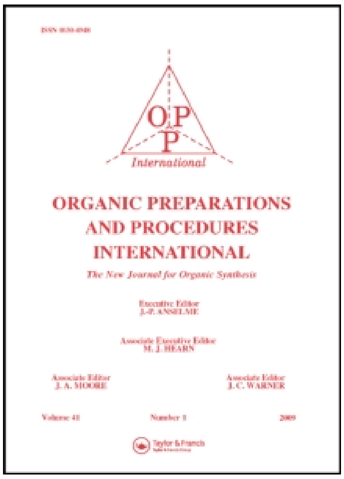


Organic Preparations and Procedures International
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t902189982

THE SYNTHESIS AND CHARACTERIZATION OF NOVEL *bis*(FORMAZANS)

Yasar Gok[a]; H. Basri Senturk[a]
[a] Department of Chemistry, Karadeniz Technical University, Trabzon, TURKEY

To cite this Article Gok, Yasar and Senturk, H. Basri(1995) 'THE SYNTHESIS AND CHARACTERIZATION OF NOVEL *bis*(FORMAZANS)', Organic Preparations and Procedures International, 27: 1, 87 — 91
To link to this Article: DOI: 10.1080/00304949509458182
URL: http://dx.doi.org/10.1080/00304949509458182

THE SYNTHESIS AND CHARACTERIZATION OF NOVEL *bis*(FORMAZANS)

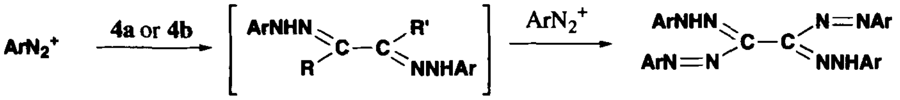
Submitted by
(06/24/94)

Yasar Gok* and H. Basri Senturk

Department of Chemistry
Karadeniz Technical University
61080 Trabzon, TURKEY

Formazans[1] and their transition metal complexes are of interest in the area of dyes, medicine and biochemistry.[2] Tetrazolium salts, the oxidation products of formazans, have attracted attention as biological indicators.[3] Rapid tautomerism and hydrogen bonding are the two most important chemical properties of these compounds.[4] One of the various methods to prepare formazans involves the coupling of diazonium salts with compounds containing an active methylene group, e. g., nitromethane, acetoacetic ester, cyanoacetic acid and malonic acid; even acetylacetone has been used for the synthesis of formazans. We now report that acetonylacetone (**4a**) and levulinic acid (**4b**) each with two active methylene groups, can be utilized efficiently to synthesize novel *bis*(formazans).

bis[N,N'-(2,2'-Dihydroxy-5,5'-dicarboxydiphenyl)formazan] (**3a**) and *bis*[N,N'-(2,2'-dicarboxy-4,4'-dihydroxydiphenyl)formazan] (**3b**) were obtained by coupling the diazonium salt of 3-amino-4-hydroxybenzoic acid (**1a**) and 2-amino-5-hydroxybenzoic acid (**1b**), respectively, with levulinic acid in strong alkaline media. *bis*[N,N'-(2,2'-Dihydroxy-4,4'-dinitrodiphenyl)formazan] (**3c**), *bis*[N,N'-(2,2'-dihydroxy-5,5'-dinitrodiphenyl)formazan] (**3d**), *bis*[N,N'-(2,2'-dihydroxy-5,5'-dimethyldiphenyl)formazan] (**3e**), *bis*[N,N'-(2,2'-dicarboxy-4,4'-dinitrodiphenyl)formazan] (**3f**), *bis*[N,N'-(2,2'-dicarboxy-5,5'-dinitrodiphenyl)formazan] (**3g**) and *bis*[N,N'-(2,2'-dihydroxy-4,4'-disulfonic-diphenyl)formazan] (**3h**) were prepared from the reaction of the diazonium salt of 2-amino-5-nitrophenol (**1c**), 2-amino-4-nitrophenol (**1d**), 2-amino-4-methylphenol (**1e**), 2-amino-5-nitrobenzoic acid (**1f**), 2-amino-4-nitrobenzoic acid (**1g**) and 3-hydroxy-4-aminobenzenesulfonic acid (**1h**) with acetonylacetone in alkaline medium. In the case of **3a,b**, loss of the acetyl and carboxy groups occurs while two acetyl groups are lost for **3c-3h**. The structure of these novel formazans (Scheme) was confirmed by elemental analysis (Table 1) and ^{1}H NMR (Table 2), IR (Table 3) and UV-VIS (Table 4) spectra. The molecular weights of some *bis*(formazans) were determined by osmometric methods.



