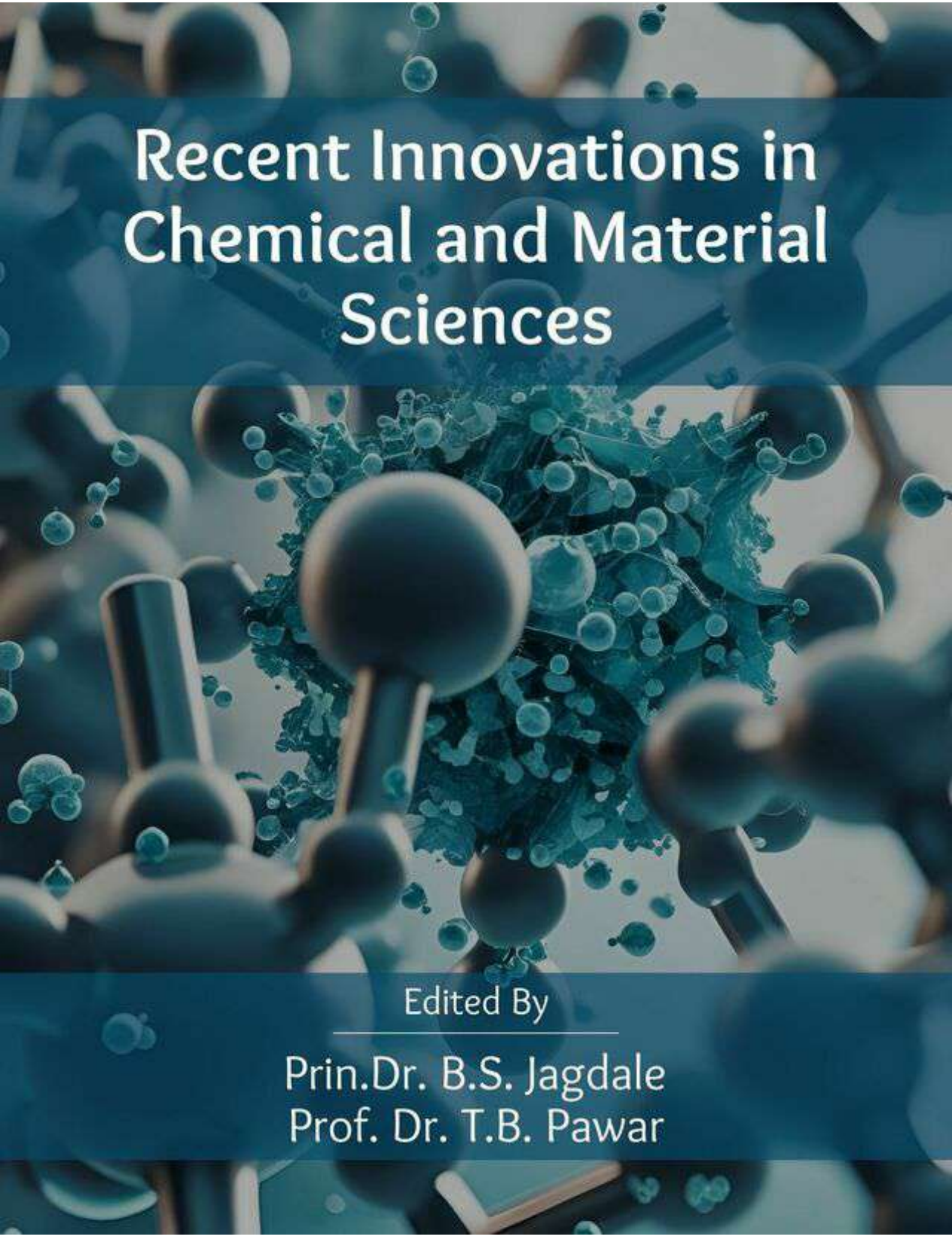


Recent Innovations in Chemical and Material Sciences

Edited By

Prin.Dr. B.S. Jagdale
Prof. Dr. T.B. Pawar

Recent Innovations in Chemical and Material Sciences

Edited By

Prin.Dr. B.S. Jagdale

Prof. Dr. T.B. Pawar

Dr. V.A. Adole

Dr. S.A. Ahire

Dr. N.V. Sadgir

Dr. S.L. Dhonnar

walnutpublication.com

INDIA • UK • USA

Paperback ISBN: 978-93-6926-691-3

First Published in November 2025

Published by Walnut Publication

(an imprint of Vyusta Platforms Private Limited)

www.walnutpublication.com

India

Unit# 909, 9th Floor, Wave Silver Tower, Sector-18, Noida - 201301

UK

71-75 Shelton Street, Covent Garden, London, WC2H 9JQ, UK

Distributed by

ZopioTail

Contents

CH.54 - SYNTHESIS AND PHARMACOLOGICAL EVALUATION OF 2-(2-HYDRAZINEYL)THIAZOLE DERIVATIVES FOR ANTIBACTERIAL AND ANTIFUNGAL APPLICATIONS

