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Review Article

A Review on Heterocyclic: Synthesis and Their Application in Medicinal Chemistry of Imidazole Moiety

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Abstract: In an organic chemistry, largest families of organic compounds are belongs in the heterocyclic compounds. In our daily life important of heterocyclic compounds are of very essential. It has broad range of application in medicinal chemistry and in agrochemicals products. Applications are also found in as developers, as corrosion inhibitors, sanitizers, as copolymers, antioxidants, dye stuff. There is always an important thing about an efficient methodology for synthesizing of new heterocycles moiety. Now in literature survey reveals that more than 85-95% new drugs containing heterocycles which has bright scientific insight in the biological system. In this review work, I mainly focus such type of heterocycle and their families which has main utility in medicinal chemistry. In the recent past developments of imidazole-based compounds in the wide range of medicinal chemistry such as antihypertensive, antineuropathic, antitubercular, antiviral, anti-inflammatory, antibacterial, antiobesity, antiparasitic, antifungal, antihistaminic, anticancer, and other potential medicinal agents with their broad applications in pathology and diagnostics. Derivatives of imidazole have placed a unique position in the medicinal chemistry field. The involvement of the imidazole scaffold is a key of synthetic strategy in the drug discovery system. The imidazole moiety is a part of several important naturally occurring products, including histamine, purine, nucleic acid and histidine. It is expected that this brief review could be attractive for new thoughts from academia and pharmaceutical industries to designs of more biologically active and non-toxic imidazole-based drugs. The aims of this review work to the reported imidazole derivatives with pharmaceuticals activity during the past years.

Keywords: Heterocyclic, Imidazole, Anti-Cancer, Anti-Bacterial, Anti-Hypertensive, Anti-Inflammatory

1. Introduction

Heterocyclic compounds are of mainly interest in medicinal chemistry. The most complex branches of chemistry are normally heterocyclic chemistry. It is equally contributed in interesting for the industrial and physiological significances and for its diversity of its synthetic procedure as well as its theoretical implication. Synthetic heterocyclic chemistry has not only played an important role in every place of human life and also found their application in diverse field as agriculture, medicine, polymer and various industries. Most of the synthetic heterocyclic compounds act as a drug is used as anticonvulsants, hypnotics, antineoplastics, antiseptics, antihistaminics, antiviral, anti-tumor etc. In every year large number of heterocyclic drugs is being introduced in pharmacopeias. The size and type of ring structures, together with the effective substituent groups of the mother scaffold, showed strongly their physicochemical properties [1-2]. Among the various medical applications, heterocyclic compounds have a significant active role as anti-viral [3], anti-bacterial [4-5], anti-inflammatory [6], anti-fungal [7], and anti-tumor drugs [8-10]. Heterocycle's general applications are as immense as they are various and are not extensively encompassed in the scope of this brief review. The alkaloids form a most important group of naturally occurring heterocyclic compounds having wide-ranging biological

activity. Most of the alkaloids contain basic nitrogen atoms. Here I mainly focused on imidazole heterocycle. Recent developing organic synthetic methodologies on heterocyclic chemistry are more successful pathways for the chemists to prepare useful bulk chemicals and fine. This is not only their strategies are influenced by economical aspects, expressed in enhancement of reaction yield and purity, but the environmental aspect is gaining additional importance as well.

2. History of Heterocyclic Chemistry

The history of the heterocyclic chemistry began in 1800s, in step with the improvement of organic chemistry. Some noteworthy developments-

1818: From uric acid, Brugnatelli isolates alloxan.

1832: Dobereiner produces furfural (a furan) by mixing starch with sulfuric acid.

1834: Runge isolates pyrrole ("fiery oil") by bones dry distillation.

1906: Friedlander discovered indigo dye, allowing synthetic chemistry methodologies to displace a large number of agricultural industry.

1936: Treibs syntheses chlorophyl derivatives from crude oil, explaining the biological source of petroleum.

1951: Chargaff's rules are explained, importance the role of heterocyclic compounds (pyrimidines and purines base) in the genetic code.

3. Brief Review on Imidazole

Medicinal chemistry is the discipline anxious with determing the manipulate of chemical structure in biological field to determine activity and in the practice of medicinal chemistry unfolded from an empirical one connecting organic synthesis of new compound based mainly on the modification of structure and then find out their biological activity [11-12]. Medicinal chemistry concerns with the development, discovery, interpretation and the identification of mechanism path way of biologically active compounds at molecular level [13]. Synthetic biologically active compounds have mainly five-membered nitrogen-containing heterocyclic ring structures [14]. Structural frameworks have been explained as privileged structures and in particular, N-containing polycyclic hetero structures have been reported to be linked with a broad range of biological activity. In the field of heterocyclic five membered ring structures imidazole nucleus shows diverse properties. The elevated therapeutic behaviors of the imidazole moiety connected drugs have encouraged in the medicinal field to chemists to synthesize a bulky number of novel chemotherapeutic agents. The drugs containing imidazole ring have broadened scope in remedying a mixture of dispositions in clinical medicines. In the medicinal field imidazoles properties include 20HETE (20-Hydroxy-5,8,11,14-eicosatetraenoic acid) synthase inhibitors, anticancer, b-lactamase inhibitors, carboxypeptidase inhibitors, antiaging agents, hemeoxygenase inhibitors, anticoagulants, antibacterial, anti-inflammatory, antiviral, antifungal, antidiabetic, antitubercular and antimalarial [15-28]. At high concentrations, some imidazole drugs, could apply direct inhibitory action on membranes, without interference by way of sterols and sterol esters [29-30]. Infectious microbial disease creates worldwide problem, because microbes have protected therapy or prophylaxis longer than any other form of life. In recent decades, troubles of multidrug-resistant microorganisms have attained an alarming level in many countries in the world. Resistance of anti-microbial agents such as macrolides, β-lactam antibiotics, vancomycin and quinolones etc. and unlike species of bacteria causes increased significant global problem [31]. In the literature overview, imidazole and its derivatives have pharmacologically and physiologically active and find applications in the treatment of numerous diseases.