1 **2** **3**

RCH_2CH_2R'

4

R = R' = CH_3CO for **4a**
R = CH_3CO, R' = CO_2 for **4b**

a) A = OH, B = H C = CO_2H
b) A = OH, B = OH C = H
c) A = OH, B = NO_2 C = H
d) A = OH, B = H C = NO_2
e) A = OH, B = H, C = CH_3
f) A = OH, B = NO_2, C = H
g) A = OH, B = H, C = NO_2
h) A = OH, B = SO_3H, C = H

In the ^1H NMR spectra of **3a** and **3b**, the NH protons of the formazan group appear as rather weak singlets at δ 7.79 and δ 7.72, respectively as a result of tautomerism (Fig. 1) in the formazan skeleton.[5] These NH protons were also identified easily upon D_2O exchange and are significantly shifted downfield, as expected. The singlets at δ 8.36, 8.42 and 12.11, 11.40 correspond to carboxyl and hydroxy protons, respectively. Peaks for the aromatic protons appear at frequencies that are very close to those of **1a** and **1b**.

The primary aromatic amine protons of **1h** disappear after formazan formation and the NH protons of the new compound **3h** are observed at δ 8.21. The OH protons of the phenol groups of the above mentioned formazan appear at δ 11.23. The other chemical shifts which belong to SO_3H and the aromatic protons are similar to those of **1h**. The singlets of the ^1H NMR spectra of **3c-3g**, the singlets between δ 8.55-8.67 and 12.27-9.95 ppm correspond to carboxyl and hydroxyl protons, respectively. Peaks for aromatic and aliphatic hydrogens (**3e**) appear at frequencies that are very close

TABLE 1. Analytical and Physical Data for Formazans

Cmpd.	Color	mp.	Yield	Elemental Analyses (Calcd.)		
		(°C)	(%)	C	H	N
3a	red	<300	72	52.28 (52.47)	3.01 (3.20)	16.07 (16.32)
3b	red	232	61	52.21 (52.47)	2.96 (3.20)	16.11 (16.32)
3c	wine red	167	8	44.94 (45.21)	2.39 (2.60)	24.06 (24.32)
3d	redish brown	182	82	45.03 (45.21)	2.44 (2.60)	24.11 (24.32)
3e	pale brown	159	90	63.60 (63.34)	5.30 (5.11)	19.78 (19.57)
3f	red	148	56	44.61 (44.88)	2.02 (2.24)	20.74 (20.94)
3g	redish brown	170	68	44.68 (44.88)	2.07 (2.24)	20.69 (20.94)
3h	red	<300	56	37.40 (37.59)	2.43 (2.65)	13.28 (13.49)

TABLE 2. ^1H NMR Spectral Data (δ) for Formazans[a]

Cmpd.	OH(s)	COOH(s)	NH(s)	Arom. H(m)	Alip. H(s)	SO_3H(s)
3a	12.11(4H)	8.36(4H)	7.79(2H)	7.04-7.30(12H)	-	-
3b	11.40(4H)	8.42(4H)	7.72(2H)	6.95-7.35(12H)	-	-
3c	11.75(4H)	-	7.67(2H)	7.10-7.42(12H)	-	-
3d	12.27(4H)	-	7.75(2H)	6.87-7.18(12H)		
3e	9.95(4H)	-	6.70(2H)	6.85-7.20(12H)	2.25(12H)	-
3f	-	8.85(4H)	7.83(2H)	7.05-7.44(12H)	-	-
3g	-	8.67(4H)	7.94(2H)	7.11-7.52(12H)	-	-
3h	11.23(4H)	-	8.21(2H)	6.67-727(12H)	-	10.82(4H)

a) In DMSO-d_6 and NaOD.

TABLE 3. IR Spectral Data (cm^{-1}) of Formazans[a]

Cmpd.	(N-H)	(O-H)	(C=O)	(C=N)	(C=C)	(NH••N)	(N=N)	(N-O)	(SO_2-OH)
3a	3420	3160	1720	1670	1600	1520	1410	-	-
3b	3440	3173	1732	1665	1596	1506	1438	-	-
3c	3405	3128	-	1662	1604	1512	1420	945	-
3d	3390	3120	-	1650	1600	1508	1430	960	-
3e	3430	3125	-	1670	1605	1520	1415	-	-
3f	3408	-	1770	1655	1598	1510	1415	920	-
3g	3390	-	1725	1650	1602	1515	1428	950	-
3h	3450	3100		1665	1595	1518	1425	-	2590

