574. *Stereochemistry of* cyclo*Hexane Derivatives. Part VI.* The* 3-*Amino*cyclo*hexanols.*

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cis-3-Amino*cyclo*hexanol has been prepared stereospecifically from *cis*-3-hydroxy*cyclo*hexanecarboxylic acid, and both the *cis*- and the *trans*-isomer have been isolated after hydrogenation of *m*-acetamidophenol. The reactions of the 3-amino-alcohols and 1 : 3-diamines with nitrous acid are discussed, and reactions proceeding through participation of neighbouring groups have been examined. The infrared absorption spectra of the *cis*-3-amino*cyclo*hexanols have been examined in the 3 μ region, and intramolecular hydrogen bonds are demonstrated. No evidence for an intramolecular hydrogen bond in *cis*-1 : 3-diamino*cyclo*hexane could be obtained.

Although considerable attention has been paid to the 2-amino*cyclo*hexanols [1] the related 3-amino-compounds appear not to have been described. Hydrogenation of *m*-aminophenol [2] and its derivatives has been examined but pure isomers have not been described. It seemed desirable to assign configurations unambiguously from the outset and accordingly we undertook a preparation of *cis*-3-amino*cyclo*hexanol using the stereospecific Curtius sequence [3] with *cis*-3-hydroxy*cyclo*hexanecarboxylic acid.[4] The derived hydrazide was converted into the azide which was conveniently decomposed in hot benzene, the *iso*cyanate giving the cyclic urethane (I) from which *cis*-3-amino*cyclo*hexanol was obtained by basic hydrolysis. The urethane was re-formed when the amino-alcohol was heated with ethyl carbonate or, preferably, together with aniline, by melting the phenylcarbamoyl derivative. Reduction of urethanes with lithium aluminium hydride [5] has been shown to give methylamines and, when applied to the compound (I), afforded *cis*-3-methylamino*cyclo*hexanol in good yield.

Larger quantities of material were sought by reduction of benzenoid compounds. Reduction of *m*-aminophenol is complicated by hydrogenolysis, but good yields of the 3-acetamido*cyclo*hexanols are obtained from *m*-acetamidophenol. We have separated this mixture by utilising the greater solubilities of the *trans-ON*-diacetyl derivative and *cis*-benzamide. The configuration of the *trans*-isomer follows from oxidation of *cis*- and *trans*-3-acetamido*cyclo*hexanol to the same 3-acetamido*cyclo*hexanone. Attempts to obtain larger quantities of the *trans*-isomer were made by the hydrogenation of this ketone under acid conditions,[6] but a considerable quantity of the *cis*-compound was also formed. Reaction of *cyclo*hexylamines with nitrous acid is controlled by the position of the amino-group, equatorial amines giving mainly alcohols of the same configuration whereas the axial amines produce a large amount of olefin.[7] When treated in this way *cis*-3-amino*cyclo*hexanol gave about 15% of the *cis*-diol, but the major product (40%) was an unsaturated aldehyde (max. for $C{=}CH_2$ at 913 and 987 $cm.^{-1}$) corresponding to hex-5-enal. This structure was established by reduction to the alcohol with lithium aluminium hydride and comparison with a sample similarly obtained from hex-5-enoic acid. With nitrous acid *trans*-3-amino*cyclo*hexanol and *cis*- and *trans*-1 : 3-diamino*cyclo*hexane gave hex-5-enal.

* Part V, *J.*, 1956, 4391.

[1] (*a*) McCasland, Clark, and Carter, *J. Amer. Chem. Soc.*, 1949, **71**, 637; McCasland and Smith, *ibid.*, 1950, **72**, 2190; McCasland and Horswill, *ibid.*, 1951, **73**, 3923; McCasland, *ibid.*, p. 2293, 2295; Fodor and Kiss, *ibid.*, 1950, **72**, 3495; (*b*) Winstein, Goodman, and Boschan, *ibid.*, pp. 2311, 4669.

[2] Billman and Buehler, *ibid.*, 1953, **75**, 1345.

[3] Wallis and Lane, "Organic Reactions," Wiley, New York, 1946, Vol. III, p. 272; Hewgill and Jefferies, *J.*, 1956, 805.

[4] Perkin and Tattersall, *J.*, 1907, **91**, 489.

