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AN OVERVIEW: MEDICINALLY IMPORTANT HETEROCYCLIC MOIETY BENZOTRIAZOLE

Hasit V. Vaghani *, Sarika P. Patel and Shweta A. Patel

Mehsana Urban Institute of Sciences, Ganpat Unversity, Kherva, Mehsana - 384012, Gujarat, India.

Keywords:

Benzotriazole, Antifungal, Antibacterial, Anticancer, Anticorrosive, Anti-inflammatory *etc*.

Correspondence to Author:
Dr. Hasit V. Vaghani

Assistant Professor,
Department of Chemistry,
Mehsana Urban Institute of Sciences,
Ganpat Unversity, Kherva, Mehsana - 384012, Gujarat, India.

E-mail: hvv01@ganpatuniversity.ac.in

ABSTRACT: In organic chemistry, the largest families of organic compounds belong in the heterocyclic compounds. In our daily life, the importance of heterocyclic compounds is very essential. It has a broad range of applications in medicinal chemistry. Benzotriazole is a bicyclic heterocyclic system consisting of three nitrogen atoms and a fused benzene ring, shows wide range of biological and pharmacological activities. Benzotriazole has been a matter of discussion among the scientific community due to its potential characteristics and touched areas such as medicinal, pharmacological, industrial, *etc*. Benzotriazole derivatives have shown several pharmacological activities, which are antimicrobial activity, anti-inflammatory, analgesic activity, anticancer, antifungal, antibacterial, anticancer, anthelmintic, antidepressant, antioxidative, antitubercular, antiviral, anticorrosive, plant growth inhibitor, anti-inflammatory, *etc*.

INTRODUCTION: Benzotriazole is coming from benzo-fused azoles are a class of heterocyclic compounds of great interest in the pharmaceutical and medicinal chemistry area. Benzotriazole has great characteristics in the context of electron-donating nature, group release, anion director in surrounding, *etc*. Benzotriazole is easy to introduce into molecules by a variety of addition, condensation, and substitution reactions. Benzotriazole comprises two fused rings; its five-membered rings can show tautomerism.

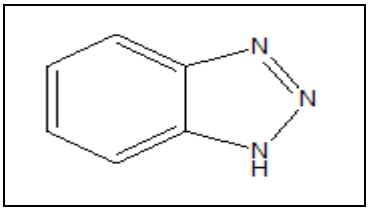

FIG. 1: ITS COMMON STRUCTURE IS STATED IN FIG. 1

QUICK RESPONSE CODE

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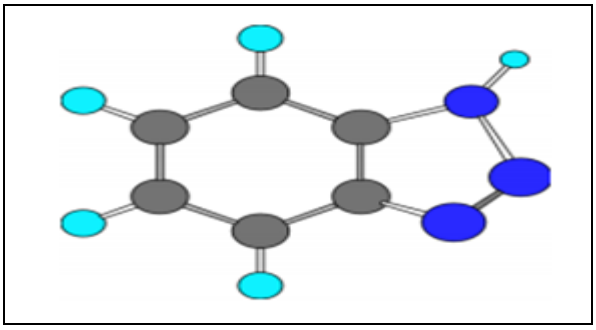
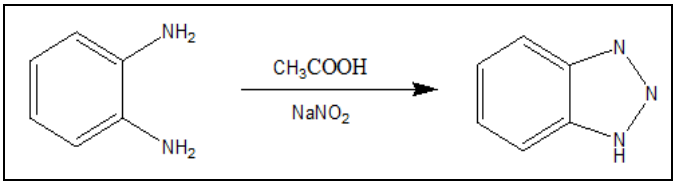


FIG. 2: 3D MODEL OF THE BENZOTRIAZOLE MOLECULE

A synthesis of the Benzotriazole involves the following reaction: The reaction among the o-phenylenediamine, $NaNO_2$ and CH_3COOH will prepare the Benzotriazole [1]. The conversion is done by diazotization of one of the amine groups [2]. The synthesis is able to exist better by doing it in low temperatures [3] (5 to 10°C).



Product Specifications:

Molecular formula	:	$C_6H_5N_3$
Molecular weight	:	119.1240
Melting point	:	98.5-100°C
Appearance	:	White to Yellow Flakes
Nature	:	White to brown crystalline powder
Density	:	1.36 g/cm^3
Solubility in water	:	g/100 ml is 2 (moderate)
pH	:	5.5 to 6.5
CAS Registry Number	:	95-14-7
UV absorbance	:	286 nm

Structure and Pharmacological Activities of Benzotriazole: The 1H-benzo[d] [1,2,3] triazole (Benzotriazole) **Fig. 1** can be considered as a privileged structure for its several pharmacological activities. Useful as a scaffold for the design of new pharmacologically active compounds, Benzotriazole is undergoing rapid development in the synthesis of heterocyclic. From a purely chemical point of view, the benzotriazole structure proved extremely versatile applicabilities. For instance, it is currently used as a synthetic auxiliary [4-9].

In particular, it is interesting the use of the acylbenzotriazole methodology, developed by Katrizsky and co-workers [10]. The N-acyl-benzotriazole is an easy-to-handle acylating agent for advantageous N-, O-, C- and S-acylations. Benzotriazole also acts as an electron-donor or a precursor of radicals or carbanions. It is easily insertable into other chemical structures through a series of reactions, such as condensation, addition reactions, and benzotriazolyl-alkylation [11-13]. However, the main interest on Benzotriazole is focused in the pharmaceutical field, as suitably substituted benzotriazole derivatives can boast the most different biological properties, including plant growth regulator [14-17].

Benzotriazole and derivatives show diverse pharmacological activities on the basis of a variety of literature surveys.

Anticonvulsant activity, Anticancer, Antimicrobial activity, Antitubercular, Anti-inflammatory, Analgesic activity, Antifungal, Antibacterial, Anthelmintic, Antidepressant, Antioxidative, Antiviral, Anticorrosive, Plant growth inhibitor, Anti-inflammatory *etc*.

