Tetrahedron Vol 24, pp 3031 to 3041 Pergamon Press 1968 Printed in Great Britain

STUDIES OF THE ELIMINATION OF 1,2-DIARYL-4-DIMETHYLAMINOBUTAN-2-OLS—III[1]

THE CONFIGURATION OF SOME ISOMERIC 1,2-DIARYL-4-DIMETHYLAMINO-3-METHYLBUT-1-ENES

A. F. CASY, A. PARULKAR* and P. POCHA

Department of Pharmacy, Chelsea College of Science, University of London
and
Faculty of Pharmacy, University of Alberta, Edmonton, Alberta†

(*Received in the UK* 14 *August* 1967; *accepted for publication* 23 *October* 1967)

Abstract—Configurations are assigned to isomeric 1,2-diaryl-4-dimethylamino-3-methylbut-1-enes on the basis of differences in the PMR characteristics of isomeric pairs. To aid the work, the influence of α-substituents upon vinylic chemical shifts in a series of *cis* and *trans* α-substituted stilbenes has been determined and interpreted in terms of probable conformations.

ACID catalysed elimination of 1,2-diaryl-4-dimethylamino-3-methylbutan-2-ols (I) was previously shown to result in the exclusive formation of mixtures of the corresponding *cis* and *trans* but-1-enes (II) of unestablished configurations.[2] In view of the use of PMR spectroscopy in assigning configurations to the related butenes (III), in which a 3-Me substituent is absent,[1] the PMR characteristics of a series of isomeric pairs of 3-methylbut-1-enes (II) were recorded (Table 1); data for the minor isomers were derived from spectra of the total elimination product in cases where only the major form was isolated in a pure condition.

$NMe_2 \cdot CH_2 \cdot CHMe \cdot C(OH)Ar \cdot CH_2Ar'$

I

$NMe_2 \cdot CH_2 \cdot CHMe \cdot CAr : CHAr'$ II

$NMe_2(CH_2)_2CPh : CHAr$ III

In the butene isomers III, the *trans* vinylic proton has a 15–16 c/s lower field chemical shift than the corresponding *cis* signal, a difference which provides evidence of configuration[1] (the degree of molecular planarity is greater in the *trans* isomer and hence the *trans* vinylic proton is more deshielded by the aromatic system than the same proton of the *cis* isomer).

In isomeric 1-phenyl and 1-*p*-substituted phenyl-3-methylbutenes II, however, *cis* and *trans* vinylic protons have near-coincident chemical shifts (Table 1, Nos 1–3), results which indicate that vinylic screening factors (which must be similar in such isomeric pairs) are significantly influenced by the additional 3-Me substituent.

* Post Doctoral Fellow, University of Alberta.
† Present address (A.F.C.).

TABLE 1. PMR CHARACTERISTICS OF 1,2-DIARYL-4-DIMETHYLAMINO-3-METHYLBUT-1-ENES IN $CDCl_3$[a]

No.	Aryl groups	Proton group	Form	Chemical shift		Difference[b]
				Major isomer	Minor isomer	
1	1,2-Diphenyl (3:2)[f]	vinylic[d]	base	391	390·5	+ 0·5
			HCl[e]	398·5	397	+ 1·5
		NMe_2	base	134[d]	123[d]	+11
			HCl	171, 168[f] (J 4)	160, 156[f] (J 4)	+11·5
		3-Me	base	68·7[g] (J 7)	66·6[g] (J 7)	+ 2·1
			HCl	90[h] (6)	88[g] (J 7)	+ 2
2	1-*p*-Tolyl-2-phenyl	vinylic[d]	base	388	388	0
			HCl	395	*i*	
		NMe_2	base	132[d]	123[d]	+11
			HCl	171[f]	*i*	—
		3-Me	base	66[g] (J 7)	64·5[g] (J 7)	+ 1·5
			HCl	88[h] (6)	*i*	--
3	1-*p*-MeO-phenyl-2-phenyl	vinylic[d]	base	386·5	386·5	0
			HCl	392	*i*	
		NMe_2	base	135[d]	124[d]	+11
			HCl	168[f]	*i*	--
		3-Me	base	67[g] (J 7)	66[g] (J 7)	+ 1
			HCl	91[h] (6)	*i*	
4	1-*o*-Tolyl-2-phenyl (2:1)[f]	vinylic[d]	base	393	384	+ 9
			HCl	404	397	+ 7
		NMe_2	base	134[d]	120·5[d]	+13·5
			HCl	169[f]	155[f]	+14
		3-Me	base	72[g] (J 7)	62[g] (J 7)	+10
			HCl	95[h] (6)	84[g] (J 7)	+11
5	1-Phenyl-2-*p*MeO phenyl	vinylic[d]	HCl	397	401	− 4
		NMe_2	HCl	171[f] (J 4)	157[f] (J 4)	+14
		3-Me	HCl	90[h] (6)	88[g] (J 7)	+ 2
6	1-*o*-F-phenyl-2-phenyl (3:2)[f]	vinylic[d]	base	395	380	+15
			HCl	405	395	+10
		NMe_2	base	133[d]	122[d]	+11
			HCl	169[f] (J 4)	157[f] (J 4)	+12
		3-Me	base	69[g] (J 7)	64[g] (J 7)	+ 5
			HCl	93·5[h] (6)	88[g] (J 7)	+ 5·5