3.1. Structure and Pharmacological Activities of Imdazole

Imidazoles are very important heterocyclic compounds which have important feature of various medicinal agents. Imidazole is a 5-membered planar ring compound, which is soluble in polar solvents water. It exists in two canonical tautomeric forms because the hydrogen atom can be situated on either of the two nitrogen atoms. It is very much polar compound, as evidenced by a calculated 3.61D dipole moment. Imidazole compound is treated as aromatic due to the presence of sextet of π-electrons, consisting of a pair of electrons on the nitrogen atom. Imidazole is amphoteric, i.e. it can acts as a both base and an acid.

Imidazole derivatives shows diverse pharmacological activities on the basis of a variety of literature surveys

1. Anti analgesic activity and inflammatory activity
2. Anti-bacterial activity and Anti fungal
3. Anti depressant activity
4. Anti tubercular activity
5. Anti viral activity
6. Antileishmanial activity
7. Anti cancer activity

3.2. Development of the Synthesis of Imidazoles

Imidazoles are very omnipotent class of drug due its wide-ranging antimalarial, antibacterial, antifungal, anti-inflammatory, antiviral, antitubercular and finally anti cancer activity. The development of synthesis of imidazoles moiety as well as its functionalisation at various position is still going on to raise its activity. Generally, these procedures involve harsh condition, various name reaction, multicomponent reaction, multi-step strategy, and use of lewis base and lewis acid, metal free condition, costly transition metal catalyst or in solvent and solvent-free condition. In this literature survey, we mainly focus on the different route of synthesis part of imidazoles and functionalisation at its various positions.

In 2007, M. Kidwai and co-workers, syntheses one pot multicomponent tri- and tetra-substituted imidazole using molecular iodine as a catalyst with diketo system, substituted

aldehyde and ammonium acetate and substituted amine as a source of nitrogen. They proposed a mechanism where iodine not only acts as a mild lewis acid catalyst to activate the carbonyl system of the parent diketo compound as well as initiate the formation of diamine intermediate to produced iso-imidazole followed by dehydration and finally to sigma topic rearrangement to produced imidazoles [32].

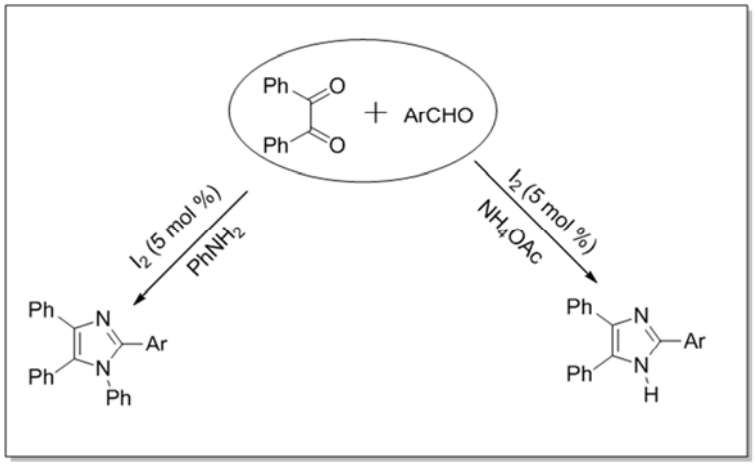

Figure 1. *Synthesis of substituted imidazoles catalyzed by molecular iodine.*

In 2008, S. Sharma and coworkers, typically syntheses substituted imidazole from acid chloride and ethylenediamine at 0°C in non polar solvent, dry dioxane and stirring at room temperature to furnish the N-acyl-1,2-ethylenediamine derivatives followed by the addition of strong lewis acid triflouroboronetherate. They used acid chloride containing long-chain at the alkyl group is not available in the commercial source. This was synthesized from hydroxyl olifinic and olifinic long acids chain in situ preparation [33].

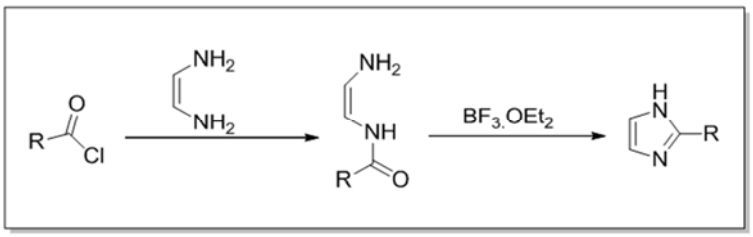

Figure 2. *Preparation of 2-substituted imidazoles using lewis acid.*

In 2009, J. pandey et al. described the synthesis of 1,3-bis-(2-propyl-imidazol-1-yl) propane from the reaction between 2-propyl imidazole and 1,3-dibromopropropane in presence of NaH in polar aprotic solvent at 0-30° C for 4 hrs. Using this synthetic pathway it is possible to synthesis the several substituted imidazoles and their multi coupling products. Among the whole compounds, 1,3-bis-(2-propyl-imidazol-1-yl) propane serve as a better antitubercular activity [34].

