INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Research Article

Synthesis And Evaluation of Antifungal Activity of Novel Naphthalene Hydrazone Derivative

Dukare Sakshi*, Badhe Chaitali, Fulsunder A. S.

Department of chemistry, Samarth Institute of Pharmacy, Belhe, Pune 412410, Maharashtra, India.

ARTICLE INFO

Published: 28 April. 2025
Keywords:
Naphthalene, Hydrazone, Antifungal Agents, Antifungal Activity, TLC, IR.
DOI:
10.5281/zenodo.15297090

ABSTRACT

Fungal infections, particularly those caused by Candida albicans (ATCC 10231), pose significant challenges due to increasing resistance and the adverse effects of existing treatments. This study investigates the synthesis and characterization of novel naphthalene Hydrazone compounds as possible squalene epoxidase inhibitors with enhanced antifungal activity. The derivative were synthesized, and their progress was monitored using thinlayer chromatography (TLC). The characterization of the compounds involved melting point analysis and various spectroscopic techniques including infrared (IR) spectroscopy. The antifungal efficacy of compounds was evaluated specifically against Candida albicans (ATCC 10231), with Napthalene hydrazone derivative showing superior activity compared to standard antifungal agents naftifine and nystatin. This research lays a promising foundation for the development of novel antifungal therapies, addressing the urgent need for more effective treatments with fewer side effects.

INTRODUCTION

Fungal Infections:

Fungal infections, also known as mycoses, are infections caused by fungi. Fungi can live in soil, on plants, and on household surfaces and skin. While many fungi are harmless, some can cause disease under specific conditions, particularly when the immune system is weakened. Prevalence of fungal infections:

- Global burden
- Dairy industry
- Human health

Impact of Fungal Infections:

1. Economic losses:
2. Food safety
3. Human health
4. Antimicrobial resistance

***Corresponding Author:** Dukare Sakshi
Address: Department of chemistry, Samarth Institute of Pharmacy, Belhe, Pune 412410, Maharashtra, India.
Email ✉: dukaresakshi856@gmail.com
Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Types of fungal infections:

I. Superficial Fungal Infections:

- Dermatophytosis (Tinea)
- Candidiasis:

Involves infections by Candida species, commonly affecting the skin, nails, and mucous membranes, such as oral thrush and vaginal yeast infections.

- Pityriasis Versicolor

II. Subcutaneous Fungal Infections:

- Sporotrichosis:
- Chromoblastomycosis:
- Mycetoma:

III. Systemic (Invasive) Fungal Infections:

- Histoplasmosis
- Coccidioidomycosis
- Aspergillosis
- Cryptococcosis

Challenges in treating fungal infections

Fungal infections pose significant challenges to healthcare due to a variety of factors including resistance, limited treatment options, diagnostic difficulties, and the impact on immunocompromised patients. Addressing these challenges requires a comprehensive understanding and innovative approaches.

1. **Antifungal Resistance:** Antifungal resistance is a growing concern, particularly with species such as Candida and Aspergillus. Resistance limits the effectiveness of standard treatments and increases the risk of treatment failure.

- **Candida auris:** This emerging pathogen is resistant to multiple antifungal drugs, complicating treatment efforts and leading to high mortality rates.

- **Aspergillus fumigatus:** Resistance to azole antifungals, commonly used to treat aspergillosis, is increasing, leading to more difficult-to-treat infections.ncreases the risk of treatment failure.

2. **Limited Treatment Options:** There are fewer antifungal agents compared to antibiotics, and many have significant side effects or toxicity issues.

- **Drug Toxicity:** Amphotericin B, while effective, is associated with severe nephrotoxicity.
- **Lack of New Drugs**: The development pipeline for new antifungal agents is relatively sparse compared to other types of antimicrobials.

3. **Diagnostic Difficulties:** Accurate and timely diagnosis of fungal infections is challenging due to non-specific symptoms and limitations in current diagnostic methods.

- **Non-Specific Symptoms:** Many fungal infections present with symptoms similar to bacterial or viral infections, leading to misdiagnosis or delayed diagnosis.
- **Diagnostic Tools:** Current tools like culture methods are time-consuming and often lack sensitivity, while newer molecular methods are not yet widely available in all healthcare settings.

