Tetrahedron Letters No. 49, pp 4955 - 4958.   0040-4039/78/1201-4955$02.00/0
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ELECTROCHEMICAL SYNTHESIS OF TETRAHYDRO-1,2-SUBSTITUTED 3-PYRIDAZINONES AND 3,6-PYRIDAZINEDIONES

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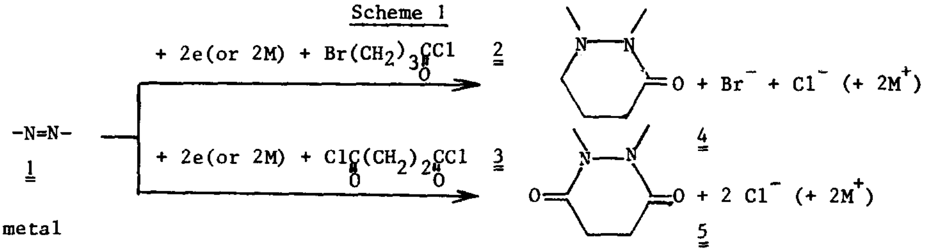
The reductive cyclisation of aromatic azo compounds leading to hexahydropyridazine derivatives is known[1-3]. A synthesis of hexahydro-1,2-diphenyl-pyridazine by chemical[1,2] or electrochemical[3] reduction of azobenzene 1a in the presence of 1,4-dibromobutane has been performed.

The synthesis of tetrahydro-1,2-substituted 3-pyridazinones 4 and 3,6-pyridazinediones 5 by chemical or electrochemical reduction of aromatic azo compounds 1 in the presence of 4-bromobutyryl chloride 2 and succinyl chloride 3 (scheme 1) has never been described.

Scheme 1



M = Alkali metal

We describe here the one step electrochemical synthesis, according to the scheme 1, of 4 and 5 derivatives. They are obtained by electrochemical reduction, in D.M.F., on a mercury pool electrode, of azobenzene 1a, cinnoline 1b and benzo(c)cinnoline 1c in the presence of acid chlorides 2 and 3.

In D.M.F., the electrochemical reduction of azobenzene 1a occurs in two one-electron steps (waves A and B)[4,5]. First, azobenzene is reduced in a rapid one-electron transfer reaction, to a stable anion radical[5]. The behaviour in aprotic media of 1b[6] and 1c[7,8], is similar to that of azobenzene. The half-wave potentials in D.M.F. of waves A and B (E_A and E_B) are given in table 1. In the presence of acid chloride 2 or 3, two more waves C and D are observed at more positive potentials. C is a kinetic wave. Their heights increase with increasing concentrations of acid chloride 2 or 3. Their half-wave potentials E_C and E_D are given in Table 1 in the case of succinyl chloride 3. The E_C and E_D values are similar in the case of 2.

In the presence of acid chloride 2 or 3, the polarographic modifications are the same as the ones observed by LUND and SIMONET[9] when acetyl chloride is added to cinnoline and pyridazine derivatives. The wave C has been attributed to the reduction of the kinetically generated N-acylium species [9]. A N,N'-diacylated compound is usually obtained. D corresponds to the reversible formation of a radical anion, then its acylation and further reduction.

Table 1

	$E_A^{a,b}$	$E_B^{a,b}$	$E_C^{a,b}$	$E_D^{a,b}$
1a + 3	- 1.30	- 2.00	- 0.20	- 1.10
1b + 3	- 1.49	- 2.44	- 0.32	- 1.30
1c + 3	- 1.40	- 2.40	- 0.28	- 1.30

a : V vs SCE ; b : Bu_4NPF_6 0.1 M as supporting electrolyte.

In Table 2 are given the experimental conditions and the results of a series of preparative electrolyses. After dilution of the catholyte with water, neutralization, extraction with ether or benzene, and evaporation of the solvent in vacuo, the electrolysis products are purified by column chromatography on silica.

The yields of the N,N'-succinyl-dihydrazo derivatives 5a[10], 5b and 5c which are obtained when azo compounds are reduced in the presence of 3, are very little modified by an increase of the acid chloride 3 concentration (see V and VI). When a large excess of 3 is present, the number of $F.mol^{-1}$ consumed is much larger than 2 (see I and VI) due to the reduction of 3 (E 1/2 = - 1.4 V).