a) As KBr pellet

TABLE 4. UV-VIS Spectra of Compounds **3a**

Cmpd.	λ.max.(log ε)
3a	610(3.83), 520(4.11), 440(4.32), 350(4.51), 320(4.13), 277(4.36), 270(4.43)
3b	615(3.62), 515(3.98), 438(4.41), 351(4.69), 273(4.18), 268(4.27)
3c	538(4.21), 514(4.11), 438(4.34), 395(4.48), 355(4.69), 314(4.71), 276(4.52), 265(4.73)
3d	540(4.70), 512(4.39), 432(4.31), 351(4.65), 312(4.28), 278(4.69)
3e	551(4.15), 447(4.18), 362(4.76), 331(4.89), 278(4.28)
3f	599(4.51), 456(4.19), 377(4.96), 354(4.78), 315(4.34), 269(4.87)
3g	532(4.88), 420(4.44), 395(4.13), 351(4.92), 327(4.58), 277(4.96)
3h	614(3.92), 470(4.62), 435(4.81), 410(4.48), 354(4.87), 316(4.57), 275(4.75), 258(4.62)

a) In DMF except for **3h** which was determined in EtOH

to those of **1c-1g**. A clear relationship exists between the magnitude of the chemical shift and the electron-withdrawing character of a carboxy, nitro or sulfonic substituent group or the electron-donating character of a methyl group. Because of the substituent effects, the chemical shifts in **3f-3g** which belong to carboxy groups have been observed up field. Even though N=N stretching vibrations are infrared-inactive for symmetrical *trans* azo compounds, they appear in general in the 1400-1450 cm^{-1} region for cis azo groups.[6] The corresponding vibrations of the formazan ring were observed at 1500-1520 cm^{-1}, as reported in the literature.[7] The secondary aromatic amine groups appear on at 3405-3450 cm^{-1} broad band resulting from the presence of NH•••N intramolecular hydrogen bonds.[8]

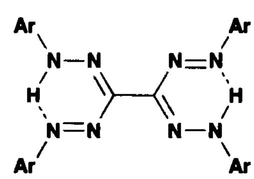


Fig. 1

The UV-VIS spectra offormazans show peaks at 350-354 nm characteristic of the π* transition of azo groups.[9,10] Bands observed in the 306-331 nm region in all of the formazans are assignable to the n→σ* transition of the C=N chromophore[11-12] while the absorptions in the 268-278 nm range correspond to the combination of benzenoid bands.[13] The presence of NO_2, SO_3H, COOH and OH substituents in formazans results in significant shifts in the absorption bands. For example, in phenyl derivatives of formazans, the absorptions occur at 478 and 485 nm.[14] These values are shifted to 512, 520 and 531 nm by the electron-withdrawing character of the NO_2, SO_3H and CO_2H substituents.[15] The spectra of formazans, **3a-3h** display sharply defined peaks in the 500-520 nm region with larger extinction coefficients (log ε 4.39-4.70).[16]

EXPERIMENTAL SECTION

^1H NMR Spectra were recorded on a Bruker AC-80 and Bruker AC-200 FT-NMR spectrophotometer. Elemental analyses were performed on a Perkin - Elmer 240C and Hewlet Packard 85 CHN analyzer. IR and UV-VIS spectra were recorded on a PerkinElmer 1600 FT-IR and GBC 911 spectrophotometers, respectively. 3-Amino-4hydroxybenzoic acid, 2-amino-5-nitrophenol, 2-amino-4-nitrophenol, 2-amino-4methylphenol, 2-amino-5-hydroxybenzoic acid (Fluka) and 3-hydroxy-4-aminobenzenesulfonic acid, 2-amino-5-nitrobenzoic acid, 2-amino-4-nitrobenzoic acid (Aldrich), levulinic acid and acetonylacetone (Merck) were used without further purification.

***bis*[N,N'-(2,2'-Dihydroxy-5,5'-dicarboxydiphenyl)]formazan (3a) and *bis*[N,N'-2,2'-Dicarboxy - 4,4'-dihydroxydiphenyl)]formazan (3b)**.- To a solution of 3-amino-4-hydroxybenzoic acid or 2-amino-5-hydroxybenzoic acid (1.53 g, 10 mmol) was dissolved in 2.5 mL ofconc. HCl cooled an ice bath, was added $NaNO_2$ (0.69 g, 10 mmol) in small portions, the presence of excess $NaNO_2$ was checked with potassium iodide starch paper. The diazonium solution was then treated with 10% KOH solution (30 mL) at -5°. A solution of levulinic acid (**4b**) (1.06 g, 10 mmol) in 25 mL of 10% KOH solution at -5° was added to the above diazonium solution. During this procedure, the dark yellow color turned red and $COHCl_2$ was evolved. After stirring for 5 hrs at -5°, this solution was acidified by 0.2 M HCl to pH 4.8 and the red formazan precipitated. The crude product was collected, washed with water and dried *in vacuo*. The product was purified by dissolving in aqueous alkali (0.2 M NaOH) followed by precipitation with 0.2 M HCl.