TABLE 1. PMR CHARACTERISTICS OF 1,2-DIARYL-4-DIMETHYLAMINO-3-METHYLBUT-1-ENES IN CDCl

No	Aryl groups	Proton group	Form	Chemical shift		Difference[b]
				Major isomer	Minor isomer	
7	1-*o*-Cl-phenyl-2-phenyl (2:1)[c]	vinylic[d]	base	400	386	+14
			HCl	406	395	+11
		NMe_2	base	134[d]	122·5[d]	+11·5
			HCl	173[f] (*J* 4)	157[f] (*J* 4)	+16
		3-Me	base	71[g] (*J* 7)	65[g] (*J* 7)	+ 6
			HCl	94[h] (6)	87[g] (*J* 7)	+ 7

[a] Chemical shifts in c/s from tetramethylsilane (60 Mc/s operating frequency), coupling constants and widths at half height (*WH*) in c/s.

[b] Major chemical shift- minor chemical shift in c/s.

[c] Major : minor ratio from N-Me or 3-Me integrals.

[d] Narrow singlet.

[e] The spectrum of the major (*trans*) HCl was very similar to that of a 3-methylbutene HCl, m.p. 165 168 , kindly supplied by Geigy Laboratories and considered to be a but-2-ene;[12] it contained the *cis* but-1-ene HCl as a contaminant.

[f] Doublet of doublets becoming singlet in presence of D_2O.

[g] Doublet.

[h] Mid-point of doublet showing virtual coupling, outer peak separation in parenthesis.

[i] Not recorded.

[j] Broad singlet.

[k] Integrals in parenthesis.

[l] Triplet *J* = 7 c/s.

[m] Centre of overlapping quartets.

[n] Centre of broad triplet.

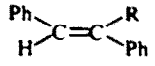
[o] The 6 c/s difference between the vinylic chemical shifts of the alkenes derived from X and those obtained from XIII (R = Et) are attributed to instrumental variations, spectra of the former samples being recorded in London and the latter in Edmonton on different makes of instrument.

[p] Quartet.

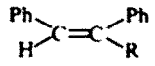
Further data on this point was sought by a study of the PMR characteristics of a series of *cis* and *trans* α-substituted stilbenes (preparation described later) which are non-basic analogues of the 4-aminobut-1-enes II and III.

Vinylic chemical shifts in *cis* and *trans* stilbene and α-substituted derivatives are given in Table 2. In *trans* stilbene (IV, R = H) both aromatic rings may be coplanar with the double bond and it is evident from models of this conformation that the vinylic protons fall within the paramagnetic deshielding zones[3] of both aromatic rings. The ring adjacent to an alkenic proton must have the major influence upon its chemical shift, but the contribution of the α-aromatic group is significant as is evident from a comparison of vinylic chemical shifts in *trans* stilbene (426 c/s) and styrene (near 400 c/s for α-proton)[4, 5] When R in IV is Me, interactions between this group and *o*-aromatic protons are generated in planar conformations which may be relieved by rotation of the aryl rings out of the double bond plane. The rotation of either ring will result in the vinylic proton being less deshielded (since both contribute) and will

cause this proton to come to resonance at a higher field position. As R increases in size from Me to i-Pr, the extents to which the planar system is perturbed will increase with consequent progressive upfield shifts of the vinylic resonance signal, as are observed. In *cis* stilbene (V, R = H) severe aromatic interactions preclude an overall



IV



V

planar molecule and a likely conformation is one in which the interplanar angle of the rings is near 45°, the *ortho* proton of one ring lying immediately above the plane of the other ring (Fig. 1); this arrangement allows minimum divergence of aromatic and double bond planes. Support for the favoured nature of this conformation derives