In the presence of 2, mono and diacylated hydrazo compounds 7 and 8 are obtained when the electrolysis is run at a potential corresponding to the plateau of C (see II and VII). No cyclisation is observed. 7 and 8 may be prepared in almost quantitative yields in the presence of a large excess of 2 during the electrolysis. If the applied potential corresponds to the plateau of D, tetrahydro pyridazinones 4a and 4c are obtained (see III and VIII). At potentials of D, there is a competition between the reduction into 10 of the kinetically generated species 9 (path A of scheme 2) and the direct reduction to a radical anion 1' of 1 (path B). Since the final compounds of both paths are different (7 and 8 in the case of A and cyclic compounds 4a and 4c in the case of B), we suggest that the radical anion 1' may lead to the anion 11 which is able to cyclise, on as opposed to 10. An increase of the concentration of 1' should favor the path B and the formation of 4.

Scheme 2

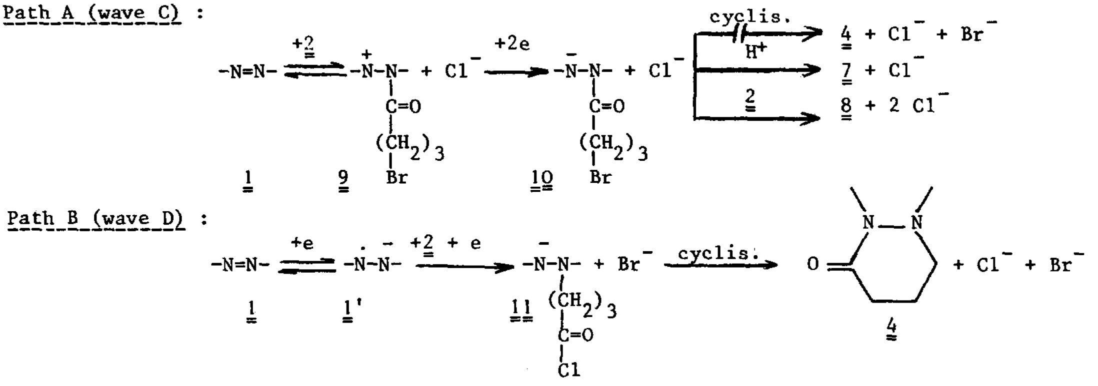
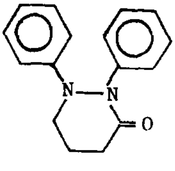


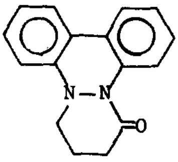
Table 2

Azo Compound	Electrolysis n°	Azo mmol	2 mmol	3 mmol	Applied Pot. (V)^a	F consumed	Isolated Compounds	Yield (%)
1a	I	11		89	-1.2^b	3.6	5a	49
	II	2.75	2.75		-0.6^c	1.3	1a 7	30 30
	III	2.75	2.75		-1.3^c	2.0	1a Hydrazobenzene 4a	21 12 8
1b	IV	3.8		22	-1.3^b	2.8	5b	26
1c	V	2.8		2.8	-1.2^c	2.3	5c	49
	VI	11.1		89	-1.2^b	4.3	5c	54
	VII	2.8	5.6^d		-0.5^c	2.1	1 8	30 40
	VIII	2.8	2.8		-1.5^c	2.2	1c 8 4c	20 10 16

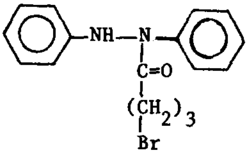
a : vs SCE ; b : Bu$_4$NI 0.1 M ; c : Bu$_4$NPF$_6$ 0.1 M ; d : added dropwise during the electrolysis.



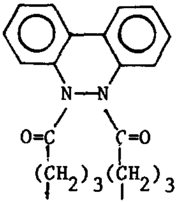
4a[13]



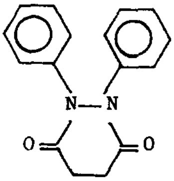
4c[14]



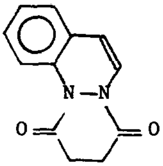
7[15]



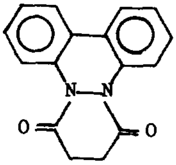
8[16]



5a[10]



5b[17]



5c[18]

A high yield of **4c** (62 %) was thus obtained in the following experimental conditions : stable dark green radical anion[11,12] of benzocinnoline **1c** was generated in the electrolysis cell in the absence of acid chloride **2**. A solution of **2** in D.M.F. was added dropwise until depletion of the green color. Faradaic current was passed again until the dark green coloration appears again. Addition of **2** was thus repeated again several times, as previously, until total depletion of the faradaic current (2.8 F $mole^{-1}$ consumed).

