Acta Pharm. 53 (2003) 213–221 Original research paper

Studies on thiazolopyridines – A novel synthesis of bis-thiazolopyridines as promising antimicrobial agents

MOHAMED E. AZAB[1]
GAMEEL A. M. EL-HAG ALI[2]*
ASHRAF H. F. ABD EL-WAHAB[2]

[1] *Department of Chemistry*
Faculty of Science, Ain Shams University
Cairo, Egypt

[2] *Department of Chemistry*
Faculty of Science, Al-Azhar University
Nasr City, P.O. Box 11884, Cairo, Egypt

Received March 20, 2003
Accepted July 4, 2003

A variety of novel bis-thiazolopyridine derivatives **4a-e** were synthesized *via* the reaction of bis-thiazolinone **3** with different arylcinnamonitrile derivatives (1:2 molar ratio), whereas the reaction of bis-compounds **7a-e** with malononitrile in ethanol solution containing a few drops of piperidine afforded the novel bis-thiazolopyridines **8a-e**. The structures of the synthesized compounds were established by elemental analyses and spectral data. Some of the newly synthesized compounds show moderate to high antimicrobial activity.

Keywords: bis-thiazolopyridines, synthesis, antimicrobial activity

Derivatives of thiazolo[3,2-a]pyridines have been reported to furnish various biological activities such as antimicrobial (1), bactericidal (2), coronary dilating, antihypertensive and muscle relaxing (3). In addition, bis-heterocyclic compounds exhibit various biological activities (4–6) and exert much higher antibacterial activity than heterocyclic compounds (7). It was reported that 2-cyanomethyl-4-thiazolinone (**1**) was used as starting material for the synthesis of thiazolo[3,2-a]-pyridines (8–11). In view of the above facts and in continuation of our work on the chemistry of thiazolo[3,2-a]pyridines (12–14), we report here on the synthesis of some novel bis-thiazolo[3,2-a]pyridines starting from compound **1** in order to investigate their biological activity.

EXPERIMENTAL

All melting points are uncorrected (Stuart Scientific Co., UK). The IR spectra were measured in KBr pellets on a Shimadzu IR 200 spectrophotometer (Shimadzu Japan). ^{1}H NMR spectra were recorded in DMSO-d_6 at 200 MHz on a Varian Gemini NMR spectrometer (Varian, UK), using tetramethylsilane as internal reference. Elemental analyses were carried out at the Microanalytical Center of Cairo University (Egypt).

* Correspondence, e-mail: elahag1970@hotmail.com

The physico-chemical data for the compounds are given in Table I. The spectral data are collected in Table II. Compounds **1** and **6a-e** were prepared according to the reported methods (11, 13).

Syntheses

*1,2-Bis[2-(2-cyanomethyl-4-oxo-4,5-dihydrothiazol-5-ylidenemethyl)-phenoxy]-ethane (**3**).* – A mixture of thiazoline **1** (0.02 mol) and bis-aldehyde **2** (0.01 mol) in the presence of abso-