The calculated and osmometrically-found molecular weights of the potassium salts (**3a**) and (3b) were 826 (calcd) and 824.6 and 830 (calcd.) and 827.9 g mol^{-1} respectively.

General Procedure for Compounds 3c-3g.- The diazonium solution prepared from 10 mmol of **1c-g** was prepared as above then treated with 10% KOH solution (20 mL) at -5° and a further 5 ml of 10% KOH solution was added. A solution of acetonylacetone (1.49 g, 10 mmol) in 10 mL of 10% KOH solution -5°, was added to the diazonium solution. Work up as above gave **3c-g**.

***bis*[N,N'-(2,2'-Dihydroxy-4,4'-disulfodiphenyl]formazan [3h]**.- Sodium nitrite (1.89g, 10 mmol) was added in small portions to a solution of 3-amino-4-hydroxybenzenesulfanilate, prepared by addition of a solution of Na_2CO_3 (0.530 g, 5 mmol) to the acid in warm water (25 mL) for 2 hrs. The mixture was cooled below 0° in an ice bath. The solution was diazotized below 0° by the addition of conc. HCl (2.5 mL). The dark red solution was evaporated to dryness and then the residue was extracted three times with 40 mL portions of THF. The combined organic extracts were dried over anhydrous magnesium sulfate. The solvent was evaporated *in vacuo*. The dark red residue was washed with cold ethanol and ether and then dried *in vacuo* to yield, 1.19 g (57%) of **3h**.

Acknowledgements.- This work was supported by The Research Fund of Karadeniz Technical University (Trabzon-Turkey).The authors are indebted to Prof. Dr. Ahmet Gul (I.T.U. Istanbul-Turkey) and Prof. Dr. Aykut Ikizler (K.T.U. Trabzon-Turkey) for valuable discussions.

REFERENCES

1. P. Friese, *Ber.*, **8**, 1078 (1875).

2 R. Price, in "*The Chemistry of Synthetic Dyes*", Vol. 3, Ed. K. Venkataraman, Academic Press, New York, NY, 1970, p.303; H. Zollinger, in "*Color Chemistry*", VCH Verlagsgeseltschaft, Weinheim, 1987, p. 308; F. E. Smith, *Science*, **113**, 753 (1951).

3. T. T. Bamgboye and D. A. Bamgboye, *Inorg. Chim. Acta.*, **133**, 247 (1987).

4. A. Fischer, B. Kaul and H. Zollinger, *Helv. Chim. Acta.*, **51**, 1449 (1968).

5. V. D. Tiers, S. Polvan and S. J. Searles, *J. Org. Chem.*, **25**, 285 (1960).

6. N. B. Colthup, L. H. Doly and S. E. Wiberley in "*Introduction to Infrared and Raman Spectroscopy*", Academic Press, New York, 1964, p.287

7. C. Schiele, K. Holfar and G. Arnold, *Tetrahedron.*, **23**, 2693 (1967).

8. W. J. R. Le Fevre, *Australian J. Chem*, **9**, 151 (1956).

9. R. Wizinger, *Z. Naturfosch*, **96**, 739 (1954).

10. Y. Gok, *Dyes Pigments.*, **11**, 101 (1989); *Chem. Abs.*, **111**., 114, 17160b (1989).

11. Y. Gok and H. B. Senturk, *Dyes Pigments.*, **15**, 279 (1991); *Chem. Abs.*, **115**., 108, 10835h (1991).

12. M. Agarwa, J. Tandon and R. Mehrotra, *Indian J. Chem*, **21A**, 381 (1982).

13. R. M. Silverstein, G. C. Bassler and T. C. Morrill, in "*Spectrophotometric Identification of Organic Compounds*", John Wiley Inc, New York, NY, 1974, p. 249.

14. H. Irving, J. B. Gill and W. R. Cross, *J. Chem. Soc.*, 2087 (**1960**); F. Beffa, P. Lienhard, E. Steiner and G. Schetty, *Helv. Chim. Acta*, **46**, 1369 (1963).

15. Y. Gok and H. B. Senturk, *Inorg. Chim. Acta*, **180**, 53 (1991).

16. J. B. Gill, H. M. N. H. Irving and A. Prescott, *J. Chem. Soc., Perkin Trans. II*, 1963 (**1977**).

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