Yuvraj R. Sable[1,2], Vishnu A. Adole[1*]

[1]Research Centre in Chemistry

Mahatma Gandhi Vidyamandir's Loknete Vyankatrao Hiray Arts, Science and Commerce College, Panchavati, Nashik, Maharashtra, India-422003

(Affiliated to Savitribai Phule Pune University, Pune– 411007)

[2]Department of Chemistry

Dr. Patangrao Kadam Mahavidyalaya Ramanandanagar (Burli), Palus, Sangli, India-416308

(Affiliated to Shivaji University, Kolhapur)

Contact No: 8459186955 Email: sabley70@gmail.com.

ABSTRACT

The emergence of drug-resistant bacterial and fungal strains has created an urgent need for novel antimicrobial agents. In this context, 2-(2-Hydrazineyl)thiazole derivatives have attracted significant attention due to their potential pharmacological activities. This chapter outlines the synthesis and pharmacological evaluation of a series of 2-(2-Hydrazineyl)thiazole derivatives, focusing on their antibacterial and antifungal properties. The derivatives were synthesized using conventional methods, and their chemical structures were confirmed by spectral analysis techniques such as NMR, IR, and mass spectrometry. The antimicrobial efficacy of the compounds was evaluated against a range of clinically significant bacterial and fungal strains using standard in vitro assays. The results demonstrated that several derivatives exhibited promising antibacterial and antifungal activities, with certain compounds showing potent inhibition against both Gram-positive and Gram-negative bacteria, as well as fungi. The structure-activity relationship (SAR) analysis highlighted key molecular features that contribute to the enhanced antimicrobial activity of these derivatives. The findings suggest that 2-(2-Hydrazineyl)thiazole derivatives represent a promising class of compounds for the development of novel antimicrobial agents to combat resistant pathogens.

Keywords: Drug resistance, Pharmacological evaluation, 2-(2-Hydrazineyl)thiazole derivatives, Antibacterial activity, Antifungal activity, Novel antimicrobial compounds.

INTRODUCTION

The development of novel antimicrobial agents is critical in the face of increasing resistance to conventional antibiotics and antifungal drugs. In particular, bacterial and fungal infections continue to pose significant threats to public health, leading to an urgent need for new therapeutic options. Among various heterocyclic compounds, thiazole derivatives have gained considerable attention due

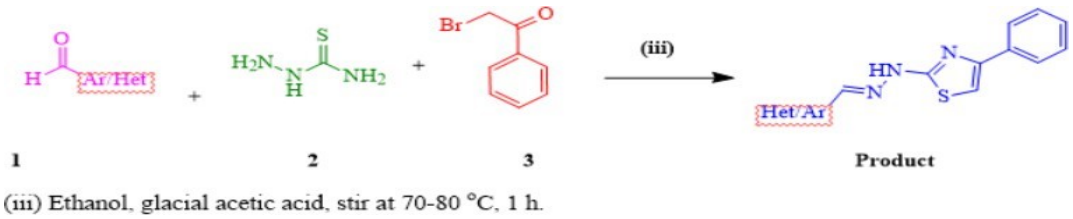
to their broad spectrum of biological activities, including antibacterial, antifungal, anti-inflammatory, and anticancer properties. The rapid increase in antimicrobial resistance (AMR) has become a major global health challenge, highlighting the urgent need for the development of new and effective antimicrobial agents. Bacterial and fungal infections, particularly those caused by resistant strains, are leading to high morbidity and mortality rates worldwide. Among the various classes of compounds being explored for their antimicrobial properties, thiazole derivatives have emerged as an important class of heterocyclic compounds due to their diverse biological activities, including antibacterial, antifungal, anticancer, and anti-inflammatory effects.

The introduction of hydrazine groups at the 2-position of the thiazole ring results in 2-(2-hydrazineyl)thiazole derivatives, a novel class of compounds with significant potential in medicinal chemistry. These derivatives combine the beneficial properties of both thiazole and hydrazine functionalities, which are known to interact with microbial cells in a manner that disrupts essential processes. This chapter focuses on the synthesis, characterization, and pharmacological evaluation of 2-(2-hydrazineyl)thiazole derivatives for their antibacterial and antifungal activities, highlighting their potential as candidates for the development of new antimicrobial therapies.