Table I. Physico-chemical data for prepared compounds

Compd. No.	Yield (%)	Crystallization solvent	M.p. (°C)	Mol. formula (M_r)	Elemental analysis Calcd./found (%)		
					C	H	N
3	70	Benzene	> 300	$C_{26}H_{18}N_4O_4S_2$ (514.57)	60.69 60.60	3.53 3.50	10.89 10.80
4a	65	Benzene	90–92	$C_{46}H_{28}Br_2N_8O_4S_2$ (980.69)	56.32 56.50	2.85 2.90	11.44 11.40
4b	52	Benzene/ethanol	139–140	$C_{46}H_{28}Cl_2N_8O_4S_2$ (891.89)	61.95 61.90	3.16 3.20	12.56 12.50
4c	82	Benzene/ethanol	210–212	$C_{48}H_{34}N_8O_4S_2$ (850.96)	67.75 67.70	4.00 4.00	13.17 13.10
4d	72	Benzene	125–127	$C_{48}H_{34}N_8O_8S_2$ (914.95)	63.01 63.20	3.71 3.62	12.25 11.90
4e	63	Ethanol	245–246	$C_{46}H_{28}F_2N_8O_4S_2$ (858.81)	64.33 64.30	3.26 3.30	13.05 12.90
7a	73	Benzene	270–272	$C_{40}H_{24}Br_2N_4O_4S_2$ (848.57)	56.62 56.60	2.85 2.80	6.60 6.50
7b	74	Benzene/ethanol	271–273	$C_{40}H_{24}Cl_2N_4O_4S_2$ (759.77)	63.24 63.20	3.18 3.10	7.37 7.40
7c	53	Benzene/ethanol	190–191	$C_{42}H_{30}N_4O_4S_2$ (718.84)	70.18 70.20	4.21 4.10	7.79 7.70
7d	59	Benzene	> 300	$C_{40}H_{24}N_6O_8S_2$ (780.77)	61.53 61.50	3.10 3.00	10.76 10.80
7e	62	Ethanol	258–260	$C_{48}H_{30}N_4O_4S_2$ (790.91)	72.89 72.80	3.82 3.80	7.08 7.00
8a	65	Benzene/ethanol	217–219	$C_{46}H_{28}Br_2N_8O_4S_2$ (980.69)	56.34 56.30	2.88 2.92	11.43 11.50
8b	63	Benzene	228–230	$C_{46}H_{28}Cl_2N_8O_4S_2$ (891.89)	61.95 62.00	3.16 3.10	12.56 12.48
8c	69	Benzene	179–181	$C_{48}H_{34}N_8O_4S_2$ (850.96)	67.75 67.80	4.03 4.10	13.17 13.20
8d	80	Benzene	238–240	$C_{46}H_{28}N_{10}O_8S_2$ (912.90)	60.52 60.50	3.09 3.00	15.34 15.30
8e	71	Benzene	218–220	$C_{54}H_{34}N_8O_4S_2$ (922.03)	70.27 70.30	3.71 3.60	12.14 12.10