4. **Immunocompromised Patients:** People with weakened immune systems, such as those with HIV/AIDS, cancer, or organ transplants, face a greater risk of developing severe fungal infections.

- **Opportunistic Infections:** Fungal pathogens exploit weakened immune defenses, leading to severe and often disseminated infections.
- **Treatment Challenges:** These patients often cannot tolerate aggressive antifungal therapy due to their already compromised health status.

Antifungal Agents

Antifungal agents play a vital role in controlling and treating fungal infections. These agents target various components of fungal cells to inhibit growth or eradicate the fungi, thereby alleviating symptoms and preventing the spread of infection. The classification of antifungal agents is determined by their mechanism of action and chemical properties. However, their use is limited by various factors, including resistance development and side effects.

Classification of Antifungal Agents:

Antifungal agents are broadly classified into the following categories:

- Azoles
- Echinocandins
- Polyenes
- Allylamines
- Others: eg. Griseofulvin

Limitations of Antifungal Agents:

- **Toxicity:** Many antifungal agents, especially polyenes, can cause severe side effects. Amphotericin B is known for its nephrotoxicity and infusion-related reactions.
- **Narrow Spectrum:** Some antifungals have a narrow spectrum of activity. For example, echinocandins are effective against Candida species but not against Cryptococcus or other molds.
- **Drug Interactions:** Azoles, in particular, have significant interactions with other medications due to their inhibition of cytochrome P450 enzymes, affecting the metabolism of various drugs.

Squalene Epoxidase: A Multifaceted Therapeutic Target

Squalene epoxidase (SE) is an essential enzyme in the sterol biosynthesis pathway, catalyzing the first oxygenation step of squalene to 2,3-oxidosqualene. This enzyme plays a crucial role in the biosynthesis of ergosterol in fungi and cholesterol in humans. Due to its pivotal role, SE is a significant target for antifungal, anticancer, and cholesterol-lowering therapies.

Mechanism of Action:

The mechanism of action for squalene epoxidase inhibitors involves the blockage of the enzyme's active site, inhibiting the conversion of squalene to 2,3-oxidosqualene. This results in the buildup of squalene and a subsequent decrease in ergosterol or cholesterol levels. In fungi, Depletion of ergosterol impairs cell membrane integrity and function, which lead to increased permeability and cell death. In humans, inhibition of squalene epoxidase results in lowered cholesterol levels, beneficial in treating hypercholesterolemia.

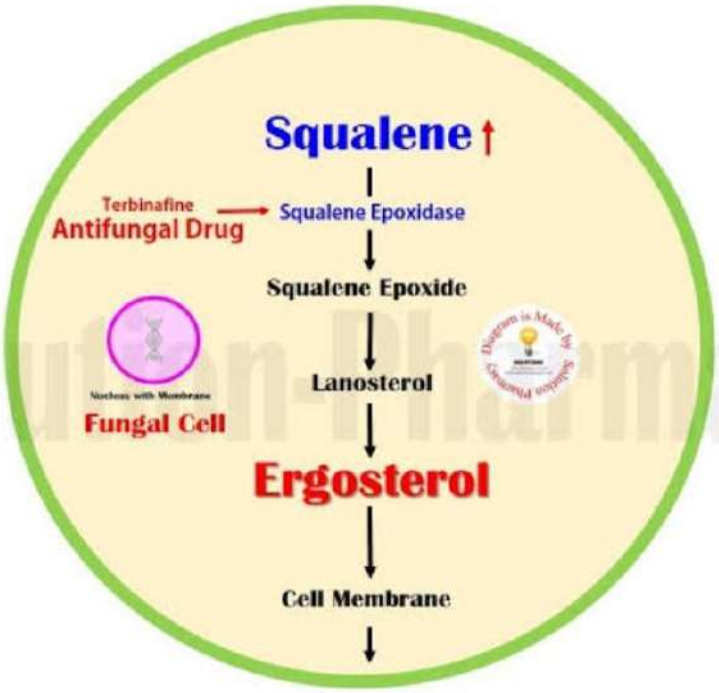


Fig. The Mechanism of action of Antifungal Agents

Squalene Epoxidase Inhibitors as an Antifungal Agent

As an antifungal agent, squalene epoxidase inhibitors are particularly effective against pathogenic fungi like Candida albicans. By inhibiting squalene epoxidase, these agents prevent the production of ergosterol, a essential part of the fungal cell membrane. This disturbance in ergosterol synthesis leads to increased permeability of membranes and fungal cell death.. squalene epoxidase inhibitors are crucial in treating fungal infections resistant to other antifungal drugs.