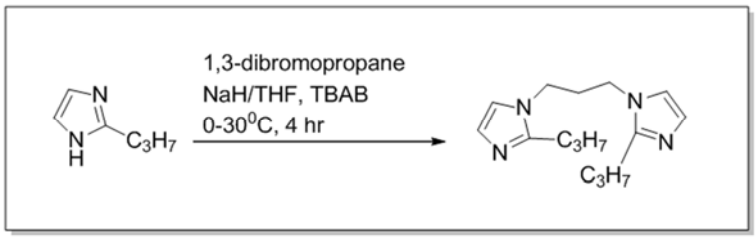

Figure 3. *Preparation of antitubercular active compound from 2-propyl imidazole.*

In 2010, Hasanin ejad et al. reported the multi-component catalyst free polysubstituted imidazole in presence of neutral ionic liquid. This methodology has several advantages as compared to other method due to in this procedure reaction has carried out under microwave one pot multi-component condition as well as catalyst free. Finally using of ionic liquid it is more facile to accept a greener process [35].

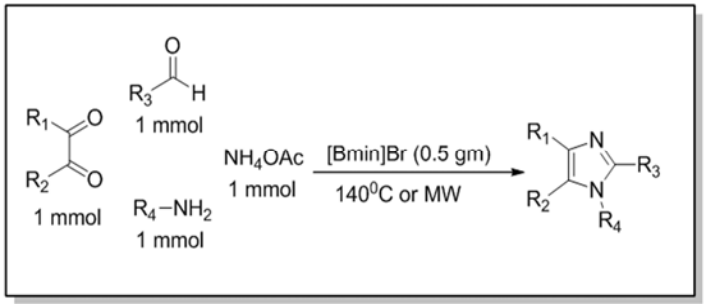

Figure 4. *Preparation of polysubstituted imidazole using ionic liquid.*

In 2010, there is another important work to synthesis of substituted imidaole, C. Mukhopadhyay et al. at first syntheses the mercaptopropylsilica in water medium. It is a very efficient catalyst to synthesis the imidazole derivatives because of its large surface area which increases the binding ability as a catalyst. C. Mukhopadhyay et al. reported the synthesis of polysubstituted imidazole using this catalyst in water/ethanol mixture (1:1) at room temperature. One scheme is reported as follow [36].

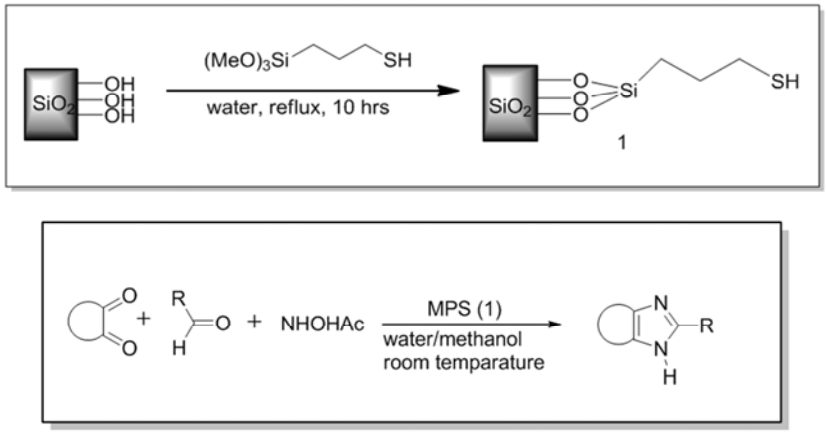

Figure 5. *Synthesis of polysubstituted imidazole using MPS as a catalyst.*

In 2011, H. R. Shaterian, M. Ranjbar reported the synthesis of tri- and tetra-substituted imidazoles from benzyl or benzoin and substituted aldehyde and substituted aniline or ammonium acetate as a source of nitrogen in presence of Bronsted acidic ionic liquid, N-methyl-2-pyrrolidonium hydrogen sulfate under solvent-free thermal condition [37].

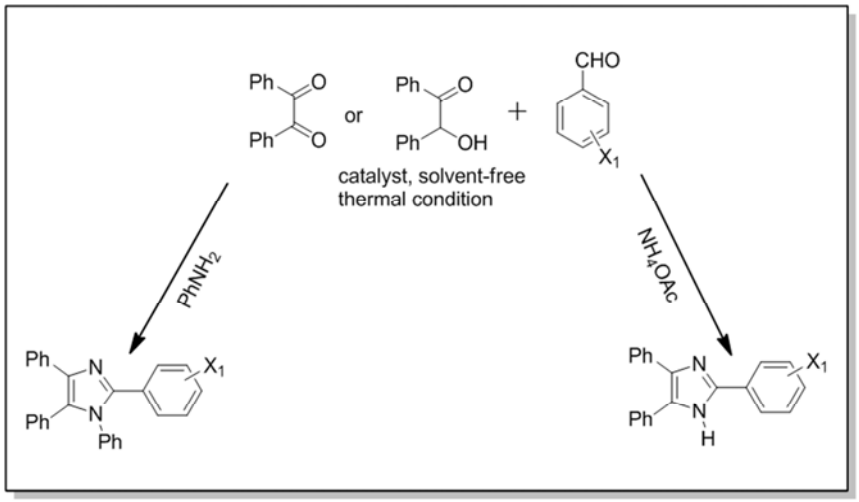

Figure 6. *Preparation of tri- and tetra-substituted imidazoles using Bronsted acidic ionic liquid.*

In 2012, Shun-Jun Ji and co-workers reported a novel method of preparation of highly substituted imidazoles with ketones and benzylamines using $CuI/BF_3.Et_2O$ cocatalyzedaerobic oxidative in the presence of O_2 through aerobic oxidation. In presence of CuI, co-catalyst activity of $BF_3.Et_2O$ is much more increased [38].

