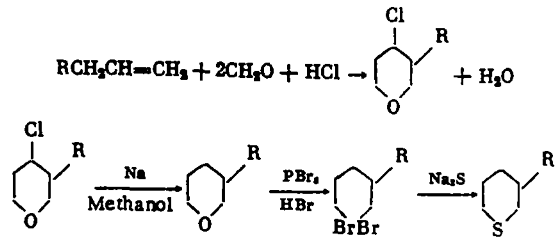
PREPARATIVE SYNTHESIS OF 3-ALKYL(CYCLOALKYL)THIACYCLOHEXANES

N. P. Volynskii, L. P. Shcherbakova,
and G. D. Gal'perin

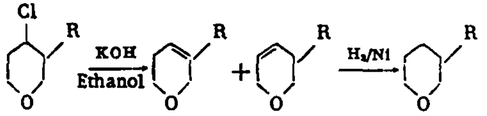
UDC 542.91:547.592.14

No methods of synthesizing 3-alkylthiacyclohexanes, which are of interest as model compounds for investigating sulfides of petroleum origin, have been adequately developed. The known syntheses of such compounds are difficult and are multistep processes [1-6].

We used 3-alkyl-4-chlorotetrahydropyrans, which are easily formed in high yields [7] from α-olefins and CH_2O under the effect of gaseous HCl at −60 to −70°C,* for the preparative synthesis of 3-alkylthiacyclohexanes.



Thus, a four-step synthesis has been accomplished starting from readily available α-olefins. When it is necessary to synthesize 3-alkylthiacyclohexanes with substituents of a more complex structure, the appropriate alkyl halides are converted to the required α-olefins by the known reaction in [9]. Dechlorination can be carried out by the action of sodium in methanol [7] and also in two steps by splitting off HCl with an alcoholic alkali and hydrogenating the dihydropyrans formed.



The latter method is especially convenient for synthesizing 3-substituted tetrahydropyrans in large quantities.

Unexpected difficulties arose when converting the 3-substituted tetrahydropyrans to the corresponding 1,5-dibromides. The known methods of cleaving the tetrahydropyrans (the action of gaseous HBr, boiling with 48% HBr in the presence of H_2SO_4, etc.) led only to the formation of tars and to an insignificant yield of the dibromide. We propose a method which includes the slow addition of 48% HBr to a mixture of the 3-substituted tetrahydropyran with PBr_3 at 140-150°C, which enabled us to obtain the 1,5-dibromides quantitatively in a practically pure state.

We tested the proposed scheme by preparing 3-butyl-, 3-hexyl-, and 3-cyclohexylthiacyclohexanes, which were characterized by converting them to the sulfoxides and sulfones.

---

*Somewhat later a paper was published in which 3-alkyl-4-chlorotetrahydropyrans were synthesized in yields of 20-50% by reacting α-olefins with bis(α-chloromethyl) ether in the presence of $ZnCl_2$. The drawback to this method is the necessity of slowly introducing the olefin into a boiling ethereal solution of the bis(α-chloromethyl) ether.

A. V. Topchiev Institute of Petrochemical Synthesis, Academy of Sciences of the USSR, Moscow. Translated from Izvestiya Akademia Nauk SSSR, Seriya Khimicheskaya, No. 10, pp. 2299-2302, October, 1976. Original article submitted September 12, 1975.

