International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 117-122 www.ijprajournal.com ISSN: 2456-4494

"Imidazole: A Versatile scaffold for Biological Activity"

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Date of Submission: 05-07-2025 Date of Acceptance: 15-07-2025

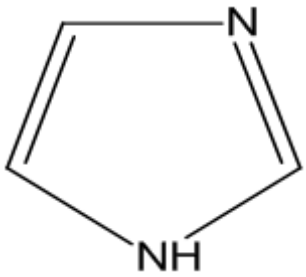
ABSTRACT:
Imidazole nucleus is a constituent of many bioactive heterocyclic compounds that are of wide interest because of their diverse biological and clinical applications. This created interest in researchers to synthesize variety of imidazole derivatives and to screen them for their various biological activities viz. anti-cancer, antihypertensive, anti-fungal, anti-mycobacterial, anti-inflammatory, analgesic, anthelmintic and anti-dengue activities.

Key Words: Imidazole, Biological activities

I. INTRODUCTION:

Heterocyclic compounds occupy a central position in medicinal chemistry and are of particular interest and significant importance in the search for new bioactive molecules in the pharmaceutical industry. The nitrogen-containing heterocycles, in particular, exhibit diverse range of biological activities due in part to their similarities with many natural and synthetic molecules with known biological activities. Imidazole is a 5-membered planar ring, which is soluble in water and other polar solvents. It exists in two equivalent tautomeric forms because the hydrogen atom can be located on either of the two nitrogen atoms.(1)) and aromatic heterocycle widely present in the important biological building blocks, such as amino acid histidine (a normal constituent of most proteins), histamine, purines, and biotin. (2)

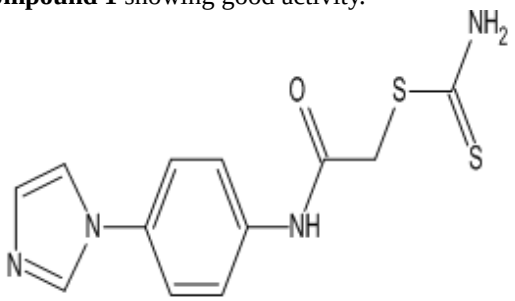
The main part of the imidazole in the production is used in production of biologically active compounds. Imidazole derivatives show different antimicrobial, anti-inflammatory, analgesic, anti-cancer and other properties. Possible improvements of its properties may be due to slight changes in the substituents on the core of imidazole. Chemistry of compounds that contain residue imidazole have a flat configuration and the associated hydrogen bonds. (3) Imidazoleand its derivatives are reported to be physiologically and biologically active and find applications in the treatment of several diseases. (4)



II. REVIEW OF LITERATURE

ANTI-FUNGALACTIVITY

1.**Ayşen Işık et al**have synthesized some novel imidazole derivatives and evaluated for their invitro antifungal activity against C. Krussi.All the compounds were characterized by using IR,1H NMR,13C NMR & MS Spectroscopy. The molecular docking study of the active compound with target Lanosterol 14 α-demethylase (CYP 51). **Compound 1** showing good activity. (5)



FOR COMPOUND 1

2.**Siham Slassi et al** have reported imidazole & azo-based Schiff base ligands and tested against antifungal activity against S. apiospermum, A fumigatus&C. albicans. The ligands were examined for their ability to scavenge DPPH radicals. All the active compounds were Uv-visible absorption. **Compound 2** was found to be antifungal activity. (6)

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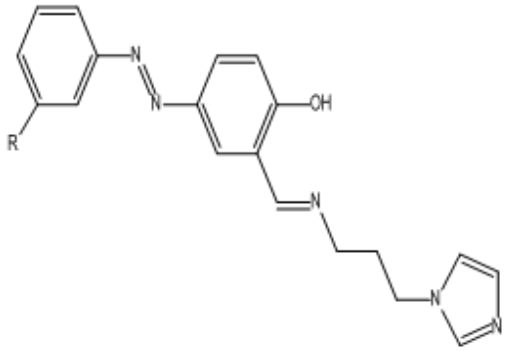
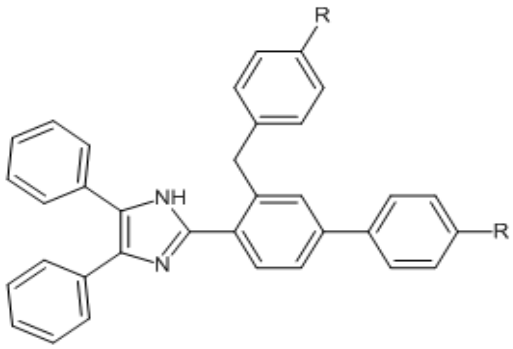