Squalene Epoxidase Inhibitors and Candida albicans:

squalene epoxidase inhibitors are particularly effective against Candida albicans, a common cause of fungal infections. The inhibition of squalene epoxidase in Candida albicans disrupts ergosterol synthesis, leading to compromised cell membranes and fungal cell death. Terbinafine and other allylamines have shown significant efficacy against Candida albicans, making them valuable in clinical antifungal therapy.

Naphthalene

Naphthalene is a polycyclic aromatic hydrocarbon made up of two fused benzene rings. It is white and crystalline, volatile solid with a distinct smell, commonly used in mothballs and as a chemical intermediate in the production of various compounds. Naphthalene is derived from coal tar and petroleum, and its derivatives are widely used in the pharmaceutical industry due to their diverse biological activities.

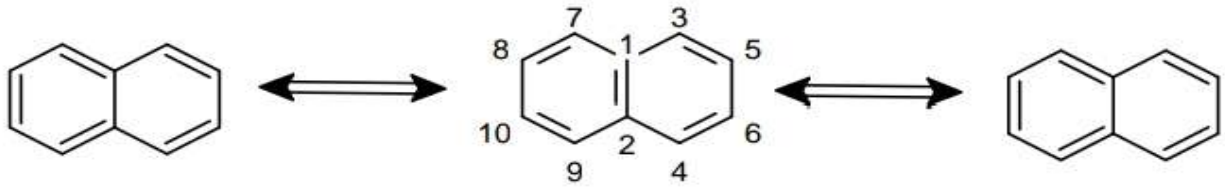


Fig. Resonance Structure of Naphthalene

Naphthalene-Containing Drugs

Naphthalene derivatives have shown a wide variety of pharmacological properties, which makes them useful for creating medicinal substances. These derivatives are used in the treatment of several diseases, including infections, inflammation, and cancer. Naphthalene-containing drugs often exhibit enhanced stability and bioavailability, contributing to their effectiveness as therapeutic agents.

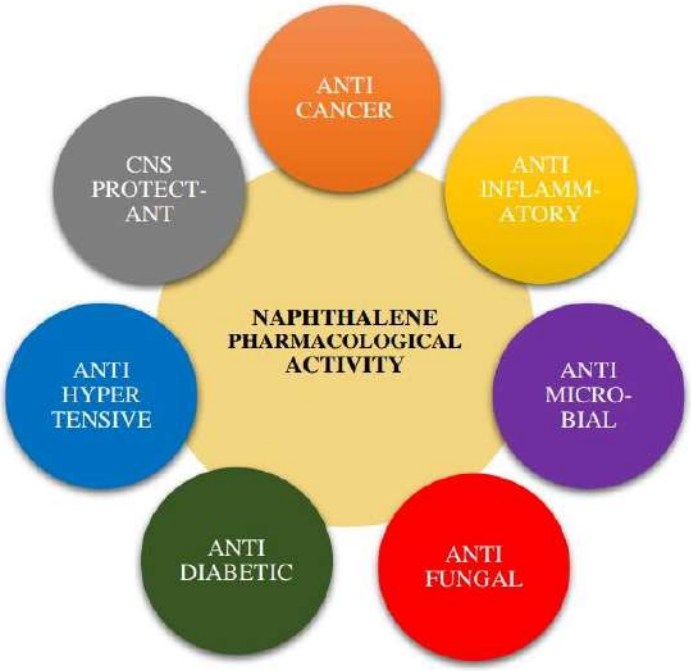


Fig. Pharmacological Activities of Naphthalene

Naphthalene-Containing Antifungal Drugs:

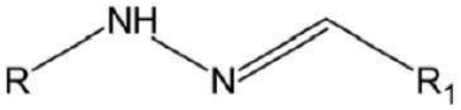
Naphthalene derivatives are particularly notable for their antifungal activity. They act by inhibiting key enzymes involved in the synthesis of ergosterol, a crucial part of the fungal cell membranes. This inhibition leads to increased membrane permeability and ultimately results in fungal cell death.

