N-ANIONS OF HETEROAROMATIC AMINES

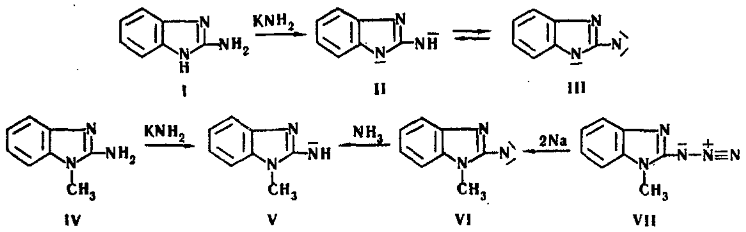
IV.* ACTION OF SOME OXIDIZING AGENTS ON N-ANIONS OF 2-AMINOBENZIMIDAZOLES

T. P. Filipskikh, A. F. Pozharskii, and É. A. Zvezdina

UDC 547.785.5+542.943+66.062.183

The corresponding 2,2'-azobenzimidazoles are formed by the oxidation of N-anions of 2-aminobenzimidazole and 1-methyl-2-aminobenzimidazole in liquid ammonia by means of potassium permanganate and potassium persulfate, as well as by oxidation with iodine in ether and autooxidation. In the case of the dianion of 1-methyl-2-aminobenzimidazole, it was demonstrated that the reaction proceeds through a step involving the formation of a hydrazo derivative. Quantitative yields of the previously unknown 2,2'-hydrazobenzimidazoles were obtained by reduction of 1,1'-dimethyl- and 1,1'-diphenyl-2,2'-azobenzimidazoles with phenylhydrazine.

It has been demonstrated that the polyanions of 2-aminobenzimidazole (I) readily undergo autooxidation, and dianion II gives 2,2'-azobenzimidazole, while trianion III gives 2-nitrobenzimidazole [2]. The monoanions of I and 1-methyl-2-aminobenzimidazole (IV) form only traces of the azo derivative under the same conditions.



The aim of the present research was a study of the action of a number of other oxidizing agents on N-anions II and V. It is not yet possible to investigate trianion III in this plan, since, in liquid ammonia, where polyanions are generated, it is always obtained along with a large amount of dianion II (≤50%) because of ammonolysis [2].

Dianion II was obtained by the action of excess potassium amide (4 mole) on I in liquid ammonia. Under these conditions, the concentration of III in the mixture does not exceed 15% [2]. Monoanion V was obtained in liquid ammonia by the action of 1-2 moles of sodium amide on IV.

An attempt was also made to obtain dianion VI by reductive cleavage of 1-methyl-2-azidobenzimidazole (VII) with sodium in liquid ammonia [3] and by debenzylation of 1-methyl-2-benzylaminobenzimidazole (VIII). The N-anions were oxidized in liquid ammonia (by $KMnO_4$, $K_2S_2O_8$, and air), and, in some cases (I_2, air), the dry residue remaining after evaporation of the ammonia was subjected to oxidation. The oxidation of N-anions with iodine in liquid ammonia leads to pronounced resinification.

---

* See [1] for communication III.

Rostov State University, Rostov-on-Don. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 2, pp. 238-241, February, 1972. Original article submitted January 25, 1971.

© 1974 Consultants Bureau, a division of Plenum Publishing Corporation, 227 West 17th Street, New York, N. Y. 10011. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, microfilming, recording or otherwise, without written permission of the publisher. A copy of this article is available from the publisher for $15.00.

TABLE 1. Results of the Oxidation of Anions II and V

Starting compound	Base	N-Anion formed	Oxidizing agent*	Yield of azo compound,%
I	KNH_2 (4)**	II (+15% III)	$KMnO_4$	88
	KNH_2 (4)	II (+15% III)	$K_2S_2O_8$	52
	KNH_2 (4)	II (+15% III)	Air	84†
IV	$NaNH_2$ (1)	V	$KMnO_4$	21
	$NaNH_2$ (2)	V	$KMnO_4$	21
	$NaNH_2$ (1)	V	$K_2S_2O_8$	7
	$NaNH_2$ (2)	V	I_2	43
	$NaNH_2$ (2)	V	Air	1
VII	Na (3)	V	$KMnO_4$	19
	Na (3)	V	$K_2S_2O_8$	7
VIII	Na (3)	VI‡	Air	38
	Na (3)	VI	I_2	70

* One mole of oxidizing agent was usually taken for 1 mole of the starting compound. Increasing the amount of oxidizing agent did not lead to an increase in the yield of azo compound.

† 2-Nitrobenzimidazole (14%) is also formed.

‡ Up to 50-60% of monoanion V is probably present in the oxidized residue.