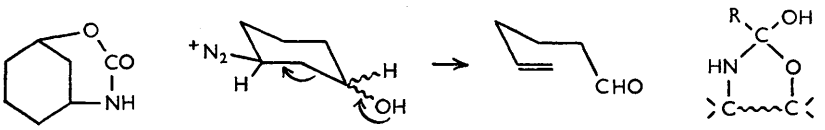
[5] Dannley, Lukin, and Shapiro, *J. Org. Chem.*, 1955, **20**, 92.

[6] Barton, *J.*, 1953, 1027.

[7] Bose, *Experientia*, 1953, **9**, 256; Mills, *J.*, 1953, 260.

A similar splitting has been observed in the dehydration of acyclic 1 : 3-diols [8] and in the solvolysis of some steroid 3 : 5-diols as the 3-toluene-*p*-sulphonates.[9] Since our work was completed the rupture in low yield of some highly substituted acyclic 3-amino-alcohols with nitrous acid has been reported.[10] It has been suggested [11] that oxides are intermediates in the rupture of the diols and their monotoluene-*p*-sulphonates, and although the formation of an oxide could be expected for the reaction of *trans*-3-amino*cyclo*hexanol an unusual mechanism would be required for the *cis*-isomer. The mechanism (II ⟶ III) is accordingly preferred.

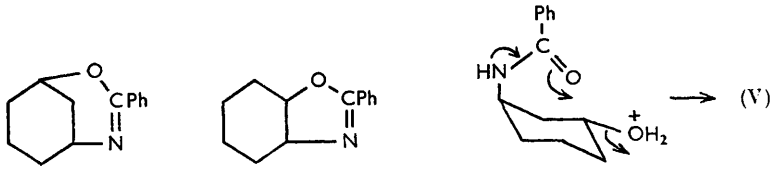
The reversible N ⟶ O migration of acyl groups in amino-alcohols has been studied extensively.[12] For migration with retention of configuration the formation of a cyclic intermediate (IV) is necessary. Such an intermediate could arise from *cis*-3-amino*cyclo*hexanol derivatives in the diaxial conformation. All attempts to effect migration under standard conditions with the acetamide or benzamide failed. Treatment of the latter with hot aqueous acid gave a base which was not the expected *cis*-3-amino*cyclo*hexyl benzoate but gave analyses for a dehydration product. The infrared absorption spectrum showed absence of OH and NH groups and bands at 1491, 1582, and 1598 cm.$^{-1}$ due to the phenyl



(I) (II) (III) (IV)

group, together with a band at 1643 cm.$^{-1}$. This indicated the dihydro-oxazine structure (V) arising by dehydration of the corresponding compound (IV). The analogous oxazoline (VI) has been obtained on reaction of *trans*-2-benzamido*cyclo*hexanol and its derivatives involving participation of the benzamido-group.[1b] The oxazoline (VI) showed maxima at 1497, 1581, and 1602 cm.$^{-1}$ due to the phenyl group and at 1642 cm.$^{-1}$ which must be the C=N stretching frequency which is known to occur in this region; [13] and the band at 1643 cm.$^{-1}$ in the oxazine derivative (V) is similarly assigned.

To determine if participation of the benzamido-group might occur in *trans*-3-benzamido-*cyclo*hexanol the latter was submitted to acid hydrolysis and, as for the *cis*-isomer, the oxazine derivative (V) was obtained. This reaction must involve a rear displacement (VII ⟶ V).



(V) (VI) (VII)

The dihydro-oxazine (V) was prepared in good yield by treating the *trans*-benzamide with thionyl chloride. Winstein, Goodman, and Boschan [1b] report that solvolysis of *trans*-2-benzamido*cyclo*hexyl toluene-*p*-sulphonate occurs readily with formation of the oxazoline ester, and similarly we find boiling in benzene sufficient to convert the 3-isomer into the toluene-*p*-sulphonate of the dihydro-oxazine (V). Solvolysis of the *trans*-3-benzamido*cyclo*hexyl ester was examined in ethanolic potassium acetate at 50·2° and k_1 was