FOR COMPOUND 2
R=H

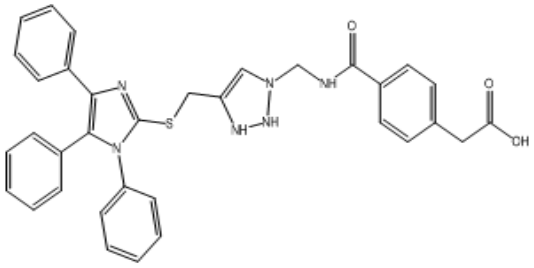
ANTI-CANCER ACTIVITY

3.**Behbood Taheri et al**have created imidazole & carbazole derivatives & evaluated for anti-cancer activity against three human cancer cell lines MCF-7(human breast cancer), HT29(human colon cancer) and Hela (human cervical cancer). All the synthesized compounds were determined by MTT assay method, **Compound 3** showing good activity. [7]



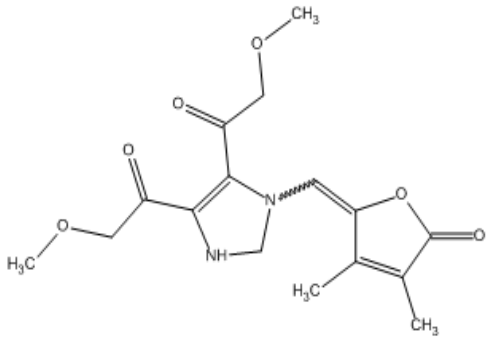
FOR COMPOUND 3
R=NO_2

4**. Fawzia Al-blewi et al** have reported synthesis of novel imidazole derivatives and tested for anti-cancer activity against 4 cancer cell cells (Caco-2, HCT-116, Hela & MCF-7 and determined by MTT assay method and all the active compounds were characterized by IR,^{1}H &^{13}C NMR spectroscopic techniques. In-silico molecular docking investigation on the cancer target receptor glycogen synthase kinase-3 (GSK-3). **Compound 4** showing potent activity. [8]



FOR COMPOUND 4

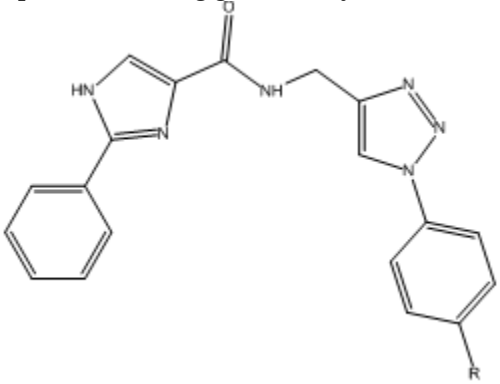
5.**Karlo Wittineet al** have created a series of novel 1,2,4-triazole & imidazole L-ascorbic acid (1,2,3,5,6, & 9) imino ascorbic acid (4,7,8) and evaluated for antitumour cells against hepatitis c virus (HCV) replication & human tumour cell proliferation. **Compound 5 sho**wing best activity. [9]



FOR COMPOUND 5

ANTI-TUBERCULAR ACTIVITY

6**.C.B. Pradeep Kumar et al have**reported a series of novel 1,2,3-triazole based imidazole and tested for anti-tubercular activity against Mycobacterium tuberculosis 1H37RV (mtb). All the active compounds were characterised by using 1H NMR,13C NMR spectroscopy. **Compound 6** showing good activity. [10]



