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The Preparation and Rearrangement of 2-Allylbenzimidazole

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This paper reports the preparation of 2-allylbenzimidazole (I) and the facile migration of its double bond to the known isomeric 2-propenylbenzimidazole (II). The proposed mechanisms of reactions of this type, involving a prototropic rearrangement, have been thoroughly discussed (1,2).

Treatment of *o*-phenylenediamine with vinylacetic acid gave the desired 2-allylbenzimidazole (I). The attempted recrystallization of this compound from benzene resulted in the formation of the thermodynamically more stable 2-propenylbenzimidazole (II). Reid and Urlass (3) reported the preparation of 2-propenylbenzimidazole (II) from the reaction of crotonaldehyde and *o*-phenylenediamine in the presence of copper acetate. Reid and Stahlhofen (4) prepared 2-propenylbenzimidazole (II) from 4-(*o*-aminophenylimino)-1-butanol.

In order to preclude the possibility that vinylacetic acid was isomerized to crotonic acid followed by reaction with *o*-phenylenediamine to give rise to 2-propenylbenzimidazole (II), crotonic acid was allowed to react with *o*-phenylenediamine under the conditions employed for the synthesis of 2-allylbenzimidazole (I). The only compound isolated was 4,5,6,7-tetrahydro-7-methyl-5-oxo-1*H*-2,3-benzo-1,4-diazepine (III), (see figure 1). The literature confirmed that crotonic acid and *o*-phenylenediamine react with each other to give rise to compound III (3, 5), which has also been prepared by other procedures (6, 7). The above reaction indicated that vinylacetic acid and *o*-phenylenediamine, in 4 *N* hydrochloric acid, formed the terminal olefinic compound I and eliminated the possibility of the rearranged compound II, proceeding by either of the mechanisms as shown in figure 2. Ultraviolet studies, as discussed below, were in agreement with these findings.

From ultraviolet analysis studies, the following was found: 1) During the reaction which took place in refluxing 4 *N* hydrochloric acid, only 2-allylbenzimidazole and no rearranged 2-propenylbenzimidazole was formed; 2) Recrystallization of 2-allylbenzimidazole, using ether as a solvent, resulted in the formation of considerable quantities of 2-propenylbenzimidazole which remained in solution; 3) 2-Allylbenzimidazole placed in refluxing benzene was rearranged totally to the thermodynamically more stable 2-propenylbenzimidazole.

The one ml. aliquots taken directly from the reaction mixture to be used in the ultraviolet analysis

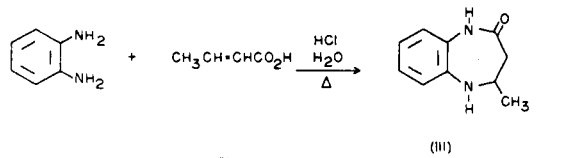


Figure 1.

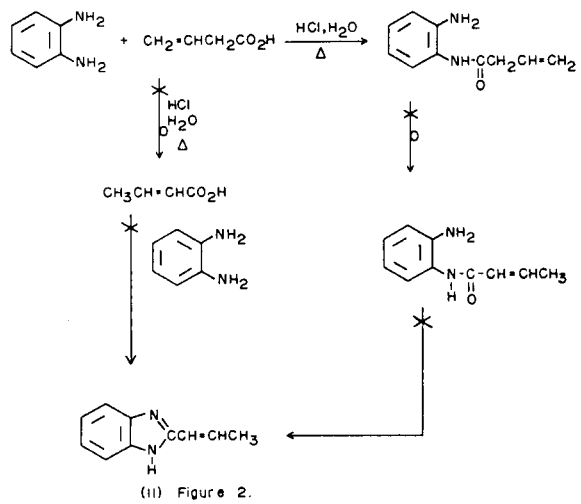


Figure 2.

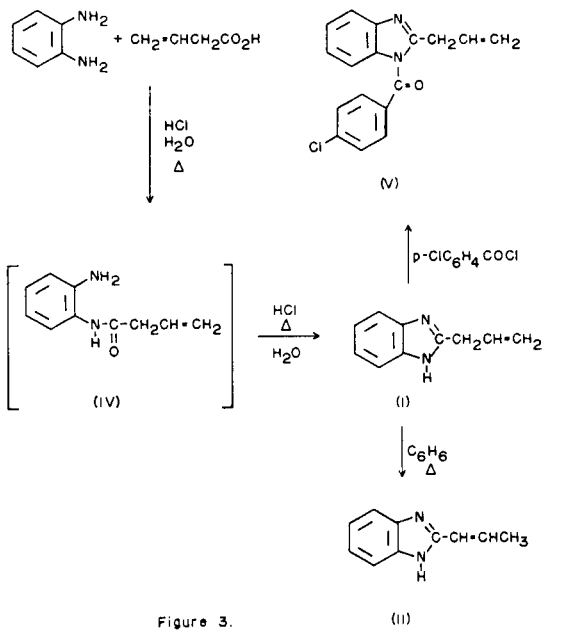


Figure 3.