Application of the Benzotriazole Moiety in Drug Synthesis:

Anti-convulsant Activity: S D Srivastava and Co-workers [18]. Synthesized a new series of 2-aryli-denylamino- 5- (N1 - benzotriazolomethyl)-1, 3, 4-thiadiazoles (4) and 1- [5'- (N1 benzotriazolo-methyl)- 1, 3, 4- thiadiazol-2'-yl]-4-(substituted phenyl)- 3- chloro-2-oxo-azetidines (5) derivatives **Fig. 3**. All the compounds were investigated for their anticonvulsant activities. Pentylene tetrazole were selected as standard.

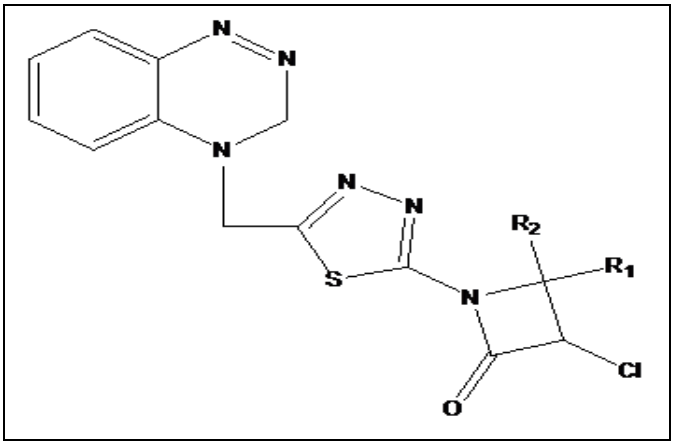


FIG. 3: SHOW ANTICONVULSANT ACTIVITY

Below compound that shows good activity from all the compounds

R1	R2
H	2-OH-C_6H_4
H	2-Cl-C_6H_4
H	-CH=CH-C_6H_5
C_6H_5	C_6H_5
CH_3	C_6H_5

Anticancer Activity: Cancer is actually the second leading cause of death worldwide after cardiovascular diseases, accounting for about 8 million deaths. Viswanathan CL and Co-workers [19]. New series were synthesized of the Benzotriazole derivatives **Fig. 4**. The entire compound was investigated for anticancer activity. Derivative designed and synthesized further to improve the chemosensitizing activity of the drug. The synthesized drug shows the 29.9% inhibition of the growth of the cells in murine lymphocytic leukemia cell, which was best than the standard drug Verapamil which inhibit 9.3% cell growth at 80 µg/mL concentration.

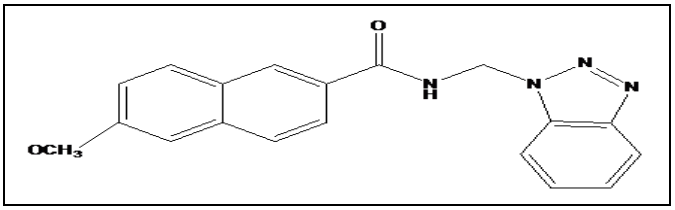


FIG. 4: SHOW ANTICANCER ACTIVITY

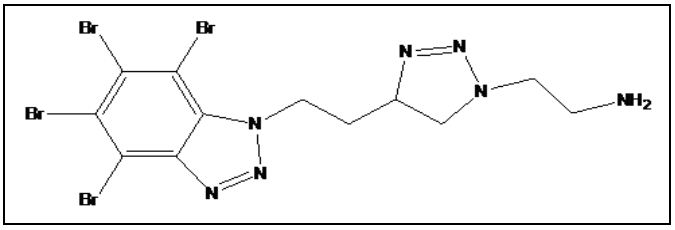


FIG. 5: SHOW ANTICANCER ACTIVITY

The above compound also show anticancer activity which is the benzotriazole derivative.

Anthelmintic Agent: Anthelmintis are a group of antiparasitic drugs that expel parasitic worms and other internal parasites from the body by either stunning or killing them and without causing significance damage to the host they may also be called vermicides. They affect the poorest and most deprived communities and are recognized as cause of chronic ill-health amongst the people living in tropical and subtropical areas [20]. Benzotriazole derivatives effectively working as aanthelmintic agent. Benzotriazoles with 1- and 2-carbamoyl substituents give anthelmintic activity [21] **Fig. 6**.

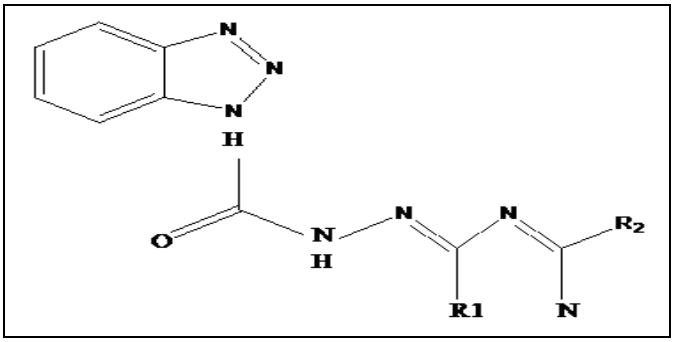


FIG. 6: SHOW ANTHELMINTIC ACIVITY

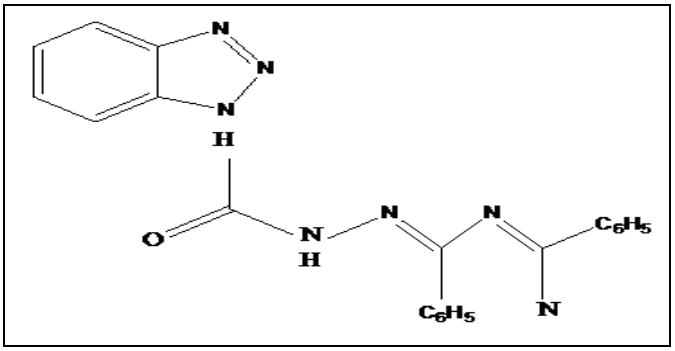


FIG. 7: SHOW ANTHELMINTIC ACIVITY

R1	R2
C_6H_6Cl	C_6H_6
C_6H_6Cl	$C_6H_6NO_2$
C_6H_6Cl	C_6H_6Br

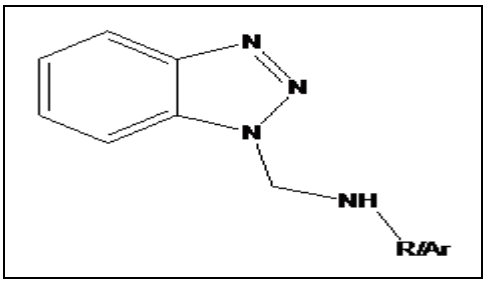


FIG. 8: SHOW ANTHELMINTIC ACIVITY

In this connection, a series of benzotriazole-1-carbonyl-3, 5- arylformazans was synthesized by Sudhir *et al.,* colleagues under ultrasonic and solvent free conditions. All compounds were tested for activity against adult earthworm Pheretima posthuma using mebendazole and albendazole as reference drugs.