1. Naftifine
2. Terbinafine
3. Tolnaftate

Hydrazones:

A class of chemical compounds known as hydrazones is distinguished by the functional group R1 C=NNHR. They are typically form by the reaction of condensation hydrazines with

aldehydes or ketones. Hydrazones have a variety of biological actions, such as antimicrobial, antitumor, anti-inflammatory, and antitubercular properties, which making them valuable scaffolds in medicinal chemistry.



Hydrazone-Containing Drug:

Hydrazone derivatives have been developed into various therapeutic agents due to their ability to interact with biological targets through hydrogen bonding, metal coordination, and other interactions. These compounds are versatile in their pharmacological profiles, leading to the development of drugs for different therapeutic applications.

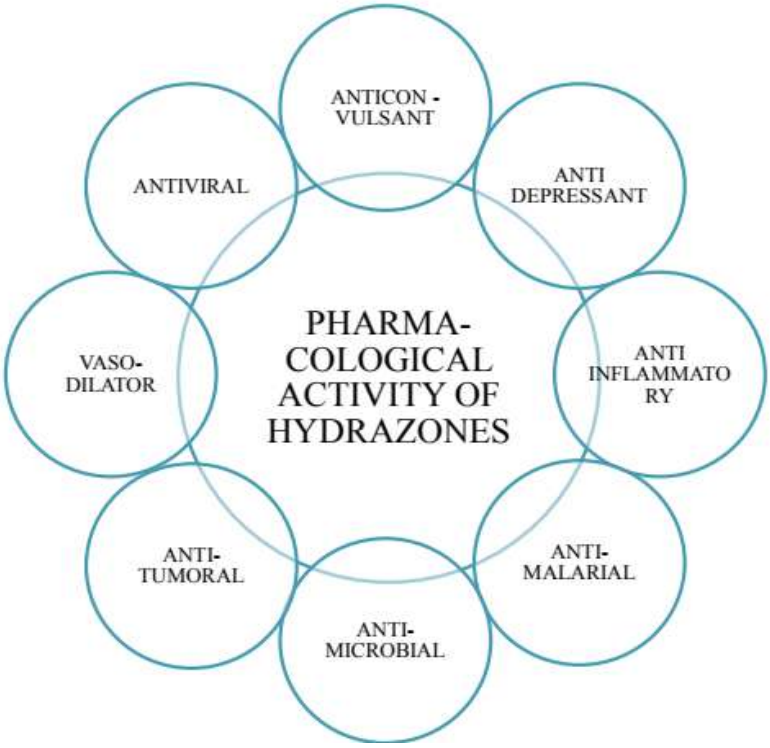


Fig. Pharmacological Activities of Hydrazones

Naphthalene Hydrazone:

In recent years, naphthalene hydrazone derivatives have attracted a lot of attention because of their wide range of biological activities. These compounds have demonstrated potent antifungal, antibacterial, and anti-inflammatory properties, making them attractive candidates for the development of novel antifungal agents. This study focuses on the synthesis and antifungal evaluation of novel Naphthalene hydrazone derivative.

MATERIALS AND METHODS:

1. Synthesis of compounds:

- To Synthesize derivative through established organic synthesis methods and monitor the reaction progress using Thin Layer Chromatography (TLC).

- The solvents used for synthesis were distilled off before use.

