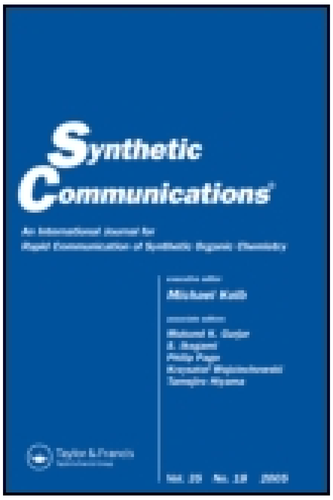
This article was downloaded by: [Stony Brook University]
On: 19 October 2014, At: 00:55
Publisher: Taylor & Francis
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/lsyc20

SYNTHESIS AND NUCLEOPHILIC REACTIONS OF N-(1-NAPHTHYL)- 3,4-METHYLENEDIOXYBENZYL-IDINEHOMOPHTHALISOIMIDIUM PERCHLORATE

M. E. Azab [a], H. M. F. Madkour [a] & M. R. Mahmoud [a]
[a] Synthetic Org. Chem. Lab., Chem. Dept., Faculty of Science, Ain Shams University, Abbassiya, Cairo, Egypt
Published online: 16 Aug 2006.

To cite this article: M. E. Azab, H. M. F. Madkour & M. R. Mahmoud (2002) SYNTHESIS AND NUCLEOPHILIC REACTIONS OF N-(1-NAPHTHYL)- 3,4-METHYLENEDIOXYBENZYL-IDINEHOMOPHTHALISOIMIDIUM PERCHLORATE, Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry, 32:3, 393-402

To link to this article: http://dx.doi.org/10.1081/SCC-120002123

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the “Content”) contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at http://www.tandfonline.com/page/terms-and-conditions

SYNTHETIC COMMUNICATIONS, 32(3), 393–402 (2002)

SYNTHESIS AND NUCLEOPHILIC REACTIONS OF *N*-(1-NAPHTHYL)-3,4-METHYLENEDIOXYBENZYLIDINEHOMOPHTHALISOIMIDIUM PERCHLORATE

M. E. Azab, H. M. F. Madkour,* and
M. R. Mahmoud

Synthetic Org. Chem. Lab., Chem. Dept.,
Faculty of Science, Ain Shams University,
Abbassiya, Cairo, Egypt

ABSTRACT

N-(1-Naphthyl)-3,4-methylenedioxybenzylidinehomophthalisoimidium perchlorate **6** was obtained via treatment of *N*-(1-naphthyl)-3,4-methylenedioxybenzylidine homophthalamic acid **5** with perchloric acid in acetic anhydride. The behaviour of **6** towards active methylene-containing compounds, Grignard reagents and aromatic primary amines and hydrocarbons, has been investigated.

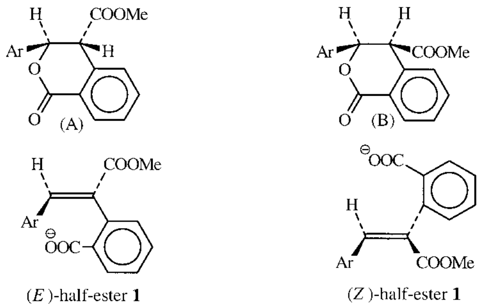
---

*Corresponding author.

www.dekker.com

A connection with our previous interest in developing new approach for the synthesis of heterocycles utilizing readily obtainable starting materials,[1–4] we report in the present work the synthesis of some new heterocylic systems utilizing the title compound.

Thus, when 3,4-methylenedioxybenzaldehyde was condensed with dimethyl homophthalate in the presence of sodium hydride as a condensing agent, the *Z*-half-ester **1** was obtained in approximately 90% yield (cf. Scheme 1). The preferential formation of the *Z*-configuration for the half-ester may be rationalized by considering the high strain associated with the *E*-isomer due to steric interference between the *ortho*-carboxyphenyl and the bulky substituted aryl group.



