, 1H, $CH_3CH=C$): MS(70ev,m / z): 110(M^+– C_2H_5COOH– $CH_2=CHCH=CH_2$, 6%); 109(9); 82(100); 81(26); 57(83); 54(4).

(+)–cis–(1R)–3–isopropenyl–2,2–dimethylcyclobutaneethanol(4f):

2(2.4 g,14 mmol) and $MePh_3PI$ (6.5 g,16 mmol) was converted into 4f(0.7 g,29.2%).IR(film):3310(OH); 3080(=CH_2); 1645(C=C); 1365[$C(CH_3)_2$]; 1050(C–O); 880(C=CH_2)cm^{-1}. ^{1}HNMR(δ,ppm):0.85, 1.28[2 s,3H each, $C(CH_3)_2$]; 1.09–1.39 (m,1H,CH_2CHCH_2); 1.61–1.91(m,2H,$CHCH_2CH$); 1.83(s,3H,$CH_3C=CH_2$); 1.96–2.21(m,2H, $CHCH_2CH_2OH$); 2.49–2.92(m,1H, $CHC=CH_2$); 3.57(s,1H,OH); 3.85–4.02(t,2H, CH_2CH_2OH); 5.07–5.30(m,2H, $C=CH_2$). MS(70ev,m / z): 150(M^+–H_2O,2%); 96(17); 95(4); 82(28); 81(21); 68(23); 67(36); 57(100); 54(2).

(+)–cis–(1R)–3–(1–methyl–1–propenyl)–2,2–dimethylcyclobutaneethanol(4g):

2(2.4 g,14 mmol) and $EtPh_3PBr$ (5.9 g,16 mmol) was converted into 4g(0.5 g,19.6%).IR(film):3370(OH); 3075(=CH); 1645(C=C); 1369[$C(CH_3)_2$]; 1052(C–O); 830(C=CH)cm^{-1}.^{1}HNMR (δ,ppm):0.80,1.24[2 s,3H each, $C(CH_3)_2$]; 0.97–1.12(m,1H, CH_2CHCH_2); 1.31–1.48(m,2H, $CHCH_2CH$); 1.72(s,3H, $CH_3C=CH$); 1.79–1.88 (m,3H, $CH_3CH=CH$); 1.98–2.11(m,2H,CH_2CH_2O);2.27(s,1H,CH_2OH); 2.52–2.91(m,1H, $CH_2CHC=$); 3.90–4.08(t,2H, CH_2CH_2OH); 5.52–6.03(m,1H, $CH_3CH=C$) MS(70ev,m / z): 110(M^+–H_2O– $CH_2=CHCH=CH_2$,5%); 109(11); 82(100); 81(30); 57(91); 54(6).

(+)–cis–(1R)–3–(1–methyl–1–butenyl)–2,2–dimethylcyclobutaneethanol(4h):

2(2.4 g,14mmol) and n–$PrPh_3PBr$(6.2 g,16mmol) was converted into 4h(0.85 g,32.5%).IR(film): 3350(OH); 3050(=CH); 1590(C=C); 1366[$C(CH_3)_2$]; 1080(C–O); 825(C=CH_2)cm^{-1}. ^{1}HNMR(δ,ppm):0.88, 1.14[2s, 3H each, $C(CH_3)_2$]; 0.72 (t,3H, CH_3CH_2); 1.16(m,1H,CH_2CHCH_2); 1.21–1.32(m,2H,$CHCH_2CH$); 1.53(s,3H, $CH_3C=CH$); 1.77–1.96(m,2H,$CH_3CH_2C=$); 1.46–1.70(m,2H,CH_2CH_2OH); 2.41 (s,1H,CH_2OH); 2.23–2.45(m,1H, $CH_2CHC=C$); 3.46–3.61(t,2H,CH_2CH_2OH); 4.84–5.32(m,1H,$CH=C$); MS(70ev,m / z): 124(M^+–H_2O–$CH_2=CHCH=CH_2$,10%); 123(2); 96(6); 95(4); 82(100); 81(9); 54(2).

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References

1. Bierl-Leonhardt, B.A., Moreno, D.S., Schwarz, M.,Fargerlurd, J., Plimmer, J.R., Tetrahedron Lett., 1981, 22, 389.
2. Gaoni, Y., Tetrahedron Lett., 1982, 23, 5215.
3. Carlsen, P.H.J., Odden, W., Acta Chem. Scand. Sect. B, 1984, 38(6), 501.
4. Odinokov,V.N., Kukovinets, O.S., Isakvo, L.A., Zainullin, R.A., Moiseenkov, A.M., Tolstikov, G.A.., Dokl. Akad. Nauk SSSR 1984, 279(2),398. (C.A.,1985,103,141656a)
5. Wolk J.L., Goldschmidt, Z., Dunkelblum, E., Synthesis,1986,(4),347.
6. Odinokov,V.N., Kukovinezh, O.S., Isakova, L.A., Zainullin, R.A., Moisunkov,A.M., Tolstikov, G.A., Zh. Org. Khim. 1991, 27(3), 555. (C.A. 1991,115, 207696v)
7. Dunkelblum, E., Ben-Dov, Y., Goldschmidt, Z., Wolk, J. L., Somekh, L., J. Chem. Ecol., 1987., 13(4),863.
8. Gora, J., Smigielski, K., Kula, J., Synthesis, 1982,(4),310.
9. Barbaruah, M., Barua, N. C., Sharma, R. P., Tetrahedron Lett. 1987, 28(46), 5741.
10. Ward, D. E., Rhee, C. K., Synth. Commun., 1988, 18(16-17), 1927.
11. Ward, D. E., Rhee, C. K., Can. J. Chem., 1989, 67(7), 1206.
12. Greenwald, R., Chaykovsky, M. and Corey, E.J., J. Org. Chem. 1963, 28, 1128
13. Bergmann, W., Dusz, J.P., J.Org. Chem. 1958, 23, 1245

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