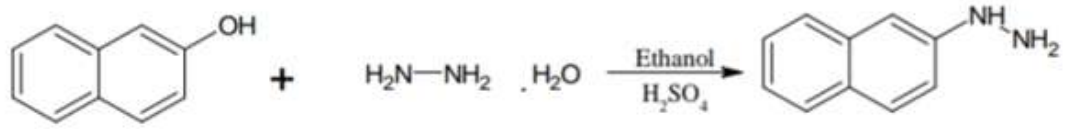
2. Characterization of Compounds:

- To verify the synthetic chemical structures using melting point analysis.
- Melting point devices in open capillaries were used to measure melting points.
- The characterization of the synthesized derivatives was performed by physical and spectral studies.
- To Characterize the compounds using spectroscopic methods such as IR, and mass spectrometry.

3. Biological Activity Testing:

- To use the disc diffusion method to assess the produced compounds' antifungal activity against Candida albicans (ATCC 10231).
- To Compare the antifungal efficacy of the novel compounds with standard drugs, naftifine and nystatin.

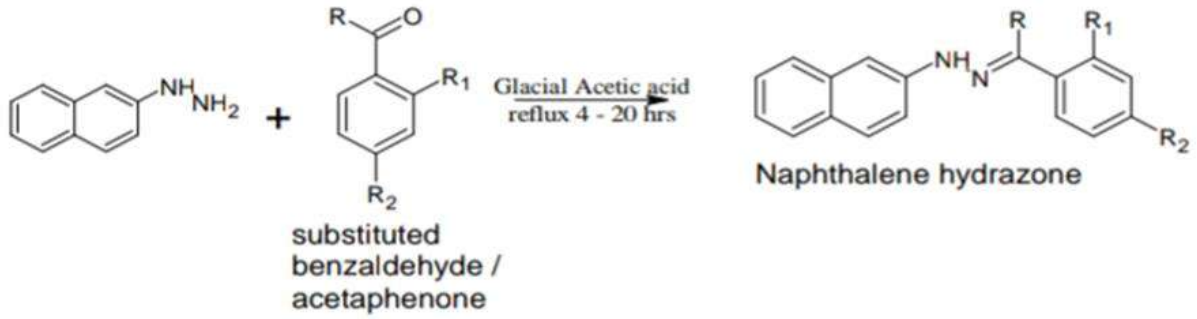
Step 1: Synthesis Of Naphthalene Hydrazine:



Beta naphthol **Hydrazine hydrate** **Naphthalene**

Take (1.4g ; 0.01mole) beta naphthol in a 250ml RBF. Add 10ml of hydrazine hydrate in it. Add few drops of H2SO4 . Then reflux the mixture for 2hrs. Pour the reaction mixture in crushed ice. Filter the precipitate and recrystallise with ethanol.

Step 2: Synthesis Of Naphthalene Hydrazone Derivatives



Take (1.76g; 0.01mole) Naphthalene hydrazine in a 250ml RBF. Add equimolar quantity of substituted benzaldehyde/acetaphenone in it. Add few drops of glacial acetic acid . Add 10ml of ethanol as a solvent. Then reflux the mixture for 4 - 20hrs. Filter the precipitate and recrystallise with ethanol.

TLC: Solvent system (n-hexane-0.8 ml : ethyl acetate-0.2ml)

Antifungal Activity:

Disc Diffusion Method:

The disc diffusion method was used to determine antifungal activity of all test compounds. Saturated solution of all test compounds were prepared in DMSO. Nafitine and Nystatin used as a standard drug to compare the activity of test compounds.

Principle of disc diffusion method

After being suspended in saline and having its turbidity standardized, the pure microbial culture is evenly swabbed on an agar plate. Agar media that has been evenly seeded with the test organism is covered with paper disks that have been impregnated with antibiotics or other substances. Antibiotics spread outward from the disc into the agar during the incubation phase. Diffusion from the disk creates the antibiotic concentration gradient, and the test organism's growth is suppressed at a distance from the disk to the organism's susceptibility. As one gets farther away from the disk, the concentration of these components will drop from its maximum value near the disk. No colonies will form if the concentration in the agar is higher than or equal to the effective concentration of antibiotics if they are effective against microorganisms at a particular concentration. The zone of inhibition is the region surrounding the disc where no growth occurs.