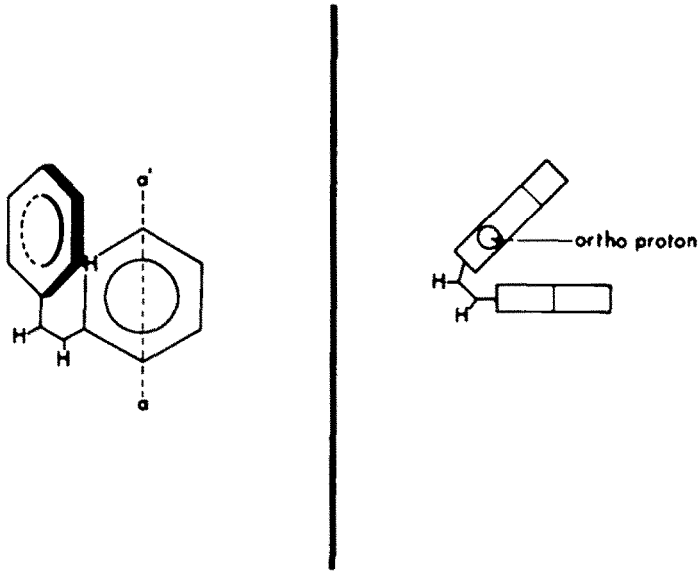


FIG. 1 Diagram of a probable *cis*-stilbene conformation. *A*: Right-hand ring in plane of paper; *B*: molecule viewed along a a' axis.

from the aromatic PMR signals of the isomeric stilbenes.[4] In *trans* stilbene, pronounced chemical shift differences amongst the aromatic protons (broad multiplet PMR signal) obtain, due to the descreening influence of the double bond substituent. The *cis* aromatic signal however, is a remarkably sharp singlet, indicative of chemical equivalence amongst aryl protons. Reduced chemical shift differences respecting these protons is to be expected if the stilbene conformation (Fig. 1) is favoured, for two reasons: (1) the non-planarity of aromatic and double bond planes as shown will reduce the magnetic influence of the vinyl substituent because of decreased conjugation; and (2) vinylic deshielding of the aromatic protons (effect on $o > m > p$)

will be offset by aromatic shielding (same order of effect).* The overall screening of *cis* compared with *trans* aromatic protons in isomeric stilbenes is shown by the higher chemical shift of the *cis* signal (*cis* 430, *trans* centre near 442 c/s) while the divergence of aromatic and double bond planes in the *cis* isomer is clearly responsible for the *cis*-resonating at a markedly higher field position than the *trans*-vinylic proton. Models show that replacement of a vinylic proton in the *cis* conformation (Fig. 1) by Me would be expected to little change the overall molecular planarity, while α-Et and α-i-Pr substituents should only affect the adjacent ring plane (it will deviate more from the double bond plane), i.e. the ring that has the least influence on the vinylic proton. The *cis* vinylic chemical shift values of Table 2 are in general agreement

TABLE 2. VINYLIC CHEMICAL SHIFTS OF SOME α-SUBSTITUTED ISOMERIC STILBENES IV AND V

No.	R	Chemical shift[a]		Difference (Δ) (*trans-cis*) c/s
		trans-vinylic	*cis*-vinylic	
1[b]	H	426[c]	394[c]	32
2	Me[d]	409[e]	390[e]	19
3	Et	398[e]	382[e]	16
4	*iso*Pr	383[e]	380[e]	3
5	$CH_2CH_2NMe_2$	406[e]	390[e]	16
6	$CHMeCH_2NMe_2$	391	390·5	0·5

[a] In c/s from tetramethylsilane (60 Mc/s operating frequency), solvent $CDCl_3$.
[b] Reference 4.
[c] Narrow singlet.
[d] Me signal is a narrow doublet (J 1·5) at 132 c/s in both isomers.
[e] Broad singlet.

with these arguments; in the *cis* stilbenes V the signal moves progressively upfield as R increases in size but the shift from R = H to R = i-Pr in the *cis* series (14 c/s) is much less than that observed in the corresponding *trans* isomers (43 c/s). While replacement of α-Et by α-i-Pr in *cis* stilbenes V has only a small influence on the vinylic resonance position, the same change in the *trans* series brings about a pronounced upfield shift with the result that the *cis* and *trans* vinylic chemical shifts of the isopropyl isomers differ by only 3 c/s (at a 60 Mc/s operating frequency).

* In the *cis* conformation (Fig. 1) the aromatic protons of one ring are subject to the magnetic influence of the other and inspection of the relative positions of one group of aryl proton (these lie above the plane of the second ring) shows that this influence should be screening, the *ortho* proton being the most and the *para*-proton the least affected. These considerations take into account the equivalent form of conformation (Fig. 1) in which the *o*- and *m*-protons are reversed; in the case of a particular *o*-proton, for example, the magnetic influence of the second ring will be an average of strong shielding (*o*-proton close to and above second ring) and weak deshielding (*o*-proton removed from and in the plane of the second ring), i.e. net shielding.