[8] Zimmerman and English, *J. Amer. Chem. Soc.*, 1954, **76**, 2285, 2291, 2294.
[9] Clayton and Henbest, *Chem. and Ind.*, 1953, 1315.
[10] English and Bliss, *J. Amer. Chem. Soc.*, 1956, **78**, 4057.
[11] See Wasserman in Newman's " Steric Effects in Organic Chemistry, Wiley, New York, 1956, p. 375.
[12] Phillips and Baltzly, *J. Amer. Chem. Soc.*, 1947, **69**, 200; Welsh, *ibid.*, 128; 1949, **71**, 3500; Fodor and Kiss, *J.*, 1952, 1589; 1951, 1858; 1950, 3495; Wendler, *Experientia*, 1953, **9**, 416.
[13] Bellamy, " The Infra-red Spectra of Complex Molecules," Methuen, London, 1954, p. 223.

found to be $3{\cdot}0(\pm 0{\cdot}3) \times 10^{-4}$ l. mole^{-1} sec.$^{-1}$. This reaction is significantly faster than that ($k_1 = 1{\cdot}2 \times 10^{-4}$ at 49·8°) reported for the *trans*-2-benzamido*cyclo*hexyl ester.[1b] Two effects which might contribute to this result are the smaller inductive effect of the benzamido-group in the 3-position and the small energy difference between the two chair conformations for this isomer, whereas the *trans*-2-benzamido*cyclo*hexyl ester would exist only to a small proportion in the diaxial conformation necessary for participation.[14]

Hydrogen bonding between amino- and hydroxyl groups has been demonstrated in a number of 1 : 2-amino-alcohols.[15] Kanzawa,[16] in a comprehensive study of the ephedrines and related compounds by the infrared method, has shown that the intramolecular bond is directed to the more basic nitrogen atom, although some free hydroxyl absorption is present, and that the magnitude of the shift ($\Delta\nu$ 170) is considerably greater than in diols. The presence of an intramolecular hydrogen bond has been demonstrated in *cis-cyclo*hexane-1 : 3-diol [17] and a similar effect would be expected in the corresponding amino-alcohol. For a wider examination we prepared *cis*-3-ethylamino*cyclo*hexanol by reduction of the acetamide with lithium aluminium hydride, and *cis*-3-dimethylamino*cyclo*hexanol by methylation of the amino-alcohol. All the *cis*-3-amino*cyclo*hexanols studied (see Table) show some free hydroxyl and in addition a broad intense band arising from intramolecular bonded hydroxyl.

In general the weak NH absorption is obscured by the bonded hydroxyl band. As expected the latter is absent in *trans*-3-amino*cyclo*hexanol. The hydrogen bonding must arise from a diaxial conformation and the free hydroxyl is most probably due to a proportion of the diequatorial conformation. Two factors which will control the proportions of the chair forms are the basicity of the acceptor atom and the Pitzer strain associated with the diaxial conformation. Successive alkyl substitution of the amino-group will increase its basicity and should give a stronger bond as measured by $\Delta\nu$. The values for the latter, given in the Table, increase as expected. Although alkyl substitution increases $\Delta\nu$, the tendency for a larger proportion of diaxial form will be opposed by the resultant increase in Pitzer strain and this probably accounts for the greater proportion of free hydroxyl in the dimethylamino*cyclo*hexanol than in the methylamino*cyclo*hexanol. For comparison, *trans*-2-amino*cyclo*hexanol has been examined, showing $\Delta\nu$ (108 cm.$^{-1}$)

Infrared bands (cm.$^{-1}$) and ε (in parentheses).

	Free OH	Bonded OH	NH	$\Delta\nu$
cis-3-Amino*cyclo*hexanol	3622 (26)	3366 (32)	3382	256
trans-3-Amino*cyclo*hexanol	3629 (42)	—	3388 (16) 3300 (13)	
cis-3-Methylamino*cyclo*hexanol	3621 (23)	3337 (64)	—	284
cis-3-Ethylamino*cyclo*hexanol	3621 (23)	3322 (64)	—	299
cis-3-Dimethylamino*cyclo*hexanol	3623 (32)	3301 (32)	—	322
trans-2-Amino*cyclo*hexanol	3629 (13)	3521 (22)	3391 (14) 3325 (12)	108
cis-1 : 3-Diamino*cyclo*hexane	—	—	3381 3318	
trans-1 : 3-Diamino*cyclo*hexane	—	—	3382 3312	

considerably less than for the 3-amino-alcohols, as expected for the five-membered ring structure in the former. The possibility of stabilisation of the diaxial conformation of *cis*-1 : 3-diamino*cyclo*hexane has been discussed before.[18] In dilute carbon tetrachloride both the *cis*- and the *trans*-isomer show similar absorptions assignable to free NH vibrations only.