Susceptibility test procedure:

- **Media Preparation:** Mueller Hinton Agar is primarily used in antibiotic susceptibility testing for aerobic organisms that grow quickly. 5% sterile defibrinated blood was added as a supplement by Mueller Hinton. For fungal cultivation use Mueller Hinton Agar + 2% glucose + 0.5mcg/ml methylene blue.7475
- **Inoculum Preparation:** fungus cultures Five separate colonies (about 1 mm) from a 24-hour-old culture produced on saturated dextrose agar and incubated at 35±2ºC are selected to create the inoculum. Five milliliters of sterile 0.85% saline are used to suspend the colonies. To obtain 1× 106-5× 106 cells/mL, swirl the resultant suspension and adjust the turbidity.

Test Procedure:

- Apply the standardized bacterial suspension on a sterile cotton swab.
- Gently press the swab on the tube wall at a level above the liquid to remove extra inoculum.
- Apply the inoculum-containing swab to the agar in a streaking motion to inoculate it.
- Repeat the rubbing process after rotating the plate by 60°. Repeat twice. This will guarantee the inoculums are distributed evenly.
- To allow for the absorption of extra moisture, let the medium's surface dry for three to five minutes, but no more than fifteen.
- Aseptic techniques should be used while applying disc.
- While depositing the disc care should be taken that their centers should be at-least 24mm apart.
- In case of fastidious organisms the distance should be at least 30mm
- Plates should be incubated inverted at 35±2°C temperature and examine each plate 20-24hrs of incubation.

Biological Activity: Bactochem Laboratories evaluated the antifungal activity of our synthesized naphthalene hydrazone compounds against Candida albicans (ATCC 10231).

Antifungal Activity

Antifungal evaluation of compound naphthalene hydrazone against Candida albicans revealed their

effectiveness, with zone of inhibition compared to naftifine and nystatin.

Compound:

- displayed moderate antifungal activity with a zone of inhibition of 13 mm, which is higher than naftifine (9 mm) but lower than nystatin (20 mm). demonstrated the most potent antifungal activity, with zones of inhibition far exceeding those of naftifine and nystatin. These results suggest that modifications in the chemical structure, particularly in derivative Naphthalene hydrazone may enhance effectiveness against Candida albicans.

CONCLUSION:

The synthesis of the naphthalene hydrazone was successfully completed, with the reaction monitored by TLC. The newly synthesized compounds were characterized by using melting point analysis, IR spectroscopy, and mass spectrometry, confirming their structures. The synthesis process resulted in high purity and good yields. In vitro antifungal activity was tested against Candida albicans (ATCC 10231), and the results showed that synthesized compound exhibited antifungal activity. The compound demonstrated superior activity compared to the standard drugs naftifine and nystatin. In conclusion, this study lays a strong foundation for the development of novel antifungal agents based on naphthalene hydrazone derivatives. Future research should prioritize optimizing the synthesis process, expanding biological testing, and advancing promising compounds to preclinical and clinical trials. By addressing these areas, the development of effective antifungal therapies can be significantly advanced, contributing to the ongoing efforts to combat fungal infections and overcome the limitations of current treatments.

REFERENCES

1. Gupta AK, Einarson TR, Summerbell RC, Shear NH. An overview of topical antifungal therapy in dermatomycoses: a North American perspective. Drugs. 1998 May;55:645- 74.
2. Fisher MC, Hawkins NJ, Sanglard D, Gurr SJ. Worldwide emergence of resistance to antifungal drugs challenges human health and food security. Science. 2018 May 18;360(6390):739-42.
3. Pappas PG, Kauffman CA, Andes DR, Clancy CJ, Marr KA, Ostrosky-Zeichner L, et al. Clinical Practice Guideline for the Management of Candidiasis: 2016 Update by the Infectious Diseases Society of America. Clin Infect Dis [Internet]. 2016 Feb 15 [cited 2024 Jul 25];62(4):e1–50.
4. Chowdhary A, Sharma C, Meis JF. Candida auris: a rapidly emerging cause of hospital-acquired multidrug-resistant fungal infections globally. PLOS pathogens. 2017 May 18;13(5).
5. Georgopapadakou NH, Bertasso A. Effects of squalene epoxidase inhibitors on Candida albicans. Antimicrob Agents Chemother [Internet]. 1992 Aug [cited 2024 Jul27];36(8):1779–81.
6. Petranyi G, Ryder NS, Stütz A. Allylamine derivatives: new class of synthetic antifungal agents inhibiting fungal squalene epoxidase. Science. 1984 Jun 15;224(4654):1239-41.
7. Ryu CK, Chae MJ. Synthesis and antifungal activity of naphthalene-1, 4-diones modified at positions 2, 3, and 5. Archives of pharmacal research. 2005 Jul;28:750-5.
8. Altıntop MD, Özdemir A, Turan-Zitouni G, Ilgın S, Atlı Ö, İşcan G, et al. Synthesis and biological evaluation of some hydrazone derivatives as new anticandidal and anticancer agents. Eur J Med Chem .