It may similarly be deduced that the planarity of the *cis* 3-methylaminobutene derivatives (Table 1, Nos. 1–3) is governed chiefly by interactions between the *cis* aryl groups while that of the corresponding *trans* isomers is influenced largely by interaction of the 1-aryl and bulky β-aminoisopropyl substituents. The two interactions appear to disturb the overall molecular planarity in similar degrees, since *cis*- and *trans*-vinylic chemical shifts in these isomers are almost identical, a fact which precludes their use in configurational assignments. The near-magnetic equivalence of vinylic protons in isomeric β-aminoisopropylstilbenes no longer obtains when the 1-Ph group of such derivatives carries an *ortho* substituent, as is evident from the well-separated vinylic chemical shifts of the isomeric butenes (Table 1, Nos, 4, 6 and 7). Models show that interactions between aromatic groups in these derivatives are

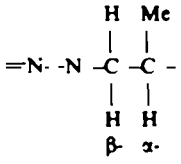
VI R' = Me, F or Cl VII

enhanced in *cis* but little changed in *trans* isomers. Further, in the *trans* conformation (VI), the vinylic proton will be deshielded by the nearby *ortho* substituent R' while the same proton in the corresponding *cis* conformer (VII) will be little affected in this respect because it is well removed from the plane of the adjacent aryl substituent (*cf.* the effects of *ortho* substituents on the chemical shifts of α-protons in substituted styrenes).[5] On these grounds, *cis* vinylic signals in the derivatives VII should be at higher, and *trans* protons in VI at lower fields than the corresponding signals of the 1,2 diphenylaminobutenes (II, Ar = Ar' = Ph), and configurational assignments have been made accordingly. UV data supports these assignments in the case of the 1-*o*-tolyl pair (Table 1, No. 4), the *trans*- having an absorption maximum at a longer wavelength (250 mμ) than that of the *cis*-member (243 mμ). The isomeric pairs (Table 1, Nos 4, 6 and 7) also differ in respect of their dimethylamino and secondary Me proton resonances, the lower field positions of these signals in the *trans* isomers being interpreted as follows: In *cis* isomers VII the C-2 side chain R is influenced magnetically only by the C-2 aryl group, the C-1 aryl group (*trans*) being too far removed to have a significant effect. In *trans* isomers VI, however, the same side chain falls under the magnetic influence of the nearby *cis* 1-aryl group as well as the C-2 aryl group. If the C-1 aryl group has a deshielding, rather than shielding influence, (as models indicate), lower field resonances of the NMe_2 and secondary Me signals are to be anticipated in the *trans* isomers. The effect of *cis* and *trans*-1-aryl groups upon the chemical shifts of C-2 side chain substituents, as considered above, should be generally true for all isomeric 3-methylbutenes (II). Hence, the configuration of isomeric pairs which have similar vinylic chemical shifts may be assigned on the basis of differences in their NMe_2 and 3-Me signals. Accordingly, the major isomers (Table 1, Nos 1–3 and 5) are given a *trans*-, and corresponding minor isomers, a *cis*-configuration.

PMR characteristics of the aminobutene (II) hydrochlorides provide several points of interest:

(1) vinylic chemical shifts in both *cis* and *trans* isomers move downfield by 5 to 16 c/s upon base protonation, a probable consequence of the greater deshielding influence of charged over neutral nitrogen. This influence is readily evident in *cis* isomers and models show that N^+ may also approach the C–H vinylic region fairly closely in *trans* analogues.

(2) While *cis* 3-methyl signals in the salts are near symmetrical doublets, corresponding *trans* signals are deformed, showing that virtual coupling effects occur in the latter isomers. Coupling of this nature will occur when the chemical shifts of the α- and β-protons in the system VIII approach one another sufficiently closely.[6] In the bases, the *cis* and *trans* α/β chemical shift differences are probably dissimilar partly as a result of the *trans*, but not the *cis*, C-2 side chain being influeced by the 1-aryl group and are of magnitudes that further downfield shifts of the β-protons (induced by base protonation) provide conditions for virtual coupling only in the *trans* isomer.

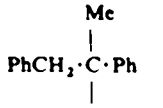


VIII

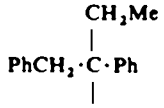
(3) The NMe_2 signal forms either a doublet of doublets or a broad singlet in $CDCl_3$ collapsing to a narrow singlet when D_2O is added, observations which show the two N-Me groups to be non-equivalent in the salts. Bonding between protonated nitrogen and the π-electron system, which would lead to restricted rotation about the nitrogen—side chain link, may be responsible for this phenomenon.