Antimicrobial Activity: Infectious diseases raise awareness of our global unsafe, the need for strong health care systems, and the potentially broad and borderless impact of the disease. Over 9.5 million people die each year due to infectious diseases – nearly all live in developing countries.

Children are particularly at risk of infectious diseases. Pneumonia, diarrhea, and malaria are leading causes of death among children under age 5; cerebral malaria can cause permanent mental impairment.

Infectious diseases are also destructive to the health of adults, causing disability, a diminished quality of life co-infection. People infected with one infectious disease become more susceptible to other diseases. Examples include HIV/AIDS co-infection with tuberculosis or malaria co-infection with multiple neglected diseases. Some old infections are resurfacing, which is a really challenging task. Treatment of these infections with rapid resistance in organisms has added fuel to the worsened situation. Some viral infections like Dengue, Hepatitis, Japanese Viral, and West Nile Viral Infections cause large-scale deaths every year as epidemics. Pharmaceutical researchers have to keep in pace with these changes to control the infections by exploring newer anti-infective agents as much as possible. The ability of mankind to synthetically

prepare medicinally important molecules during the past century has allowed for a continued decrease in the mortality rate from numerous diseases. The gravity of the situation made WHO resolve to focus on antimicrobial resistance and its global spread, particularly HIV/AIDS, tuberculosis, and malaria epidemics. These therapeutics agents bear wide range of structural differences and many of these compounds are having heterocyclic rings as their part structure. The literature survey reveals that heterocyclic compounds bearing benzotriazoles as part of the structure showed valuable biological activity particularly antibacterial and antifungal activity. Benztriazole derivatives have proven to be effective antimicrobials.

Chloro-, bromo- and methyl- analogues of 1H-benzimidazole and 1H-benzotriazole and their N-alkyl derivatives have been synthesized and tested *in-vitro* against the protozoa *Acanthamoeba castellanii*. The results indicate that 5, 6- dimethyl-1Hbenzotriazole and 5, 6-dibromo-1H- benzo-triazole have higher efficacy than the antiprotozoal agent chlorohexidine.

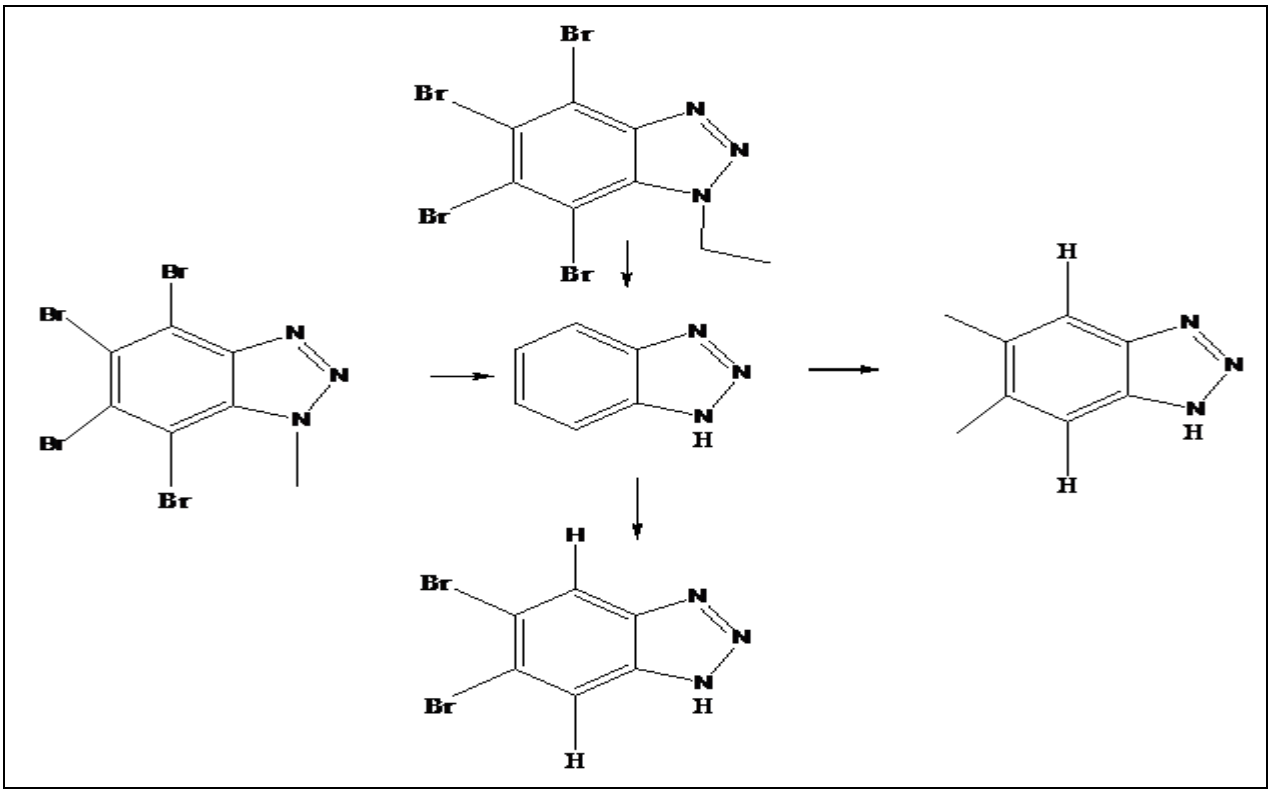


FIG. 9: DERIVATIVES OF ANTIMICROBIAL ACTIVITY

Analgesis Activity: Benzotriazole has immense properties work as an analgesic agent. An analgesic or painkiller is any member of the group of drugs used to achieve analgesia, relief from pain. Analgesic drugs act in various ways on the peripheral and central nervous systems. They are distinct from anaesthetics, which temporarily affect, and in some instances completely eliminate, sensation.