9. Rambabu N, Dubey P, Ram B, Balram B. Synthesis, characterization and antimicrobial activity of some novel hydrazone derivatives of anacardic acid. Pharma Chem. 2015 Jan 1;7:90–7.
10. Eberhardt J, Santos-Martins D, Tillack AF, Forli S. AutoDock Vina 1.2. 0: New docking methods, expanded force field, and python bindings. Journal of chemical information and modeling. 2021 Jul 19;61(8):3891-8.
11. Mahajan A, Kremer L, Louw S, Guéradel Y, Chibale K, Biot C. Synthesis and in vitro antitubercular activity of ferrocene-based hydrazones. Bioorganic & medicinal chemistry letters.2011May15;21(10):2866-8.
12. Pappas PG, Lionakis MS, Arendrup MC, Ostrosky-Zeichner L, Kullberg BJ. Invasive candidiasis. Nat Rev Dis Primer [Internet]. 2018 May 11 [cited 2024 Jul 25];4(1):18026. Available from: https://www.nature.com/articles/nrdp201826
13. Lewis RE. Current Concepts in Antifungal Pharmacology. Mayo Clin Proc [Internet]. 2011 Aug [cited 2024 Jul 25];86(8):805–17. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0025619611651835.
14. Sagatova AA. Strategies to Better Target Fungal Squalene Monooxygenase. J Fungi [Internet]. 2021 Jan 13 [cited 2024 Jul 27];7(1):49. Available from: https://www.mdpi.com/2309-608X/7/1/49
15. Dash AK. Tolnaftate. In: Analytical Profiles of Drug Substances and Excipients [Internet]. Elsevier; 1994 [cited 2024 Jul 31]. p. 543–70. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0099542808606127
16. Claudio Viegas-Junior, Eliezer J. Barreiro, Carlos Alberto Manssour Fraga. Molecular Hybridization: A Useful Tool in the Design of New Drug Prototypes. Curr Med Chem [Internet]. 2007 Jul 1 [cited 2024 Jul 27];14(17):1829–52. Available from: http://www.eurekaselect.com/openurl/content.php?genre=article&issn=0929-8673&volume=14&issue=17&spage=1829
17. Sheikhy M, Jalilian AR, Novinrooz A, Motamedi-Sedeh F. Synthesis and <i>in vitro</i> antibacterial evaluation of some thiosemicarbazides and thiosemicarbazones. J Biomed Sci Eng [Internet]. 2012 [cited 2024 Jul 29];05(02):39–42. Available from: http://www.scirp.org/journal/doi.aspx?DOI=10.4236/jbise.2012.52006
18. Scherberger RR, Kaess H, Brückner S. [Studies on the action of an anticholinergic agent in combination with a tranquilizer on gastric juice secretion in man]. Arzneimittelforschung. 1975 Sep;25(9):1460–3.
19. Kathiravan MK, Salake AB, Chothe AS, Dudhe PB, Watode RP, Mukta MS, et al. The biology and chemistry of antifungal agents: A review. Bioorg Med Chem [Internet]. 2012 Oct [cited 2024 Jul 29];20(19):5678–98. Available from: https://linkinghub.elsevier.com/retrieve/pii/S096808961200329X.
20. Ates-Alagöz Z, Alp M, Kus C, Yildiz S, Buyukbingöl E, Göker H. Synthesis and Potent Antimicrobial Activities of Some Novel Retinoidal Monocationic Benzimidazoles. Arch Pharm (Weinheim) [Internet]. 2006 Feb [cited 2024 Jul 29];339(2):74–80. Available from: https://onlinelibrary.wiley.com/doi/10.1002/ardp.200500168.
21. Sari S, Koçak E, Kart D, Özdemir Z, Acar MF, Sayoğlu B, et al. Azole derivatives with naphthalene showing potent antifungal effects against planktonic and biofilm forms of Candida spp.: an in vitro and in silico study. Int

