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Abstract

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INVESTIGATION OF THE MECHANISM OF ALKYLATION OF AMINES BY N-TRIMETHYL-α-PHENETHYLAMMONIUM IODIDE

It is known that ammonium salts of the type $Ar{-}CH_2{-}N^{\oplus} \equiv$ can alkylate primary and secondary amines by transfer of the $ArCH_2$ radical from one nitrogen atom to another ([1–3,5]).

Alkylation of amines by means of ammonium compounds is of interest in that, in this reaction, the final and starting substances belong to one and the same class of compounds:

$$R'{-}N : + R{-}\overset{\oplus}{N} \longrightarrow R'{-}\overset{\oplus}{N}{-}R + : N{-}$$

The mechanism of this reaction has not yet been studied. We investigated the alkylation of piperidine and morpholine by optically active N-trimethyl-α-phenethylammonium iodide:

$$\text{piperidine} + Ph{-}\overset{\bullet}{C}H(CH_3){-}\overset{\oplus}{N}Me_3 \longrightarrow \text{piperidinium}{-}\overset{\bullet}{C}H(Ph)(CH_3) \longrightarrow \text{piperidine}{-}\overset{\bullet}{C}H(Ph)(CH_3)$$

This reaction may proceed ([4]) either by a synchronous mechanism (scheme (A)), or by an asynchronous mechanism, with intermediate formation of a free carbonium ion (scheme (B)):

(A) $\text{piperidine} + Ph{-}\overset{\bullet}{C}H(CH_3){-}\overset{\oplus}{N}Me_3 \longrightarrow \text{piperidine}{-}\overset{\bullet}{C}H(Ph)(CH_3)$

(B) $Ph{-}\overset{\bullet}{C}H(CH_3){-}\overset{\oplus}{N}Me_3 \longrightarrow Ph{-}\overset{\oplus}{C}H(CH_3) \longrightarrow Ph{-}\overset{\bullet}{C}H(CH_3){-}N(\text{piperidyl})$

In the case in which the reaction proceeds by the synchronous mechanism (scheme (A)), the resulting N-α-phenethylpiperidine should possess optical activity. If the reaction proceeds through intermediate formation of a free carbonium ion (scheme (B)), then the reaction product should not possess optical activity.

It was found that, in the substitution process, the optical activity of the phenethyl radical is retained: the N-α-phenethylpiperidine obtained from the *d*-salt rotated to the left, while the N-α-phenethylmorpholine obtained from the *l*-salt rotated to the right. It follows from this that the reaction proceeds by the synchronous mechanism.

Since the configurations of optically active N-α-phenethylpiperidines had not previously been established, it became necessary to determine the configuration of the levorotatory N-α-phenethylpiperidine obtained by us.

For this purpose we synthesized *l*-N-α-phenethylpiperidine by a method in which the configuration at the carbon atom is not changed during the reaction. We started from *l*-α-phenethylamine, which, as a result of interaction with 1,5-dibromopentane, was converted into N-α-phenethylpiperidine, likewise possessing levorotation:

$$\bullet\mathrm{CH}(\mathrm{Ph})-\mathrm{N}\begin{pmatrix}\mathrm{H}\\ \mathrm{H}\end{pmatrix} \xrightarrow[-2\mathrm{HBr}]{\mathrm{Br(CH_2)_5Br}} \bullet\mathrm{CH}(\mathrm{Ph})-\mathrm{N}$$

Since in the reaction used the asymmetric center is not affected, it may be asserted that levorotatory N-α-phenethylpiperidine belongs to the *l*-series.

It follows from this that, in the interaction of *d*-N-trimethyl-α-phenethylammonium iodide with piperidine (and also, apparently, with morpholine), inversion of the configuration of the α-phenethyl radical takes place.

It was also found that the optical purity of N-α-phenethylpiperidine obtained in the alkylation of piperidine by *d*-N-trimethyl-α-phenethylammonium iodide depends on the duration of the reaction. On heating for 12 hr at 125°, the N-α-phenethylpiperidine formed had the specific rotation $[\alpha]_D^{20} = -7.5°$, whereas heating for 3 hr at the same temperature led to the production of a substance with specific rotation $[\alpha]_D^{20} = -15.6°$.

Apparently, the decrease in optical purity on heating occurred as a result of a secondary reaction of symmetrical substitution:

$$\text{piperidine–NH} + \bullet\mathrm{CH}(\mathrm{Ph})(\mathrm{CH_3}) - \overset{\oplus}{\mathrm{N}}\mathrm{H}\text{–piperidine} \rightleftharpoons \text{piperidine–}\overset{\oplus}{\mathrm{N}}\mathrm{H} - \bullet\mathrm{CH}(\mathrm{CH_3}) + \text{HN–piperidine}$$

Obviously, repeated occurrence of this process must have racemization as its consequence.