Asati KC *et al.*, in 2006 Synthesised of 5-arylidene-2-aryl-3- (benzotriazoloacetamidyl)-1, 3-thiazolidin-4-ones as an analgesic and antimicrobial agents.

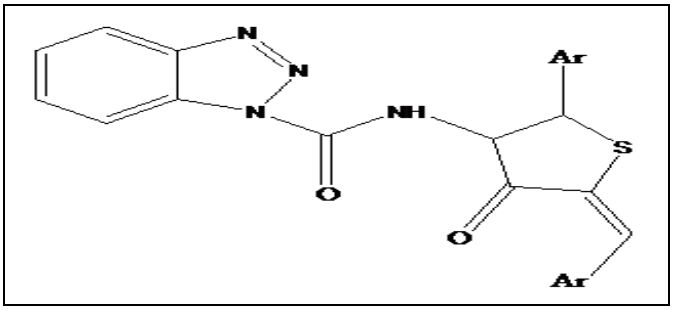


FIG. 10: SHOW ANALGESIC ACIVITY

Ar	-NO_2 C_6H_4 -Br C_6H_4 -CH_3 C_6H_4 - Cl C_6H_4

Antioxidative Activity: Benzotriazole compounds have shown remarkable antioxidative activities and large potentiality to be novel antioxidative agents or candidates. Primaquine (PQ) derivatives are well-known and wide-used antimalarial drugs, meanwhile, they are interesting molecules to develop potential antioxidative agents due to their prooxidant effects in blood.

CM Jamkhandi and John Intru Disouza in (2013) Evaluate of antioxidant activity for some benzotriazole substituted with n-phenylacetamide and acetylcarbamic acid derivatives.

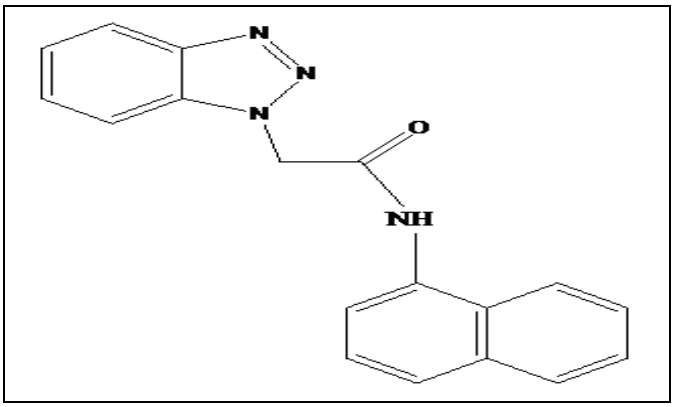


FIG. 11: SHOW ANTIOXIDATIVE ACTIVITY

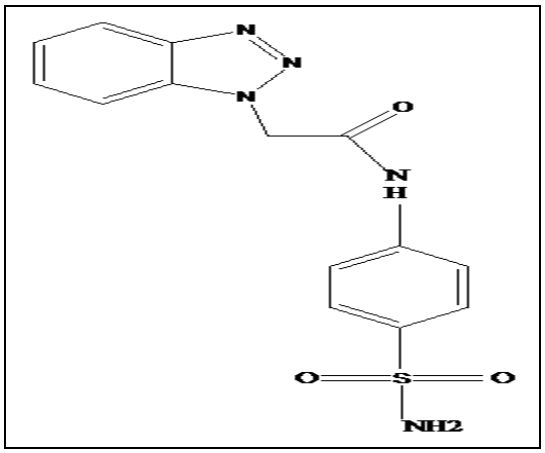


FIG. 12: SHOW ANTIOXIDATIVE ACTIVITY

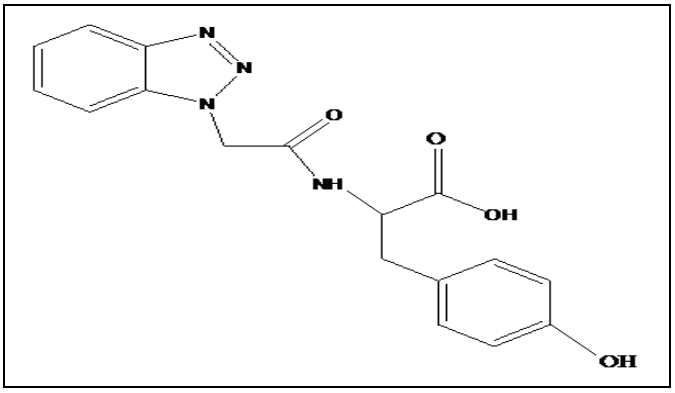


FIG. 13: SHOW ANTIOXIDATIVE ACTIVITY

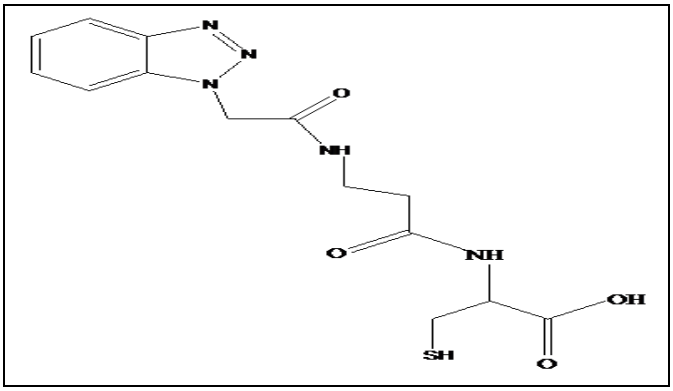


FIG. 14: BENZOTRIAZOLES SUBSTITUTED WITH N-PHENYLACETAMIDE SHOWED HIGHER ANTIOXIDANT ACTIVITY THAN ANALOGUES SUBSTITUTED WITH ACETYLCARBAMIC ACID [22]

Antituberculosis Activity: Tuberculosis (TB) is a highly infectious disease primarily caused by Mycobacterium tuberculosis. Multidrug-Resistant Tuberculosis (MDRTB) refers to M. tuberculosis strains with resistance to the two most effective antituberculosis drugs, isoniazid (INH) and rifampin (RFP). MDRTB has become a major barrier to achieving successful control of TB, as alternate therapy is less effective, associated with more adverse However, with the frequent occurrence of resistant strains and clinical adverse drug reactions of stomach and gut as well as liver damage, the uses of clinical antituberculosis drugs have been limited by the reduced efficacy and inevitable toxic side effects. Therefore, there is necessary to develop new potent anti-tubercular drugs without cross-resistance from known antimycobacterial agents. One of the most effective strategies to overcome this problem is to exploit the potentiality of standard short-course chemotherapy based on cheap and safe first-line drugs. Recently, more and more researches have shown that the nitrogen heterocyclic benzotriazole compounds have considerable potentiality to treat tuberculosis.