[14] Alt and Barton, *J.*, 1954, 4284.
[15] Bergman, Gil-Av, and Pinchas, *J. Amer. Chem. Soc.*, 1953, **75**, 68.
[16] Kanzawa, *Bull. Chem. Soc. Japan*, 1956, **29**, 398, 479, 604.
[17] Kuhn, *J. Amer. Chem. Soc.*, 1952, **74**, 2492.
[18] Hewgill and Jefferies, *J.*, 1956, 805.

Experimental

Light petroleum had b. p. 60—80°. Microanalyses were by C.S.I.R.O. Microanalytical Laboratory, Melbourne.

cis-3-*Amino*cyclo*hexanol*.—*cis*-3-Hydroxy*cyclo*hexanecarboxylic acid was prepared by hydrogenation of *m*-hydroxybenzoic acid in the presence of W-7 nickel catalyst at 180—200°/1000 lb. per sq. in. The pure acid had m. p. 130—132°. The lactone (6 g.) was converted into the *hydrazide* in boiling alcoholic hydrazine hydrate, and crystallised from alcohol–ethyl acetate as plates, m. p. 179° (Found: C, 53·3; H, 8·9; N, 17·9. $C_7H_{14}O_2N_2$ requires C, 53·1; H, 8·9; N, 17·8%). The hydrazide (4 g.) in N-hydrochloric acid (100 ml.) and ether (100 ml.) was cooled to 0°, and 25% sodium nitrite solution (16 ml.) added during 30 min. with stirring. The ether was separated and the aqueous layer extracted with ether (3 × 30 ml.). The dried ether solution was added during an hour to boiling benzene, and ether removed by fractionation and boiling continued for 2 hr. The benzene was filtered through alumina and evaporated. Crystallisation from benzene light petroleum gave 2-*oxa*-4-*aza*bicyclo[3 : 3 :1]-*nonan*-3-*one* as prisms (2·5 g.), m. p. 154—155°, forming a hydrate, m. p. 82—83° on exposure to air (Found: C, 53·2; H, 8·1; N, 8·9. $C_7H_{11}O_2N,H_2O$ requires C, 52·8; H, 8·3; N, 8·8%). This urethane (2·0 g.) was boiled for 6 hr. with 10% aqueous sodium hydroxide (150 ml.) and then continuously extracted with chloroform. Distillation of the extract gave the hygroscopic cis-3-*amino*cyclo*hexanol*, b. p. 128°/18 mm., m. p. 70°, pK_a 10·05 (Found: C, 62·7; H, 11·5; N, 12·0. $C_6H_{13}ON$ requires C, 62·6; H, 11·3; N, 12·2%).

cis-3-*Benzamido*cyclo*hexanol*, prepared by the Schotten–Baumann method and crystallised from chloroform–light petroleum, formed needles, m. p. 155° (Found: C, 71·6; H, 7·8; N, 6·4. $C_{13}H_{17}O_2N$ requires C, 71·2; H, 7·8; N, 6·4%). The ON-*diacetyl derivative*, prepared by boiling acetic anhydride, formed needles, m. p. 119—120° (Found: C, 60·5; H, 8·7; N, 7·3. $C_{10}H_{17}O_3N$ requires C, 60·3; H, 8·6; N, 7·0%), from ethyl acetate. cis-3-*Acetamido*cyclo*hexanol* was prepared by hydrolysis of the diacetate with N-sodium hydroxide at room temperature during 30 min. and isolated by continuous extraction with chloroform. Crystallisation from ethyl acetate gave plates, m. p. 119—121° (Found: C, 60·6; H, 9·7; N, 8·8. $C_8H_{15}O_2N$ requires C, 61·1; H, 9·6; N, 8·9%).