TABLE 1

Compound	Yield, %	bp., °C, (p, mm of Hg)	n_D^{20}	d_4^{20}	Empirical formula	Found, %	Calculated, %	Remarks
3-Butyl-4-chlorotetrahydropyran [8]	61	59 (3)	1,4630	1,0148	$C_9H_{17}ClO$	Cl 19,6	Cl 20,07	Mixture of cis and trans isomers
3-Hexyl-4-chlorotetrahydropyran	56	99 (4)	1,4635	0,9843	$C_{11}H_{21}ClO$	Cl 17,2	Cl 17,32	Mixture of cis and trans isomers (1 : 4)
3-Cyclohexyl-4-chlorotetrahydropyran	57	96 (3)	1,4970	1,0789	$C_{11}H_{19}ClO$	Cl 17,5	Cl 17,50	Mixture of cis and trans isomers (1 : 3)
3-Butyldihydropyran	90	73 (15)	1,4540	0,8892	$C_9H_{16}O$	C 77,00 H 11,48	C 77,08 H 11,51	Mixture of Δ^2 and Δ^4 isomers (1 : 3)
3-Hexyldihydropyran	92	67 (4)	1,4565	0,8796	$C_{11}H_{20}O$	C 78,57 H 12,04	C 78,50 H 11,98	Mixture of Δ^3 and Δ^4 isomers (1 : 4)
3-Cyclohexylhydropyran	91	75 (4)	1,4925	0,9697	$C_{11}H_{18}O$	C 79,73 H 11,05	C 79,53 H 10,92	Mixture of Δ^3 and Δ^4 isomers (1 : 9)
3-Butyltetrahydropyran [6]	88	67 (15)	1,4380	0,8632	$C_9H_{18}O$	C 76,11 H 12,67	C 76,00 H 12,75	During the reduction of 3-butyl-4-chlorotetrahydropyran with Na in methanol, the yield was 80%
3-Hexyltetrahydropyran	94	73 (4)	1,4440	0,8603	$C_{11}H_{22}O$	C 77,68 H 12,75	C 77,58 H 13,02	
3-Cyclohexyltetrahydropyran	95	79 (4)	1,4782	0,9483	$C_{11}H_{20}O$	C 78,42 H 11,65	C 78,51 H 11,98	
2-Butyl-1,5-dibromopentane [2,3]	84	100 (4)	1,4988	1,4208	$C_9H_{18}Br_2$	Br 55,4	Br 55,87	
2-Hexyl-1,5-dibromopentane [3]	91	118 (2,5)	1,4943	1,3402	$C_{11}H_{22}Br_2$	Br 50,5	Br 50,88	
2-Cyclohexyl-1,5-dibromopentane	95	136 (3)	1,5258	1,4458	$C_{11}H_{20}Br_2$	Br 50,4	Br 51,21	
2-Butylthiacyclohexane [2-5]	85	75 (6)	1,4870	0,9219	$C_9H_{18}S$	S 20,2	S 20,26	
3-Hexylthiacylclohexane [3]	88	84 (3)	1,4850	0,9084	$C_{11}H_{22}S$	S 17,2	S 17,21	
3-Cyclohexylthiacyclohexane	70	78 (2)	1,5212	1,0015	$C_{11}H_{20}S$	S 17,0	S 17,39	A mol. wt. of 184 was found (mass spectrometrically); calculated 184.3
3-Butylthiacyclohexane-1-oxide	~100	—	1,4982	1,0240	$C_9H_{18}OS$	S 18,5	S 18,40	The configuration was not investigated
3-Hexylthiacyclohexane-1-oxide	~100	—	1,4932	0,9943	$C_{11}H_{22}OS$	S 15,7	S 15,85	The same
3-Cyclohexylthiacyclohexane-1-oxide	~100	n.P. 77—78	—	—	$C_{11}H_{20}OS$	S 16,0	S 16,01	»
3-Butylthiacyclohexane-1,1-dioxide	~100	n,P 54	—	—	$C_9H_{18}O_2S$	S 16,7	S 16,85	
3-Hexylthiacyclohexane-1,1-dioxide	~100	n,P 68,5—69	—	—	$C_{11}H_{22}O_2S$	S 14,4	S 14,69	
3-Cyclohexylthiacyclohexane-1,1-dioxide	~100	n,P 114—115°	—	—	$C_{11}H_{20}O_2S$	S 14,5	S 14,82	

EXPERIMENTAL

3-Cyclohexyl-4-chlorotetrahydropyran. Into a mixture of 420 g (3.38 moles) of allylcyclohexane and 270 g (9 moles) of paraformaldehyde with agitation and cooling to −65 to −70°C was passed a rapid stream of HCl for 4 h. Later the temperature was gradually increased to ~20°C while absorbing the HCl given off with water. The reaction product was washed with an NaCl solution then with an Na_2CO_3 solution, dried over Na_2SO_4, and vacuum distilled. The fraction (390 g) with a bp of 105-110°C (4 mm) was 3-cyclohexyl-4-chlorotetrahydropyran (Table 1).