The vinylic resonances of the *cis* and *trans* 1-phenyl 2-*p*-anisylbutene pair (Table 1, No. 5) are unusual because the *cis*, rather than the *trans* signal, has a lower field position, configurational assignments to these isomers being based upon the lower field NMe_2 and 3-Me signals of the major form, the deformed nature of the 3-Me signal of the major hydrochloride and UV data [λ_{max} 232 and 256 mμ (major), 247 mμ (minor) in EtOH]. This reversal of vinylic resonances may be related to differing screening influences of the *p*-OMe substituent (demonstrated in styrene and stilbene derivatives[5,7]) in the two isomers and is being further studied.

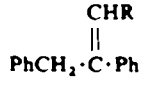
cis and *trans* α-Methylstilbene were obtained by reported methods.[8,9] While acid-catalysed dehydration of 1,2-diphenylpropan-2-ol (IX) gave α-methylstilbenes only (*trans* exclusively when a mixture of acetic and hydrochloric acids was used),



IX

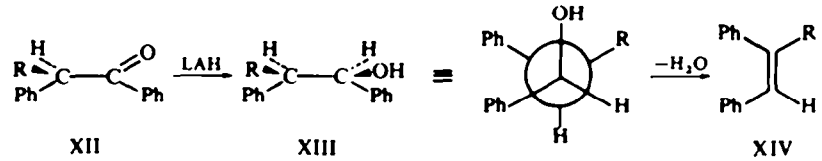


X



XI

the same dehydration of 1,2-diphenylbutan-2-ol (X) gave a mixture of α-ethylstilbenes and 3-methyl-1,2-diphenylprop-2-enes (XI R = Me) in approximately equal parts. One isomer preponderated in both the stilbene and propene pairs, the major propene isomer being previously encountered as one of the products of the base-catalysed fragmentation of 2-chloro-4-dimethylamino-3-methyl-1,2-diphenylbutane[1] (alkene analyses are based upon elemental analyses and PMR characteristics, Table 3). The route XII → XIV, which proved specific for the synthesis of *cis* α-methylstilbene,[9] was



therefore investigated as a synthetic method for the α-ethyl and isopropyl analogues. Reaction between the sodium salt of desoxybenzoin and ethyl or isopropyl bromide in toluene gave the C-alkylated product (XII, R = Et or i-Pr) in good yields (signals in the vinylic proton region of the PMR spectra of the total alkylation products gave evidence that some O-alkylation also occurred). Reduction of XII (R = Et) by LAH appeared to be stereospecific since the PMR spectrum of the total alcoholic product XIII (R = Et) displayed sharp, non-duplicated signals and was virtually identical with that of the purified solid material. Kayser[10] obtained an alcohol of similar m.p. by reducing XII (R = Et) with Na/EtOH, and a liquid diastereoisomer by treating 2-phenylbutanal with PhMgBr. If Cram's rule of asymmetric induction[9] is applicable to these reactions, the configurations of the solid and liquid isomers are probably *erythro* and *threo* respectively. In contrast, reduction of XII (R = i-Pr) gave a mixture of the diastereoisomeric alcohols XIII and isomer (R = i-Pr) (duplicate PMR signals for the $CHMe_2$ and OCH protons were well defined in the total product spectrum), a result which may be due to the fact that the ketone conformation XII is no longer preferred (over the alternative in which R and Ph are interchanged) when R is the bulky i-Pr group. The product in cold methanol deposited the mixed alcohols and the major isomer was isolated from the mother liquors. Dehydration of the secondary alcohol XIII (R = Et) by potassium hydrogen sulphate did not prove specific giving a 3:1 mixture of stilbenes XV (R = Et) and propenes XI (R = Et); the latter cannot

PhCH : CRPh	$PhCH_2 \cdot CPh : CMe_2$
XV	XVI

form directly and must be produced as the result of an equilibration process. The mixture showed PMR signals at 382 and 398 c/s (broad singlets) which almost certainly arise from the vinylic protons of the isomeric stilbenes XV (R = Et), their chemical shifts being close to those of the vinylic resonances of the *cis* and *trans* aminostilbenes III. The higher field signal had the larger integral and is assigned to the *cis* isomer on the grounds that this form should be the major stilbene since it is the initial product if elimination proceeds by a *trans* mechanism. Further, the relative

