The characteristics of the compounds that were synthesized for the first time are presented in Table 2.

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RESEARCH IN THE ISOXAZOLE SERIES.

38.* POLAROGRAPHIC REDUCTION OF 4-ARYLAZOISOXAZOLES

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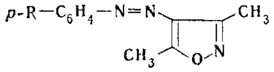
and S. D. Sokolov

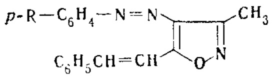
UDC 543.253:547.786

The indicated compounds are reduced on a dropping-mercury electrode in aqueous alcohol solutions at pH > 7 in one two-electron wave to 1,2-disubstituted hydrazines; four-electron reduction with the formation of amines takes place in acidic media. Two one-electron reduction waves are observed in dimethylformamide (DMF). Satisfactory $E_{1/2}-\sigma$ correlation equations were obtained for 4-arylazo-3,5-dimethyloxazoles.

We have previously studied the polarographic behavior of methyl- and phenylisoxazoles [2], as well as their halo derivatives [3], in anhydrous dimethylformamide (DMF). We established that only phenylisoxazoles undergo reduction with cleavage of the N–O bond of the hetero ring in the first step. In a continuation of our systematic studies, in the present research we studied the reduction of some arylazoisoxazoles of the I and II types and 3-phenyl-4-phenylazo-5-methylisoxazole (III) on a dropping-mercury electrode.



I a-e



II a-e

I-II a R=H; b $R=CH_3$; c $R=CH_3O$; d R=Br; e $R=NO_2$

The polarographic behavior of I was studied in both aqueous alcohol nonbuffer and buffer solutions with pH values from two to 12 and in anhydrous DMF with a saturated solution of tetramethylammonium iodide as the base electrolyte. Because of their low solubility in an

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*See [7] for Communication 37.

S. Ordzhonikidze All-Union Scientific-Research Institute of Pharmaceutical Chemistry, Moscow 119021. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 10, pp. 1320-1323, October, 1980. Original article submitted March 19, 1980.

0009-3122/80/1610-0997$07.50

TABLE 1. Half-Wave Potentials ($E_{1/2}$, V) and Diffusion Current Constants ($J = i_{lim}/c \cdot m^{2/3} \cdot t^{1/6}$) of Azobenzene and Azoisoxazoles Ia-e in 50% Alcohol

	Azobenzene		Ia		Ib		Ic		Id		Ie	
	$E_{1/2}$, V	J	$E_{1/2}$, V	J	$E_{1/2}$, V	J	$E_{1/2}$, V	J	$E_{1/2}$, V	J	$E_{1/2}$, V	J
0,1N H_2SO_4	0,038	2,09	0,246 0,665	2,11 1,78	0,268	3,53	0,290	3,82	0,242 0,767	1,78 2,03	0,072 0,356	2,07 7,24
pH 2,02	—	—	0,358 0,920	1,93 1,93	0,355 0,703	2,26 1,81	0,407	3,91	0,337 1,032	1,75 1,92	—	—
pH 4,06	0,350	2,02	0,564 1,270	1,99 1,81	0,627 1,227	2,04 1,81	0,577 1,010	2,20 1,75	0,555 1,337	1,75 1,59	0,304 0,393 0,594	2,00 1,32 6,69
pH 7,00	0,575	2,04	1,003	1,95	1,032	2,33	1,076	2,09	0,935	1,96	0,532 0,845 1,272	2,25 3,96 3,85
pH 10,76	—	—	1,025	2,11	1,058	2,04	1,105	1,86	0,980	1,96	—	—
0,1 N NaOH	—	—	0,980	1,91	1,006	2,02	1,057	1,98	0,932	1,94	0,618 1,093	3,03 4,59

aqueous alcohol medium, II were investigated only in DMF. All I give two well-expressed waves in acidic buffer solutions up to pH ~ 4 (only azoisoxazole Ib in 0.1 N H_2SO_4 solution and azoisoxazole Ic in 0.1 N H_2SO_4 solution and with a citrate–phosphate buffer with pH 2 as the base electrolyte are reduced in one wave). As the pH is increased, the waves are shifted to more negative potentials, the current of the second wave begins to decrease, and one wave remains at pH 7; the half-wave potential of the latter wave does not depend on the pH, and the current constitutes half of the overall current in an acidic medium (Table 1). Starting from the literature data [4], as well as from a comparison of the diffusion current constants (J) of derivatives of arylazoisoxazole and azobenzole, for which the number of electrons is known (n = 2) [5], it may be assumed that these waves correspond to stepwise four-electron reduction of the azo group to a 1,2-disubstituted hydrazine and subsequently to an amine. In alkaline media the reduction stops at the step involving a substituted hydrazine. A more complex picture of polarographic reduction is observed for nitro derivative Ie, for which we also observed waves of reduction of the nitro group. Electron-acceptor substituents (Br, NO_2) in the para position of the benzene ring of I facilitate the first step of reduction of the azo group, whereas electron-donor groupings (CH_3, CH_3O) hinder it. This effect is observed particularly distinctly in neutral and alkaline media, in which a linear correlation dependence of $E_{1/2}$ on the σ constants of the substituents in the benzene ring exists. At pH 7 we obtained the equation $E_{1/2} = 0.215\sigma - 1.003$ ($r = 0.989$, $S_0^2 = 0.000236$). A correlation dependence is not observed in the reduction of I in acidic media.