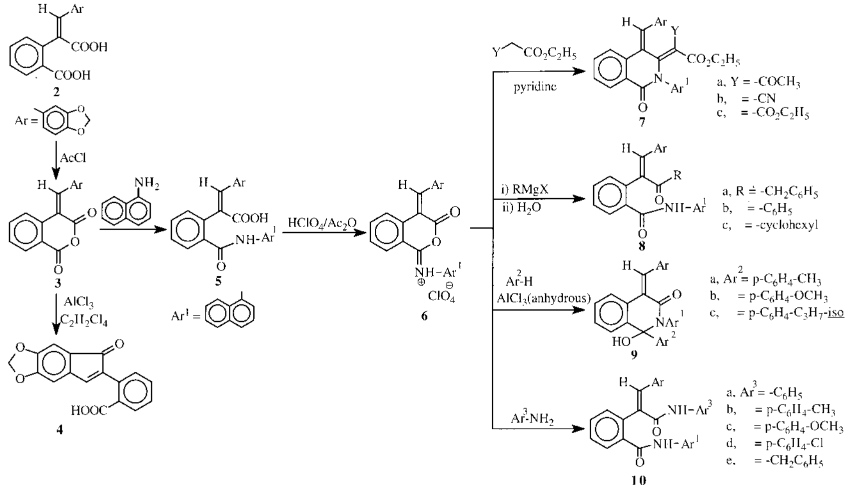
Scheme 1.

The half-ester **1** was saponified to the corresponding acid **2**. The structure assigned for the dicarboxylic acid **2** was based on its spectroscopic data. A chemical evidence for the structure assigned for the acid **2** was obtained from its conversion to the corresponding anhydride **3** by the action of acetyl chloride (cf. Scheme 2).

Compound **3** was subjected to an internal Friedel-Crafts acylation reaction with anhydrous aluminium chloride in dry acetylene tetrachloride to afford the respective oxoacid **4** in good yield (78%).

The assignment of the indenone structure **4** was based on analytical and spectroscopic data as well as its yellow color which is characteristic for indenones, its solubility in sodium carbonate solution and the formation of its DNP on reacting with dinitrophenyl hydrazine.

3,4-Methylenedioxybenzylidine homophthalic anhydride **3** was allowed to react with 1-naphthylamine in benzene to give 2-[*N*-(1-naphthyl)-carboxamido]-3,4-methylene-dioxybenzylidinephenylacetic acid (**5**). The interaction of 1-naphthylamine with compound **3** takes place on the benzoyl



Scheme 2.

carbonyl function rather than the cinnamoyl carbonyl function. This is due to two reasons; first, the benzoyl carbonyl function is sterically favorable, second, the electrophilicity of the benzoyl carbonyl function is more than that of the cinnamoyl moiety.

The homophthalamic acid derivative **5** was transformed to *N*-(1-naphthyl)-3,4-methylenedioxybenzylidine homophthalisoimidium perchlorate **6** by the action of perchloric acid in acetic anhydride.[5]

It was of interest to study the reaction of the salt **6** with active-methylene compounds in the presence of pyridine. When **6** was allowed to react with ethyl acetoacetate, diethyl malonate and/or ethyl cyanoacetate, good yields of the isoquinolinones **7a–c** were obtained.

Reaction of **6** with benzyl magnesium chloride, phenyl- and cyclohexyl magnesium bromides yielded the aralkyl-2-[*N*-(1-naphthyl)carboxamido]-3,4-methylenedioxy-benzylidinebenzyl ketone **8a–c**.

Reaction of compound **6** with aromatic hydrocarbons namely; toluene, anisole and/or cumene in the presence of anhydrous aluminium chloride, afforded good yields of the hydroxy-3,4-methylenedioxybenzylidine homophthalimidine derivatives **9a–c**.

When nitrogen nucleophiles such as primary aromatic amines namely; aniline, *p*-toluidine, *p*-anisidine, *p*-chloroaniline and/or benzyl amine react with the salt **6**, *N*,*N′*-disubstituted-3,4-methylenedioxybenzylidine homophthalamides **10a–c** were isolated. No evidence for the formation of acidic products resulting from the attack at the alternative site of the iso-imidium salt ($C{=}\overset{\oplus}{N}H$).

