Chemistry of Natural Compounds, Vol. 36, No. 6, 2000

SYNTHESIS OF THE SEX PHEROMONE OF *Lygus lineolaris* (*Heteroptera miridae*)

G. S. Shakirzyanova, V. S. Abdukakharov,
and A. A. Abduvakhabov

UDC 542.91+547.473+632.936.2

We propose a new synthesis of the sex pheromone of Lygus lineolaris *(*Heteroptera miridae*) that uses a phase-transfer version of the Wittig—Horner reaction to produce a monoene synthon of the principal component of the pheromone, E-2-hexenylbutyrate.*

Key words: *Lygus lineolaris*, pheromone, synthon, Wittig—Horner reaction, phase-transfer catalysis.

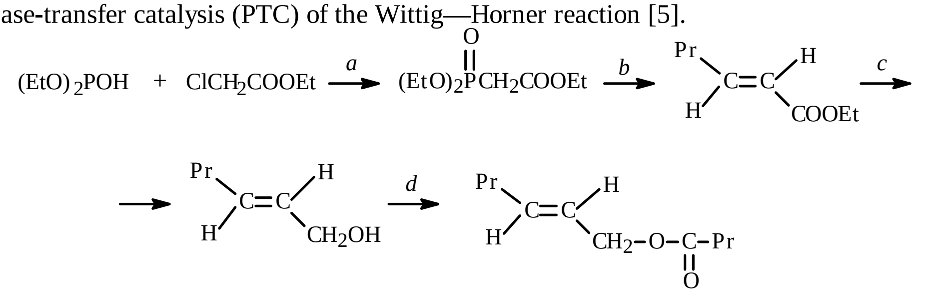
Miridae bugs belong to a family that includes about 750 genera and 6000 species. The species composition and harmfulness of these insects is insufficiently studied. The population of bugs has increased in recent years. Most losses from bugs occur on cotton plantations [1].

Field bugs are very mobile. They often fly from one field to another, changing biotopes. They are nonselective feeders and inflict great harm on grain crops, cotton, tobacco, and various medicinal, garden, and decorative plants. Bugs harm plants by causing shedding of buds and ovaries primarily on the upper stem [2].

The sex pheromone of *Lygus lineolaris* is a two-component system consisting of the hexyl ester of butyric acid and E-2-hexenylbutyrate [3, 4].

To the best of our knowledge the synthesis of the pheromone of *Lygus lineolaris* has not been reported. Therefore, we investigated the synthesis of this pheromone.

The principal step in the synthesis of E-2-hexenylbutyrate is the preparation of the monoene synthon with a *trans*-double bond via phase-transfer catalysis (PTC) of the Wittig—Horner reaction [5].



a. Na (meth.)/Et_2O; *b*. PrCHO, NaOH, H_2O/CH_2Cl_2, TBAB; *c*. $LiAlH_4/Et_2O$; *d*. PrCOOH, C_6H_6, 10 % H_2SO_4

Diethylphosphite reacts with ethylchloroacetate to give the triethyl ester of phosphonoacetic acid in 56-60% yield.

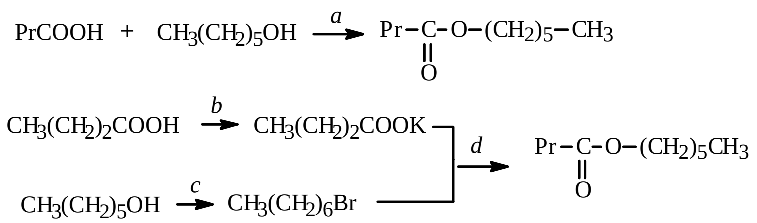
The phosphonium ion and an aldehyde undergo a Wittig—Horner reaction under PTC conditions with a tetrabutylammonium bromide (TBAB) catalyst. The following system was proposed for olefination of propanal by triethyl phosphonoacetic acid: 50% NaOH-CH_2Cl_2-TBAB. This produced the *trans*-olefin in 68% yield. The ratio of *cis*- to *trans*-isomers was 2:98.

Under mild conditions the ester of E-2-hexenic acid is reduced to the corresponding alcohol. The usual esterification of E-2-hexen-1-ol and butyric acid gave E-2-hexenylbutyrate.

The second component, hexylbutyrate, can be prepared in two ways: ordinary esterification and using PTC.

A. S. Sadykov Institute of Bioorganic Chemistry, Academy of Sciences of the Republic of Uzbekistan, Tashkent, fax (99871) 162 70 71. Translated from Khimiya Prirodnykh Soedinenii, No. 6, pp. 500-501, November-December, 2000. Original article submitted August 20, 1999.