Dehydrochlorination of 3-Cyclohexyl-4-chlorotetrahydropyran. In a stainless-steel autoclave was heated 378 g (1.87 moles) of 3-cyclohexyl-4-chlorotetrahydropyran with a solution of 210 g of KOH in 500 ml of ethanol for 1.5 h at 140°C. After cooling the mixture was poured into water, the organic layer was separated, the aqueous alcohol layer was extracted with hexane, and the residue was added to the main product. After vacuum distillation 282 g (91%) of 3-cyclohexyldihydropyran was obtained (see Table 1).

Hydrogenation of 3-Cyclohexyldihydropyran. Into a 3800 ml rotating stainless-steel autoclave was placed 274 g (1.648 moles) of 3-cyclohexyldihydropyran, 150 ml of ethanol, and 20 ml of an alcoholic Raney Ni paste. The autoclave was purged with nitrogen and H_2 was pumped in to 24 atm. The hydrogenation took place with slight evolution of heat and basically ended within 1 h. The residual hydrogen pressure (13.4 atm) was released, the autoclave was purged twice with nitrogen (to 5 atm), opened, the contents were drawn off with a tube connected to a Bunsen bottle while washing off the wall of the autoclave with a mixture of alcohol and solid CO_2 to avoid the evolution of heat from the pyrophoric catalyst. The catalyst was filtered off, the alcohol was evaporated from the filtrate, and the residue distilled. 3-Cyclohexyltetrahydropyran, 261 g (95%), was obtained.

2-Cyclohexyl-1,5-dibromopentane. Into 251 g (1.49 moles) of 3-cyclohexyltetrahydropyran was quickly poured with agitation 100 ml (1.05 moles) of PBr_3, the mixture was heated to 145-150°C, and at this temperature was added 55 ml of 48% HBr within 2.5 h. Then another 10 ml of HBr was added immediately, the mixture was cooled to ~20°C, and 80 ml of benzene was added. The lower acid layer was discarded and the upper one was neutralized by adding excess solid Na_2CO_3. After filtering through a paper filter* 10 mm thick and vacuum distilling off the benzene (100°C, 4 mm), 473 g (95%) of a colorless oil was obtained.

3-Cyclohexylthiacyclohexane.† A total of 650 ml of an aqueous alcoholic solution of Na_2S (from 480 g of $Na_2S \cdot 9H_2O$ in 500 ml of H_2O and 450 ml of alcohol) and 428 g of unpurified 2-cyclohexyl-1,5-dibromopentane were added simultaneously over a 40 minute period to a flask containing the remaining NaS_2 solution while mixing and heating, after which the mixture was boiled another 3 h. Upon cooling the upper layer was separated out and the lower aqueous alcoholic layer was extracted with 5 ml of hexane. The hexane extract was combined with the main product, dried with Na_2SO_4, and fractionally distilled (15 theor. plates).

A total of 170 g (~70%) of the impure sulfide, bp 64-85°C (2 mm), which was purified by heating with Na (100°C, 3 h) after which it was filtered and fractionally distilled (15 theor. plates), was obtained.

3-Cyclohexylthiacyclohexane-1-oxide. The oxidation of 3-cyclohexylthiacyclohexane was carried out by the method in [10] with $NaIO_4$ in an aqueous alcoholic solution at 0°C for 5 h. The sulfoxide was recrystallized from a hexane — benzene mixture.

3-Cyclohexylthiacyclohexane-1,1-dioxide. The oxidation of 3-cyclohexylthiacyclohexane was carried out by the method in [11] with H_2O_2 in AcOH (100°C, 1 h). After neutralization with an alkali the product was extracted with a benzene — ether mixture and recrystallized from a benzene — pentane mixture.

CONCLUSIONS

1. A four-step preparative method of preparing 3-alkyl(cycloalkyl)-substituted thiacyclohexanes starting from α-olefins is proposed.