EXPERIMENTAL

All melting points are not corrected, the IR spectra were measured on a Unicam SP 1200 spectrophotometer using KBr Wafer technique. The mass spectra were determined with A.E.I.M.S. 12 single focusing mass spectrometer and the percentage of the relative abundance of a peak is shown in brackets and follows the *m/z* value. The ^{1}H-NMR spectra were measured on a Varian EM 360 instrument operating at 60 MHz in DMSO-d_6 or $CDCl_3$ solution. Compounds **1–5** were prepared according to the methods described in literature.[6–9] The physical characteristics of the new compounds are listed in Table 1.

Reaction of 3,4-Methylenedioxybenzaldehyde with Dimethyl Homophthalate; Formation of Methyl-β-(3,4-methylenedioxyphenyl)-α-(2-carboxyphenyl)acrylate 1

A mixture of the aldehyde (15.01 g; 0.10 mol), dimethyl homophthalate (32.2 g; 0.15 mol), and sodium hydride (3.6 g, 0.15 mol) in 150 mL of dry benzene was stirred for 60 min at 60–70°C. The solid deposited was filtered off, dissolved in $NaHCO_3$ solution (10%) then acidified with dil HCl-ice. The half ester **1** separated as a colourless crystalline solid which was recrystallized from benzene (cf. Table 1).

IR spectrum of **1** exhibited strong bands at 1675 and 1720 cm^{-1} for aryl acid and α,β-unsaturated ester groups respectively. On the other hand, the ^{1}H-NMR (DMSO-d_6) of the half-ester **1** exhibited the following signals: δ 3.28 (s, 3H, COOMe), 6.42 (s, 2H, O-CH_2-O), 7.49 (s, 1H, CH=C), 7.77–8.25 (m, 4H, Ar-H), 8.40–8.71 (m, 3H, Ar-H of piperonyl moiety) and 10.84 (s, 1H, COOH).

Saponification of the Half-Ester 1; Formation of 3,4-Methylenedioxybenzylidine Homophthalic Acid 2

The crystalline half-ester **1** (3.3 g; 0.01 mol) was heated under reflux in 35 mL of aqueous sodium hydroxide solution (10%) for 4 h. The alkaline solution was cooled, acidified with cold dilute hydrochloric acid and the