Experimental Part

1. Interaction of *d*-N-trimethyl-α-phenethylammonium iodide with piperidine. 0.1 mole of *d*-N-trimethyl-α-phenethylammonium iodide [(4)] and

0.3 mole of piperidine were heated in a nitrogen atmosphere for 12 hr at 125°. The reaction products were dissolved in 100 ml of water; the resulting solution was made alkaline and extracted with benzene. The benzene extract was dried over powdered caustic potash.

As a result of distillation on a column there were obtained: 6.47 g of *d*-N-dimethyl-α-phenethylamine with b.p. 66–70° (8 mm), n_D^{18} 1.5032, d_4^{18} 0.9054, $[\alpha]_D^{18} = 69.0°$ (corresponding to an optical purity of 96%), and 5.47 g of N-α-phenethylpiperidine with b.p. 118–119° (9 mm), n_D^{18} 1.5292, d_4^{18} 0.9622, $[\alpha]_D^{18} = -7.5°$ (in methanol, $c = 8.1$).

In an analogous experiment, in which the reaction time was 3 hr, 3.00 g of N-α-phenethylpiperidine was obtained. B.p. 118–119° (9 mm), n_D^{20} 1.5279, d_4^{20} 0.9604, $[\alpha]_D^{20} = -15.6°$ (in methanol, $c = 9.1$).

2. Preparation of *l*-N-α-phenethylpiperidine. A mixture of 0.1 mole of *l*-α-phenethylamine* (in a threefold volume of ether) and 0.042 mole of 1,5-dibromopentane [6] was placed in a flask, which was attached to a reflux condenser equipped with a total-condensation head. The ether was slowly distilled off while heating on a water bath. The reaction began after

* Obtained by the method described in the literature [7], $[\alpha]_D^{20} = -39.8°$.

as soon as about half of the ether had been distilled off. After 4 hours the heating was stopped, and the contents of the flask were treated with 30 ml of 15% hydrochloric acid. The neutral substances were extracted with benzene. The aqueous solution was made alkaline with 8 N NaOH, and the bases that separated were extracted with benzene.

As a result of distillation, 5.93 g of *l*-α-phenethylamine, b.p. 68-69° (8 mm), and 7.43 g of *l*-N-α-phenethylpiperidine, b.p. 114-114.5° (7 mm), were obtained. The latter substance had the following constants: d_4^{20}0.9606, n_D^{20}1.5268, $[\alpha]_D^{20} = -33.0°$ (in methanol, $c = 7.2$). Picrate, m.p. 178-178.5°.

Found, %:		C 82.32; H 10.14
$C_{13}H_{19}N$.	Calculated, %:	C 82.46; H 10.12

3. Reaction of *l*-N-trimethyl-α-phenethylammonium iodide with morpholine. 0.1 mole of *l*-N-trimethyl-α-phenethylammonium iodide* and 0.4 mole of morpholine were heated in an atmosphere of nitrogen at 135° for 4.5 hours. The reaction mixture was dissolved in water and made alkaline with 8 N NaOH. The oil that separated was extracted with benzene. The benzene extract was dried with potassium hydroxide. The reaction products were distilled using a herringbone dephlegmator 120 mm high.

6.9 g of N-dimethyl-α-phenethylamine was obtained, b.p. 68.5-69.5° (8 mm), n_D^{20}1.5027, d_4^{20}0.9032, $[\alpha]_D^{23}$ (in methanol) = −29.8°, and 6.32 g of N-α-phenethylmorpholine, for which the following constants were found: b.p.

123–123.5° (8 mm), d_4^{20}1.028, n_D^{20}1.5278, $[\alpha]_D^{18} = +16.2°$ (in 90% ethanol, $c = 14.6$).

Calculated on the basis of these data, the specific rotation for pure N-α-phenethylmorpholine should be not less than +26.6°.

In a similar way, by the reaction of *dl*-N-trimethyl-α-phenethylammonium iodide with morpholine, *dl*-N-α-phenethylmorpholine was obtained. B.p. 128–9° (10 mm), d_4^{20}1.018, n_D^{20}1.5272, picrate m.p. 194–194.5°.

Found, %:		C 75.25; H 8.96; N 7.55
$C_{12}H_{17}ON$.	Calculated, %:	C 75.33; H 8.96; N 7.32

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* Optical purity 61%.

Note: Figure translations are in progress. See original paper for figures.