intensities of the two vinylic signals were reversed after the alkene mixture had been further equilibrated (in this product, the more stable *trans* α-ethylstilbene should preponderate). Reaction of the isopropyl secondary alcohol XIII and isomer (R = i-Pr), single compound or mixed diastereoisomers, and potassium hydrogen sulphate gave approximately equal amounts of α-isopropylstilbenes and the tetrasubstituted ethylene XVI. In the PMR spectrum of the dehydration product, the major stilbene component showed vinylic and secondary Me signals which were almost coincident with those of the minor isomer. Only a trace of the latter was present in this mixture which is considered to be almost completely equilibrated because its composition was little changed after further treatment with acid. When XIII and isomer (R = i-Pr) were heated with $KHSO_4$ for 20 min rather than the usual 1·75 hr, an identical alkene mixture was obtained, a result demonstrating the rapid dehydration of the alcohol and equilibration of the product. Lower field vinylic and secondary Me signals are provisionally assigned to *trans* α-isopropylstilbene on the grounds of relative intensities of the major and minor signals after equilibration. Acid-catalysed dehydration of analogues such as I (Ar = Ar′ = Ph) with a β-aminoalkyl side chain show a two-fold difference from that of XIII (R = i-Pr)—no elimination occurs into the side chain and a significant proportion of the *cis* stilbene is produced. These results may be explained in terms of protonated nitrogen retarding the equilibration of butene mixtures, as has previously been shown to be the case in the interconversion of 3- and 5-methyl-4-aryl-1,2,5,6-tetrahydropyridines.[11]

TABLE 3. PMR CHARACTERISTICS IN $CDCl_3$ OF ALKENE MIXTURES DERIVED FROM THE AMINO-ALCOHOLS X AND XIII (R = Et AND *i*-Pr)
(See Table 1 for footnotes)

Elimination substrate	Alkene component	PMR signals[a,k] Vinylic	Methylene	Methyl
X	Major stilbene XV (R = Et)	404[j]	164[m]	62[e] (14)
	Minor stilbene	388[j]		
	Major propene XI (R = Me)	365[g]	233[d]	108[g] (*J* 7) (16)
	Minor propene	unresolvable	217[d]	93[g]
XIII (R = Et)	major stilbene XV (R = Et)	382[j,o]	162, 145[g] (23)	62[e] (37)
	Minor stilbene	398[j]		
	Major propene XI (R = Me)	360[g]	229[d] (7)	107·5[g] (*J* 7) (13·5)
	Minor propene	unresolvable	214[d]	93[g] (*J* 7)
XIII (R = *iso*Pr)	Major stilbene XV (R = *iso*Pr)	383[j]		65·5[g] (*J* 6·5) (20)
	Minor stilbene	380[j]		62·5[g] (*J* 6·5)
	1-Benzyl-1-phenyl-2,2-dimethylethylene (XVI)	—	222·5[j]	114, 97[d] (25)

EXPERIMENTAL

1,2-Diaryl-4-dimethylamino-3-methylbut-2-enes. The butan-2-ol (I) hydrochlorides[13] were dehydrated with a mixture of AcOH and HCl and the butene products isolated as hydrochlorides by the previously reported method.[2] New compounds were *hydrochlorides* of the *1-phenyl-2-p-methoxyphenylbutene* (II Ar = *p*-C_6H_4OMe, Ar' = Ph) major isomer, m.p. 165–168°. (Found: C, 72·3; H, 8·2; N, 3·9. $C_{20}H_{24}ClNO$ requires: C, 72·4; H, 7·9; N, 4·2%) and minor isomer, m.p. 145–150°. (Found: C, 72·3; H, 7·8; N, 3·9%); the *2-phenyl-1-o-chlorophenylbutene* (II, Ar = Ph, Ar' = *o*-C_6H_4Cl), m.p. 187·5–188·5°. (Found: C, 67·85; H, 6·9; N, 4·2. $C_{19}H_{23}Cl_2N$ requires: C, 67·15; H, 6·75; N, 3·85%); the *2-phenyl-1-o-fluorophenylbutene* (II, Ar = Ph, Ar' = *o*-C_6H_4F), 166·5–168°. (Found: C, 71·2; H, 7·6; N, 4·2. $C_{19}H_{23}ClFN$ requires: C, 71·3; H, 7·2; N, 4·4%). The minor 2-phenyl-1-*o*-tolybutene (II, Ar = Ph, Ar' = *o*-C_6H_4Me) hydrochloride, m.p. 178–181° (Found: C, 76·0; H, 8·3; N, 4·5. $C_{20}H_{26}ClN$ requires: C, 76·1; H, 8·2; N, 4·4%) was isolated from the alkene mixture obtained from 2-chloro-4-dimethylamino-3-methyl-2-phenyl-1-*o*-tolybutane hydrochloride and pyridine.[2]