Table II. Spectral data of synthesized compounds

Compd. No.	IR (KBr, cm^{-1})	^1H NMR (DMSO-d_6) (δ, ppm)
3	2923 (CH-aliph.), 2198 (C≡N), 1720 (thiazolinone C=O)	4.01 (s, 4H, $2CH_2CN$), 4.91 (s, 4H, $(OCH_2)_2$), 7.00–7.40 (m, 10H, 8H Ar-H + 2H-methine)
4a	3417 (NH_2), 2923 (CH-aliph.), 2198 (C≡N), 1712, 1651 (thiazolinone C=O)	4.35 (s, 4H, pyridine-H), 4.70 (s, 4H, $(OCH_2)_2$), 7.18–8.03 (m, 18H, 16H Ar-H + 2H-methine), 8.54, 8.57 (2s, 4H, $2NH_2$)
4b	3394 (NH_2), 2923 (CH-aliph.), 2198 (C≡N), 1712, 1651 (thiazolinone C=O)	4.18 (s, 2H, pyridine-H), 4.70 (s, 4H, $(OCH_2)_2$), 7.49–7.69 (m, 18H, 16H Ar-H + 2H-methine), 7.95 (s, 4H, $2NH_2$)
4c	3417, 3340 (NH_2), 2923 (CH-aliph.), 2198 (C≡N), 1712, 1651 (thiazolinone C=O)	2.30 (s, 6H, $2CH_3$), 4.29 (s, 2H, pyridine-H), 4.54 (s, 4H, $(OCH_2)_2$), 7.03–7.53 (m, 18H, 16H Ar-H + 2H-methine), 7.90 (s, 4H, $2NH_2$)
4d	3340 (NH_2), 2931 (CH-aliph.), 2198 (C≡N), 1712, 1651 (thiazolinone C=O)	3.8 (s, 6H, 2 OCH_3), 4.3 (s, 2H, pyridine-H), 4.70 (s, 4H, $(OCH_2)_2$), 7.21–7.52 (m, 18H, 16H Ar-H + 2H-methine), 8.46 (s, 4H, $2NH_2$), 9.87, 10.30 (2s, 2H, 2OH)
4e	3379, 3289 (NH_2), 2198 (C≡N), 1720, 1658 (thiazolinone C=O)	4.25 (s, 2H, pyridine-H), 4.67 (s, 4H, $(OCH_2)_2$), 7.26–7.75 (m, 18H, 16H Ar-H + 2H-methine), 7.89 (s, 4H, $2NH_2$)
7a	2950 (CH-aliph.), 2191 (C≡N), 1715 (thiazolinone C=O)	4.61 (s, 4H, $(OCH_2)_2$), 7.51–7.85 (m, 20H, 16H Ar-H + 4H-methine)
7b	2900 (CH-aliph.), 2221 (C≡N), 1718 (thiazolinone C=O)	4.61 (s, 4H, $(OCH_2)_2$), 7.17–8.42 (m, 20H, 16H Ar-H + 4H-methine)
7c	2923 (CH-aliph.), 2198 (C≡N), 1681 (thiazolinone C=O)	2.23 (s, 6H, $2CH_3$), 4.43 (s, 4H, $(OCH_2)_2$), 7.11–7.29 (m, 20H, 16H Ar-H + 4H-methine)
7d	2923 (CH-aliph.), 2206 (C≡N), 1681 (thiazolinone C=O)	4.61 (s, 4H, $(OCH_2)_2$), 7.34–7.73 (m, 20H, 16H Ar-H + 4H-methine)
7e	2923 (CH-aliph.), 2198 (C≡N), 1700 (thiazolinone C=O)	4.94 (s, 4H, $(OCH_2)_2$), 7.14–8.22 (m, 26H, 22H Ar-H + 4H-methine)
8a	3417 (NH_2), 2923 (CH-aliph.), 2221 (C≡N), 1700 (thiazolinone C=O)	4.23 (s, 2H, pyridine-H), 4.61 (s, 4H, $(OCH_2)_2$), 7.17–8.42 (m, 18H, 16H Ar-H + 2H-methine), 10.02 (s, 4H, $2NH_2$)
8b	3394 (NH_2), 2923 (CH-aliph.), 2191 (C≡N), 1681 (thiazolinone C=O)	4.21 (s, 2H, pyridine-H), 4.61 (s, 4H, $(OCH_2)_2$), 7.09–7.40 (m, 18H, 16H Ar-H + 2H-methine), 10.32 (s, 4H, $2NH_2$)
8c	3340 (NH_2), 2923 (CH-aliph.), 2221 (C≡N), 1651 (thiazolinone C=O)	2.20 (s, 6H, $2CH_3$), 4.27 (s, 2H, pyridine-H), 4.70 (s, 4H, $(OCH_2)_2$), 7.21–7.40 (m, 18H, 16H Ar-H + 2H-methine), 8.02, 8.08 (2s, 4H, $2NH_2$)
8d	3355 (NH_2), 2931 (CH-aliph.), 2198 (C≡N), 1700 (thiazolinone C=O)	4.47 (s, 2H, pyridine-H), 4.60 (s, 4H, $(OCH_2)_2$), 7.17–8.06 (m, 18H, 16H Ar-H + 2H-methine), 8.44 (s, 4H, $2NH_2$)
8e		4.19 (s, 2H, pyridine-H), 4.43 (s, 4H, $(OCH_2)_2$), 6.94–7.94 (m, 24H, 22Ar-H + 2H-methine), 8.54 (s, 4H, $2NH_2$)

lute ethanol containing a few drops of piperidine (20 mL) was refluxed for 3 hours. The solid product obtained was filtered and recrystallized from a suitable solvent to give **3**.

*1,2-Bis[2-(5-amino-7-aryl-6,8-dicyano-3-oxo-7*H*-thiazolo[3,2-a]pyridin-2-ylidene-methyl)--phenoxy]-ethane (**4a-e**)*. – A mixture of **3** (0.01 mol) and arylidenemalononitriles (0.02 mol) was refluxed for 6 hours in the presence of absolute ethanol (20 mL) and a catalytic amount of piperidine (0.5 mL). The collected product was recrystallized from a suitable solvent to give **4a-e**.

*1,2-Bis[2-[2-(5-arylmethylidene-4-oxo-4,5-dihydrothiazol-2-yl)-2-cyanovinyl]-phenoxy]--ethane (**7a-e**)*. – A mixture of **6a-e** (0.02 mol) and bis-aldehyde **2** (0.01 mol) was refluxed for 6 hours in the presence of absolute ethanol (20 mL) and a catalytic amount of piperidine. The obtained product was filtered and recrystallized from suitable solvent to give **7a-e**.