Except in the case of **5a**[10], the compounds mentioned in table 2 are new.

REFERENCES

1. J. W. B. Reesor and G. F. Wright, *J. Org. Chem.*, *22*, 375 (1957).
2. G. Wittig, W. Joos and P. Rathfelder, *Liebigs Ann. Chem.*, *610*, 180 (1957).
3. T. Troll and W. Elbe, *Electrochim. Acta*, *22*, 615 (1977).
4. G. H. Aylward, J. L. Garnett and J. H. Sharp, *Analyt. Chem.*, *39*, 457 (1967).
5. J. L. Sadler and A. J. Bard, *J. Am. Chem. Soc.*, *90*, 1979 (1968).
6. B. J. Tabner and J. R. Yandel, *J. Chem. Soc.*, *A*, 381 (1968).
7. S. Millefiori, *J. Heterocycl. Chem.*, *7*, 145 (1970).
8. H. Lund, M. A. Michel and J. Simonet, *Acta Chem. Scand.*, *B28*, 900 (1974).
9. H. Lund and J. Simonet, *C. R. Acad. Sc. Paris*, *277*, 1387 (1973).
10. H. Feuer, E. P. Rosenquist and F. Brown, *Israel J. Chem.*, *6*, 587 (1968).m_p = 245°C (EtOH).
11. D. H. Geske and G. R. Padmanabhan, *J. Am. Chem. Soc.*, *87*, 1651 (1965).
12. V. Kalyanaraman, S. S. Dua, C.N.R. Rao and M. V. George, *Tetrahedron Lett.*, 235, 1968.
13. **4a** m_p = 88°C. IR(film) : 1680-1700 cm^{-1} (C=O). NMR ($CDCl_3$) : 2-2.5 (m,4H), 3.7-3.95 (t,2H) 6.7-7.45 (m,8H), 7.7-7.9 (m,2H).
14. **4c** m_p = 167°C (ether-petroleum ether). NMR ($CDCl_3$) : 2-2.4 (m,2H), 2.5-2.8 (m,2H), 3.7-3.95 (m,2H), 6.7-7.75 (m,8H). Mass (m/e) : 250 ($M^{+\cdot}$, 37 %), 194 (100 %).
15. **7** m_p = 134°C. IR(KBr) : 3300 cm^{-1} (NH), 1650 cm^{-1} (C=O). NMR ($CDCl_3$) : 2-2.4 (m,2H), 2.75 (t, J = 7 Hz, 2H), 3.6 (t, J = 6 Hz, 2H), 6.6-7.6 (m, 11H). Mass (m/e) : 334 ($M^{+\cdot}$, 1 %), 332 ($M^{+\cdot}$, 1 %), 184 (100 %), 183 (100 %).

    A partial substitution in the electrolysis mixture of a bromide by a chloride was observed in the case of **7** and **8**, which leads to chloro or dichloro derivatives of **7** and **8**.
16. **8** m_p = 120°C (ether-petroleum ether). IR(KBr) : 1690-1710 cm^{-1} (C=O). NMR ($CDCl_3$) : 1.9-2.25 (m, 4H), 2.6-2.9 (m, 4H), 3.5 (t, J = 6 Hz, 4H), 7.2-7.85 (m, 8H).
17. **5b** IR(KBr) : 1650-90 cm^{-1} (C=O). NMR ($CDCl_3$) : 2,72 (s, 4H), 5.9 (d, J = 8 Hz), 7.1 (d, J = 8 Hz), 6.9-7.2 (m, 4H). Mass (m/e), chemical ionisation : 215 ($M+1^{+\cdot}$, 100 %).
18. **5c** m_p = 161° (ethanol). IR(KBr) : 1690-1710 cm^{-1} (C=O). NMR ($CDCl_3$) : 2.8 (broad s, 4H), 7.15-7.45 (m, 4H), 7.6-7.9 (m, 4H). Mass (m/e), chemical ionisation : 265 ($M+1^{+\cdot}$, 100 %).

(Received in UK 25 September 1978)