Microbiol [Internet]. 2021 Jan [cited 2024 Jul 29];24(1):93–102. Available from: https://link.springer.com/10.1007/s10123-020-00144-y

22. Nagy M, Szemán-Nagy G, Kiss A, Nagy ZL, Tálas L, Rácz D, et al. Antifungal Activity of an Original Amino-Isocyanonaphthalene (ICAN) Compound Family: Promising Broad Spectrum Antifungals. Molecules [Internet]. 2020 Feb 18 [cited 2024 Jul 29];25(4):903. Available from: https://www.mdpi.com/1420-3049/25/4/903
23. Kodisundaram P, Amirthaganesan S, Balasankar T. Antimicrobial Evaluation of a Set of Heterobicyclic Methylthiadiazole Hydrazones: Synthesis, Characterization, and SAR Studies. J Agric Food Chem [Internet]. 2013 Dec 11 [cited 2024 Aug 14];61(49):11952–6. Available from: https://pubs.acs.org/doi/10.1021/jf404537d.
24. Dascalu AE, Ghinet A, Lipka E, Furman C, Rigo B, Fayeulle A, et al. Design, synthesis and evaluation of hydrazine and acyl hydrazone derivatives of 5-pyrrolidin-2-one as antifungal agents. Bioorg Med Chem Lett [Internet]. 2020 Jul [cited 2024 Aug 14];30(13):127220. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0960894X20303206
25. Özdemir A, Turan-zitouni G, Asim Kaplancikli Z, Demirci F, Iscan G. Studies on hydrazone derivatives as antifungal agents. J Enzyme Inhib Med Chem [Internet]. 2008 Jan 1 [cited 2024 Jul 29];23(4):470–5. Available from: https://www.tandfonline.com/doi/full/10.1080/14756360701709094
26. Shukla S, Srivastava RS, Shrivastava SK, Sodhi A, Kumar P. Synthesis, cytotoxic evaluation, docking and in silico pharmacokinetic prediction of 4-arylideneamino/cycloalkylidineamino 1, 2-naphthoquinone thiosemicarbazones. J Enzyme Inhib Med Chem [Internet]. 2013 Dec 1 [cited 2024 Aug 14];28(6):1192–8. Available from: https://www.tandfonline.com/doi/full/10.3109/14756366.2012.721783
27. Dandawate P, Khan E, Padhye S, Gaba H, Sinha S, Deshpande J, et al. Synthesis, characterization, molecular docking and cytotoxic activity of novel plumbagin hydrazones against breast cancer cells. Bioorg Med Chem Lett [Internet]. 2012 May [cited 2024 Aug 14];22(9):3104–8. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0960894X12003812
28. PHENYLHYDRAZINE. Org Synth [Internet]. 1922 [cited 2024 Aug 14];2:71. Available frShirinzadeh H, Dilek E. Synthesis, characterization and biological activity evaluation of novel naphthalenylmethylen hydrazine derivatives as carbonic anhydrase inhibitors. J Mol Struct [Internet]. 2020 Nov [cited 2024 Aug 14];1220:128657. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0022286020309820om: http://orgsyn.org/demo.aspx?prep=CV1P0442
29. Hudzicki J. Kirby-Bauer Disk Diffusion Susceptibility Test Protocol Author Information. Am Soc Microbiol. 2012;(December 2009):1–13.

HOW TO CITE: Dukare Sakshi*, Badhe Chaitali, Fulsunder A. S., Synthesis and Evaluation of Antifungal Activity of Novel Naphthalene Hydrazone Derivative, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 4, 3173-3183 https://doi.org/10.5281/zenodo.15297090