*1,2-Bis[2-(5-amino-2-arylmethylidene-6,8-dicyano-3-oxo-7*H*-thiazolo[3,2-a]-pyridin-7-yl)--phenoxy]-ethane (**8a-e**)*. – A mixture of **7a-e** (0.01 mol) and malononitrile (0.02 mol) was refluxed for 6 hours in the presence of absolute ethanol (20 mL) and a catalytic amount of piperidine (0.5 mL). The obtained product was isolated and recrystallized from an appropriate solvent to give **8a-e**.

Antimicrobial activity

Most of the newly synthesized compounds (**4c**,**e**, **7c**,**d**,**e** and **8a**,**b**,**d**) were screened *in vitro* for their antimicrobial activity against four strains of bacteria, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Bacillus subtilis*, using the paper disc diffusion method (15). The tested compounds were dissolved in *N*,*N*-dimethylformamide (DMF) to get a solution of 1 mg mL^{-1}. Inhibition zones were measured in millimeters at the end of the incubation period of 48 h at 28 °C. Dimethylformamide showed no inhibition zones. Chloroamphenicol standard was used as reference to evaluate the potency of

Table III. Antimicrobial activity of some compounds

Compd. No.	*Staphylococcus aureus*	*Bacillus subtilis*	*Escherichia coli*	*Pseudomonas aeruginosa*
4c	+	+	+++	+
4e	+	++	+	+
7c	+	++	+++	++
7d	+	++	+	++
7e	+	++	+	+
8a	++	+	++	+
8b	+	+	++	++
8d	++	+	+	++
Chloramphenicol (25 μg mL^{-1})	++++	++++	++++	++++

+ less active (0.2–0.5 cm), ++ moderately active (0.6–1.4 cm), +++ highly active (1.5–3.0 cm), ++++ very highly active (over 3.0 cm)

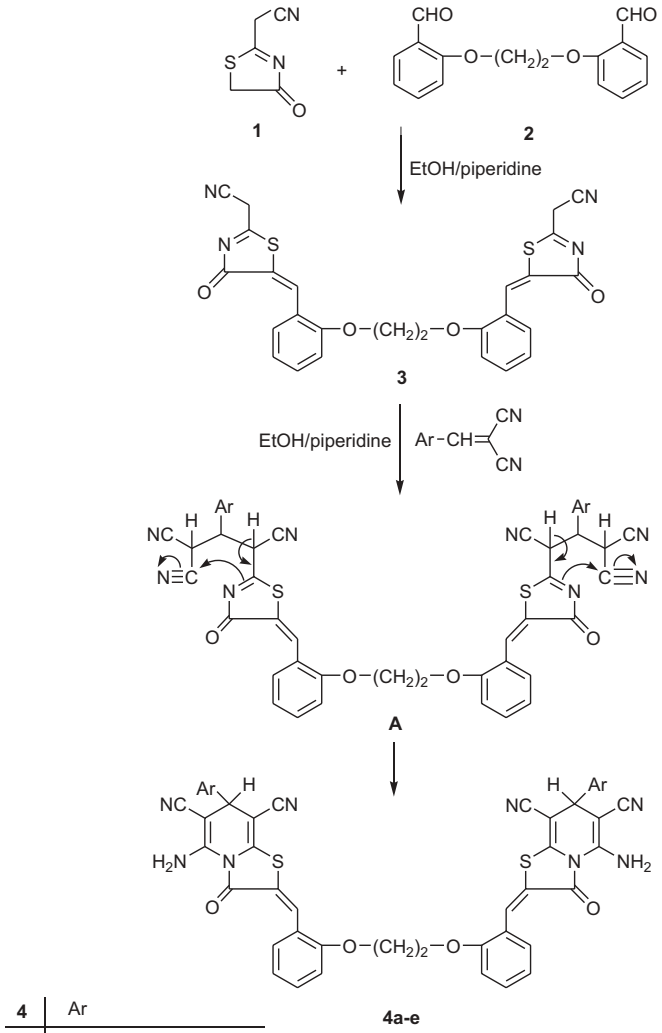
the tested compounds and was also dissolved in DMF. The inhibition zones of microbial growth produced by different compounds are given in Table III.

