EE&AE
2025 10th International Conference
on Energy Efficiency and Agricultural Engineering
5-7 November 2025, Starozagorski Bani, Bulgaria
IEEE

Synthesis and antimicrobial study of 6-phenothiazin-10-yl-benzo[*de*]isoquinoline-1,3-dione derivatives

Marin Marinov *, Iliana Nikolova, Iliana Kostova

Department of Chemistry, Phytopharmacy, Ecology and Environmental Protection, Agricultural University – Plovdiv, 4000 Plovdiv, Bulgaria, e-mail: m_n_marinov@abv.bg

GOAL OF THE STUDY

This study presents the synthesis of various new 6-phenothiazin-10-yl-benzo[*de*]isoquinoline-1,3-dione derivatives. The structures of the synthesized compounds were confirmed through physicochemical analyses, IR, ^{1}H NMR, ^{13}C NMR, and ^{13}C DEPT 135 spectral data. The antimicrobial activity of the compounds was evaluated against Gram-positive and Gram-negative bacteria, as well as yeasts and molds.

METHODOLOGY OF THE INVESTIGATION

All chemicals used were obtained from Merck and Sigma-Aldrich. Melting points were measured using an SMP-10 digital melting point apparatus. The IR spectra were recorded on a Perkin-Elmer FTIR-1600 spectrometer using KBr disks. The NMR spectra were obtained with a Bruker Avance III HD spectrometer (operating at 500.13 MHz for ^{1}H and 125 MHz for ^{13}C) in DMSO-d_6 solutions. The chemical shifts were referenced to tetramethylsilane (TMS).

MAIN RESULTS FROM THE STUDY

The compound 6-(10*H*-phenothiazin-10-yl)-1*H*,3*H*-naphtho[1,8-*cd*]pyran-1,3-dione (III) was synthesized by the reaction of 6-bromo-1*H*,3*H*-naphtho[1,8-*cd*]pyran-1,3-dione (I) with 10*H*-phenothiazine (II). Upon treatment of compound (III) with ethane-1,2-diamine and 2-aminoethan-1-ol, the corresponding derivatives 2-(2-aminoethyl)-6-phenothiazin-10-yl-benzo[*de*]isoquinoline-1,3-dione (IV) and 2-(2-hydroxyethyl)-6-phenothiazin-10-yl-benzo[*de*]isoquinoline-1,3-dione (V) were obtained, respectively. Additionally, compound (V) was reacted with *p*-toluenesulfonyl chloride in pyridine, resulting in the formation of the corresponding benzenesulfonate derivative (VII).

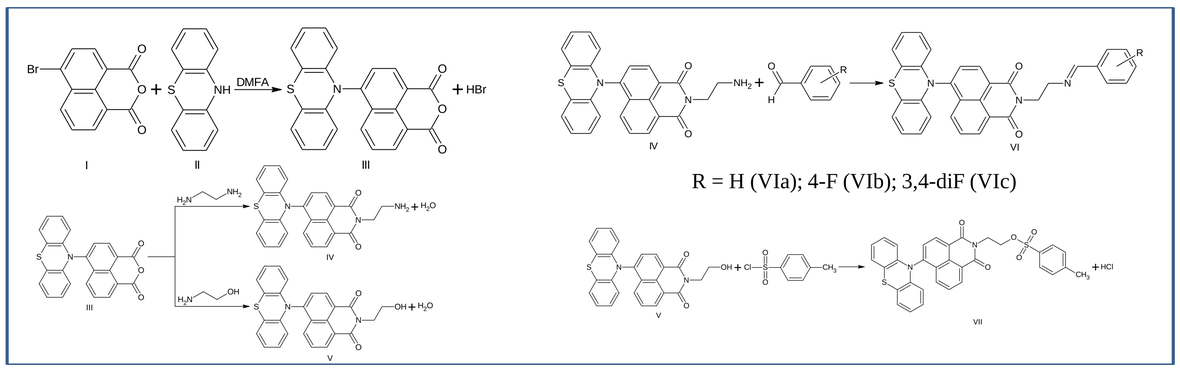

Fig. 1. Synthesis of compounds

The physicochemical characteristics of products IV, V, VIa–c and VII are presented in Table 1.

Table 1. Physicochemical parameters of compounds IV, V, VIa–c and VII

№	Systematic name	Yield, %	M. p., °C
IV	2-(2-aminoethyl)-6-phenothiazin-10-yl-benzo[de]isoquinoline-1,3-dione	78	138-139
V	2-(2-hydroxyethyl)-6-phenothiazin-10-yl-benzo[de]isoquinoline-1,3-dione	53	203-204
VIa	2-[2-[(E)-benzylideneamino]ethyl]-6-phenothiazin-10-yl-benzo[de]isoquinoline-1,3-dione	71	281-282
VIb	2-[2-[(E)-(4-fluorophenyl)methyleneamino]ethyl]-6-phenothiazin-10-yl-benzo[de]isoquinoline-1,3-dione	52	243-244
VIc	2-[2-[(E)-(3,4-difluorophenyl)methyleneamino]ethyl]-6-phenothiazin-10-yl-benzo[de]isoquinoline-1,3-dione	61	262-263
VII	2-(1,3-dioxo-6-phenothiazin-10-yl-benzo[de]isoquinolin-2-yl)ethyl 4-methylbenzenesulfonate	87	128-129

The IR, ^{1}H NMR, ^{13}C NMR, and ^{13}C DEPT 135 spectral data unequivocally confirm the proposed structures of compounds IV-VII.

The results of the antimicrobial activity studies are presented in Table 2

Table 2. Antimicrobial activity of compounds IV, V, VIa–c and VII

Test microorganism	Inhibition zone diameter (mm)					
	IV	V	VIa	VIb	VIc	VII
Staphylococcus aureus ATCC 6538	13	10.5	9.2	0	0	11.8
Staphylococcus epidermidis ATCC 12228	14.6	13.2	15.1	9.8	11.6	15.2
Bacillus subtilis ATCC 6633	18.3	21.2	17.6	14.8	23.1	14.1
Bacillus cereus ATCC 10876	15.5	14.2	13.7	12.5	12.4	17.3
Escherichia coli ATCC 8739	21.7	20.5	19.6	18.9	15.1	19.8
Pseudomonas aeruginosa ATCC 9027	11.1	12.3	13.1	0	0	15.6
Salmonella abony NTCC 6017	0	0	0	0	0	0
Candida albicans ATCC 10231	0	0	0	0	0	0
Saccharomyces cerevisiae ATCC 9763	0	0	0	0	0	0
Aspergillus brasiliensis ATCC 16404	0	0	0	0	0	0
Fusarium moniliforme	0	0	0	0	0	0

CONCLUSIONS

Six novel compounds were successfully synthesized, and their physicochemical properties were determined. Structural characterization was performed using IR, ^{1}H NMR, ^{13}C NMR, and ^{13}C DEPT 135 spectroscopy. The synthesized compounds demonstrated good antibacterial activity against Gram-positive bacteria *Staphylococcus epidermidis*, *Bacillus subtilis*, and *Bacillus cereus*, as well as the Gram-negative bacterium *Escherichia coli*. The compounds exhibited low or no activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa*. No antifungal activity was observed against the tested yeasts and molds.

ACKNOWLEDGMENT

The authors acknowledge the support of the Science Fund of the University of Ruse, Bulgaria (Project 2025/BRz-01). We are also grateful to Ms. Yoana Marinova (Sofia) for the valuable discussions.