cis-3-*Acetamido*cyclo*hexyl benzoate* was prepared from the acetamide with 1 mol. of benzoyl chloride in pyridine. It formed needles, m. p. 126—127° (Found: C, 69·3; H, 7·2; N, 5·1. $C_{15}H_{19}O_3N$ requires C, 68·9; H, 7·4; N, 5·4%), from acetone–light petroleum. cis-N-*Acetyl*-N-*benzoylamino*cyclo*hexyl benzoate* was prepared similarly, by using an excess of benzoyl chloride. Crystallisation from acetone gave prisms, m. p. 145—146° (Found: C, 72·6; H, 6·2; N, 3·6. $C_{22}H_{23}O_4N$ requires C, 72·3; H, 6·3; N, 3·8%). The N-*phenylcarbamoyl derivative*, prepared with 1 mol. of phenyl *iso*cyanate in benzene, separated from alcohol as needles, m. p. 207° (Found: C, 66·7; H, 7·7; N, 11·8. $C_{13}H_{18}O_2N_2$ requires C, 66·7; H, 7·7; N, 12·0%).

Cyclic Urethane (I).—(*a*) *cis*-3-Amino*cyclo*hexanol (1 g.) and ethyl carbonate (1·1 ml.) were heated at 180° during 5 hr. The product was taken up in ethyl acetate. Separation from amorphous material and evaporation gave a residue which was repeatedly extracted with hot ether. Evaporation of the ether and crystallisation from benzene–light petroleum gave prisms (0·1 g.), m. p. and mixed m. p. 154—155° (cf. above).

(*b*) The *N*-phenylcarbamoyl derivative (2·0 g.) was heated from 180° to 210° during 10 min. After being washed with a little ether the residue crystallised as above to give the urethane (0·8 g.), m. p. and mixed m. p. 154—155°.

cis-3-*Methylamino*cyclo*hexanol*.—The urethane (I) (2 g.) in suspension in ether (100 ml.) was treated with lithium aluminium hydride (1·2 g.). After 8 hr. the *product* was worked up in the usual way and isolated by continuous extraction with chloroform. Distillation and crystallisation from benzene gave prisms (1·0 g.), m. p. 87—88° (Found: C, 65·3; H, 11·7; N, 11·1. $C_7H_{15}ON$ requires C, 65·1; H, 11·6; N, 10·8%). The *benzamide* (Schotten–Baumann) gave prisms, m. p. 103—104° (Found: C, 72·0; H, 8·3; N, 5·8. $C_{14}H_{19}O_2N$ requires C, 72·1; H, 8·1; N, 6·0%).

cis-3-*Ethylamino*cyclo*hexanol*, prepared by similar reduction of *cis*-3-acetamido*cyclo*hexanol, crystallised from ethyl acetate as prisms, m. p. 89—90° (Found: C, 67·0; H, 11·9; N, 9·9. $C_8H_{17}ON$ requires C, 67·1; H, 11·9; N, 9·8%). Its N-*phenylcarbamoyl derivative*, prepared in benzene, crystallised from ethyl acetate as needles, m. p. 135° (Found: C, 68·6; H, 8·2; N, 10·9. $C_{15}H_{22}N_2O_2$ requires C, 68·7; N, 8·4; N, 10·7%).

cis-3-*Dimethylamino*cyclo*hexanol*.—*cis*-3-Amino*cyclo*hexanol (1 g.) was methylated by the standard procedure with formaldehyde and formic acid. Isolation of the basic product with chloroform and distillation gave the *dimethylamino-alcohol*, b. p. 130°/20 mm. (Found: C, 66·7; H, 12·0; N, 10·0%; equiv., 147. $C_8H_{17}ON$ requires C, 67·1; H, 11·9; N, 9·8%; equiv., 143). The hygroscopic base crystallised on refrigeration but could not be recrystallised.

Hydrogenation of m-*Acetamidophenol*.—This was carried out as described by Billman and Buehler.[2] Some *cis*-3-acetamido*cyclo*hexanol was separated as a hydrate on fractional crystallisation from ethyl acetate. A more convenient process was acetylation with boiling acetic anhydride, crystallisation from ethyl acetate then giving the *cis*-diacetate, m. p. and mixed m. p. 119—120°. The mother-liquors were hydrolysed with hot 10% aqueous sodium hydroxide during 4 hr., and the bases continuously extracted with chloroform and distilled. Reacetylation gave a further crop of *cis*-diacetate and the residues were hydrolysed and benzoylated directly by addition of benzoyl chloride to the alkali solution. Crystallisation of the product from chloroform readily gave trans-3-*benzamido*cyclo*hexanol* as prisms, m. p. 169° (Found: C, 71·1; H, 7·7; N, 6·5. $C_{13}H_{17}O_2N$ requires C, 71·2; H, 7·8; N, 6·4%) depressed by about 30° in admixture with the *cis*-isomer. The proportion *cis* : *trans* is approximately 4 : 1.