RESULTS AND DISCUSSION

1,2-Bis[2-(2-cyanomethyl-4-oxo-4,5-dihydrothiazol-5-ylidenemethyl)-phenoxy]-ethane (**3**) was produced *via* the reaction of 2-cyanomethyl-4-oxo-thiazoline (**1**) with bis-aldehyde **2** (12) in a molar ratio 2:1 in ethanol and in the presence of catalytic amount of piperidine. Elemental analyses and spectral data of the intermediate compound **3** are in agreement with its structure. For example, its ^{1}H NMR spectrum in DMSO-d_6 showed two singlets at 4.01 and 4.91 attributed to $2CH_2CN$ and $(OCH_2)_2$ groups, respectively. Formation of the initiating material **3** encouraged us to extend this work to involve the formation of bis-thiazolopyridines **4a-e** by cyclocondensation of compound **3** with different arylidenemalononitriles in a molar ratio 1:2 in absolute ethanol containing a few drops of piperidine under reflux conditions through the formation of intermediate A (Scheme 1) (12–14). The structures of bis-thiazolopyridines **4a-e** were established by the elemental analyses and spectral data. The IR spectrum of compound **4a** revealed the presence of absorption bands at 3417 cm^{-1} corresponding to the amino group, 2923 cm^{-1} (CH-aliph.), cyano stretch at 2198 cm^{-1} and thiazolinone carbonyl at 1712 and 1651 cm^{-1}. Also, the ^{1}H NMR spectrum of **4a** in DMSO-d_6 showed singlet at 4.35, attributed to (2H) of pyridine-H, and a singlet at 4.7 due to $(OCH_2)_2$ groups.

2-Cyanomethyl-4-oxo-thiazoline (**1**) was combined with different aromatic aldehydes **5a-e** to give the corresponding benzylidene derivatives **6a-e** (13). These derivatives, when reacted with bis-aldehyde **2** (2:1 molar ratio) afforded the novel benzylidene derivatives **7a-e**. The analytical and spectral data were consistent with their structures. The structure of **7b** was confirmed by its IR spectrum, which displayed absorption bands at 2900 cm^{-1} for CH-aliph., 2221 cm^{-1} due to C≡N and 1718 cm^{-1} corresponding to C=O (thiazolinone). Also, the ^{1}H NMR spectrum in DMSO-d_6 of compound **7b** is in agreement with its structure, which revealed a singlet at 4.61 due to $(OCH_2)_2$ and multiplet in the region 7.17–8.42 for 16Ar-H and 4H-methine. Our work was extended to synthesize a novel series of bis-thiazolopyridine derivatives **8a-e** which contain bis-1,2-phenoxyethane moiety in position 7-yl instead of position 2-yl (13). These derivatives were produced by addition of the malononitrile to the α,β-unsaturated system in bis-compounds **7a-e** followed by ring closure. The structures of bis-thiazolopyridines were proven by elemental analyses and spectral data. For example, the ^{1}H NMR spectrum of **8c** in DMSO-d_6 displayed a singlet at 4.7 attributed to $(OCH_2)_2$, a singlet at 4.27 due to pyridine-H, a singlet at 2.20 for $2CH_3$, a multiplet in the region 7.21–7.24 corresponding to 16Ar-H and 2H-methine and finally two singlets at 8.02, 8.08 for $2NH_2$ (Table II).

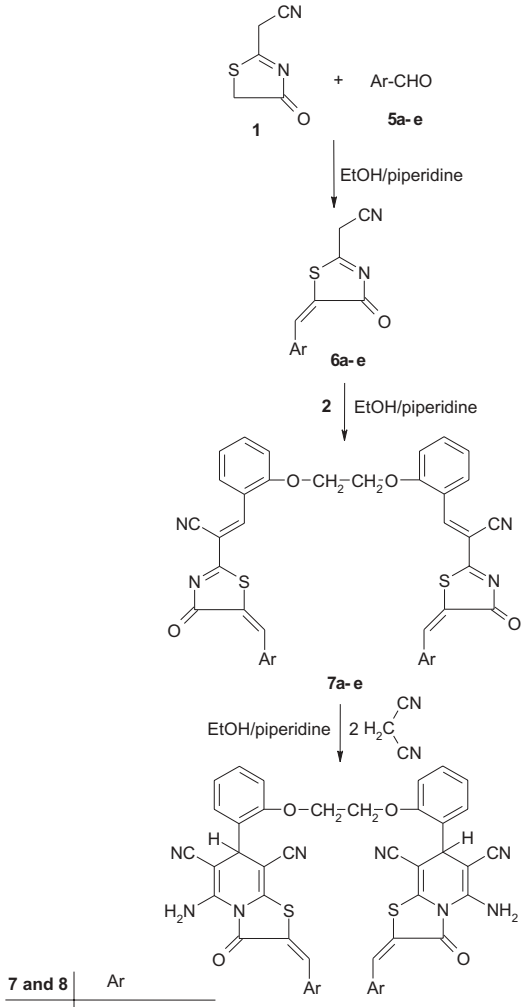
A novel 1,2-bis[2-(amino-7-aryl-6,8-dicyano-3-oxo-7*H*-thiazolo[3,2-a]pyridine-2-ylidenemethyl)-phenoxy)ethane (**4c**) and 1,2-bis[2-[2-(5-arylmethylidene-4-oxo-4,5-dihydrothiazol-2-yl)-2-cyanovinyl)phenoxy]ethane (**7c**) showed the highest antibacetrial activity among all the compounds tested. Their high activity against *Escherichia coli* may be attributed to the presence of the *p*-tolyl moiety. The most of the synthesized compounds showed moderate to low antibacterial activity. Compounds **4e** and **7c-e** showed mode-