The substitution of benzotriazole ring by halogen atoms on the benzene ring has been proved to be a useful way to enhance the bioactivity of benzotriazole derivatives. Chlorine substituted benzotriazole derivative [23]. It is worthy to note that when the chlorine atoms on the benzotriazole ring were replaced by other halogen atoms, the anti-mycobacterial activity markedly decreased. The nitro-substitution in the benzyloxy part of the molecule and the dichloro substituted benzotriazole resulted in its high biological activity.

Adesh Dubey *et al.*, 2010 give different types of halogen, nitro contained compounds for antituberculosis activity. *viz*. Like **Fig. 15, 16, 17**.

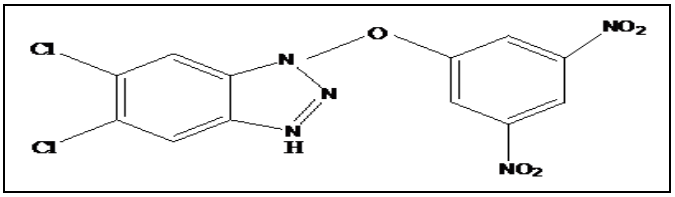


FIG. 15: SHOW ANTITUBERCULOSIS ACIVITY

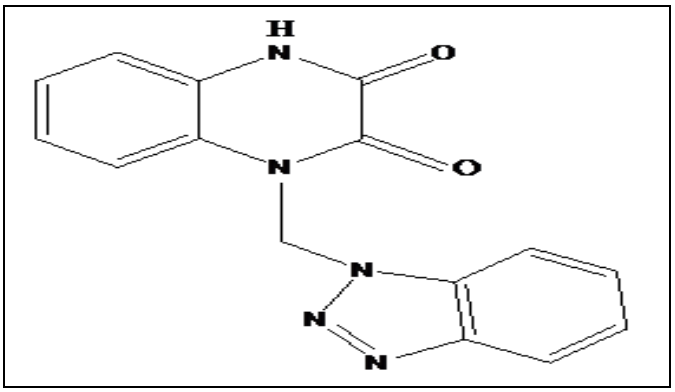


FIG. 16: SHOW ANTITUBERCULOSIS ACIVITY

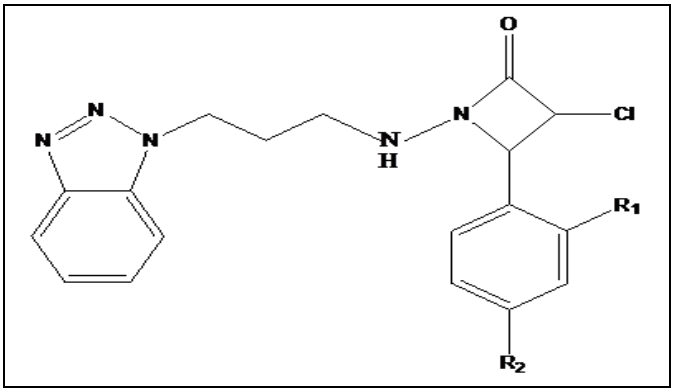


FIG. 17: SHOW ANTITUBERCULOSIS ACIVITY

R_1	R_2
Cl	H
H	NO_2

Antiviral Activity: Viruses can cause major diseases both in humans and animals and determine life lost economic losses and higher production costs. The current antiviral agents can not only inhibit the growth of the virus instead of directly destroying and killing them but also damage the host cell. For these reasons, large numbers of investigations have been focused on the design and development of non-nucleoside compounds as novel antiviral drugs in recent decades. The exploitation of new antiviral benzotriazole compounds has opened a new opportunity in this field.

Kuo-Long Yu, Yi Zhang synthesized benzotriazole derivatives as antiviral agents.

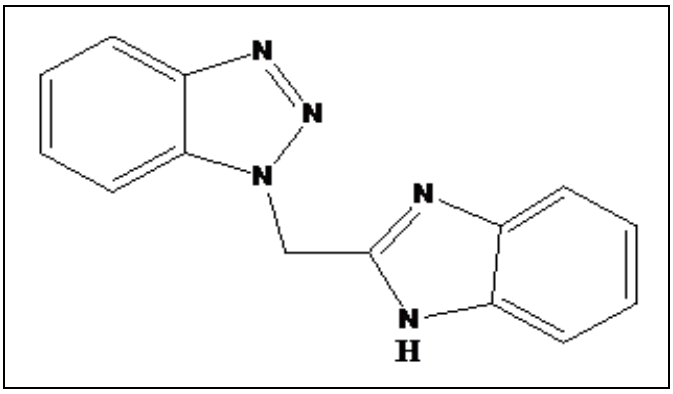


FIG. 18: SHOW ANTIVIRAL ACTIVITY

Avhad *et al.*, synthesized a series of dialkylamino side-chain derivatives of benzotriazole were and reported as potential inhibitors of the respiratory syncytial virus.

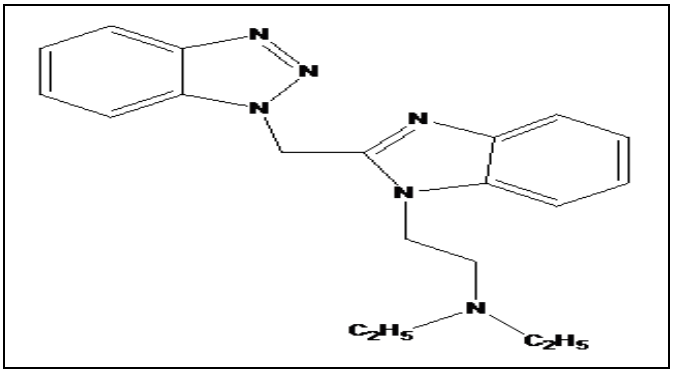


FIG. 19: SHOW ANTIVIRAL ACTIVITY

Orthohantaviruses are classified as emerging viruses that cause two life-threatening diseases: hemorrhagic fever with renal syndrome (HFRS) and orthohanta viruses pulmonary syndrome (HPS), also known as hantavirus cardiopulmonary syndrome (HCPS) [24]. Research group has published several 1(2)H-benzo[d][1,2,3]triazole, usually called benzotriazole, derivatives that have shown marked antiviral activity against many viruses [25-28].