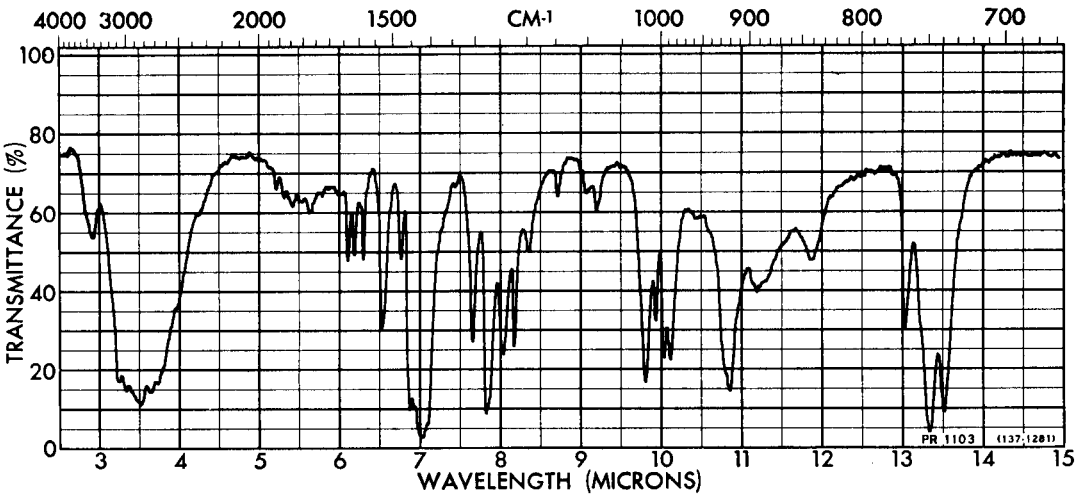
ULTRAVIOLET SPECTRA

(Characteristic Maxima Absorption) [λ]

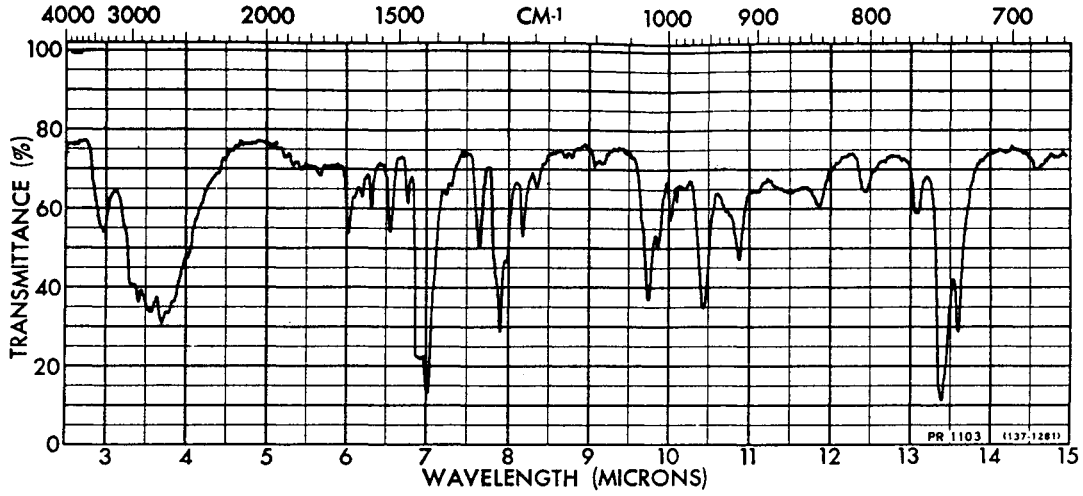
	CH_3OH	4 *N* Aqueous HCl
2-Allylbenzimidazole (I)	243, 274, 280	237 (log intensity broad peak), 269, 276
2-Propenylbenzimidazole (II)	295	237, 296

NUCLEAR MAGNETIC RESONANCE ANALYSIS

Proton	δ values (p.p.m. from T.M.S.)	Splitting	Number of Hydrognes
	Structure I ($CDCl_3$)		
N-*H*	12.13	singlet	1
C_6H_4	7.42	group of peaks	4
$C{=}CH_2$	5.18	doublet	2
$-CH{=}C$	6.07	group of peaks	1
$C-CH_2-C{=}$	3.78	doublet	2
	Structure II ($CDCl_3$)		
N-*H*	11.47	singlet	1
C_6H_4	7.36	group of peaks	4
$-CH{=}CH-$	6.81	pair of doublets	2
$=C-CH_3$	1.87	doublet	3



2-Allylbenzimidazole (I)
KBr



2-Propenylbenzimidazole (II)
KBr

studies were diluted to 100 ml. with 4 *N* hydrochloric acid. Only the absorption characteristic of 2-allylbenzimidazole was exhibited. The crude reaction product obtained after addition of ammonium hydroxide solution was also entirely 2-allylbenzimidazole. Ultraviolet absorption characteristic of 2-propenylbenzimidazole was first observed in the mother liquor obtained from the recrystallization of 2-allylbenzimidazole.