FOR COMPOUND 6
R=NH2

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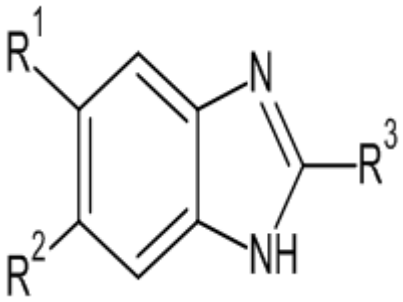
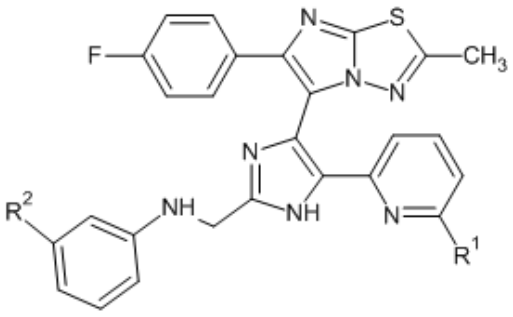
7.**Katarzyna Gobiset al** have created novel 2-(2-phenalkyl)-1H-benzo(d) imidazole and tested for anti-tubercular activity against Mycobacterium tuberculosis strains with MTC value from 0.8 to 6.2 µ(2.5-25µm). All the synthesized compounds were characterized by 1HNMR spectroscopy. **Compound 7** showing potent activity. [11]



FOR COMPOUND 7
7a=R=-CH_2-CH_2-Ph
7b=R=CH=CH-Ph
7c=R=-CH_2-CH_2-3,5, -di cl-Ph

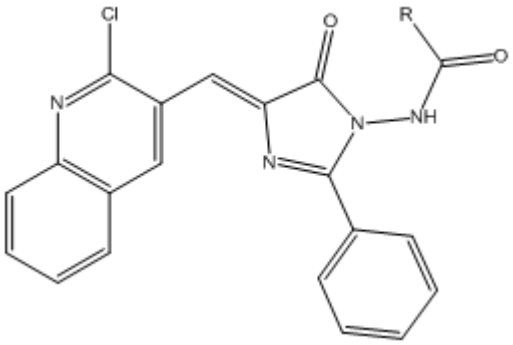
ANTI-MICROBIAL ACTIVITY

8.**Fang Yan Guoet al** have reported a series of new imidazole-fused imidazo (2,1-b) (1,3,4) thiadiazole analogues and tested for antibacterial & anti-fungal activity against Candida albicans over gram +ve & gram -ve bacteria. Gatifloxacin and fluconazole were reference drugs. **Compound 8** showing good potent activity. [12]



FOR COMPOUND 8
R^1=4-F-Phenyl
R^2=H

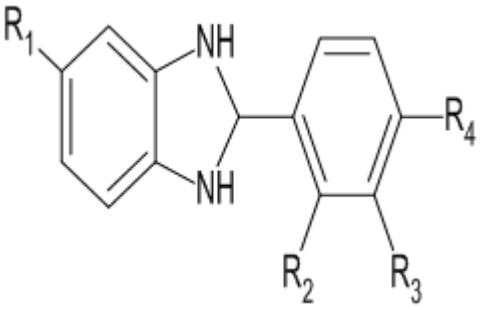
9.**N C Desaiet al** have developed the synthesis of N-(4-((2-chloroquinolin-3-yl) methylene)-5-oxo-2-phenyl-4,5-dihydro-1H-imidazol-1-yl)(aryl)amides and tested for anti-microbial activity against Escherichia coli (MTCC 443),Pseudomonas aeruginosa (MTCC 1688),Staphylococcus aureus (MTCC 96),Streptococcus pyrogens (MTCC 442).Candida albicans (MTCC-227),Aspergilus niger (MTCC 282),Aspergillus clavatus(MTCC 1323) and All the active compounds were characterized by IR,1HNMR &^{13}C NMR.**Compound 9** showing good activity.[13]



FOR COMPOUND 9
9a, R=-4-Cl-C_6H_4
9b, R=-4-NO_2-C_6H_4-

ANTI-HYPERTENSIVE ACTIVITY

10. **Gabriel Navarrette et al have**reported a series of 1H-bezo(d) imidazole analogues and screened for anti-hypertensive effect, The active compounds were characterized by 1H NMR spectroscopy. **Compound 10** Showing good activity with EC50 value is 1.81µm & Emax is 91.7%. [14]