0009-3130/00/3606-0623$25.00



a. C_6H_6, 10% H_2SO_4; *b*. KOH, H_2O; *c*. PBr_3/Et_2O, Py; *d*. TBAB

The potassium salt of butyric acid was isolated. The reaction of PBr_3 with hexanol gave 1-bromohexane. The esterification was performed under PTC conditions. The reaction was carried out for 5 h at 160°C with TBAB catalyst. The yield was 81%.

The usual esterification [6] took 30 h and gave a yield of 73%. Therefore, performing the esterification under PTC conditions significantly simplified and accelerated production of the ester.

Thus, a new method for synthesizing the sex pheromone of the bug *Lygus lineolaris* using a PTC version of the Wittig—Horner reaction has been developed.

EXPERIMENTAL

PMR spectra were recorded on a Varian XL-200 spectrometer at working frequency 200 MHz. The solvent was CCl_4 with HMDS as an internal standard. Analysis of all compounds agreed with the calculated values.

E-2-Hexenic Acid Ethyl Ester. A mixture of TBAB (0.966 g, 0.003 mol), NaOH (50%, 71 mL), and CH_2Cl_2 (106 mL) was stirred until the solution was homogeneous. A solution of butanal (4.62 g, 0.06 mol) and the triethyl ester of phosphonoacetic acid (12.85 g, 0.06 mol) in CH_2Cl_2 (160 mL) was added dropwise. The mixture was refluxed for 2 h and washed with water. The organic layer was dried over $MgSO_4$. The solvent was removed under reduced pressure. The solid was distilled under vacuum, bp 65-67°C at 7 mm Hg, yield 5.5 g (68%).

PMR (ppm): 6.87 (1H, dt, J = 16.0, 6.5, H_A), 5.75 (1H, d, J = 16.0 Hz, H_B), 4.09 (2H, q, J = 6.2 Hz, OCH_2), 2.20 (2H, m, $=C–CH_2$), 1.1-1.6 (4H, m, CH_2), 1.27 (3H, t, J = 6.3 Hz, $OCH_2–CH_3$), 0.98 (3H, t, J = 6.9 Hz, CH_3).

***Trans*-2-hexen-1-ol.** A suspension of $LiAlH_4$ (2 g, 0.052 mol) in anhydrous ether (50 mL) at room temperature was treated dropwise with the ethyl ester of *trans*-2-hexenic acid (4.2 g, 0.029 mol) and refluxed for 3 h. The cooled mixture was treated with water. The organic layer was separated. The aqueous layer was extracted with ether (3×50 mL). The combined extracts were dried over $MgSO_4$. After solvent was removed, the solid was vacuum distilled, bp 65-67°C at 2 mm. Yield 1.3 g (55%), n_D^{20} = 1.4274.

***Trans*-2-hexenylbutyrate.** A solution of E-2-hexen-1-ol (1.33 g, 0.014 mol) and butyric acid (1.21 g, 0.014 mol) in benzene (10 mL) and H_2SO_4 (0.55 g, 10%) was refluxed for 3 h with a Dean—Stark trap. The cooled solution was poured onto ice, extracted with ether, and dried over $MgSO_4$. Solvent was removed. The crude product was chromatographed with elution by hexane—acetone (4:1) on Chemapol L100/250 silica gel, R_f = 0.95. Yield 0.91 g (40%), n_D^{20} = 1.4076.

Hexylbutyrate. Potassium butyrate (3.02 g, 0.024 mol), TBAB (0.16 g), and bromohexane (4 g, 0.024 mol) were mixed. The reaction mixture was held on a glycerine bath at 160°C for 5 h. After the reaction was complete, the solid mixture was filtered off and washed with anhydrous ether. The solvent was removed. The solid was distilled, bp 178°C. Yield 3.34 g (81%).

REFERENCES

1. A. Sh. Khamraev, *Zashch. Rast.*, 25 (1993).
2. R. J. Freeman and A. J. Mueller, *J. Entomol. Sci.*, 218 (1989).
3. A. V. Skirkyavichus, *Pheromone Handbook* [in Russian], Vilnius, Institute of Zoology and Parasitology, Academy of Sciences of the Lithuanian SSR (1988).
4. R.C. Gueldner and W. Parrott, *Insect Biochem.*, **4**, 389 (1978).
5. Z. Mouloungui, M. Delmas, and A. Gaset, *J. Org. Chem.*, **68**, 3936 (1989).
6. Weygand-Hilgetag, *Experimental Methods in Organic Chemistry* [in Russian], Khimiya, Moscow (1968).