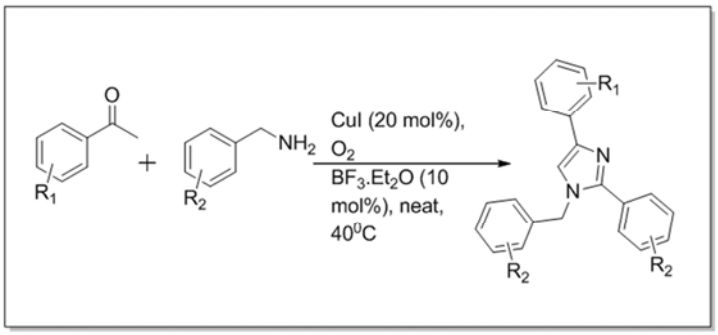

Figure 7. *CuI/BF_3.Et_2O cocatalyzed synthesis of tri-substituted imidazoles.*

In 2013, Bao-Hua Chen et al. reported the multisubstituted imidazole via copper catalyzed cycloadditions reaction. The preparation of multisubstitutedimidazoles from 4-methyl-N-phenylbenzamidine and 1-(2-nitrovinyl)benzene using 2,2-bipyridyl (bipy) as the ligand and CuI as the catalystin DMF at 90 °C under air conditions. In this case Cu^{I} was primarily oxidized to Cu^{II} in presence of oxygen atmosphere. Finally a copper catalyzed cycloaddition reaction to formation of substituted imidazoles was developed [39].

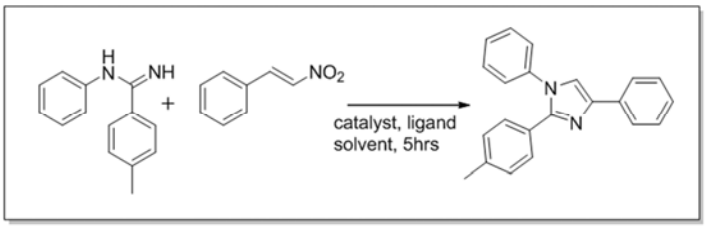

Figure 8. *Copper catalysed synthesis of multisubstitutedimidazoles via cycloadditions.*

In 2013, Jeh-Jeng Wang and co-workers reported a metal free multicomponent acid catalyst synthesis of substituted imidazoles with diphenylacetylene and benzaldehyde using various additives, oxidants, solvent and temperature to produced tri-substituted imidazole and derivatives of aniline used for tetra-substituted imidazoles [40].

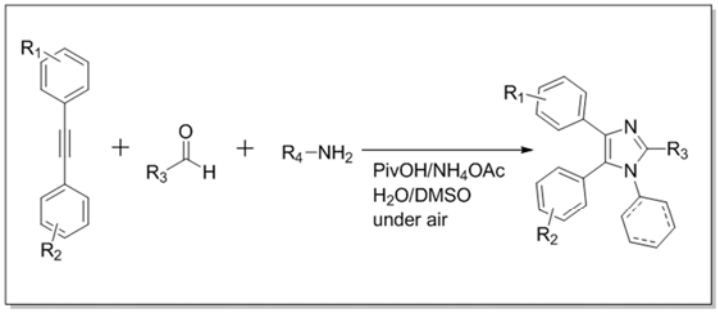

Figure 9. *Synthesis of imidazole derivatives via multi-component acid catalyzed reactions.*

In 2014, Ahmad Reza Moosavi-Zare and co-workers demonstrated one pot synthesis of tetra-substituted imidazole using trityl chloride (TrCl or Ph_3CCl) with benzyl, derivatives of aldehydes, ammonium acetates and finally substituted aniline under solvent-free condition at 90°C. This methodology furnished the more efficient products. Using the all reagents in this method is eco-friendly so it's denoted as a greener process [41].

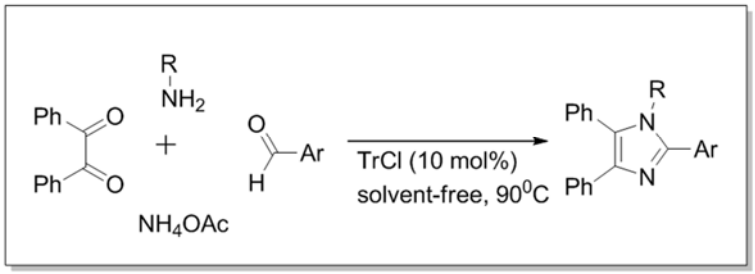

Figure 10. *Trityl chloride catalyzed synthesis of tetra-substituted imidazole.*

In 2014, Iftikhar Ahsan et al described an efficient strategy for the synthesis of derivatives of imidazole containing 2-(4-chlorophenyl)-4, 5-diphenyl imidazole ring as antimicrobial and anti-inflammatory agents with benzyl and chlorobenzaldehyde and ammonium acetate under glacial acetic acid condition. Further, the 2-(4-chlorophenyl)-4, 5-diphenyl imidazole was converted by the corresponding substituent at NH- position to give biological active compound that showed anti-inflammatory and antimicrobial activity [42].

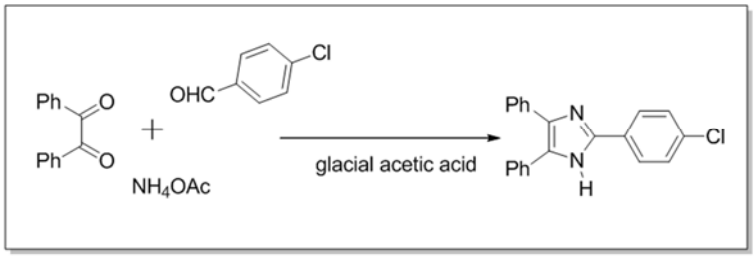

Figure 11. *Preparation of 2-(4-chlorophenyl)-4, 5-diphenyl imidazole from benzyl in presence of glacial acidic acid.*

In 2015, Irishi N. N. Namboothiri et al. envisioned a one-pot reaction to synthesis of highly substituted and bioactive imidazoles ring connecting of Morita-Baylis-Hillman (MBH) acetates of nitroalkenes and amidines under mild conditions. The significant 1,2- and 1,3-bielectrophilic character of nitroallylic acetates and 1,3-binucleophile such as amidine has leads the reaction to produce substituted imidazole with a efficient conversion in presence of a base, DABCO at room temperature [43].