FOR COMPOUND 10
R_1=-NO_2
R_2=-H
R_3=-Ome
R_4=-OH

11.**Vineet Malhotra et al** have created Substituted imidazole derivatives and screened for cardio-vascular activity. Clonidine was a reference drug. **Compound 11** showing good activity with ALD≥1000mg/Kg. ([15]

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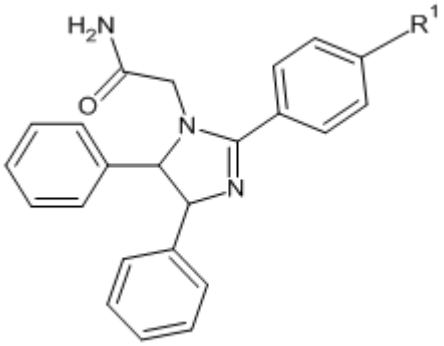
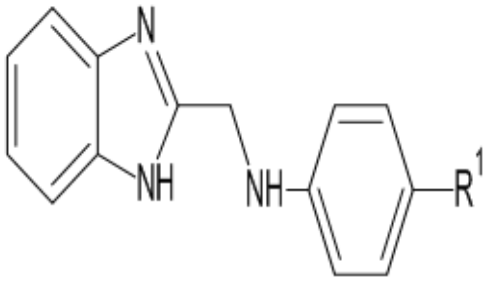


FOR COMPOUND 11
R=-O-(OH)

ANTI-INFLAMMATORY ACTIVITY

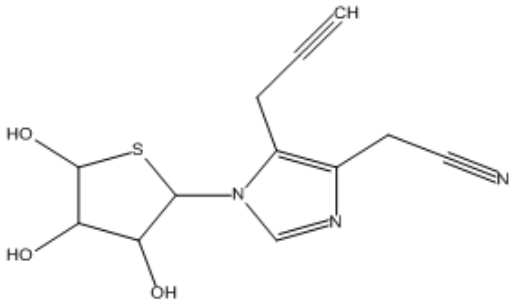
12.**Kavitha C.S. Achar et al** have created a series of 2-methylamino benzimidazole derivatives and tested for anti-inflammatory activity and all the synthesized compounds were characterized by using IR,1H NMR,^{13}C NMR, GC-MS & elemental analysis. **Compound 12** showing good activity and compared with Nimesulide was the standard drug. [16]



FOR COMPOUND 12
R=H, Br, NO_2
R^1=H, Cl, Br, CH_3, OCH_3

ANTI-DENGUE VIRUS ACTIVITY

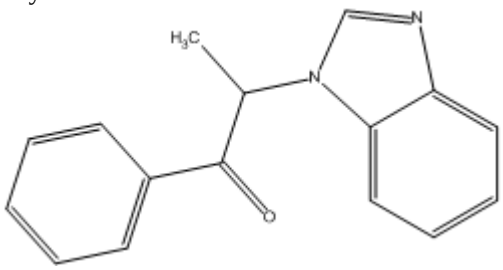
13.**Yuki Okanoa et al** have Synthesized and biological evaluation of novel imidazole nucleosides and screened for anti-dengue virus against DENV and all the synthesized compound were characterized by 1H, and ^{13}C NMR spectroscopy. Ribavirin was a positive control**. Compound13** showing good activity. ([17]



COMPOUND 13

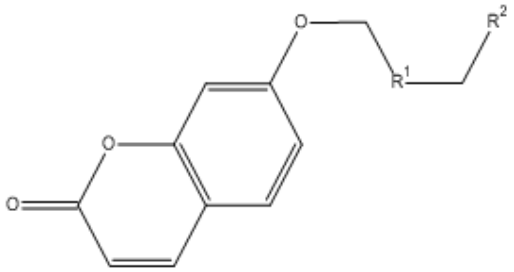
ANTHELMINTIC ACTIVITY

14.**Nadia Asghar et al have** created benzimidazole molecule (BM &CMB) propiophenone & benzoyl chloride and tested for anthelmintic activity against Meloidegyne incognita. All the compounds were characterized by using UV/Visible, IR, E-mass & 1H NMR spectroscopy. **Compound 14** showing potent activity. [18]