The researcher performed the same broad antiviral screening on a series of 2-phenyl-benzotriazole from the library, or newly synthesized all showed in **Fig. 20**.

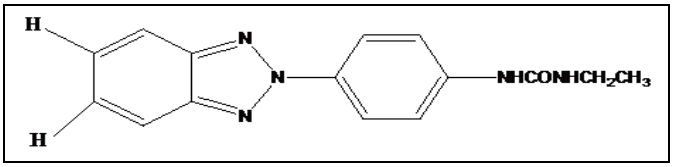


FIG. 20: SHOW ANTIVIRAL ACTIVITY

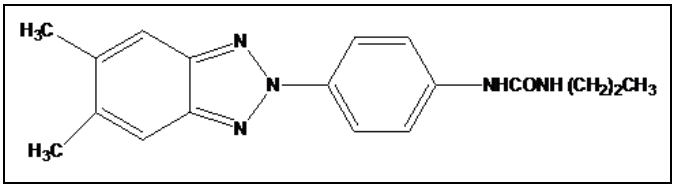


FIG. 21: SHOW ANTIVIRAL ACTIVITY

Antifungal Activity: During the past two decades, the frequency of invasive and systemic fungal infections has increased dramatically due mainly to Candida species. During the past two decades, the frequency of fungal infection increased dramatically due mainly to candida species [29]. Recently, the expansion of antifungal drug research has occurred because there is a critical need for new antifungal agents to treat these life-threatening invasive fungal infections [30]. Among different kinds of antifungal agents, azole compounds have been rapidly developed as the mainstream for fungal infection treatment and are widely used in clinic [31-33].

A variety of antifungal azoles representing as an important class of nitrogen-containing heterocycles with desirable electron-rich properties, have been early discovered and successfully used to develop clinical agents.

1-Carbamoyl-1H-benzotriazole (benzotriazole-1-carboxamide, 2a), an effective carbamoyl chloride substitute, and a range of its analogs can be synthesized in good yields in simple steps from 1,2-diaminobenzene.

Christopher John Perry *et al.*, in 2008 gives different substituted of benzotriazole with good antifungal activity [35].

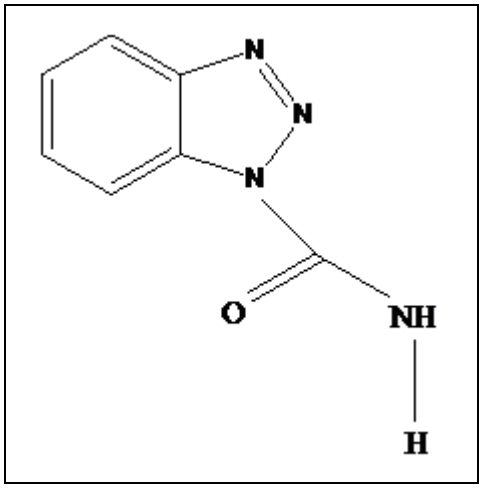


FIG. 22: SHOW ANTIFUNGAL ACIVITY

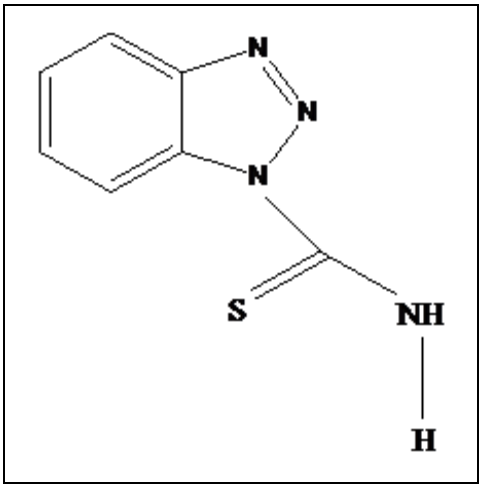


FIG. 23: SHOW ANTIFUNGAL ACIVITY

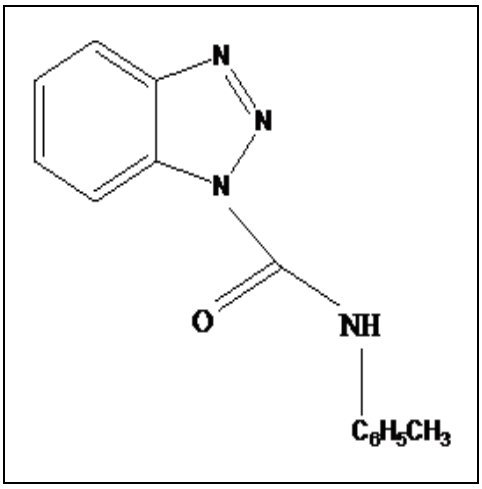


FIG. 24: SHOW ANTIFUNGAL ACIVITY

Ren Y, Zhang L, Zhou CH, Geng RX (2014) gives different metal complexes of benzotriazoles and exhibit a strong and typical property of action as bridging ligands metal ions, such as Ag(I) and Cu(II) ions. The Ag(I)- (triazole)-1-benzotriazole complex gives inhibitory effect against *Physalospora piricola* as well as good antifungal activity [35].

