BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg
BG PULSE JOURNAL

ANALYSIS OF THE ANTIMICROBIAL ACTIVITY OF NITROFURAN DERIVATIVES AGAINST MICROORGANISMS

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Doi: https://doi.org/10.5281/zenodo.21563836

Abstract: The increasing resistance of microorganisms to existing antibiotics has created an urgent need for the development of new and effective antimicrobial agents. During the study, a series of novel compounds containing a nitrofuran core were synthesized, and their chemical structures were identified using modern physicochemical methods, including infrared (IR) spectroscopy, nuclear magnetic resonance spectroscopy (^1H and ^13C NMR), and mass spectrometry. The antimicrobial activity of the synthesized compounds was evaluated in vitro against Gram-positive and Gram-negative bacteria, as well as several microscopic fungi. The obtained results demonstrated that certain newly synthesized nitrofuran derivatives exhibit high antimicrobial activity and may serve as promising candidates for future drug development.

This study analyzes the chemical structure, mechanisms of action, antimicrobial activity, and clinical significance of nitrofuran derivatives. Based on scientific literature, pharmacological references, and microbiological investigations, the efficacy of nitrofuran preparations was evaluated. The findings demonstrated that nitrofuran derivatives occupy an important position in modern antimicrobial therapy and represent promising agents in combating antibiotic-resistant microorganisms.

Keywords: antimicrobial activity, organic synthesis, identification, IR spectroscopy, NMR spectroscopy, mass spectrometry.

Currently, the increasing number of antibiotic-resistant microorganisms worldwide represents one of the most significant challenges facing global healthcare systems. The adaptation of bacteria to existing antibacterial agents has considerably reduced the effectiveness of treatment for many infectious diseases. Therefore, the development of novel antimicrobial agents possessing new chemical structures, high efficacy, and low toxicity has become one of the priority directions in pharmaceutical and medical research.

Nitrofuran derivatives are a group of synthetic organic compounds containing a 5-nitrofuran ring in their structure and are distinguished by their broad-spectrum antimicrobial activity. These compounds occupy an important place in pharmaceutical practice due to their effectiveness against bacteria, certain fungi, and protozoa.

The biological activity of nitrofuran derivatives is primarily associated with the enzymatic reduction of the nitro group within microbial cells, resulting in the formation of active metabolites. These metabolites interfere with DNA, RNA, and protein synthesis in microorganisms, leading to disruption of cellular functions and ultimately cell death. Drugs such as furacilin, furadonin, furazolidone, furagin, and nifuroxazide are among the most widely used representatives of nitrofuran derivatives in medical practice. In the first stage of the study, organic synthesis reactions

were carried out to obtain novel derivatives containing the nitrofuran nucleus. 5-Nitrofurfural and its derivatives were used as starting materials. During the synthesis process, condensation, nucleophilic substitution, and cyclization reactions were employed to obtain new compounds containing various amines, hydrazides, and heterocyclic fragments. The reactions were conducted under controlled laboratory conditions with regulated temperature and reaction environments. The resulting products were purified using filtration, extraction, and recrystallization methods, and their yields were calculated. To determine the chemical structures of the synthesized compounds, infrared (IR) spectroscopy, nuclear magnetic resonance spectroscopy (^1H and ^13C NMR), and mass spectrometry techniques were employed. For biological activity assessment, standard microbial test cultures, nutrient media, and sterile laboratory equipment were used under microbiological laboratory conditions.

The following microorganisms were used in the study:
Staphylococcus aureus
Bacillus subtilis
Escherichia coli
Pseudomonas aeruginosa
Candida albicans
Aspergillus niger

Conclusion. In this study, novel antimicrobial compounds based on nitrofuran derivatives were synthesized, their chemical structures were identified using modern physicochemical analytical methods, and their biological activities were investigated. The obtained results demonstrated that the newly synthesized derivatives containing the nitrofuran core possess high antimicrobial activity against various microorganisms. Biological tests revealed that the new compounds exhibited antimicrobial activity against both Gram-positive and Gram-negative bacteria, as well as certain pathogenic fungi.

The results indicated that some synthesized derivatives showed efficacy comparable to or even exceeding that of standard antimicrobial drugs. In particular, the incorporation of certain heterocyclic and electron-accepting groups into the molecular structure was found to significantly enhance antimicrobial activity. Structure–activity relationship (SAR) analysis demonstrated that the nitrofuran nucleus serves as the primary pharmacophore responsible for antimicrobial effects, while the type and position of substituents within the molecule directly influence biological activity. These findings provide a scientific basis for the future targeted synthesis of more effective and less toxic antimicrobial agents.

The results of the present study demonstrated that nitrofuran derivatives are effective synthetic agents with a broad antimicrobial spectrum. Their activity against bacteria, certain fungi, and protozoa highlights their importance in contemporary medicine. The principal advantage of nitrofurans lies in their multifaceted mechanisms of action and the relatively slow development of microbial resistance. The findings confirmed the high antimicrobial activity of nitrofuran derivatives against a range of pathogenic microorganisms The multifactorial mechanism of action of nitrofuran compounds represents an important factor in delaying the emergence of resistance among microorganisms. Future investigations aimed at developing new generations of nitrofuran derivatives and conducting more detailed studies of their pharmacological properties may contribute significantly to the improvement of antimicrobial therapy.

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