2. An effective method of splitting the cyclic ethers and converting them into the dibromides has been developed.

---

*Paper filters of any thickness are conveniently prepared as follows: Filter paper is soaked in water, ground, the pulp obtained is transferred to a Buchner funnel or to a sintered glass funnel, the water is sucked off, and the compact paper filter that is formed is washed with acetone, then with any suitable solvent.

†Carried out by the method in [1].

LITERATURE CITED

1. E. V. Whitehead, R. A. Dean, and F. A. Fidler, J. Am. Chem. Soc., 73, 3632 (1951).
2. R. Emmott, J. Inst. Petrol., 39, 695 (1953).
3. M. M. Gerasimov, V. I. Snegotskii, and V. A. Snegotskaya, The Chemistry of the Organosulfur Compounds Contained in Petroleum and Petroleum Products [in Russian], Vol. 8, Khimiya (1968), p. 85.
4. Yu. K. Yur'ev, Yu. A. Pentin, and O. M. Revenko, Neftekhimiya, 1, 742 (1961).
5. Yu. K. Yur'ev and O. M. Revenko, Zh. Obshch. Khim., 32, 1822 (1962).
6. Yu. K. Yur'ev and O. M. Revenko, Vestn. Mosk. Un-ta, Ser. Khim., 17, No. 2, 68 (1962).
7. P. R. Stapp, J. Org. Chem. 34, 479 (1969).
8. A. A. Gevorkyan, Sh. O. Badanyan, A. A. Manukyan, and P. I. Kazaryan, Armyan. Khim. Zh., 24, 909 (1971).
9. K. Weygand and G. Hilgetag, Preparative Organic Chemistry, Wiley-Interscience (1972).
10. C. R. Johnson and D. McCants, Jr., J. Am. Chem. Soc., 87, 1113 (1965).
11. K. Weygand and G. Hilgetag, Preparative Organic Chemistry, Wiley-Interscience (1972).

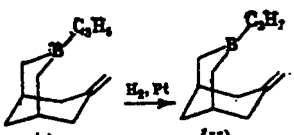
BOROORGANIC COMPOUNDS

321. THE SYNTHESIS AND PROPERTIES OF 1-BORAADAMANTANE AND 3,5-DIMETHYL-1-BORAADAMANTANE

B. M. Mikhailov, V. N. Smirnov, and V. A. Kasparov

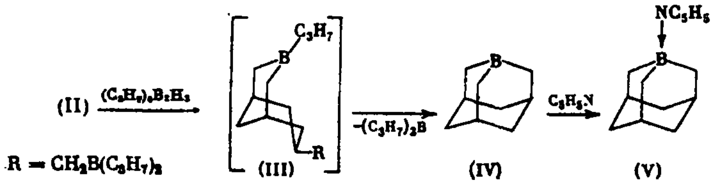
UDC 542.91:547.1'127

3-Allyl-7-methylene-3-borabicyclo[3.3.1]nonane (I), obtained on condensing triallylborane and allene [1, 2], was used for the synthesis of 1-boraadamantane. The reasons for this were first the conformation of the compound which provides a favorable disposition of dialkyl boryl groups on hydroboration of this compound, and second the inclination of diboron compounds towards closing into rings [3]. Since diboron compounds with alkyl radicals on the boron atom are more inclined to intramolecular cyclization, according to [4], compound (I) was partially hydrogenated over Pt black to 3-propyl-7-methylene-3-borabicyclo[3.3.1]nonane (II). This was achieved as a result of the large difference in the rates of hydrogenation of the terminal and exocyclic double bonds.



(I) (II)

On reacting tetrapropyldiborane with (II), 3-propyl-7-(dipropylboryl)methyl-3-borabicyclo[3.3.1]nonane (III) was formed, which cyclized with cleavage of tripropylborane into 1-boratricyclo[3.3.1.1^{3,7}]decane (1-boraadamantane) (IV) [2, 5]. The latter was readily distillable in vacuum, thermally unstable, and formed colorless crystals oxidizing in air.



N. D. Zelinskii Institute of Organic Chemistry, Academy of Sciences of the USSR, Moscow. Translated from Izvestiya Akademii Nauk SSSR, Seriya Khimicheskaya, No. 10, pp. 2302-2308, October, 1976. Original article submitted July 16, 1975.