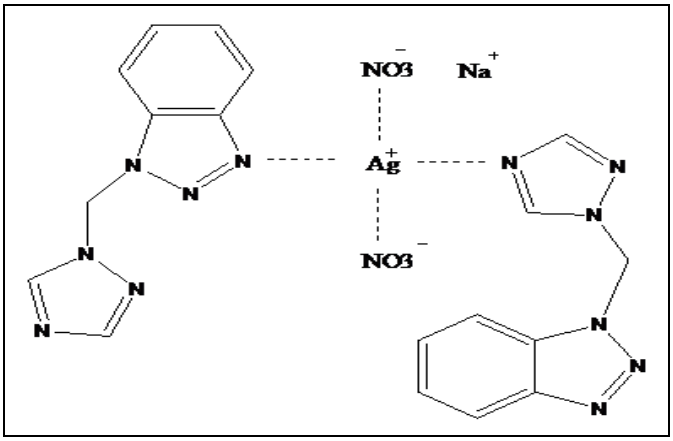


FIG. 25: SHOW ANTIFUNGAL ACIVITY

The Cu(II) complex of benzotriazole derivative showed potentially antifungal activities against *Penicillium expansum*, *Botrydepladia thiobromine etc*.

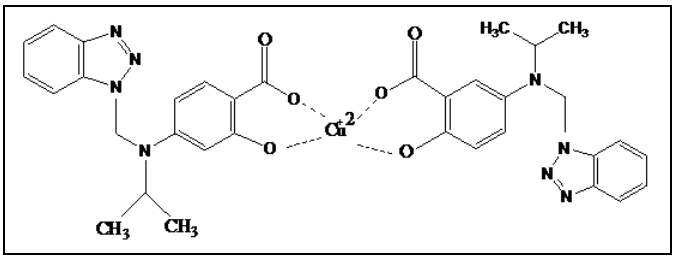


FIG. 26: SHOW ANTIFUNGAL ACIVITY

CONCLUSION: This review gives an overview of the broad spectrum of pharmacological activities displayed by Benzotriazole. Benzotriazoles are regarded as an important class of bioactive hetero-cyclic compounds that exhibit a range of biological activities. Therefore, this nucleus appears very interesting in the drug discovery and development processes. As proved in this paper, benzotriazole is useful to wide develop analysis on different classes of pharmacological agents. Benzotriazole derivatives are focused on screening biological activities such as antibacterial, antiviral, antitubercular, anti-cancer, antimicrobial, antiinflammatory, anticonvul-sant, analgesic, antioxidant, *etc*. It can act as an important tool for medicinal chemists to develop newer compounds possessing benzotriazole moiety that could be better agents in terms of efficacy and safety.

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CONFLICTS OF INTEREST: The authors declare no competing financial interest.

REFERENCES:

1. Furmiss BS, Hannaford AJ, Smith PWG and Tatchell AR: Vogel's textbook of practical organic chemistry. Pearson 2008; 5: 1163.
2. RA, PhenyleneSmiley and Toluenediamines: Ullmann's Encyclopedia of Industrial Chemistry 2002.
3. Guzen ATG, Claudio MP, Pereira HA and Stefaniand KP: Letters in Organic Chemistry 2006; 4(31): 43-46.
4. Kale R, Prasad V, Mohapatra P and Tiwari V: Recent developments in benzotriazole methodology for construction of pharmacologically important heterocyclic skeletons, Monatsh. für Chem. - Chem. Mon 2010; 141: 1159-82.
5. Briguglio I: Benzotriazole: An overview on its versatile biological behavior, European Journal of Medicinal Chemistry (2014), http://dx.doi.org/10.1016/j.ejmech. 2014.09.089
6. Katritzky AR., Lan X, Yang JZ and Denisko OV: Properties and synthetic utility of N-substituted benzotriazoles. Chem Rev 1998; 98: 409-548.
7. Katritzky AR., Khelashvili L, Mohapatra PP and Steel PJ: Efficient N-aroylation of substituted indoles with N-aroylbenzotriazoles, Synthesis 2007; 23: 3673-77.
8. Katritzky AR, Angrish P and Todadze E: Chiral acylation with N-(protected aaminoacyl)benzotriazoles for advantageous synthesis of peptides and peptide conjugates. Synlett 2009: 2392-2411.
9. Katritzky AR and Rogovoy BV: Benzotriazole: an ideal synthetic auxiliary, Chemistry 2003; 9: 4586-93.
10. Katritzky AR, Tala SR, Abo-Dya NE, Gyanda K, Gendy DE, Samii a nd Steel PJ: Selective synthesis and structural elucidation of S-acyl- and N-acylcysteines. J Org Chem 2009; 74: 7165-67.
11. Katritzky AR, Rogovoy BV, Chassaing C and Vvedensky V: Di(benzotriazol-1- yl)methanimine: a new reagent for the synthesis of tri- and tetrasubstituted guanidines. J Org. Chem 2000; 65: 8080-82.
12. Katritzky AR, Rogovoy V, Vedensky VY, Kovalenko K,. Steel PJ, Markov VI and Foroode B: Synthesis of N,N-disubstituted 3-amino-1,2,4- triazoles, Synthesis 2001; 6: 897-903.
13. Katritzky AR, Xie L and Toader L: Serdyuk, General and efficient carbon insertion route to one-carbon-homologated alpha-aryl, alpha-Alkenyl, alpha-alkoxy, and alpha-phenylthio alkyl ketones. J Am Chem Soc 1995; 117: 12015-161
14. Davis D: Benzotriazole: a plant-growth regulator. Science 1954; 120: 989.
15. Picci V: Effect of benzotriazole and of 2 benzotriazolylacetic acids on plant growth. Farm Sci 1966; 21: 172-77.
16. Sparatore F, Rotonda MIL, Paglietti G, Ramundo E, Silipo C and Vittoria A Benzotriazole derivatives active on plant growth. I. Preparation, characterization, and correlation between physicochemical properties and structure. Farm. Sci 1978; 33: 901-23.
17. Sparatore F, Rotonda MIL, Ramundo E and Silipo C: A. Vittoria, Effect of benzotriazole derivatives on plant growth. II, Farm. Sci 1978; 33: 924-44.
18. Rawat TR and Srivastava SD: Indian Journal of Chemistry, May 1999; 38: 623-27.
19. Lokhande TN, Viswanathan CL and Juvekar AS: Chem Pharm Bull 2008; 56: 894-96.
20. Augustynowicz-Kope ÄE, Zwolska Z, Orzeszko A and Kazimierczuk Z: Synthesis and antimycobacterial activity of selected nitrobenzyloxylated benzotriazoles. Acta Pol Pharm 2008; 65: 435-39.
21. Jamkhandi CM and Disouza JI: Evaluation of antioxidant activity for some benzotriazole substituted with n-phenylacetamide and acetylcarbamic acid derivatives. Int J Pharm Pharm Sci 2013; 5(2): 249-53.
22. Kuo-Long Y, Yi Z, Civiello RL and Kathleen F: Kadow, Christopher Cianci, Mark Krystal and Nicholos A. Meanwell. Bioorg Med Chem Letters 2003; 13: 2141-44.
23. Yu KL, Zhang Y, Civiello RL, Kadow KF, Cianci C and Krystal M: Fundamental structure–activity relationships associated with a new structural class of respiratory syncytial virus inhibitor. Bioorganic & Medicinal Chemistry Letters 2003; 13: 2141-44.