** The amount (gram-mole) of base taken per gram-mole of the starting substance is indicated in parentheses.

The results of experiments on the oxidation of anions II and V, which are presented in Table 1, enable one to draw the following conclusions.

1. The best results are obtained when potassium permanganate is used.

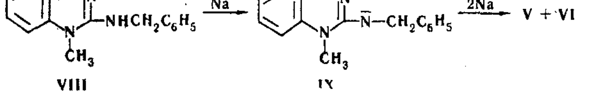
2. From a preparative point of view, the oxidation of dianion II with potassium permanganate does not have advantages over autooxidation, while the yield of azo compound for monoanion V increases substantially in this case, particularly for oxidation with iodine in ether suspensions.

3. The same results of the oxidation of the N-anions generated from IV and VII demonstrate that dianion VI, which is formed initially during reduction of the azide, apparently undergoes ammonolysis to monoanion V. This conclusion is in agreement with the conclusion drawn on the basis of experiments on the methylation of monoanion V, obtained by both methods [1].

4. The absence of 2-nitrobenzimidazole in the products of the oxidation of a mixture of anions II and III with potassium permanganate, potassium persulfate, and iodine is evidence that it is formed only as a result of autooxidation of trianion III. The formation of 2-nitrobenzimidazole apparently is not associated with the action of any intermediately formed oxidizing agent on trianion III. One such possible compound – sodium peroxide – absolutely does not oxidize anions II (in mixtures with III) and V. The latter are also inert to Caro's acid and benzoyl peroxide.

The concentration of dianion VI is maintained at a rather high level during the debenzylation of VIII with sodium in liquid ammonia (which will be discussed in detail in a subsequent communication) up until complete evaporation of the ammonia. This is explained by the fact that, because of the slowness of the debenzylation of monoanion IX, the benzyl anions formed in the process go into solution uniformly over the course of a long time. As a very strong base, the benzyl anion naturally inhibits ammonolysis of dianion VI.

Anion VI undergoes autooxidation in the dry state rather slowly but with considerably more ease than the autooxidation of monoanion V. The yield of azo compound is 40% after 24 h.

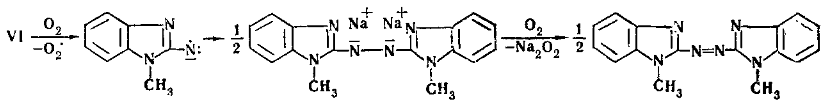


VIII IX

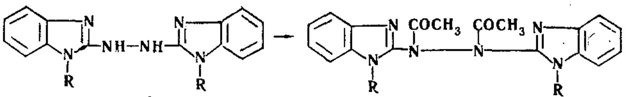
When the oxidation time is increased, the yield of azo compound does not increase. This indicates that the residue is apparently the monoanion, which is formed during the ammonolysis of dianion VI during evaporation of the ammonia.

In the case of the autooxidation of VI, we found that the corresponding hydrazo compounds are intermediates in the formation of 2,2'-azobenzimidazoles.*

The thin-layer chromatogram of a sample of the oxidized mixture (Al_2O_3, chloroform) contains a colorless zone surrounded by a red coloration when it is exposed to iodine vapors. The R_f value of this zone coincides exactly with the R_f of a known sample of 1,1'-dimethyl-2,2'-hydrazobenzimidazole (Xa). The reaction probably proceeds via the following scheme:



The previously unknown 2,2'-hydrazobenzimidazoles (X) were obtained in high yields by the reduction of the corresponding azo compounds with phenylhydrazine. The reduction proceeds readily at room temperature. The 2,2'-hydrazobenzimidazoles are oxidized extremely readily in air to azo compounds, and they were therefore also characterized as the N,N'-diacetyl derivatives (XI). We were unable to obtain 2,2'-hydrazobenzimidazole (X, R=H) itself, probably because of its extreme instability.



Xa, b XIa, b

Xa XI a R=CH_3; Xb XI b R=C_6H_5

EXPERIMENTAL

N-Anions (II, V). These were obtained by the introduction of the appropriate 2-aminobenzimidazole (0.01 mole) into a solution of freshly prepared potassium amide (0.04 g) or sodium amide (0.01-0.02 mole) in 50 ml of liquid ammonia. The mixture was stirred at −78°C for 1 h, after which the oxidizing agent ($KMnO_4$, $K_2S_2O_8$, or Na_2O_2) was added. Anion V was generated from azide VII by the gradual addition of small lumps of sodium metal (0.03 g-atom) to a suspension of the azide (0.01 mole) in 50 ml of liquid ammonia.