trans-3-*Amino*cyclo*hexanol*.—The benzamide (11 g.) was boiled with 10% sodium hydroxide solution (300 ml.) for 24 hr. Filtration from a trace of unchanged amide and continuous extraction with chloroform gave a crystalline residue of base, b. p. 122°/18 mm., which recrystallised from benzene as plates, m. p. 94—95° (Found: C, 62·9; H, 11·4; N, 12·5. $C_6H_{13}ON$ requires C, 62·6; H, 11·3; N, 12·2%). The pK_a was 10·1. The N-*phenylcarbamoyl derivative* prepared as for the *cis*-analogue crystallised from acetone as plates, m. p. 187—188° (Found: C, 66·8; H, 7·6; N, 12·3. $C_{13}H_{18}O_2N_2$ requires C, 66·7; H, 7·7; N, 12·0%). Only amorphous products were obtained after the urea had been heated at 180—210°, as for the *cis*-isomer. The *diacetate*, prepared as for the *cis*-compound, crystallised from benzene–light petroleum as prisms, m. p. 103° (Found: C, 60·3; H, 8·3; N, 7·2. $C_{10}H_{17}O_3N$ requires C, 60·3; H, 8·6; N, 7·0%). trans-3-*Acetamido*cyclo*hexanol* separated from benzene as plates, m. p. 111—113° (Found: C, 61·3; H, 9·3; N, 9·0. $C_8H_{15}O_2N$ requires C, 61·1; H, 9·6; N, 8·9%). trans-3-*Benzamido*cyclo*hexyl toluene*-p-*sulphonate* was obtained as described for the 2-isomer.[1b] Crystallisation from warm (<40°) benzene gave plates, m. p. 111° (Found: C, 64·5; H, 6·1; N, 3·6; S, 8·5. $C_{20}H_{23}O_4NS$ requires C, 64·3; H, 6·2; N, 3·8; S, 8·6%).

3-*Acetamido*cyclo*hexanone*.—The *cis*-, the *trans*-, and the epimeric mixture of acetamido-*cyclo*hexanols were oxidised with chromic acid in acetic acid in the usual way during 24 hr. Isolation of the products with chloroform and crystallisation from benzene gave, in each case, the *ketone* as prisms, m. p. 86° (Found: C, 62·3; H, 8·3; N, 9·1. $C_8H_{13}O_2N$ requires C, 62·0; H, 8·4; N, 9·0%). The 2 : 4-*dinitrophenylhydrazone* separated from alcohol as needles, m. p. 222—224° (decomp.) (Found: C, 50·4; H, 5·1; N, 20·6. $C_{14}H_{17}O_5N_5$ requires C, 50·2; H, 5·1; N, 20·9%). 3-Acetamido*cyclo*hexanone (2·5 g.) was reduced under atmospheric conditions in acetic acid (20 ml.) with platinic oxide (0·04 g.). After 5 hr. absorption ceased (1·1 mol.). From the product *cis*-3-acetamido*cyclo*hexanol (0·5 g.) was isolated and the residue afforded *trans*-3-benzamido*cyclo*hexanol (0·7 g.).

Reactions with Nitrous Acid.—(*a*) *cis*-3-Amino*cyclo*hexanol (3·0 g.) in water (20 ml.) and acetic acid (5 ml.) was treated with a solution of sodium nitrite (3·0 g.) in water. After 4 hr. the solution (*A*) was treated with sulphamic acid and extracted with ether, and the extract washed with aqueous sodium hydrogen carbonate, dried, and reduced by lithium aluminium hydride. After 30 min. the mixture was worked up in the usual way, and the product isolated with ether and esterified with 3 : 5-dinitrobenzoyl chloride in pyridine. Isolation in the usual manner and repeated crystallisation from light petroleum gave, in addition to an unidentified higher-melting product, the *ester* of hex-5-en-1-ol, m. p. 42—43° (Found: C, 52·8; H, 4·4; N, 9·5. $C_{13}H_{14}O_6N_2$ requires C, 53·1; H, 4·8; N, 9·5%). Bands at 912 and 988 cm.$^{-1}$ (in CS_2) are assigned to $=CH_2$. A sample was similarly prepared from hex-5-enoic acid [19] and had m. p. and mixed m. p. 42—43° with the above sample. The solution (*A*) was exhausted with ether: the residue gave *cis-cyclo*hexane-1 : 3-diol (0·45 g.) on crystallisation from acetone–light petroleum. The m. p. was undepressed on admixture with an authentic sample, m. p. 85—86°, prepared by separation of the benzoates obtained from the sodium–alcohol reduction of *cyclo*hexane-1 : 3-dione.