4	Ar
a	C_6H_4Br-*p*
b	C_6H_4Cl-*p*
c	$C_6H_4CH_3$-*p*
d	$C_6H_3(OCH_3)(OH)$-3,4
e	C_6H_4F-*p*

Sheme 1

rate activity against *Bacillus subtilis*, whereas **7c** and **7d** exerted moderate activity against *Pseudomonas aeruginosa* as well. This may be attributed to the *o*-nitro-phenyl moiety in **7d** and α-naphthyl moiety in **7e**. Compound **8a** showed moderate activity against *Staphylococcus aureus* and *Escherichia coli*, which may be due to *p*-bromophenyl moiety. Com-



7 and 8	Ar
a	C_6H_4Br-*p*
b	C_6H_4Cl-*p*
c	$C_6H_4CH_3$-*p*
d	$C_6H_4(NO_2)$-*o*
e	α-naphthyl

Sheme 2

pounds **8b** and **8d** showed moderate activity against *Pseudomonas aeruginosa*, compound **8b** showed moderate activity also against *Escherichia coli*, whereas compound **8d** showed the same activity against *Staphylococcus aureus*.

CONCLUSIONS

Among the series of newly synthesized bis-thiazolopyridines, 1,2-bis[2-(5-amino-7--aryl-6,8-dicyano-3-oxo-7*H*-thiazolo[3,2-a]pyridine-2-ylidenemethyl)-phenoxy)ethane and 1,2-bis[2-[2-(5-arylmethylidene-4-oxo-4,5-dihydrothiazol-2-yl)-2-cyanovinyl)phenoxy]-ethane showed the highest antibacterial activity. They showed high activity against *Escherichia coli* probably due to the presence of *p*-tolyl moiety.