24. Schmaljohn C and Hooper JW: Bunyaviridae: The viruses and their replication. In Fields Virology, 4th ed.; Knipe, D.M., Howley, P.M., Griffin, D.E., Lamb, R.A., Martin, M.A., Roizman, B., Straus, S.E., Eds.; Lippincott Williams & Wilkins: Philadelphia, PA, USA, 2001; 1581-1602.
25. Corona PS, PIbba R, Riu F, Sanna G, Madeddu S, Delogu I, Loddo and Carta R: A novel benzotriazole derivatives as selective inhibitors of Coxsackies B5 virus: 1-[4-(5,6-dimethyl(H)-1H(2H)-benzotriazol-1(2)-yl)phenyl]-3-alkyl(aryl)urea. Med Chem 2020: 16: 1.
26. Carta, Loriga A, Piras G, Paglietti S, Ferrone G, Fermeglia M, Pricl M, Colla SL, Secci B and Collu G: Synthesis and *in-vitro* evaluation of the anti-viral activity of N-[4-(1H(2H) benzotriazol-1(2)-yl)phenyl]alkylcarboxamides. Med Chem 2006; 2: 577-89.
27. Carta, Loriga A, Piras M, Paglietti S, Ferrone G, Fermeglia M, Pricl M, Colla SL, Collu G and Sanna T: Synthesis and anti-picornaviridae *in-vitro* activity of a new class of helicase inhibitors the N,N'-bis[4 -(1H(2H)-benzotriazol-1(2)-yl)phenyl] alkyldicarboxamides. Med Chem 2007; 3: 520-32.
28. Pricl CA, Piras S, Fermeglia S, Colla ML and Loddo R: Activity and molecular modeling of a new small molecule active against NNRTI-resistant HIV-1 mutants. Eur. J. Med Chem 2009; 44: 5117-22.
29. Carta, Briguglio A, Piras I, Corona S, Boatto P, Nieddu G, Giunchedi M, Marongiu P, Giliberti ME and Iuliano F: Quinolinetricyclic derivatives. Design, synthesis and evaluation of the antiviral activity of three new classes of RNA-dependent RNA polymerase inhibitors. Bioorg. Med. Chem 2011; 19: 7070-84.
30. Giraud F, Guillon R, Logé C, Pagniez F, Picot C and Borgne ML: Synthesis and structure-activity relationships of 2-phenyl-1-[(pyridinyl- and piperidinylmethyl) amino] -3-(1H-1,2,4-triazol-1-yl) propan-2-ols as antifungal agents. Bioorgan Med Chem Lett 2009; 19: 301-04.
31. Andriole VT: Current and future antifungal therapy: New targets for antifungal therapy. Int J Antimicrob Ag 2000; 16: 317-21.
32. Cui SF, Ren Y, Zhang SL, Peng XM and Damu GL: Synthesis and biological evaluation of a class of quinolone triazoles as potential antimicrobial agents and their interactions with calf thymus DNA. Bioorg Med Chem Lett 2013; 23: 3267-72.
33. Zhou CH and Mi JL: Preparation of Fluotrimazole ether derivatives as antimicrobial agents. CN Patent CN101391986 (A) 2009.
34. Zhou CH, Fang B and Gan LL: chloride tertiary amine double azole antimicrobial compounds, preparation and medical use thereof. CN Patent CN101323594 (B) 2008.
35. Perry CJ and Holding K and Tyrrell E: "Simple, Novel Synthesis for 1CarbamoyllH-benzotriazole and Some of Its Analogs" Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry 2009.
36. An CX, Han XL, Wang PB, Zhang ZH and Zhang HK: Synthesis, crystal structures, and biological activities of silver(I) and cobalt(II) complexes with an azole derivative ligand. Transition Met Chem 2008: 33: 835-41.
37. Patel PK and Patel PD: Synthesis, characterization, metal complexation studies and biological screening of some newly synthesized metal complexes of 1-(4-carboxy-3-hydroxy-N-isopropyl phenyl amino methyl) benzotriazole with some transition metals. Int J Chem Tech Res 2010: 2: 1147-52.
38. Case DA, Cerutti DS, Cheatham TE, Darden TA, Duke RE and Giese TJ: AMBER 2017. San Francisco, CA: University of California 2017
39. Betancourt W and Shulman L: Polioviruses and Other Enteroviruses. Global Water Pathogen Project; Meschke, J.S; Girones, R., Ed.; Michigan State University 2018.
40. Piras S, Sanna G, Carta A, Corona P, Ibba R, Loddo R, Madeddu S, Caria P, Aulic S, Laurini E, Fermeglia M and Pricl S: Dichloro-phenyl-benzotriazoles: A new selective class of human respiratory syncytial virus entry inhibitors. Front Chem 2019; 7: 247.
41. Jamkhandi CM, Kumbhar PS, Disouza JI and Patil SM: QSAR study and evaluation of *in-vitro* anti-inflammatory activity for 1h-benzotriazol-1-yl{2-hydroxy-5-[(e) phenyldiazenyl]phenyl} methanone. European Journal of Pharmaceutical and Medical Research 2015; 2: 1004-10.
42. Gitanjali KP, Harshada CP, Indira MP, SL Borse and Pawar SP: Benzotriazole – The Molecule of Diverse Biological Activities" WJPPS 2015; 4(5).
43. Singh VK, Rishishwar P, Bhardwaj P and Alok S: Benzotriazole: a heterocyclic molecule with diversified pharmacological activities. IJPSR 2017: 8(2): 446-56.

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