Table 1. Physical Characteristics for New Compounds

Compd. No.	Solvent of Crystallization M.P. (°C)	Yield (%)	Mol. Formula (M. wt.)	Analysis (Found/Cald.)			
				C%	H%	N%	Cl%
1	152–154	88	$C_{18}H_{14}O_6$	66.61	4.17	–	–
	(B)*		(326)	66.26	4.29	–	–
2	212–214	90	$C_{17}H_{12}O_6$	65.01	4.14	–	–
	(B/M)		(312)	65.38	3.85	–	–
3	138–139	65	$C_{17}H_{10}O_5$	69.92	3.56	–	–
	(L.P./B)		(294)	69.39	3.40	–	–
4	205–207	78	$C_{17}H_{10}O_5$	69.49	3.21	–	–
	(B/M)		(294)	69.39	3.40	–	–
5	190–200	46	$C_{27}H_{19}NO_5$	74.35	4.19	3.70	–
	(M)		(437)	74.14	4.35	3.20	–
6	196	42	$C_{27}H_{17}NO_8Cl$	62.05	3.61	4.42	6.86
	(T)		(518.5)	62.40	3.28	2.70	6.85
7a	92–94	41	$C_{33}H_{25}NO_6$	74.42	4.79	2.77	–
	(L.P.)		(531)	74.58	4.71	2.64	–
7b	210–212	36	$C_{32}H_{22}N_2O_5$	74.38	4.66	5.59	–
	(B)		(514)	74.71	4.29	5.45	–
7c	110–112	38	$C_{34}H_{27}NO_7$	72.87	4.59	2.58	–
	(L.P.)		(561)	72.73	4.81	2.50	–
8a	220–221	69	$C_{34}H_{25}NO_4$	79.82	4.81	2.61	–
	(T)		(511)	79.84	4.89	2.74	–
8b	240–242	65	$C_{33}H_{23}NO_4$	79.63	4.66	2.61	–
	(M)		(497)	79.68	4.63	2.82	–
8c	213–215	72	$C_{33}H_{29}NO_4$	78.51	5.88	2.87	–
	(B)		(503)	78.73	5.77	2.78	–
9a	260	32	$C_{34}H_{25}NO_4$	79.55	5.14	2.78	–
	(B/M)		(511)	79.84	4.89	2.74	–
9b	206	35	$C_{34}H_{25}NO_5$	77.17	4.91	2.82	–
	(M)		(527)	77.42	4.74	2.66	–
9c	182–184	42	$C_{36}H_{29}NO_4$	80.03	5.29	2.82	–
	(B)		(539)	80.15	5.38	2.60	–
10a	214–216	73	$C_{33}H_{24}N_2O_4$	77.13	4.79	5.10	–
	(B)		(512)	77.34	4.69	5.47	–
10b	220–222	69	$C_{34}H_{26}N_2O_4$	77.33	5.21	5.50	–
	(T)		(526)	77.57	4.94	5.32	–
10c	191–192	60	$C_{34}H_{26}N_2O_5$	75.17	4.90	5.11	–
	(B)		(542)	75.28	4.80	5.17	–
10d	146–148	54	$C_{33}H_{23}N_2O_4Cl$	72.08	4.13	5.28	6.30
	(T)		(546.5)	72.46	4.21	5.12	6.50
10e	253	70	$C_{34}H_{26}N_2O_4$	77.19	5.20	5.23	–
	(M)		(526)	77.57	4.94	5.32	–

*B = benzene; M = methanol; L.P. = light petroleum 80–100°C; T = toluene.

precipitated substance was filtered off and recrystallized from the suitable solvent to give **2** (cf. Table 1).

IR spectrum of **2** showed a single absorption band at 1680 cm^{-1} for both aryl conjugated and α,β-unsaturated acids. The ^{1}H-NMR ($CDCl_3$) of **2** indicates the presence of olefinic and aromatic protons: δ 6.49 (s, 2H, O-CH_2-O), 7.46 (s, 1H, CH=C), 7.70–8.34 (m, 4H, Ar-H), 8.52–8.77 (m, 3H, Ar-H of piperonyl moiety), 10.74 (s, 1H, CO_2H) and 10.84 (s, 1H, CO_2H). The MS of **2** exhibited the following peaks: 312 (50), 294 (53), 249 (20), 193 (33), 165 (100), 152 (62), 135 (45), 63 (82) and 51 (39).

Conversion of the Diacid 2 to 3,4-Methylenedioxybenzylidine Homophthalic Anhydride 3

Refluxing the diacid **2** (3.12 g, 0.01 mol) in acetyl chloride (35 mL, 0.5 mol) for 2 h, followed by distilling off the excess acetyl chloride afforded a yellow solid which upon recrystallization gave the anhydride **3** (cf. Table 1).

IR spectrum of **3** showed the carbonyl absorption bands at 1725 and 1790 cm^{-1} characteristic for six-membered ring anhydride fused aromatic system.[10] The ^{1}H-NMR (DMSO-d_6) of **3**: δ 6.39 (s, 2H, O-CH_2-O), 7.51 (s, 1H, HC=C), 7.75–8.19 (m, 4H, Ar-H), 8.59–8.84 (m, 3H, Ar-H of piperonyl moiety). The MS of **3**: 294 (20), 264 (8), 249 (6), 257 (4), 221 (12), 192 (30), 180 (8), 163 (100), 152 (18), 137 (16), 129 (22), 111 (19), 101 (60), 87 (80), 75 (82), 63 (72) and 50 (37).