(*b*) *cis*-3-Amino*cyclo*hexanol (0·2 g.) was treated as above and the exit gases passed through

[19] Linstead and Rydon, *J.*, 1934, 1995.

2 : 4-dinitrophenylhydrazine sulphate solution. After 4 hr. a quantity of the reagent was added to the reaction mixture. The 2 : 4-dinitrophenylhydrazone (0·2 g.) separated from methanol as orange plates, m. p. 96° (lit.,[20] m. p. 94°) (Found : C, 52·2; H, 5·1; N, 19·8. Calc. for $C_{12}H_{14}O_4N_4$: C, 51·8; H, 5·0; N, 20·2%), $=CH_2$ max. at 913 and 987 cm.$^{-1}$ (in CS_2). *trans*-3-Amino*cyclo*hexanol was treated in the same way and gave 30% of the hexenal derivative. *cis*- and *trans*-1 : 3-Diamino*cyclo*hexane gave the same product (m. p. and mixed m. p.) in similar yield.

Reaction of 3-*Benzamido*cyclo*hexanols with Acid.*—The *cis*- and the *trans*-benzamide (1·0 g.) were separately boiled with 15% aqueous sulphuric acid for 4 hr., a homogeneous solution being obtained. On cooling, some unchanged amide was deposited. The solution was basified and extracted with chloroform. Evaporation and crystallisation from light petroleum gave prisms, m. p. 102° (Found : C, 77·9; H, 7·7; N, 6·7. Calc. for $C_{13}H_{15}ON$: C, 77·6; H, 7·5; N, 7·0%). The base was recovered almost unchanged after being boiled with 10% aqueous sodium hydroxide or 10% sulphuric acid during 8 hr. After 48 hr. with the latter a quantity of benzoic acid was obtained.

Reaction of trans-3-*Benzamido*cyclo*hexanol and Thionyl Chloride.*—The amide (1 g.) and thionyl chloride (3 ml.) were left for 3 hr. The mixture was decomposed with water, filtered from a little amorphous material, and boiled for 15 min. Basification, filtration, and crystallisation gave the base (0·7 g.), m. p. and mixed m. p. 102°.

Isomerisation of trans-3-*Benzamido*cyclo*hexyl Toluene*-p-*sulphonate.*—The ester (1·0 g.) was boiled in benzene (20 ml.) for 4 hr. Evaporation and crystallisation from benzene gave the *salt*, m. p. 88—89° (Found : N, 3·4; S, 8·1. $C_{20}H_{23}O_4NS$ requires N, 3·8; S, 8·6%). The free base, obtained in the usual way, had m. p. and mixed m. p. 102°. Solvolysis of the *trans*-3-benzamido*cyclo*hexyl ester was measured in absolute alcoholic potassium acetate as described by Winstein *et al.*[1b]

Attempted Acyl Migrations.—*cis*-3-Acetamido*cyclo*hexanol was left for 3 days in anhydrous methanolic hydrogen chloride at room temperature. Unchanged material was recovered, and quantitative study showed negligible absorption of acid. Similarly the benzamide was recovered unchanged after 30 days in acetone containing N-hydrogen chloride.

Infrared Spectra.—Absorption spectra were measured in a 1 cm. cell in CCl_4 (unless otherwise stated) at concentrations ~0·01M, under the general conditions described previously.[21]

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[20] Kharasch, Kuderna, and Nudenberg, *J. Org. Chem.*, 1953, **18**, 1225.
[21] Cole and Jefferies, *J.*, 1956, 4391.