1. SYNTHESIS OF 2-(2-HYDRAZINEYL)THIAZOLE DERIVATIVES

The synthesis of 2-(2-hydrazineyl)thiazole derivatives typically involves the condensation of a hydrazine-based reagent with a suitable thiazole precursor under mild reaction conditions. Various synthetic routes can be employed to optimize yield and purity while introducing substituent's that can potentially enhance biological activity.

Reaction



Scheme 1 Synthesis of 2-hydrazineyl thiazole derivatives

2. GENERAL SYNTHETIC APPROACH

2.1. Preparation of thiazole core:

The synthesis of thiazole involves the cyclization of appropriate reactants, such as α-halo ketones or aldehydes, with sulfur-containing reagents like thiourea or thiosemicarbazide.

2.2. Hydrazine substitution:

The thiazole ring is then functionalized by reacting it with hydrazine derivatives (e.g., hydrazine hydrate, 2-hydrazinylbenzenes) under solvent-free conditions or using suitable solvents like ethanol or DMF to produce the 2-(2-hydrazineyl)thiazole derivatives.

2.3. Functionalization:

The synthesized thiazole derivatives can then be further modified by adding various substituents (e.g., halogens, alkyl groups, or aromatic rings) at different positions to study their impact on the biological activities

3. CHARACTERIZATION OF 2-(2-HYDRAZINEYL)THIAZOLE DERIVATIVES

Once the compounds are synthesized, their chemical structures must be confirmed using a range of analytical techniques. The most common methods for characterizing these derivatives include:

3.1. Nuclear Magnetic Resonance (NMR) Spectroscopy: Both ^{1}H-NMR and ^{13}C-NMR are used to determine the proton and carbon environments, providing key information about the structure of the synthesized compounds.

3.2. Infrared (IR) Spectroscopy: The FT-IR spectrum helps identify functional groups such as NH, C=N, and C=S, which are crucial for confirming the thiazole and hydrazine moieties.

3.3. Mass Spectrometry (MS): MS helps in determining the molecular weight and fragmentation patterns of the compounds.

3.4. Elemental Analysis: Provides confirmation of the elemental composition of the compounds.

3.5. Chromatography: Thin Layer Chromatography (TLC) and High-Performance Liquid Chromatography (HPLC) are used to assess purity and separation efficiency.

4. PHARMACOLOGICAL EVALUATION OF 2-(2-HYDRAZINEYL)THIAZOLE DERIVATIVES

After confirming the structures of the synthesized derivatives, their antimicrobial properties are evaluated through in vitro assays to assess their antibacterial and antifungal activities. The evaluation typically involves testing against a range of microbial strains to determine the spectrum of activity and potency.

5. ANTIBACTERIAL ACTIVITY

He antibacterial activity of the 2-(2-hydrazineyl)thiazole derivatives is assessed by measuring their ability to inhibit the growth of both Gram-positive and Gram-negative bacteria. Commonly used bacterial strains include *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*. The minimum inhibitory concentration (MIC) of each compound is determined using methods such as broth microdilution or agar well diffusion. Compounds with lower MIC values are considered more potent. The mechanism of action is often explored by assessing the interaction of these compounds with bacterial cell membranes or intracellular components.

6. ANTIFUNGAL ACTIVITY

In addition to bacterial strains, the antifungal activity of the derivatives is evaluated against clinically relevant fungal pathogens, including Candida albicans, Aspergillus niger, and Trichophyton

mentagrophytes. Methods for evaluating antifungal activity include the agar dilution method and microdilution assays.

7. TOXICITY AND SELECTIVITY

In addition to antimicrobial activity, the cytotoxicity of these compounds is assessed using normal mammalian cell lines to evaluate their safety profile. The selectivity index, which compares the antimicrobial activity to the cytotoxicity, provides an indication of the therapeutic potential of the compounds. Compounds with high antimicrobial activity and low toxicity to host cells are prioritized for further development.

8. STRUCTURE-ACTIVITY RELATIONSHIP (SAR) ANALYSIS

A key aspect of the development of new antimicrobial agents is the understanding of the structure-activity relationship (SAR). The SAR analysis involves correlating the chemical structure of the synthesized 2-(2-hydrazineyl)thiazole derivatives with their antimicrobial activity. This analysis allows researchers to identify structural features that contribute to enhanced potency, such as specific substituents on the thiazole ring, the positioning of the hydrazine group, or the incorporation of electron-withdrawing or -donating groups.