REFERENCES

1. S. A. Shiba, A. A. El-Khamry, M. E. Shaban and K. S. Atia, Synthesis and antimicrobial activity of some bis-quinazoline derivatives, *Pharmazie* **52** (1997) 189–194.
2. N. C. Deasi, Synthesis and antimicrobial activity of some dithiocarbamates, 2-aryl-amino-4--oxo-thiazolidines and their 5-arylidene derivatives, *Indian J. Chem. Sec. B* **32** (1993) 343–346.
3. H. N. Liu, Z. C. Li and T. Anthosen, Synthesis and fungicidal activity of 2-imino-3-(4-arylthiazol-2-yl)-thiazolidin-4-ones and their derivatives, *Molecules* **5** (2000) 1055–1061.
4. A. M. Shalby, O. A. Fathalla, E. M. M. Kassem and M. E. A. Zaki, Synthesis of new 5-N-pyrazolylamino acids, pyrazolopyrimidine derivatives, *Acta Chim. Solv.* **47** (2000) 187–203.
5. U. Olthoff, K. Matthey and B. Ditscher, *Thiazolo[3,2-a]pyridines*, Ger. (East) 84, 850 (Cl. C07d), 05 Oct (1971), Appl. WP CO7d/148 314, 16 Jun (1970); ref. *Chem. Abstr.* **78** (1973) 72121y.
6. M. Horst, B. Friedrich, V. Wulf and S. Kurt, *Pharmaceutical Pyridine Derivative*, *Ger. Offen*, 2, 210, 633 (Cl. C07d), 20 Sep. (1973), APPl. P22 10 633.8, 06 Mar (1972); ref. *Chem. Abstr.* **79** (1973) 146519d.
7. B. S. Holla, R. Gonsalves and S. Shenay, Synthesis and antimicrobial studies of a new series of 1,2-bis(1,3,4-oxadiazol-2-yl)-ethanes and 1,2-bis(4-amino-1,2,4-triazol-3-yl)-ethanes, *Eur. J. Med. Chem.* **35** (2000) 267–271.
8. C. Jyhjian and W. Ingjing, Synthesis of some 2- and 7-pyrenyl substituted thiazolo[3,2-a]pyridine derivatives, *Dyes Pigm.* **30** (1996) 173–82.
9. F. F. Abdel-Latif and R. M. Shaker, Heterocycles synthesis through reactions of nucleophiles with acrylonitriles, Part 5. Synthesis of several new thiazol and thiazolo[3,2-a]pyridine derivatives, *Phosphorus, Sulfur, Silicon, Rel. Elem.* **48** (1990) 217–21.
10. O. S. Abdel Meguid, G. H. Elgemeie, N. G. AbdelMoein and M. H. Elnagdi, Activated nitriles in heterocyclic synthesis; Synthesis of 6-thiophen-2-yl and 6-furan-2-yl-thiazolo[2,3-a]pyridine derivatives, *Monatsh. Chem.* **117** (1986) 105–10.
11. S. K. Usef, E. A. Hafez, M. Abo Elfetouh and M. H. Elnagdi, Activated nitriles in heterocyclic synthesis: The reaction of substituted cinnamonitriles with 2-functionally substituted methyl-2--thiazolin-4-one derivatives, *Z. Naturforsch. B, Anorg. Chem. Org. Chem.* **39B** (1984) 824–828.
12. A. A. El-Maghraby, G. A. M. El-Hag Ali, A. H. Ahmed and M. S. A. El-Gaby, Studies on thiazolopyridines. Part 1. Antimicrobial activity of some novel flourinated thiazolo[3,2-a]pyridines and thiazolo[2′,3′:1,6]pyrido[2,3-d]pyrimidines, *Phosphorus, Sulfur, Silicon.* **177** (2002) 293–302.
13. G. A. M. El-Hag Ali, A. Khalil, A. H. Ahmed and M. S. A. El-Gaby, Studies on thiazolopyridines. Part 2. Synthesis and antimicrobial activity of novel thiazolo[3,2-a]pyridine and thiazolo--[3,2-a][1,8]naphthyridine derivatives having two different aryl moieties, *Acta Chim. Solv.* **49** (2002) 365–376.
14. G. A. M. El-Hag Ali, Studies on thiazolopyridines. Part 3. Reactivity of thiazolo-[3,2-a]-3-aza--[1,8]naphthyridine towards some nucleophiles, *Phosphorus, Sulfur, Silicon* **178** (2003) 711–720.
15. W. Hewitt and S. Vincent, *Theory and Application of Microbiological Assay,* Academic Press, New York 1989.

S A Ž E T A K

Tiazolopiridini – Nova sinteza bis-tiazolopiridina s potencijalnim antimikrobnim djelovanjem

MOHAMED E. AZAB, GAMEEL A. M. EL-HAG ALI i ASHRAF H. F. ABD EL-WAHAB

Reakcijom bis-tiazolinona **3** s derivatima arilcinamonitrila (u molnom omjeru 1:2) sintetizirani su različiti bis-tiazolopiridini **4a-e**. Bis-spojevi **7a-e** s malononitrilom u etanolnoj otopini s nekoliko kapi piperidina daju nove bistiazolopiridine **8a-e**. Strukture spojeva potvrđene su elementarnom analizom i spektroskopski. Sintetizirani spojevi pokazuju umjereno do jako antimikrobno djelovanje.

Ključne riječi: bis-tiazolopiridini, sinteza, antimikrobno djelovanje

Department of Chemistry, Faculty of Science, Ain Shams University, Cairo, Egypt

Department of Chemistry, Faculty of Science, Al-Azhar University, Nasr City, Cairo, Egypt