Two one-electron waves corresponding to reduction of the azo group to a substituted hydrazine (which is confirmed by a comparison of the diffusion current constants of the investigated compounds with the diffusion current constants of the previously investigated azobenzene [6] and with the data in [2]) are observed in the reduction of I on a dropping-mercury electrode in DMF. The isoxazole ring is not reduced in this case (compare this with the results in [2, 3]). Waves of reduction of the bromo and nitro groups are also visible on the polarograms of the bromo and nitro derivatives (Id and Ie). As one might have expected, phenylisoxazole III gives, in addition to waves of reduction of the azo group, a four-electron wave of reduction of the isoxazole ring (Table 2). It follows from this table that II are reduced more easily than I and that the reduction of the azo group occurs at less negative potentials in the case of isoxazole derivatives II than in the case of azobenzene. In addition to two one-electron waves of the N=N group, the polarograms of II contain another wave at more negative potentials corresponding to the transfer of four electrons; these waves were not studied in greater detail. The carbon–carbon double bond in the styryl residue evidently undergoes subsequent reduction. In addition waves of reduction of the bromo and nitro groups are present in the polarograms of azoisoxazoles IId and IIe.

In all cases the polarograms of the investigated compounds in DMF with tetramethylammonium iodide as the base electrolyte contain a small forewave, which probably corresponds to reduction of the protonated form of the azo derivatives of isoxazole and is due to the presence of a certain amount of residual water in the DMF. Our assumption was verified by experiments with the addition of small portions of a solution of benzoic acid (10 mmole/liter) or a solution of tetrabutylammonium hydroxide (10 mmole/liter) to a solution of Ia

TABLE 2. Half-Wave Potentials ($E_{1/2}$, V) and Diffusion Current Constants ($J = i_{lim}/c \cdot m^{2/3} \cdot t^{1/6}$) of Ia-e and IIa-e in DMF with a Saturated Solution of $(CH_3)_4NI$ as the Base Electrolyte

		a	b	c	d	e	Azobenzene
		I					
$E_{1/2}$, V	Forewave	1,344	1,391	1,458	1,246	0,889	—
	1	1,511	1,544	1,608	1,418	1,205	1,392
	2	2,066	2.077	2,148	2,286	1,924	1,822
J	Forewave	0,76	0,65	0,78	0,69	1,99	—
	1	1,44	1,59	1,54	1,55	1,37	2,10
	2	0,85	0,72	0,81	3,04	8,83	1,54
Sum of J		3,05	2,96	3,13	5,28	12,19	3,64
		II					III
$E_{1/2}$, V	Forewave	1,027	1,079	1,128	1,018	0,747	—
	1	1,167	1,217	1,260	1,128	1,042	1,360
	2	1,712	1,740	1,755	1,681	1,858	2,267
	3	2,121	2,005	1,990	2,026	2,062	2,397
	4	2,470	2,207	2,208	2,215	2,232	—
	5	—	—	—	2,458	—	—
J	Forewave	0,76	0,77	0,76	0,80	1,33	—
	1	1,31	1,33	0,76	0,70	1,33	2,14
	2	1,43	1,39	1,07	0,98	5,72	1,82
	3	4,41	3,39	2,71	2,72	5,31	8,36
	4	2,67	4,80	3,59	2,72	3,52	—
	5	—	—	—	4,09	—	—
Sum of J		10,58	11,68	8,89	12,01	17,21	12,32

(1 mmole/liter). In the presence of benzoic acid the forewave becomes larger with a simultaneous decrease in the first wave. However, the addition of tetrabutylammonium hydroxide led to disappearance of the forewave. It follows from the data in Table 2 that the nature of the substituents in the para position of the phenyl group has an appreciable effect on the ease of transfer of the first electron to the azo group; the $E_{1/2}$ values correlate satisfactorily with the Hammett σ constants in this case. The parameters of the correlation equation for I in DMF are $E_{1/2} = 0.375\sigma - 1.500$ ($r = 0.997$, $S_0^2 = 0.000201$); for II, $E_{1/2} = 0.198\sigma - 1.185$ ($r = 0.981$, $S_0^2 = 0.000350$). It follows from the data presented above that the para substituent in I (i.e., in the case of 3,5-dimethyl-substituted isoxazoles) has the greatest effect on the reduction potentials. A similar effect was studied in [6] for p-substituted azobenzenes in an aprotic medium (DMF) with sodium nitrate solutions (0.2 mole/liter) as the base electrolyte, in which case the reversible one-electron transfer in the first step was followed. The correlation equation $E_{1/2} = 0.365\sigma - 1.301$ ($r = 0.992$), where the ρ value, which characterizes the sensitivity of the system to the effects of substituents, is very close to the ρ value that we obtained (ρ = 0.375) for p-substituted phenylazodimethylisoxazoles under the same conditions, was obtained. Hence, it may be concluded that replacement of a phenyl group by a 3,5-dimethylisoxazole group has virtually no effect on the mechanism of the transmission of the electronic effects of substituents to the azo group. In the case of II with a styryl group in the 5 position, which has a rather strong effect on the reduction of the azo group, the effect of a substituent in the para position of the phenyl ring is manifested to a smaller extent (ρ = 0.198).