Elimination of the t-alcohols IX *and* X. A soln of 1,2-diphenylpropan-2-ol, m.p. 48–49° (reported[14] m.p. 50–51°) (11·5 g) in Ac_2O (20 g) and AcCl (10 g) was heated under reflux for 8 hr and then concentrated. The residue was crystallized from EtOH to give *trans* α-methylstilbene (7 g), m.p. 78–80° (reported[8] m.p. 83–83·5°). The mother liquors contained 2-acetoxy-1,2-diphenylpropane and the isomeric stilbenes. *trans*-α-Methylstilbene (9·5 g) was the exclusive product when the alcohol IX (10 g) was heated for 3 hr at the reflux temp with a mixture of AcOH (50 ml) and HCl (20 ml). 1,2-Diphenylbutan-2-ol (20 g), b.p. 120°/0·5 mm (prepared from propiophenone and benzyl magnesium chloride (Found: C, 84·9; H, 7·8. $C_{16}H_{18}O$ requires: C, 85·0; H, 8·0%) was heated under reflux with Ac_2O (40 g) and AcCl (20 g), concentrated and the residue fractionally distilled. The fraction b.p. 122°/0·6 mm was a mixture of alkenes (Found: C, 91·9; H, 7·7. $C_{16}H_{16}$ requires: C, 92·3; H, 7·7%). characterized by its PMR spectrum (Table 3).

Alkylations of desoxybenzoin. Sodamide (2·5 g) was added to desoxybenzoin (10·8 g) in toluene (50 ml) and the mixture heated under reflux for 5 hr, cooled and treated with EtBr (6·5 g) in toluene (25 ml). After a further reflux period of 20 hr, a second portion of EtBr (1·6 g) was added and the reflux temp maintained for an extra 4 hr. The cold product was decomposed with water (75 ml) and the organic phase separated, dried (Na_2SO_4) and concentrated. The residue gave a distillate (9 g) b.p. 122–126°/1·0 mm which solidified and was crystallized from MeOH to give α-ethyldesoxybenzoin m.p. 55–56° (reported[15,16] m.p. 58° and 56–57°); characteristic PMR signals (c/s) in CCl_4: 257·5 triplet J = 7 (methine proton); 120, centre of multiplet $\underline{CH_2}Me$); 52, triplet J = 7 ($CH_2\underline{Me}$). About 5% of the O-alkyl isomer was present in the total alkylation mixture; characteristic PMR signals (c/s): 358, singlet (vinyl proton); 223, quartet J = 7 ($O\underline{CH_2}Me$); 75 triplet J = 7 ($OCH_2\underline{Me}$). Sodamide (10 g) was added to desoxybenzoin (43·2 g) in toluene (200 ml) and the mixture heated under reflux for 8 hr, cooled and treated with i-PrBr (29·5 g) in toluene (50 ml). After a further reflux period of 20 hr, more i-PrBr (7·4 g) was added and the reflux temp maintained for an extra 10 hr. The alkylation mixture, isolated as before, gave a distillate (39 g) b.p. 130–135°/1 mm which solidified and was crystallized from MeOH to give *α-isopropyldesoxybenzoin*, m.p. 71·5–72°. (Found: C, 85·4; H, 7·3. $C_{17}H_{17}O$ requires: C, 85·7; H, 7·6%); characteristic PMR signals (c/s) in CCl_4: 244, doublet J = 10 (α-methine proton); 150, centre of multiplet ($Me_2\underline{CH}$); 43 and 58, pair of doublets J = 7 ($\underline{Me_2}CH$). About 5% of the O-alkyl isomer was present in the total alkylation mixture; characteristic PMR signals (c/s): 356, singlet (vinyl proton); 71, doublet J = 7 ($OCH\underline{Me_2}$).