Action of Aluminium Chloride upon the Anhydride 3; Formation of 2-(2-Carboxyphenyl)-5,6-methylenedioxyind-2-enone 4

To a solution of the anhydride **3** (2.94 g; 0.01 mol) in excess acetylene tetrachloride (50 mL), anhydrous aluminium chloride (1.6 g; 0.012 mol) was added dropwise and the reaction mixture was stirred for 15 h at room temperature, left to stand overnight and hydrolyzed with ice-cold dilute hydrochloric acid. The solvent was removed by steam distillation and the product was taken up in ether, washed with Na_2CO_3 solution (10%). The alkaline extract on acidification afforded the oxoacid **4** (cf. Table 1).

IR spectrum of **4** exhibited $\nu_{C=O}$ at 1690 and 1700 cm^{-1} for aryl acid and ring ketonic functions.[10] ^{1}H-NMR ($CDCl_3$) of **4** exhibited the following signals: δ 6.42 (s, 2H, O-CH_2-O), 7.42–8.18 (m, 5H, Ar-H), 8.81 (s, 1H, Ar-H of piperonyl moiety), 8.98 (s, 1H, Ar-H of piperonyl moiety) and

10.81 (s, 1H, COOH). The MS of **4**: 294 (38), 250 (100), 220 (20), 173 (14), 148 (3), 120 (46) and 77 (65).

Action of 1-Naphthylamine on the Cyclic Anhydride 3; Formation of 2-[*N*-(1-Naphthyl)carboxamido]-3,4-methylenedioxybenzylidinephenylacetic Acid 5

A solution of **3** (2.94 g; 0.01 mol) and 1-naphthylamine (1.43 g; 0.01 mol) in 50 mL of benzene was refluxed for 4 h. Most of the solvent was distilled off and the solid that separated out after cooling was collected by suction and recrystallized from suitable solvent to give **5** (cf. Table 1).

IR spectrum of **5** exhibited two absorption bands at 1668 and 1703 cm^{-1} characteristic for $\nu_{C=O}$ (amide) and $\nu_{C=O}$ (α,β-unsaturated acid). The ^{1}H-NMR ($CDCl_3$) of **5** exhibited the following signals: δ 6.46 (s, 2H, O-CH_2-O), 7.48 (s, 1H, HC=C), 7.63–8.28 (m, 11H, Ar-H), 8.45–8.77 (m, 3H, Ar-H of piperonyl moiety) and 10.77 (s, 1H, COOH). The MS of **5**: 437 (61), 419 (32), 393 (8), 315 (24), 267 (20), 251 (12), 222 (100), 170 (12), 143 (9) and 77 (37).

Reaction of *N*-(1-Naphthyl)-3,4-methylenedioxybenzylidine Homophthalamic Acid 5 with Acetic Anhydride and Perchloric Acid; Formation of *N*-(1-Naphthyl)-3,4-methylenedioxybenzylidine Homophthalisoimidium Perchlorate 6

Perchloric acid (10 mL) was slowly added for 15 min to a suspension of **5** (4.37 g; 0.01 mol) in freshly distilled acetic anhydride (100 mL) kept in an ice bath. The solid salt that precipitated was collected by filtration, washed with petroleum ether (60–80°C), dried and recrystallized from the proper solvent to afford **6** (cf. Table 1).

IR spectrum of **6** was found to be consistent with the proposed structure. Thus compound **6** displayed $\nu_{C=O}$ at 1830 cm^{-1} together with strong absorption band at 1662 cm^{-1} ($\nu_{C=N^+}$). The ^{1}H-NMR (DMSO-d_6) of **6**: δ 6.39 (s, 2H, O-CH_2-O), 6.27–7.95 (m, 12H, Ar-H and HC=C), 8.50–8.78 (m, 3H, Ar-H of piperonyl moiety) and 9.00 (s, 1H, $=\overset{\oplus}{\underset{|}{N}}H$).