Oxidation of the N-Anions. The N-anions were oxidized with $KMnO_4$, $K_2S_2O_8$, Na_2O_2, or benzoyl peroxide by the addition of an equivalent amount of dry oxidizing agent to a solution of the N-anion in liquid ammonia. After this, the ammonia was gradually evaporated in a stream of dry ammonia (to avoid oxidation of the N-anions by air). The dry residue was treated with 40 ml of water, and the insoluble material was removed by filtration. The 2,2'-azobenzimidazole was precipitated by acidification of the filtrate with hydrochloric acid. 1,1'-Dimethyl-2,2'-azobenzimidazole is insoluble in water and alkali. It was extracted with chloroform and purified by chromatography with a column packed with Al_2O_3 with elution by chloroform.

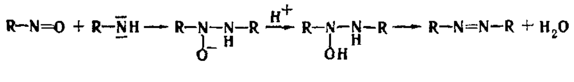
Air oxidation (autooxidation) was usually carried out by simple evaporation of the ammonia with subsequent storage of the dry residue in air for 24 h. Increasing the time of exposure to air did not affect the yield of azo compound.

Iodine oxidation was carried out by the addition of 30 ml of an ether solution of iodine (0.01 mole) to the dry residue after evaporation of the ammonia (in a stream of dry NH_3). The day after evaporation of the ether, the mixture was treated with 40 ml of water, and the azo compound was isolated in the usual manner.

1,1'-Dimethyl-2,2'-hydrazobenzimidazole (Xa). A 0.3 g (1 mmole) sample of 1,1'-dimethyl-2,2'-azobenzimidazole [5] was stirred in a test tube with 6 ml of freshly distilled phenylhydrazine. The reaction began at room temperature, as evidenced by the evolution of nitrogen and the change in the color from red to light-yellow. As soon as gas evolution ceased, the test tube was sealed and allowed to stand for 24 h

---

* An alternative mechanism might consist in the condensation of the intermediately formed nitroso compound and the N-anion [4]:



$$R{-}N{=}O + R{-}\bar{N}H \longrightarrow R{-}\underset{O^-}{N}{-}\underset{H}{N}{-}R \xrightarrow{H^+} R{-}\underset{OH}{N}{-}\underset{H}{N}{-}R \longrightarrow R{-}N{=}N{-}R + H_2O$$

in a refrigerator. The resulting precipitate was then removed by filtration, washed thoroughly with ether, and dried in a desiccator over $CaCl_2$ under nitrogen. The yield of colorless crystals of the hydrazo compound with mp 205-207° was quantitative. Found: C 65.5; H 5.5%. $C_{16}H_{16}N_6$. Calculated: C 65.7; H 5.5%.

N,N'-Diacetyl-1,1'-dimethyl-2,2'-hydrazobenzimidazole (XIa). A 0.32 g (1 mmole) sample of Xa was heated with 5 ml (40 mmole) of acetic anhydride on a water bath for 30 min. The excess acetic anhydride was removed by vacuum distillation, and the residue (0.41 g) was dissolved in chloroform. The chloroform solution was filtered, and petroleum ether was added to precipitate a product with mp 173-174°. Found: C 64.1; H 5.2; N 22.4%. $C_{20}H_{20}N_6O_2$. Calculated: C 63.8; H 5.4; N 22.3%.

1,1'-Diphenyl-2,2'-hydrazobenzimidazole (Xb). This compound was obtained in 97% yield from 1,1'-diphenyl-2,2'-azobenzimidazole [5] (in analogy with Xa) as colorless crystals with mp 209-210°. The product was insoluble in benzene and acetone and slightly soluble in alcohol. Found: C 74.6; H 5.0%. $C_{26}H_{20}N_6$. Calculated: C 75.0; H 4.8%.

N,N'-Diacetyl-1,1'-diphenyl-2,2'-hydrazobenzimidazole (XIb). This compound was obtained in 80% yield by a method similar to that used to prepare XIa by acylation of Xb and had mp 216-217° (from isopropyl alcohol). Found: C 71.6; H 5.0; N 16.9%. $C_{30}H_{24}N_6O_2$. Calculated: C 72.0; H 4.8; N 16.8%.

LITERATURE CITED

1. A. F. Pozharskii, É. A. Zvezdina, I. S. Kashparov, Yu. P. Andreichikov, V. M. Mar'yanovskii, and A. M. Simonov, Khim. Geterotsikl. Soedin., 1230 (1971).
2. A. F. Pozharskii, É. A. Zvezdina, Yu. P. Andreichikov, A. M. Simonov, V. A. Anisimova, and S. F. Popova, Khim. Geterotsikl. Soedin., 1267 (1970).
3. A. F. Pozharskii and É. A. Zvezdina, Zh. Organ. Khim., 3, 2251 (1967).
4. R. Konaka, K. Kuruna, and S. Terable, J. Am. Chem. Soc., 90, 1801 (1968).
5. A. F. Pozharskii, É. A. Zvezdina, and A. M. Simonov, Khim. Geterotsikl. Soedin., 184 (1967).