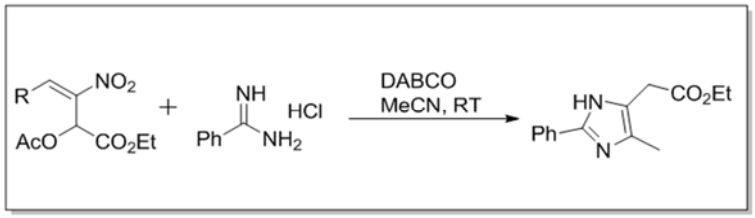

Figure 12. *Synthesis of substituted imidazole from MBH acetates having Trypanocidal activity.*

In 2015, Jianli Li and co-workers demonstrated here an efficient and facile route for the preparation of tetrasubstitutedimidazoles with amidines and chalcones through $FeCl_3$/ I_2-catalyzed from aerobic oxidative coupling reaction has been developed. This reaction is highly regioselective and more functional groups tolerance as well as mild reaction conditions [44].

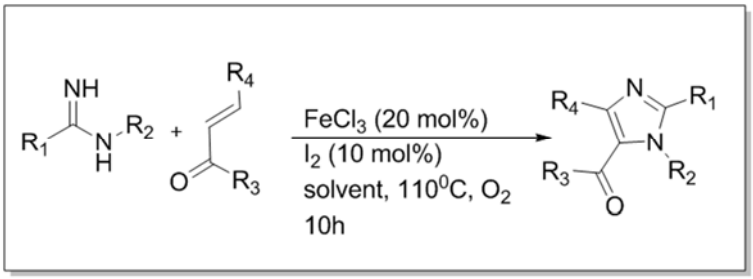

Figure 13. *Formation of tetrasubstituted imidazole from amidines and chalcones.*

In 2016, Anxin Wu and team reported 1,2,5-trisubstituted imidazole via a formal (2+1+1+1) type annulationsthroughRadziszewski-type reaction in presence of molecular iodine catalyzed mediated with methyl ketones, tosylmethylisocyanideand anilines has been unfolded. It is the first time reported example where methyl ketones act as the α-dicarbonyl compounds and aldehydes act in Radziszewski-type reactions. Discussing the mechanistically the reaction may be proceeds by way of a key C-acylimine intermediate and I_2 plays a significant role in the self-sorting tandem reaction [45].

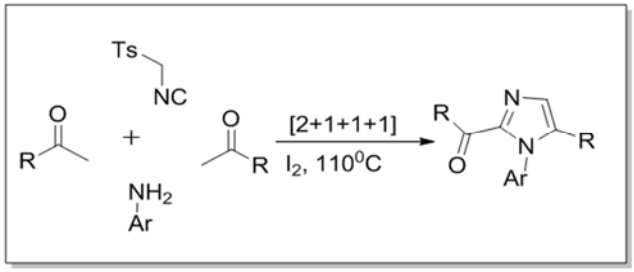

Figure 14. *Radziszewski-type synthesis of 1,2,5-trisubstituted imidazole reaction catalyzed by molecular Iodine.*

In 2016, K Pradhan and co-workers, unfolded a self-catalytic syntheses of imidazoles derivatives, 1-hydroxyimidazole 3-oxides and imidazole N-oxides from different dicarbonyl scaffold in the condensed phase reactions medium. The whole process was conducted under solvent-free multi-component medium, syntheses was explored using a combination methods viz., theory, reactivity, and spectroscopy. With the help of IR studies revealed that group frequency shifted even in solid as well as solution state in without catalyzed medium as compared with in the catalyzed medium. From this it was predicted that carbonyl molecules gets activated by itself. This activation continued up to twenty HCHO monomers. It was proved from the quantum mechanical calculations. This type of catalytic behavior named as 'self-catalytic activity' without using any catalyst. Using HPLC a comparative study was investigated between catalyzed and un-catalyzed reaction to predict the mechanistic insights for the formation of imidazole derivatives [46].

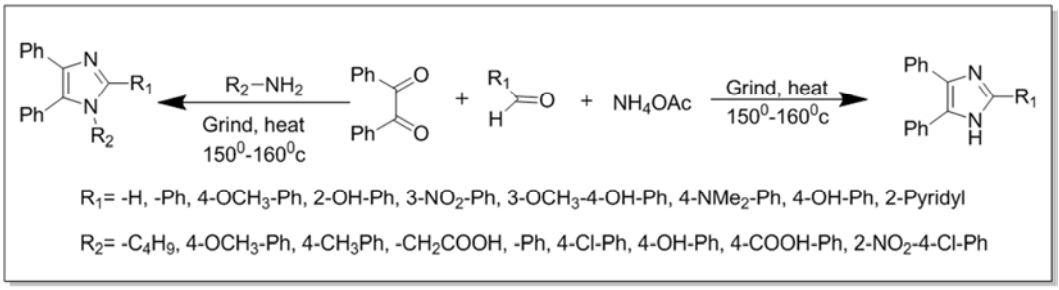

Figure 15. *One-pot synthesis of tri- and tetra-substituted imidazole derivatives.*

Very recently, Esmail vessally and co-workers revels that synthesis of imidazole derivatives from N-propargyl-benzamidines and aryl halides via a tandem aminopalladation or reductive elimination or isomerization process involving $Pd(PPh_3)_4$ as a catalyst and CuI act as a co-catalyst and in presence of a base, K_2CO_3 in anhydrous DMF medium. The role of co-catalyst is very crucial for the success of this reaction. Even in found that in absence of co-catalyst, reaction will proceed at a longer time and low yield [47].

