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ALLYLIC SUBSTITUTIONS IN THE 2-BENZALINDAN, 2-BENZYLINDENE SERIES

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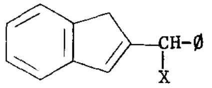
In previous papers[2,3], it was reported that the allylic substitutions of 2-(α-aminobenzyl)-1-indenones and 3-halogeno-2-benzal-1-indanones with primary and secondary amines occur only with inversion of the allylic system by a bimolecular mechanism. The orientation and the ease of the preceding reactions have been associated with the presence of the electron-withdrawing carbonyl group. Similarly, in the 3-(α-haloalkyl)benzo [b] thiophene 1,1-dioxide series, the sulfonyl group was claimed to increase the reactivity of the allylic system toward amines in reducing the electron density in the C=C bond and in delocalizing the negative charge developed at the β-position in the transition state.[4] Therefore, a study of the corresponding indene-indan systems 1 and 2 (X=halogen) was planned. It has now been found that the reaction of 2-(α-chlorobenzyl)-indene, 1 (X=Cl), with amines in acetonitrile gives both the direct substitution product and the "abnormal" substitution product.



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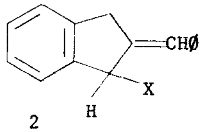

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The reduction of *trans* 2-benzal-1-indanone with NaBH$_4$ in aqueous methanol occurred exclusively by 1,2-addition[5] and gave *trans* 2-benzal-1-indanol, mp=111-112[6]; in the presence of LiAlH$_4$ a *trans* 2-benzyl-1-indanol was formed[7]. The nmr spectrum[8] of the prepared indanol is in agreement with the proposed structure, showing 9H aromatic between 2.3 and 2.8τ, 1H vinyl at 3.10τ (quadruplet, J *allyl* = 2.3 Hz), 1H benzyl at 4.40τ (doublet, J = 9Hz), 2H methylene at 6.12τ and OH at 7.57τ (doublet, J = 9Hz). The uv spectrum of the alcohol showed absorptions at 258 and 270 (Sh) mμ (ε=20,000, 12,500). The structure of the allylic alcohol was further proved by reducing *trans* 2-deuterobenzal-1-indanone under the same conditions; the signal of the vinyl proton is absent in the nmr spectrum of the deuterated alcohol.

Treatment of *trans* 2 (X=OH) with thionyl chloride in benzene or ether at room temperature yielded only one allyl chloride (mp = 56-58°); its nmr spectrum showed a multiplet between 2.5

and 3.0τ (9H aromatic), a quadruplet at 3.32τ (1H vinyl, J allyl ∿ 1.7 Hz), a singlet at 4.07τ (1H benzyl), and a singlet at 6.60τ (2H methylene). The allyl chloride has the structure 1 (X=Cl) as shown by repeating the preceding experiment with trans 2-deuterobenzal-1-indanol; the corresponding H benzyl signal is absent in the nmr spectrum of the deutero-product, the H vinyl signal is a triplet (J allyl = 1.7 Hz) and the methylene signal is a doublet (J allyl = 1.7 Hz). The allyl chloride absorbs in the uv at 267 mμ (ε=13,700).

The reaction of five molar equivalents of t-butylamine with 1 (X=Cl) in acetonitrile at 25°C gave very readily two amino allyl isomers isolated by chromatography on florisil: 22% of 1 (X=t-butyl) and 78% of 2 (X=t-butyl). The isomer 1 shows nmr signals between 2.4 and 3.0τ (9H aromatic), at 3.21τ (1H vinyl, quadruplet, J allyl ∿ 1.5 Hz), at 5.10τ (1H benzyl), at 6.73τ (2H methylene), at 8.60τ (NH), and at 8.91τ (9H t-butyl); uv absorptions were found at 260 and 265 mμ (ε=15,800 and 15,200). The isomer 2 shows nmr signals between 2.3 and 2.8τ (H aromatic), at 3.14τ (H vinyl, quadruplet, J allyl = 2.6 Hz), at 5.13τ (H benzyl), at 6.11τ (methylene) and at 8.67τ (NH and t-butyl); the uv absorption is at 251 mμ (ε=26,300). The nmr analysis of the reaction product of 2-(α-chlorodeuterobenzyl)-indene with t-butylamine confirms the proposed structures of the two allylamines; all the signals of the two non-deuterated compounds are present except the H vinyl signal of 2-deuterobenzal-1-t-butylamino-indan (the H benzyl and H methylene signals are broad singlets: J < 1 Hz) and the H benzyl signal of 2-(α-t-butylamino-deuterobenzyl)-indene (the H vinyl signal is a triplet and the H methylene signal a doublet: J allyl = 1.6 Hz). It must be noted that the allylic coupling constant between H vinyl and H benzyl is expected to be larger in the rigid molecule 2 than in the compound 1 where H benzyl of the lateral chain is probably near the plane of the molecule[9]; this relation is in agreement with the preceding conclusions based on deuteration, and it can be used to assign a structure to the isomers 1 and 2 (X=NH_2) when R is relatively bulky. The nmr absorptions of compounds 1 and 2 are consistent with those of parent compounds[7]. The similarities in the uv and nmr spectra of trans 2-benzal-1-indanol and the allylamines 2 (X=NR_2) suggest that the latter have the structure trans in which the $A^{(1,3)}$ strain[10] is smaller than in the cis isomer.

When the concentration of 1 (X=Cl) was held constant, it was found that the relative propositions of isomers 1 (X=t-butyl) and 2 (X=t-butyl) at completion of reaction were constant when the number of molar equivalents of amine were increased from 2 to 13 in acetonitrile solvent. The ratio 1/2 also depends on the nature of the reacting amine: it increases in the following sequence of amines: diisopropylamine (15/85), t-butylamine (28/72), isopropylamine (35/65), and piperidine (52/48). The allyl chloride 1 (X=Cl) is stable at room temperature in solvent acetonitrile-d_3; at 60°C, decomposition occurs slowly and without rearrangement. These results suggest that SN_2 and SN_2' reactions occur simultaneously; however an SNi' mechanism (prior to substitution[4]) cannot be ruled out *a priori*. Kinetic studies are being carried out to check these hypothesis. On the other hand, the reaction of thionyl chloride with *trans* 2-benzal-1-indanol in ether is believed to be SNi' because of the relatively low reactivity of the chloride ion in displacement reactions under these conditions[11], and because of the favorable steric conditions in the transition state.

Attempts are being made to prepare the isomer 2 (X=halogen) and to compare its reactivity toward amines with the reactivities of 1 (X=halogen) and 3-halogeno-2-benzal-1-indanone.

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