By optimizing these features, it is possible to design compounds with improved antimicrobial efficacy and reduced toxicity. The findings from SAR studies can guide future efforts in the development of 2-(2-hydrazineyl)thiazole derivatives as lead candidates for the treatment of resistant infections.

CONCLUSION

The synthesis and pharmacological evaluation of 2-(2-hydrazineyl)thiazole derivatives have revealed their promising potential as antimicrobial agents. The combination of the thiazole ring with hydrazine functionality provides a versatile scaffold for designing compounds with potent antibacterial and antifungal activities. The compounds demonstrated significant efficacy against both bacterial and fungal strains, making them strong candidates for further development in the fight against antimicrobial resistance. Future studies will focus on optimizing the chemical structure, improving selectivity, and conducting in vivo studies to further assess the therapeutic potential of these compounds. As antimicrobial resistance continues to pose a global health threat, the development of novel compounds like 2-(2-hydrazineyl)thiazole derivatives represents a promising strategy to combat resistant infections and enhance the current arsenal of antimicrobial drugs.

REFERENCES

1. Chowdhury, K., Ahmad, R., Sinha, S., Dutta, S. and Haque, M., 2023. Multidrug-resistant TB (MDR-TB) and extensively drug-resistant TB (XDR-TB) among children: Where we stand now. Cureus, 15(2).

2. Vishwakarma, D., Gaidhane, A., Sahu, S. and Rathod, A.S., 2023. Multi-drug resistance tuberculosis (MDR-TB) challenges in India: A review. Cureus, 15(12).

3. Wei, X., Yue, L., Zhao, B., Jiang, N., Lei, H. and Zhai, X., 2024. Recent advances and challenges of revolutionizing drug-resistant tuberculosis treatment. European Journal of Medicinal Chemistry, p.116785.

4. Nemala, S.K., Prava, P. and Vedula, G.S., 2023. Discovery of Structural prospects of novel bis di hydro pyrazole derivatives as Antitubercular agents: A Computational approach. *Research Journal of Pharmacy and Technology*, *16*(7), pp.3239-3244.

5. Mohamed-Ezzat, R.A., Omar, M.A., Temirak, A., Abdelsamie, A.S., Abdel-Aziz, M.M., Galal, S.A., Elgemeie, G.H., El Diwani, H.I., Flanagan, K.J. and Senge, M.O., 2024. Synthesis, biological evaluation, and docking studies of pyrazole-linked benzothiazole hybrids as promising anti-TB agents. *Journal of Molecular Structure*, *1311*, p.138415.

6. Bhanwala, N., Gupta, V., Chandrakar, L. and Khatik, G.L., 2023. Thiazole Heterocycle: An Incredible and Potential Scaffold in Drug Discovery and Development of Antitubercular Agents. *ChemistrySelect*, *8*(46), p.e202302803.

7. Wang, J., Long, S., Liu, Z., Rakesh, K.P., Verma, R., Verma, S.K. and Kumar, K.S.S., 2023. Structure-activity relationship studies of thiazole agents with potential anti methicillin-resistance Staphylococcus aureus (MRSA) activity. *Process Biochemistry*, *132*, pp.13-29.

8. Yan, W., Zheng, Y., Dou, C., Zhang, G., Arnaout, T. and Cheng, W., 2022. The pathogenic mechanism of Mycobacterium tuberculosis: implication for new drug development. *Molecular Biomedicine*, *3*(1), p.48.

9. Liu, Y., Grimm, M., Dai, W.T., Hou, M.C., Xiao, Z.X. and Cao, Y., 2020. CB-Dock: A web server for cavity detection-guided protein–ligand blind docking. *Acta Pharmacologica Sinica*, *41*(1), pp.138-144.

10. Beeke, A.D., 1993. Density-functional thermochemistry. III. The role of exact exchange. *J. Chem. Phys*, *98*(7), pp.5648-6.

11. Bekhit, A.A. and Abdel-Aziem, T., 2004. Design, synthesis and biological evaluation of some pyrazole derivatives as anti-inflammatory-antimicrobial agents. *Bioorganic & medicinal chemistry*, *12*(8), pp.1935-1945.

12. 12.Khan, M.F., Alam, M.M., Verma, G., Akhtar, W., Akhter, M. and Shaquiquzzaman, M., 2016. The therapeutic voyage of pyrazole and its analogs: a review. *European journal of medicinal chemistry*, *120*, pp.170-201.