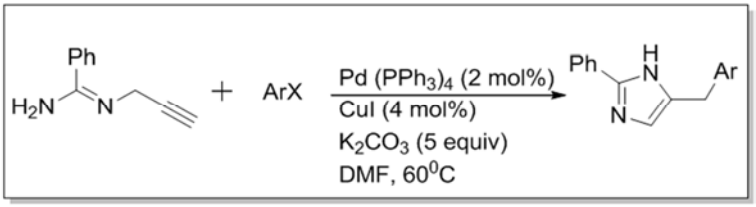

Figure 16. *Synthesis of substituted imidazoles from N-propargyl-benzimidines via palladium catalyzed.*

In very recent, M Hossain and team developed an expeditious, mild, one-pot, solvent-free and room temperature synthetic route for the synthesis of derivatives of 2-chloroimidazoles from C-2 position of imidazole N-oxide. Straightforward mixing of the imidazole N-oxide with oxalyl chloride in open air in an agate mortar and pestle affords the required products to excellent yields. The method has been examined with differently substituted N-phenyl ring. The derivatives of 2-chlorinated imidazole moiety are very useful precursors and subunits of numerous pharmacologically important drugs [48]. In 2018, R Thomas and co-workers reveals the comparison study via experimentally and computationally with the 2-chloroimidazole derivatives, besides spectroscopy techniques such as IR, FT-Raman and NMR, reactivity study also done based on density functional theory (DFT) calculations, molecular electrostatic potential (MEP), average local ionization energy (ALIE) values, bond dissociation energies (BDE) and Fukui functions. Antimicrobial analysis has been done against 2-chloroimidazole derivatives in both gram positive and gram negative bacteria [49]. In 2018, M Smitha and team studied reactive properties of 2-chloroimidazole derivatives on the basis of molecular dynamics (MD) simulations and density functional theory (DFT) calculations. Anti-bacterial activity reveals that all compounds showed good immense and more sensitive against in both gram positive and gram negative bacteria. With the help of molecular docking procedure, interactions of these novel 2-chloroimidazole derivatives with particular protein have been explored by computationally. From the docking studies it was suggested that the selected compounds might demonstrate inhibitory activity capacity against APO-liver alcohol dehydrogenase inhibitor [50].

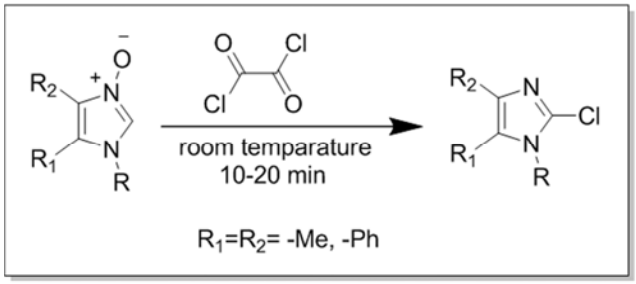

Figure 17. *Synthesis of 2-chloroimidazole derivatives from imidazole N-oxide.*

3.3. Pharmacological Activities of Some Imidazole Moiety

3.3.1. Anti Analgesic Activity and Inflammatory Activity

Kavitha C.S. et al reported a series of derivatives of 2-methylaminibenzimidazole and newly synthesized drugs were screened for inflammatory and anti- analgesic activities. Analgesic activity of these compounds compared with the standard nimesulide drug [47].

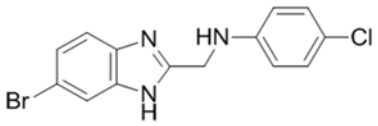

Figure 18. *N-((6-bromo-1H-benzo[d]imidazol-2-yl) methyl)-4-chloroaniline.*

Puratchikody A. et al reported 2-substituted-4, 5-diphenyl-1H-imidazoles and their anti-inflammatory activity of this compound were examined by using Carrageenan-induced paw edema method. Finally found the maximum activity of this compound with reference as an indomethacin drug [48].

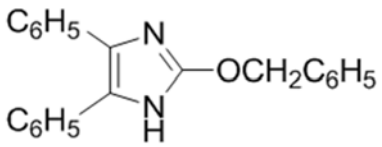

Figure 19. *2-(benzyloxy)-4,5-diphenyl-1H-imidazole.*

3.3.2. Anti-Bacterial Activity and Anti Fungal

Deepika Sharma et al have described [2-(substituted phenyl)-imidazol-1-yl]-menthanone and 2-(substituted phenyl)-1H-imidazole analogues and tested for their antimicrobial activity against Gram negative, gram positive and fungal species. Norfloxacin used as a reference drug [49].

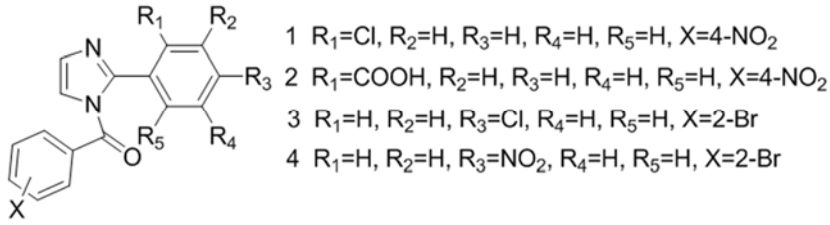

Figure 20. *[2-(substituted phenyl)-imidazol-1-yl]-menthanone and 2-(substituted phenyl)-1H-imidazole analogues.*

Ramya v et al reported a novel series of 5-(nitro/bromo)-styryl-2-benzimidazole derivatives and studies for the anti-bacterial activity against Escherichia coli, Staphylococcus aureus, Klebsiellapneumoniae and Enterococcus faecalis and anti-fungal activity against Aspergillus fumigates and Candida albicans. This was compared with ciprofloxacin as reference drug [50].