Reaction of 6 with Active Methylene Containing Compounds Namely: Ethyl Acetoacetate, Ethyl Cyanoacetate, and Diethyl Malonate; Formation of the Lactams 7a–c

A solution of **6** (5.19 g; 0.01 mol) in pyridine (30 mL) was stirred with the appropriate active methylene compound (0.1 mol) at room temperature for 1 h. The reaction solution was left overnight, then, cold hydrochloric acid was added with stirring. The solid that deposited down was collected by filtration and recrystallized from the suitable solvent (cf. Table 1).

IR spectrum of **7** showed one carbonyl absorption band at ca. 1685–1672 (6-membered lactam). The ^{1}H-NMR (DMSO-d_6) of **7b**: δ 1.66 (t, 3H, CH_2CH_3), 3.97 (q, 2H, CH_2CH_3), 6.42 (s, 2H, O-CH_2-O), 6.27–7.85 (m, 12H, Ar-H and HC=C) and 8.42–8.57 (m, 3H, Ar-H of piperonyl moiety).

Reaction of 6 with Grignard Reagents; Formation of Aralkyl-2-[*N*-(1-naphthyl)carboxamido]-3,4-methylenedioxybenzylidinebenzyl Ketone 8a–c

A solution of the appropriate Grignard's reagent (0.3 mol) in dry ether (50 mL) was added dropwise to a solution of **6** (5.19 g; 0.01 mol) in dry ether (50 mL) with occasional shaking. The reaction mixture was refluxed for 6 h on water bath, then left overnight and decomposed with saturated aqueous ammonium chloride solution. The organic layer was separated then evaporated to afford the crude solid product which recrystallized to afford **8** (cf. Table 1).

IR spectra of **8** showed two absorption bands for the carbonyl stretching frequencies of ketones and amides at ca. 1695 and 1662 cm^{-1} as well as ν_{NH} of amides at ca. 3310 cm^{-1}. The ^{1}H-NMR (DMSO-d_6) of **8a** exhibited the following signals: δ 4.06 (s, 2H, -$CH_2C_6H_5$), 5.57 (s, 1H, -NH), 6.42 (s, 2H, O-CH_2-O), 7.54 (s, 1H, HC=C) and 7.72–7.93 (m, 5H, Ar-H of benzyl moiety), 8.10–8.33 (m, 11H, Ar-H) and 8.42–8.57 (m, 3H, Ar-H of piperonyl moiety).

Reaction of 6 with Aromatic Hydrocarbons; Formation of Hydroxy-3,4-methylenedioxybenzylidine Homophthalimidine Derivatives 9a–c

To a stirred cold solution or suspension of **6** (5.19 g; 0.01 mol) in aromatic hydrocarbon (50 mL), anhydrous $AlCl_3$ (0.03 mol) was added portionwise. The mixture was, then stirred for 5 h at room temperature and left overnight, then, hydrolyzed with ice cold hydrochloric acid. The resulting

Marcel Dekker, Inc.
270 Madison Avenue, New York, New York 10016

organic product was filtered off, washed with cold water, dried and crystallized from the proper solvent to give **9** (cf. Table 1).

IR spectra of **9** exhibited one carbonyl absorption band at ca. 1674–1660 cm^{-1} and a broad band at 3100–3460 cm^{-1} (ν_{OH}). The ^{1}H-NMR (DMSO-d_6) of **9b** exhibited the following signals: δ 3.27 (s, 3H, OCH_3), 5.81 (s, 1H, OH), 6.45 (s, 2H, O-CH_2-O), 7.69 (s, 1H, HC=C) and 7.80–8.54 (m, 18H, Ar-H).

Reaction of 6 with Primary Aromatic Amines; Formation of *N*,*N*′-Disubstituted-3,4-methylenedioxybenzylidine Homophthalamide 10a–e

Compound **6** (5.19 g; 0.01 mol) was added to a stirred solution of the appropriate amine (0.01 mol) namely, aniline, *p*-toluidine, *p*-anisidine, *p*-chloroaniline and benzylamine in benzene (30 ml). The reaction mixture was then stirred for one hour at room temperature. Excess solvent was distilled off to afford a solid product which on recrystallization from suitable solvent gave **10a–e** (cf. Table 1).