Reduction of the α-alkyldesoxybenzoins XII. The desoxybenzoin XII (R = Et; 11·3 g) in ether (40 ml) was added during 0·5 hr to a stirred suspension of LAH (1·9 g) in ether (40 ml). The mixture heated under reflux for 1·5 hr, then cooled and decomposed with water. The ether phase was separated, dried (Na_2SO_4) and evaporated leaving an oily residue (9 g) which soon solidified. This was crystallized from MeOH to give 1,2-diphenylbutanol, m.p. 77·5–78° (reported[17,10] m.p. 79–80° and 82°). Characteristic PMR signals (c/s) in CCl_4: 270, doublet J = 7·5 ($OC\underline{H}$); 155, quartet J = 7 ($C\underline{H}Et$); 100, singlet ($O\underline{H}$); 85, quartet J = 7 ($C\underline{H_2}Me$); 38, triplet J = 7 ($CH_2\underline{Me}$). α-Isopropyldesoxybenzoin (23·8 g) was similarly reduced with LAH (4·16 g) to give a diastereoisomeric mixture of *1,2-diphenyl-3-methylbutanols* (21 g), b.p. 148–150°/1·5 mm (Found: C, 85·25; H, 8·3. $C_{17}H_{20}O$ requires: C, 84·9; H, 8·4%). The product in cold MeOH deposited the mixed alcohols and the mother liquors contained a single (major) isomer after several crops had been collected, as confirmed by PMR spectroscopy. This isomer distilled at 138–140°/0·1 mm (Found: C, 85·0; H, 7·9%) and had the following PMR characteristics (c/s) in CCl_4: 292·5, doublet J = 6 ($OC\underline{H}$); 137, singlet ($O\underline{H}$); 53, 39, doublet of doublets J = 6 ($CH\underline{Me_2}$). PMR signals of the minor isomer (obtained from the spectrum of the mixture) were: 276, doublet J = 4 ($OC\underline{H}$); 49, 51, doublet of doublets J = 6.

Elimination of the s-alcohols XIII (R = Et or i-Pr). A mixture of 1,2-diphenylbutanol (4·5 g) and finely

powdered $KHSO_4$ (14 g) was heated for 1·75 hr in an oil-bath maintained at 190–200°. The cooled melt was dissolved in water (50 ml) and the separated oil extracted with ether. The residue from the dried extract was distilled to give a mixture of the alkenes XI and XV (R = Et); 4·1 g), b.p. 105–109°/2 mm. (Found: C, 92·3; H, 7·55. $C_{16}H_{16}$ requires: C, 92·3; H, 7·7%) characterized by its PMR spectrum (Table 3). Equilibration of the mixture (virtually complete after 0·75 hr) was achieved by treating 1 g with a mixture of glacial AcOH (50 ml) and saturated $HBr-H_2O$ (1 ml) at the reflux temp. Treatment of the diastereoisomeric 1,2-diphenyl-3-methylbutanols (16 g) with $KHSO_4$ (56 g) as described above gave a mixture of the alkenes XV (R = i-Pr) and XVI (14 g), b.p. 123–126°/2·5 mm (Found: C, 91·8; H, 8·0. $C_{17}H_{18}$ requires: C, 91·8; H, 8·2%) characterized by its PMR spectrum (Table 3). A similar mixture was obtained from the pure diastereoisomeric alcohol.

The PMR spectra were obtained on Varian A-60 and Perkin Elmer R-10 instruments with TMS as internal standard and $CDCl_3$ or CCl_4 as solvent. We thank Mr. G. McDonough (University of London) for recording the Perkin Elmer spectra and Professor D. J. Cram for a sample of *cis*-α-methylstilbene.

REFERENCES

[1] Part II. A. F. Casy and P. Pocha, *Tetrahedron* **23**, 633 (1967).
[2] A. F. Casy, J. L. Myers and P. Pocha, *Ibid.* **22**, 1001 (1966).
[3] C. E. Johnson and F. A. Bovey, *J. Chem. Phys.* **29**, 1012 (1958).
[4] NMR Spectra Catalog, Varian Associates (1962), Nos. 305 and 306.
[5] Gurudata, J. B. Stothers and J. D. Talman, *Canad. J. Chem.* **45**, 731 (1967).
[6] J. I. Musher and E. J. Corey, *Tetrahedron* **18**, 791 (1962).
[7] H. Gusten and M. Salzwedel, *Ibid.* **23**, 173, 187 (1967).
[8] H. Ley, *Chem. Ber.* **50**, 243 (1917).
[9] D. J. Cram and F. A. Abd Elhafez, *J. Am. Chem. Soc.* **74**, 5828 (1952).
[10] F. Kayser, *C.R. Acad. Sci., Paris* **199**, 1424 (1934).
[11] A. F. Casy, A. H. Beckett and M. A. Iorio, *Tetrahedron* **23**, 1405 (1967).
[12] W. G. Stoll, Ch. J. Morel and Ch. Frey, *Helv. Chim. Acta* **33**, 1194 (1950).
[13] A. F. Casy and P. Pocha, *J. Chem. Soc.* (B), 1160 (1966).
[14] C. Hell, *Chem. Ber.* **37**, 457 (1904).
[15] V. Meyer and L. Oelkers, *Ibid.* **21**, 1295 (1888).
[16] W. vE. Doering and R. H. Haines, *J. Am. Chem. Soc.* **76**, 482 (1954).
[17] E. L. May and T. D. Perrine, *J. Org. Chem.* **18**, 1572 (1953).