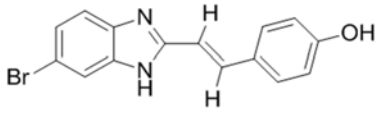

Figure 21. *(E)-4-(2-(6-bromo-1H-benzo[d]imidazol-2-yl) vinyl) phenol.*

Daniele Zampieri et al reported bis-imidazole derivatives and tested for anti mycobacterial and antifungal activity. All compounds have moderate to good activity against Candida glabrata and Candidaalbicans. Miconazole used as a standard reference drug [51].

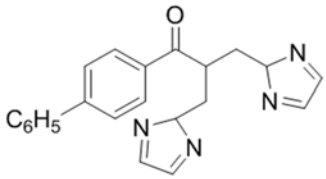

Figure 22. *2-((2H-imidazol-2-yl) methyl)-1-([1,1'-biphenyl]-4-yl)-3-(2H-imidazol-2-yl) propan-1-one.*

Dorota Olender et al reported nitroimidazole derivatives and studies for their antifungal activity against sclerophomapityophila using the standard nutrient method. After successfully examined, finally found more potent fungistatic activity of this compound [52].

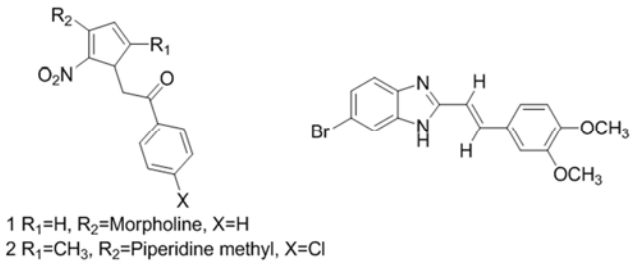

Figure 23. *Nitroimidazole derivatives and (E)-6-bromo-2-(3,4-dimethoxystyryl)-1H-benzo[d] imidazole.*

3.3.3. Anti Depressant Activity

Farzin Hadizadeh et al reported moclobemide analogues by changing moclobemide phenyl ring with derivative of imidazole and tested for the antidepressant activity of this compound using forced swimming test. Compounds 7a-c was found to be more potent as a drug than moclobemide [53].

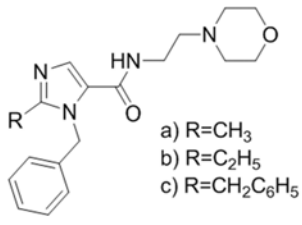

Figure 24. *Moclobemide analogues.*

3.3.4. Anti Tubercular Activity

Preeti Gupta et al illustrate anti-mycobacterium tuberculosis activities of 3-(2-alkyl-1H-imidazole-4-yl)-propionic acid derivatives and substituted ring -1H-imidazole-4-carboxylic acid derivatives against durg-resistent and durg-sensetive M. tuberculosis strains. The compounds 2f and 2h were found most potent as a drug [54].

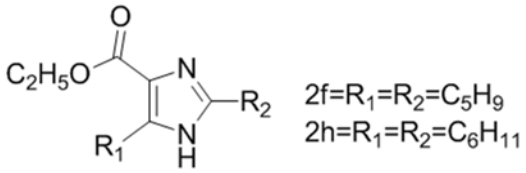

Figure 25. *3-(2-alkyl-1H-imidazole-4-yl)-propionic acid derivatives and substituted ring -1H-imidazole-4-carboxylic acid derivatives.*

Ramya V et al developed a novel series of 5-(nitro/bromo)-styryl-2-benzimidazoles (1–12) derivatives and tested for in vitro anti-tubercular activity of these series against Mycobacterium tuberculosis and all these compounds responded good anti-tubercular activities. Streptomycin was used as a standard reference drug [50].

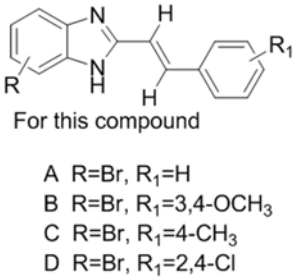

Figure 26. *5-(nitro/bromo)-styryl-2-benzimidazole derivatives.*

Jyoti Pandey et al reported a series of substituted imidazole derivatives and compounds were tested against M. tuberculosis where this compound showed excellent anti-tubercular activity [55].

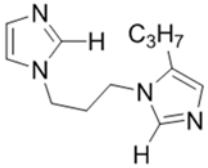

Figure 27. *1-(3-(1H-imidazol-1-yl) propyl)-5-propyl-1H-imidazole.*

3.3.5. Anti Viral Activity

Deepika Sharma et al reported derivatives of imidazole and their antiviral activity against viral strains, testing of (substituted phenyl)-[2-(substituted phenyl)-imidazol-1-yl]-methanones analogous indicated that compounds A and B showed as the most potent antiviral agents. Ribavirin was used as standard reference drug [49].

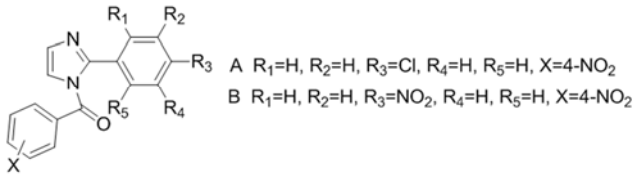

Figure 28. *(Substituted phenyl)-[2-(substituted phenyl)-imidazol-1-yl] -methanones analogous.*

Michele Tonelli et al reported seventy six 2-phenylbenzimidazole derivatives and invented their cytotoxicity and anti-viral activity against a DNA and RNA viruses. Compound ([56-dichloro-2-(4-nitrophenyl) benzimidazole]) showed a high activity as a more potent drug than reference drugs 6-azauridine and smycophenolic acid [56].