IR spectra of **10** exhibited $\nu_{C=O}$ at 1652–1636 cm^{-1} (amide) and ν_{NH} at 3250–3152 cm^{-1}. The ^{1}H-NMR (DMSO-d_6) of **10b** showed the following signals: δ 2.00 (s, 3H, CH3), 5.54 (s, def., 2H, 2NH), 6.42 (s, 2H, O-CH_2-O), 7.69 (s, 1H, HC=C) and 7.81–8.54 (m, 18H, Ar-H).

REFERENCES

1. Madkour, H.M.F.; Mahmoud, M.R.; Nassar, M.H.; Habashy, M.M. Sulfur Letters **1998**, *21*(6), 253–261.
2. Mahmoud, M.R.; Madkour, H.M.F. Synthetic Communication **1996**, *26*(20), 3799–3808.
3. Mahmoud, M.R.; Soliman, E.A.; Ibrahim, G.A.; Rabie, A.M. Phosphorus, Sulfur and Silicon **1998**, *5*(4), 1–10.
4. Pellicciari, R.; Natalini, B.; Costanlino, G.; Mahmoud, M.R.; Mattoli, L.; Sedeghpour, B.M. J. Med. Chem. **1994**, *37*, 647–655.
5. Bayder, A.E.; Boyd, G.V. J. Chem. Soc. Perkin Trans. 1 **1978**, 1360.
6. Mahmoud, M.R.; El-Nagdy, S.; El-Bassiouny, F.A. J. Chem. Soc. Pak. **1988**, *10*(2), 261; Chem. Abstr. **1989**, *110*, 134842z.
7. Mahmoud, M.R. J. Chem. Soc. Pak. **1989**, *11*(2), 144; Chem. Abstr. **1990**, *112*, 178248f.
8. Enayat, E.I.; Abdel-Hamide, H.A.; Mahmoud, M.R. Indian J. Chem. **1990**, *29*(B), 331.

9. Abdel-Hamide, H.A.; Enayat, E.L.; Mahmoud, M.R. J. Chem. Soc. Pak. **1990**, *12*(2), 128; Chem. Abstr. **1990**, *113*, 58630y.
10. Bellamy, L.J. *The Infrared Spectra of Complex Molecules*, Vol. 1, 3rd. edn. (Chapman and Hall, London), 1975.

Received in the USA March 19, 2001

MARCEL DEKKER, INC.
270 Madison Avenue, New York, New York 10016

Downloaded by [Stony Brook University] at 00:55 19 October 2014

Request Permission or Order Reprints Instantly!

Interested in copying and sharing this article? In most cases, U.S. Copyright Law requires that you get permission from the article's rightsholder before using copyrighted content.

All information and materials found in this article, including but not limited to text, trademarks, patents, logos, graphics and images (the "Materials"), are the copyrighted works and other forms of intellectual property of Marcel Dekker, Inc., or its licensors. All rights not expressly granted are reserved.

Get permission to lawfully reproduce and distribute the Materials or order reprints quickly and painlessly. Simply click on the "Request Permission/Reprints Here" link below and follow the instructions. Visit the U.S. Copyright Office for information on Fair Use limitations of U.S. copyright law. Please refer to The Association of American Publishers' (AAP) website for guidelines on Fair Use in the Classroom.

The Materials are for your personal use only and cannot be reformatted, reposted, resold or distributed by electronic means or otherwise without permission from Marcel Dekker, Inc. Marcel Dekker, Inc. grants you the limited right to display the Materials only on your personal computer or personal wireless device, and to copy and download single copies of such Materials provided that any copyright, trademark or other notice appearing on such Materials is also retained by, displayed, copied or downloaded as part of the Materials and is not removed or obscured, and provided you do not edit, modify, alter or enhance the Materials. Please refer to our Website User Agreement for more details.

Order now!

Reprints of this article can also be ordered at

http://www.dekker.com/servlet/product/DOI/101081SCC120002123