EXPERIMENTAL

The compounds were obtained by the methods described in [7], and their constants were in agreement with the literature data; chromatographically pure samples were used for the polarographic study. A capillary with a blade for forced detachment of the drops was used for the experiments in an aprotic medium: m = 0.73 mg/sec, t = 0.30 sec, and $m^{2/3}t^{1/6} = 0.662$. A silver wire immersed in the test solution served as the anode. The half-wave potentials of the investigated compounds were scaled relative to a saturated calomel electrode with respect to a "standard" (potassium) scale [8]. A capillary with forced detachment of the drops was also used for the experiments in aqueous alcohol media: m = 1.06 mg/sec, t = 0.305 sec, and $m^{2/3}t^{1/6} = 0.85$. The polarographic measurements were made in a thermostatted cell (at 25 ± 0.1°C) with a PO-4 polarograph (Radiometer, Denmark). The oxygen was removed from the solutions to be polarographed by means of a stream of purified nitrogen. The DMF was rendered anhydrous by means of fused KOH and was distilled *in vacuo*.

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1,3-OXAZINES.

INTRAMOLECULAR CYCLIZATION OF 1-DIAZO-3-BENZAMIDOPROPAN-2-ONES

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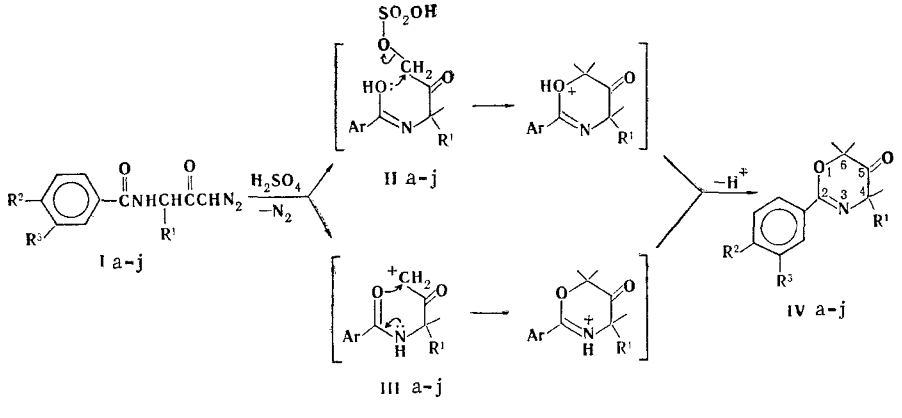
UDC 547.867.2

2-Aryl-5,6-dihydro-4H-1,3-oxazin-5-ones were obtained in the reaction of 1-diazo-3-benzamidopropan-2-ones with acidic agents.

Continuing our research on the intramolecular cyclization reactions of diazo ketones under the influence of acidic agents, which lead to heterocycles [1], we studied the possibility of the formation of the 1,3-oxazine system from 1-diazo-3-benzamidopropan-2-ones (I).

The reaction of Ia-j with concentrated sulfuric acid at room temperature for a few seconds leads to 5,6-dihydro-4H-1,3-oxazin-5-one derivatives (IVa-j). The reaction may proceed both through the carbonium ion (III) generated by protonation of diazo ketones I and through a sulfo ester (II). In both cases the oxygen atom of the benzoyl group undergoes intramolecular alkylation with subsequent splitting out of a proton and the formation of oxazines IVa-j. Alternative ring closing at the nitrogen atom to give an azetidine system does not occur.



I, IV a $R^1=R^2=R^3=H$; b $R^1=R^3=H$, $R^2=CH_3$; c $R^1=R^3=H$, $R^2=Cl$; d $R^1=R^3=H$, $R^2=Br$; e $R^1=R^3=H$, $R^2=NO_2$; f $R^1=H$, $R^2=R^3=OCH_3$; g $R^1=CH_3$, $R^2=R^3=H$; h $R^1=C_2H_5$, $R^2=R^3=H$; i $R^1=CH_2C_6H_5$, $R^2=R^3=H$; j $R^1=CH_2C_6H_5$, $R^2=R^3=OCH_3$

Branch of the Institute of Chemical Physics, Academy of Sciences of the USSR, Chernogolovka 142432. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 10, pp. 1324-1326, October, 1980. Original article submitted February 14, 1980.

0009-3122/80/1610-1000$07.50