REACTION OF *n*-BUTYLLITHIUM WITH *cis*- AND *trans*-4-*tert*-BUTYLCYCLOHEXYL BROMIDE AND MERCURIC BROMIDE

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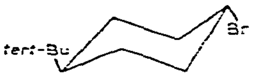
It is known from many examples[1,2] that the vinyllithium compounds react with a high degree of retention of steric configuration. An analogous stability is also observed in some cyclopropyllithium[3,4] and saturated alkyllithium[5,6] reagents. The steric stability of lithium compounds is also known to be highly dependent on the nature of the substituents[1,4,7,8] and of the solvent[9].

In the present paper attempted preparations of stereoisomeric cyclohexyllithium compounds are described. It was of interest to prepare such compounds in order to study their configurational stability in comparison with other saturated lithium reagents.

The system chosen for the exchange reactions with *n*-butyllithium was *cis*- and *trans*-4-*tert*-butylcyclohexyl bromide (I, II). The *cis*-bromide, (I), was prepared[10] by treating *trans*-4-*tert*-butylcyclohexanol with phosphorus pentabromide, and the *trans*-isomer, (II), from 4-*tert*-butylcyclohexanecarboxylic acid by the Hunsdiecker reaction[11].

I



II

III

IV

When (I) in pentane was treated with *n*-butyllithium at 0° for 30 min and the reaction mixture added to dry ice, a small amount (~ 5 %) of 4-*tert*-butylcyclohexene was obtained; most of the starting material being recovered unchanged, as shown by vapor phase chromatography and infrared spectra. The same product was obtained with lithium covered with copper[9] or with *n*-butyllithium in ether. However, it is noteworthy that the reaction proceeds much faster in ether than in pentane.

The *trans*-bromide (II) reacts with *n*-butyllithium giving the same product, but only under more drastic conditions than for the *cis*-isomer. Thus, no 4-*tert*-butylcyclohexene could be isolated when (II) was treated with *n*-butyllithium in pentane at 0° for 30 min. However, treatment of (II) with *n*-butyllithium in ether for 4 h at 25° gave, after carbonation, 4-*tert*-butylcyclohexene in 25 % yield.

In both systems studied the elimination reaction is the predominant one. An analogous behaviour is observed in the exchange reactions of butyllithium with vinyl

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bromides containing hydrogen atoms on both the α- and β-carbons (–CH=CHBr), when the main or even the sole product is an acetylene derivative[1,12,13].

It was hoped that by employing the corresponding *cis*- and *trans*-mercuric bromide (III, IV), it might be possible to prepare the desired lithium reagents. These two mercuric bromides have been prepared and separated by a method analogous to that used for *cis*- and *trans*-4-methylcyclohexyl mercuric bromide[14]. The isomer with the lower solubility and higher melting point was assumed to be isomer(IV). The low melting form undergoes isomerization to the high melting form by heating at 170° and this fact is also in agreement with the above assignment. The *cis*- and *trans*-4-methylcyclohexyl mercuric bromide pair shows similar properties[14].

Treatment of *trans*-mercuric bromide (IV) with *n*-butyllithium in ether for 30 min at 0° gave, after carbonation, 4-*tert*-butylcyclohexene and di-*n*-butylmercury in 25 and 30% yield, respectively, without any formation of acid. The same products were also obtained from the *cis*-isomer (III).

EXPERIMENTAL

Preparation of cis- and trans-4-tert-butylcyclohexyl bromide (I, II)

4-*tert*-Butylcyclohexanone[15] was reduced to *trans*-4-*tert*-butylcyclohexanol[16] by using a mixture of aluminum chloride–lithium aluminum hydride. Treatment of the *trans*-4-*tert*-butylcyclohexanol with phosphorus pentabromide[10] gave the *cis*-bromide (I), b.p. 73–74°/2.5 mm (ref.[10] b.p. 70°/2 mm).

The *trans*-bromide (II) was prepared by treating the silver salt of 4-*tert*-butylcyclohexanecarboxylic acid[17] with bromine[11]. The reaction product was contaminated with *cis*-isomer (I), which was destroyed by treating the reaction mixture with a solution of potassium hydroxide. Upon removal of the solvent the residue was repeatedly fractionated to give the *trans*-bromide (II), b.p. 117–119°/23 mm (ref.[10] b.p. 120°/24 mm).

Vapor-phase-chromatographic analysis of (I) and (II) through an 8-ft. column packed with silicone at 160° gave single peaks with retention times 22.8 and 24 min respectively. Furthermore, the infrared spectra of (I) and (II) in carbon disulfide were almost identical with those given in the literature[10].