COMOOUND 14

15.**Guang-Lu-Liuet al** have synthesized coumarin-imidazole hybrid derivatives and screened for anthelmintic activity against Dactylogyrus intermedius at the dose range from 1 to 10mg. All the synthesized compounds were characterized by ESI-MS, 1H and 13C NMR spectroscopy. Compound**15** showing good activity. [19]



COMPOUND 15
R^1=-C_4H_8

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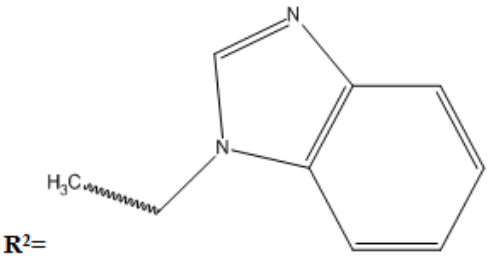
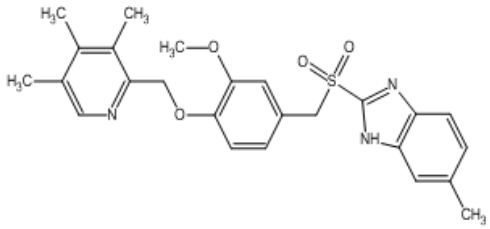


R²=

ANTI-ULCER ACTIVITY

20.**R.Rajesh et al** have created Substituted methoxybenzyl-sulfonyl-1H-benzo[d]imidazoles and tested for anti-ulcer activity and effective H+ /K+ -ATPase inhibitors. All the compounds were characterized by IR,^{1}H NMR,^{13}C NMR,^{19}F NMR & mass spectral analysis. **Compound 16** showing best activity and the molecular docking study found b/w 0.02-1.8µm. [20]



FOR COMPOUND 16

III. CONCLUSION

Imidazole is a versatile heterocyclic compound with significant biological activity, making it an important scaffold in medicinal chemistry. Its unique structural features enable it to interact effectively with various biological targets, including enzymes, receptors, and nucleic acids. Imidazole and its derivatives exhibit a wide range of biological properties, such as antibacterial, antifungal, antihypertensive, anti-inflammatory, anticancer activities. Due to its ability to coordinate with metal ions and participate in hydrogen bonding, imidazole also plays a crucial role in many biochemical processes, including acting as a functional group in the amino acid histidine. The imidazole ring system remains a key component in drug development, offering significant potential for the design of novel therapeutic agents.

REFERENCES:

[1]. Verma A, Joshi S, Singh D. Imidazole: having versatile biological activities. J Chem. **2013(**1):329412.

[2]. Gaba M, Mohan C. Development of drugs based on imidazole and benzimidazole bioactive heterocycles: recent advances and future directions. Med Chem Res, MCR. **2016**; 25:173-210.

[3]. Abbasov VM, Marzouk AA, Mammadov AM, Kazimova SZ, Talybov AH. Imidazole derivatives, synthesis and biological activity. Process Petrochem. oil-refining. **2012**; 13:52.

[4]. Shalini K, Sharma PK, Kumar N. Imidazole and its biological activities: a review. Der Chemica Sinica**. 2010**;1(3):36-47.

[5]. Işık A, Acar Çevik U, Sağlık BN, Özkay Y. Synthesis, characterization, and molecular docking study of some novel imidazole derivatives as potential antifungal agents. J Heterocycl Chem. **2019** ;56(1):142-52.

[6]. Slassi S, Fix-Tailler A, Larcher G, Amine A, El-Ghayoury A. Imidazole and azo-based schiff bases ligands as highly active antifungal and antioxidant components. Heteroat Chem. **2019**;(1):6862170.

[7]. Taheri B, Taghavi M, Zarei M, Chamkouri N, Mojaddami A. Imidazole and carbazole derivatives as potential anticancer agents: molecular docking studies and cytotoxic activity evaluation. Bull Chem Soc Ethiop. **2020**;34(2):377-84.

[8]. Al-Blewi F, Shaikh SA, Naqvi A, Aljohani F, Aouad MR, Ihmaid S, Rezki N. Design and synthesis of novel imidazole derivatives possessing triazole pharmacophore with potent anticancer activity, and in silico ADMET with GSK-3β molecular docking investigations. Int J Mol Sci. **2021**;22(3):1162.