The course of the rearrangement was followed, when pure 2-allylbenzimidazole was placed in refluxing benzene, by the disappearance of the characteristic peaks of 2-allylbenzimidazole and appearance of peaks exhibited by the presence of 2-propenylbenzimidazole.

The protonated 2-allylbenzimidazole, present during the reaction, appears to be much more resistant to rearrangement than the free base; however, once compound I is isolated as the free base, a certain degree of care is required to prevent rearrangement. 2-Allylbenzimidazole did not appear to rearrange on being stored as a solid over a period greater than six months.

Structure I by the action of *p*-chlorobenzoyl chloride gave 1-*p*-chlorobenzoyl-2-allylbenzimidazole (V).

The structure of I and II was confirmed via elemental, infrared, ultraviolet and nuclear magnetic resonance analysis (See Spectral Data). Compound II is a known structure whose melting point agrees with the literature (3,4).

EXPERIMENTAL

2-Allylbenzimidazole (I).

Vinylacetic acid (12.9 g., 0.15 mole), *o*-phenylenediamine (10.8 g., 0.10 mole) and 4 *N* hydrochloric acid (100 ml.) were heated under reflux and stirred for one hour. After standing overnight, the reaction mixture was diluted with water (200 ml.) followed by the addition of 7 *N* ammonium hydroxide (75 ml.) while stirring in an ice bath. A solid material (m.p. 169-176°) formed which was removed by filtration and represented a yield of 63% (10.0 g.). Recrystallization from ether gave a yield of 3.8 g. (23%) which melted with decomposition at 184-188°.

Anal. Calcd. for $C_{10}H_{10}N_2$: C, 75.92; H, 6.37; N, 17.71. Found: C, 76.14; H, 6.64; N, 17.95.

2-Propenylbenzimidazole (II).

2-Allylbenzimidazole was heated under reflux in benzene for two hours. On cooling, a nearly quantitative amount of rearranged product (II) deposited having a m.p. of 192-194° (lit. (4) 193°).

Anal. Calcd. for $C_{10}H_{10}N_2$: C, 75.92; H, 6.37; N, 17.71. Found: C, 75.54; H, 6.26; N, 17.50.

4,5,6,7-Tetrahydro-7-methyl-5-oxo-1*H*-2,3-benzo-1,4-diazepine (III).

Crotonic acid (12.9 g., 0.15 mole), *o*-phenylenediamine (10.8 g., 0.10 mole) and 4 *N* hydrochloric acid (100 ml.) were heated under reflux and stirred for one hour. After standing overnight, the reaction mixture was diluted with water (200 ml.) followed by the addition of 7 *N* ammonium hydroxide (75 ml.) while stirring in an ice bath. A solid material was removed by filtration and recrystallized from benzene giving a 7.6 g. (48%) yield of compound III, having a m.p. of 185-186° (lit. (5) 184-185°).

Anal. Calcd. for $C_{10}H_{12}N_2O$: C, 68.16; H, 6.86; N, 15.90. Found: C, 68.32; H, 6.74; N, 15.92.

2-Allyl-3-chlorobenzoylbenzimidazole (V).

To a rapidly stirred and cooled partial suspension of 2-allylbenzimidazole (10.0 g., 0.063 mole), triethylamine (13.0 g.) and benzene (700 ml.), a solution of *p*-chlorobenzoyl chloride (11.0 g., 0.063 mole) in benzene (100 ml.) was added dropwise. After the addition was complete, the reaction mixture was permitted to stand overnight at room temperature and finally heated under reflux for two hours. Upon cooling, water (300 ml.) was added, the reaction mixture was stirred for 45 minutes and the layers separated. The aqueous layer was washed three times with benzene (150 ml.). The organic layer was dried, filtered and the solvent removed, leaving an oily solid (22.0 g.). Recrystallization from an ether-cyclohexane mixture gave a 9.4 g. (49%) yield of product V with a melting point of 82-84°. Further recrystallizations raised the melting point to 83-85°, infrared absorption (KBr) max. 1712 (amide C=O), 922, 1648 (CH_2-CH-) cm^{-1}.

Anal. Calcd. for $C_{17}H_{13}ClN_2O$: C, 68.81; H, 4.42; N, 9.44. Found: C, 68.83; H, 4.62; N, 9.25.

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