Reaction of n-butyllithium with cis- and trans-bromide (I, II)

In a typical experiment, to a solution of 0.5 g of (I) in 20 ml of dry pentane cooled at 0° under an atmosphere of dry nitrogen was added a 10% excess of a solution of *n*-butyllithium in pentane[18]. After 30 min at this temperature the reaction mixture was poured into a large excess of dry ice. On warming to room temperature the solution was washed with dilute hydrochloric acid, then extracted with 0.4 *N* sodium hydroxide solution. The aqueous solution was acidified with 10 *N* sulfuric acid but the only acid isolated was valeric acid. [The separation and estimation of *cis*- and *trans*-4-*tert*-butylcyclohexanecarboxylic acid, if formed, might have been achieved by transforming the acids to methyl esters with diazomethane and submitting to vapor phase chromatography. The retention times of authentic samples were 10.2 and 11.8 min, respectively, using an 8-ft. column packed with silicone at 200°.]

The organic layer of the reaction product was washed with water and dried over anhydrous sodium sulfate. Removal of the solvent gave an oil, which was submitted to vapor phase chromatography through an 8-ft. column packed with silicone at 160°. The retention times of 6.7 and 22.8 min were identical with those of 4-*tert*-butylcyclohexene and *cis*-bromide (I), respectively. The yield of 4-*tert*-butylcyclohexene was ~ 5 %. The infrared spectrum in carbon tetrachloride of the compound with retention time 6.7 min was identical with that of 4-*tert*-butylcyclohexene (b.p. 60–61°/14 mm). The same product was also obtained by using lithium covered with copper[9] or after changing solvent, temperature and reaction time.

No reaction took place when *trans*-bromide (II) was treated for 30 min with *n*-butyllithium in pentane at 0°, but when the reaction was carried out in ether at 25° for 4.5 h 4-*tert*-butylcyclohexene was obtained in 25 % yield as shown by vapor phase chromatography.

Preparation of cis- and trans-4-tert-butylcyclohexyl mercuric bromide (III, IV)

4-*tert*-Butylcyclohexyl bromide (40 g) was treated with 4.5 g of magnesium turnings in 220 ml of anhydrous ether. To the Grignard solution was added 65 g of mercuric bromide and the mixture was stirred for 2 h, decomposed with ice and acidified with 25 ml of concentrated hydrobromic acid. Upon removal of the ether the remaining solid material (50 g) was recrystallized from benzene. The first three crops were crude *trans*-mercuric bromide (IV). These were recrystallized from a mixture of benzene–ether to give 25 g (33 % yield) of (IV), m.p. 216°, whose infrared spectrum (potassium bromide disc) showed peaks at 1482, 1450, 1395, 1365, 1270, 1142, 1070, 1000, 885 and 670 cm^{-1}. (Found: C, 28.4; H, 4.5. $C_{10}H_{19}BrHg$ calcd.: C, 28.6; H, 4.6 %.)

Separation of the mother liquid on alumina gave *cis*-mercuric bromide (III) (10 %), m.p. 140–142° (after recrystallization from benzene); infrared spectrum (potassium bromide disc) had peaks at 1480, 1447, 1395, 1345, 1310, 1245, 1137, 1010, 900, 765 and 655 cm^{-1}. (Found: C, 28.9; H, 4.5 %.)

The infrared spectrum of *cis*-(III) became identical with that of *trans*-(IV) after being heated at 170° for a few minutes.

Reaction of n-butyllithium with cis- and trans-mercuric bromide (III, IV)

The *trans*-mercuric bromide (IV), treated, as previously described, with *n*-butyllithium in ether at 0° for 30 min followed by carbonation, left no acid. Removal of the solvent from the organic layer left an oil, which when submitted to vapor phase chromatography through an 8-ft. column packed with silicone at 160° gave mainly two peaks with retention times 6.7 and 20.6 min, identical with those for 4-*tert*-butylcyclohexene and di-*n*-butylmercury, respectively .These compounds, whose infrared spectra were identical with those of authentic samples, were obtained in yields of 25 and 30 %, respectively.

The same products were also obtained from *cis*-mercuric bromide (III) under the same conditions or after changing solvent, temperature and reaction time.

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SUMMARY

Cis- or *trans*-4-*tert*-butylcyclohexyl bromide give 4-*tert*-butylcyclohexene with *n*-butyllithium while the corresponding mercuric bromides give 4-*tert*-butylcyclohexene and di-*n*-butylmercury, although from these reactions the formation of stereoisomeric lithium reagents was expected.

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