[9]. Wittine K, Babić MS, Makuc D, Plavec J, Pavelić SK, Sedić M, Pavelić K, Leyssen P, Neyts J, Balzarini J, Mintas M. Novel 1, 2, 4-triazole and imidazole derivatives of L-ascorbic and imino-ascorbic acid: synthesis, anti-HCV and antitumor activity evaluations. Bioorg Med Chem. **2012** ;20(11):3675-85.

[10]. Kumar CP, Prathibha BS, Prasad KN, Raghu MS, Prashanth MK, Jayanna BK, Alharthi FA, Chandrasekhar S, Revanasiddappa HD, Kumar KY. Click synthesis of 1, 2, 3-triazole based imidazoles: antitubercular evaluation, molecular docking and HSA binding studies. Bioorg Med Chem Lett. **2021**; 36:127810.

[11]. Gobis K, Foks H, Suchan K, Augustynowicz-Kopeć E, Napiórkowska A, Bojanowski K. Novel 2-(2-phenalkyl)-1H-

benzo [d] imidazoles as antitubercular agents. synthesis, biological evaluation and structure–activity relationship. Bioorg Med Chem. **2015**;23(9):2112-20.

[12]. Yan Guo F, Ji Zheng C, Wang M, Ai J, Ying Han L, Yang L, Fang Lu Y, Xuan Yang Y, Guan Piao M, Piao HR, Jin CM. Synthesis and antimicrobial activity evaluation of imidazole-fused imidazo [2, 1-b] [1, 3, 4] thiadiazole analogues. ChemMedChem. **2021**;16(15):2354-65.

[13]. Desai NC, Maheta AS, Rajpara KM, Joshi VV, Vaghani HV, Satodiya HM. Green synthesis of novel quinoline based imidazole derivatives and evaluation of their antimicrobial activity. J Saudi Chem Soc. **2014** ;18(6):963-71.

[14]. Navarrete-Vázquez G, Hidalgo-Figueroa S, Torres-Piedra M, Vergara-Galicia J, Rivera-Leyva JC, Estrada-Soto S, León-Rivera I, Aguilar-Guardarrama B, Rios-Gómez Y, Villalobos-Molina R, Ibarra-Barajas M. Synthesis, vasorelaxant activity and antihypertensive effect of benzo [d] imidazole derivatives. Bioorg Med Chem. **2010** ;18(11):3985-91.

[15]. Malhotra V, Pathak SR, Nath R, Mukherjee D, Shanker K. substituted imidazole derivatives as novel cardiovascular agents. Bioorg Med Chem Lett. **2011**;21(3):936-9.

[16]. Achar KC, Hosamani KM, Seetharamareddy HR. In-vivo analgesic and anti-inflammatory activities of newly synthesized benzimidazole derivatives. Eur J Med Chem.**2010** ;45(5):2048-54.

[17]. Okano Y, Saito-Tarashima N, Kurosawa M, Iwabu A, Ota M, Watanabe T, Kato F, Hishiki T, Fujimuro M, Minakawa N. Synthesis and biological evaluation of novel imidazole nucleosides as potential anti-dengue virus agents. Bioorg Med Chem. **2019;**27(11):2181-6.

[18]. Asghar N, Akhtar S, Naeem S, Ahmed A, Faizy S, Arif M, Saify ZS. Synthesis, characterization and SAR of novel bezimidazole derivatives as nematicidal agents. Pak J Pharm Sci. **2018**;31(3):827-33.

[19]. Liu GL, Hu Y, Chen XH, Wang GX, Ling F. Synthesis and anthelmintic activity of coumarin–imidazole hybrid derivatives against dactylogyrus intermedius in goldfish. Bioorg Med Chem Lett. **2016**;26(20):5039-43.

[20]. Rajesh R, Manikandan A, Sivakumar A, Ramasubbu C, Nagaraju N. Substituted methoxybenzyl-sulfonyl-1H-benzo [d] imidazoles evaluated as effective H+/K+-ATPase inhibitors and anti-ulcer therapeutics. Eur J Med Chem. **2017**; 139:454-60.