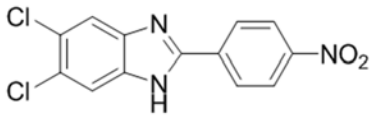

Figure 29. *5,6-dichloro-2-(4-nitrophenyl)-1H-benzo[d] imidazole.*

3.3.6. Anti Leishmanial Activity

Kalpanabhandari et al reported a novel series of substituted aryloxy aryl alkyl and aryloxy alkyl imidazole and evaluated for their anti-leishmanial activity against Leshmaniadonovani in vitro process. Most of the compounds showed 94–100% inhibition [57].

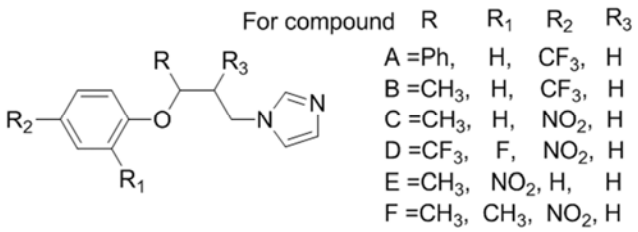

Figure 30. *Substituted aryloxy aryl alkyl and aryloxy alkyl imidazole.*

3.3.7. Anti Cancer Activity

Yusuf Ozkay et al reported so many novel imidazole-(Benz) azole and derivatives of imidazole epiperazine with the purpose of study of anticancer activity. Anticancer activity showing results exposed that these were the most anticancer active compounds in these series. Cisplatin was used as a standard reference drug [58].

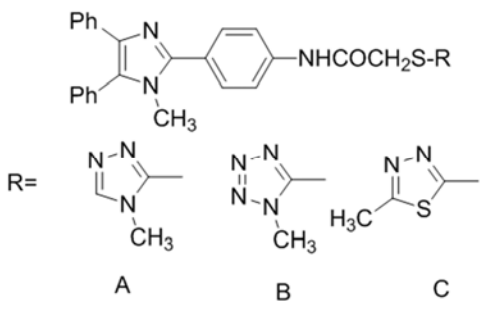

Figure 31. *Imidazole-(Benz) azole and derivatives of imidazole epiperazine.*

Hanan M. Refaat et al developed various type of 2-substituted benzimidazole. Several of the unfolded products were subjected for anticancer testing which exposed that all the tested compounds displayed antitumor activity against breast adenocarcinoma, human hepatocellular carcinoma and human colon carcinoma. The following two compounds exhibited the maximum potency resistant to human hepatocellular carcinoma [59].

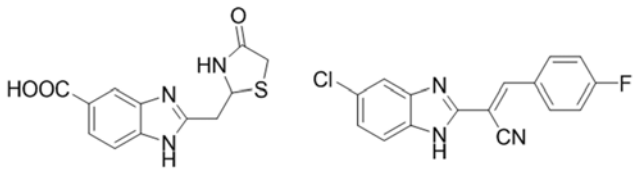

Figure 32. *Antitumor activity against human hepatocellular carcinoma.*

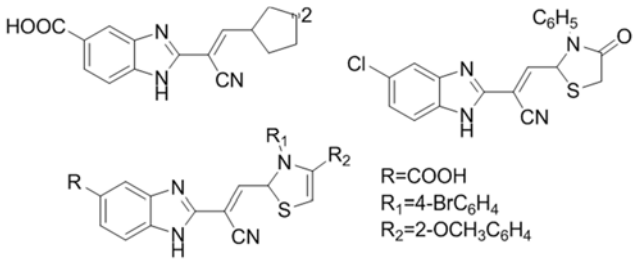

Figure 33. *Most active against human breast adenocarcinoma and moderately against human colon carcinoma.*

3.4. Biological Significance of Imidazole

Imidazole is built-in into many significant biological molecules. The most essential is the amino acid histidine, which has an imidazole ring side chain. Histidine is present in many enzymes and proteins play a fundamental role in the structure and hemoglobin binding functions. Histidine can also be decarboxylated to histamine, which is also a familiar biological compound. It is a part of the toxin that sources urticaria, i.e. allergic. The decarboxylation of histidine to histamine are shown below.

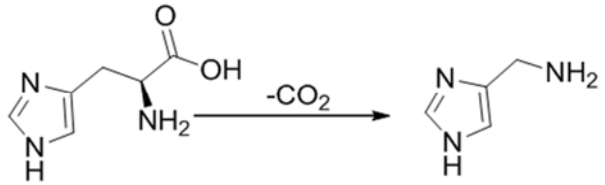

Figure 34. *Synthesis of histamine from histidineunder decarboxylation.*

4. Conclusion

The above mentions information about imidazole ring containing compounds has clearly shown that the structurally simple imidazole moiety plays a significant role in medicinal chemistry and the related research has been being unusually active subjects. A large amount of work has been reported toward imidazole-based a highly biological activity in medicinal chemistry. Numerous outstanding achievements exposed that imidazole moiety containing compounds possess widely potential application as medicinal drugs, pathologic probes and diagnostic agents. In particular, a huge number of imidazole-based compounds as clinical antibacterial, anticancer, antifungal, antihypertensive, antineuropathic, antiparasitic, antihistaminic agents and so have been successfully expanded, marketed and widely used in the clinic in preventing and treating different types of diseases with high bioavailability, low toxicity, good biocompatibility and curative effects. An expanding attempt from all over the universe has been directly focusing on imidazole moiety containing compounds for potential clinical application in the diagnosis and treatment of diverse types of diseases. Excitingly, a growing number of derivatives of imidazole have been becoming scientific drug candidates in actively constant research and developments. All these have powerfully suggested the infinite potentiality application of imidazole derivatives in the field of medicine.

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