Journal of Advances in Science and Technology
Vol. 19, Issue No. 1, March-2022, ISSN 2230-9659

A Review of Heterocyclic Composites Compounds in Synthetic Strategies for Pyridine Derivatives

Alok Kumar[1]*, Dr. Rajesh Kumar Kushwaha[2]

[1] Research Scholar, Shri Krishna University, Chhatarpur. M.P.India

Email: alokkumar1990@live.com

[2] Associate Professor, Shri Krishna University, Chhatarpur. M.P., India

Abstract- ***This review provides a comprehensive analysis of synthetic strategies employed in the preparation of pyridine derivatives, focusing on the intricate landscape of heterocyclic composite compounds. Pyridine, as a quintessential heterocycle, holds immense importance in medicinal chemistry, agrochemicals, and materials science, prompting continuous advancements in synthetic methodologies. The review encompasses an in-depth exploration of classical and contemporary synthetic routes for pyridine derivatives, emphasizing the key role played by diverse heterocyclic composites. the impact of heterocyclic composites on reaction selectivity and the diversification of pyridine derivatives, highlighting the significance of nitrogen-containing building blocks in these synthetic pathways.***

Keywords- Heterocyclic Composites, Nitrogen, Pyridine Derivatives, Synthetic Strategies

----------X----------

INTRODUCTION

Heterocyclic compounds played a vital role in biological process and are widely spread as natural products. This is the main reason behind different heterocycles using in our daily life of the human living system. The great biochemical significance of heterocycles is the ability of many heterocycles to produce a stable complex with metal ions. A low concentration of nitrogen and sulfur heterocycles also found in various petroleum products. 1 They are widely found in nature particularly in nucleic acids, plant alkaloids, anthocyanin, and flavones as well as in heam and chlorophyll. Additionally, proteins some vitamins, hormones contain aromatic heterocycles. 2 This is not an overstatement if we think that the majority of macromolecules constituting living organisms are built around heterocyclic motifs. Many heterocyclic compounds are found as key components in biological processes. Essential diet ingredients such as vitamin groups - Thiamin (Vitamin B1), Riboflavin (Vitamin B2), Nicotinamide (Vitamin B3), Pyridoxal (Vitamin B6) are Nitrogen containing heterocyclic compounds working either as co-enzymes or their precursors.3-4 Another most remarkable vitamin is vitamin C or Ascorbic acid. It is very important for our life because it is not only involved in several collagen synthesis reactions for wound-healing and for preventing bleeding from capillaries but also acts as an antioxidant against free radicals and the oxidative stress.5 They are also major components of biological molecules such as DNA, RNA, and ATP etc. DNA is, without doubt, the most important macromolecule of life. Nucleotides, the building blocks of our genes are derivatives of pyrimidine and purine ring structures. Chlorophyll and heme, the oxygen carriers in plants and animals respectively are derivatives of large porphyrin rings which are composed of modified pyrrole subunits.

PYRIDINE

Replacing a -CH in benzene with nitrogen gives us the pyridine nucleus. It is a unique ring with basic as well as aromatic nature. They are present in many natural products, such as vitamins, coenzymes, and alkaloids. Their remarkable features such as small size, basicity, water solubility, stability, and hydrogen bond-forming ability make them interesting candidates in drug designing. They are significant in pharmacokinetic studies because they are able to act as the bioisosteres of amines, amides, aromatic rings, and other nitrogen moieties. The first synthetic method reported for pyridine was the Hantzsch pyridine synthesis (Philips 1949)6 which is the condensation of beta-keto esters with an aldehyde and ammonia or its salt. The product obtained is oxidized to get substituted pyridine. A few examples of drugs containing the pyridine rings are as shown below (Figure 1) (Baumann 2013)7.

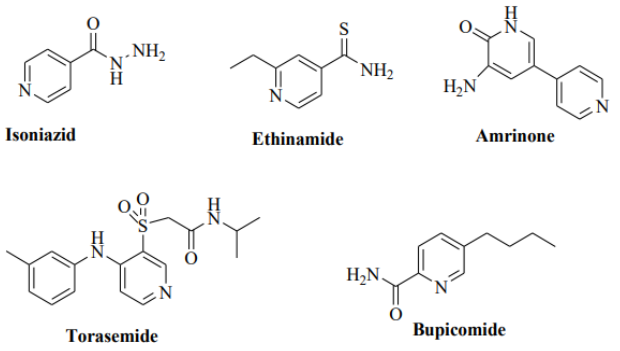


Figure 1: Pyridine containing drug molecules

INTRODUCTION TO SYNTHETIC STRATEGIES FOR PYRIDINE DERIVATIVES

A six-membered heterocyclic compound having one nitrogen atom and five carbon atoms in the ring is known as pyridine. The molecular structure of pyridine is very close to that of benzene, with the exception that it has one set of N-H bonds instead of C-H ones. Figure 2 shows the most basic structure of pyridine.

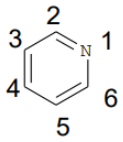
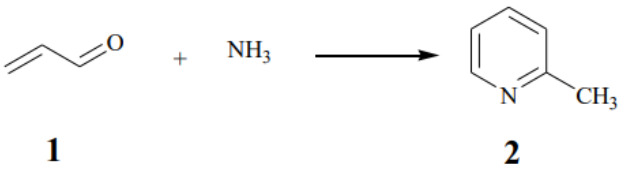


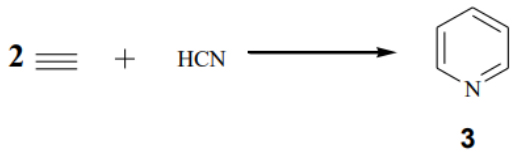
Figure 2: Structure of Pyridine

Pyridine name is derived from the Greek two words “pyr” used for fire and “idine” means aromatic bases. There were a number of discoveries made in the 19th century about the chemistry of pyridine. In 1846, Thomas Anderson isolated the first pyridine base (picoline from bone oil). Wilhelm Körner in 1869 and James Dewar in 1871 both have independently formulated a mono-aza analogue of benzene. A number of new synthetic methods were devised; the first was the 2-picoline (2) synthesis described by Baeyer, which involved reacting acrolein with aqueous ammonia (1).



Scheme 1: Synthesis of 2-picoline

In 1876, pyridine 8 was the first time laboratory synthesized by Ramsey (Ramsey 1876). In Scheme 2, he created the heterocycle (3) by reacting acetylene & hydrogen cyanide in a red-hot tube.



Scheme 2.2: Pyridine synthesis

The B2-derived niacinamide & niacinic acid were isolated in the 1930s by Koehn and Elvehjem (Koehn 1937)9. They laid the groundwork for a new approach to treating human pellagra with their finding. From this discovery, researchers and chemists were giving close attention to pyridine derivative synthesis and their biological property evaluation (Figure 3).

Figure 3: Nicotinamide (4) & Nicotinic acid (5)

A basic comprehension of the chemical & biological characteristics was supplied by the pyridine chemistry. Among the several heterocyclic moieties found in living things, pyridine is among the most prevalent. For instance, NADP+ (6), which stands for nicotinamide adenine dinucleotide phosphate, plays a crucial role in a number of biological oxidation-reduction reactions (Figure 4). Farhanullah 2003. 100

The pyridine moiety found in more than a thousand pharmaceutical, agrochemical drugs (Matolcsy 1988)11, and a large number of natural products (7–10) having different biological properties (Figure 5). (Henkel 1999, Santos 2012, Bull 2012)12-14

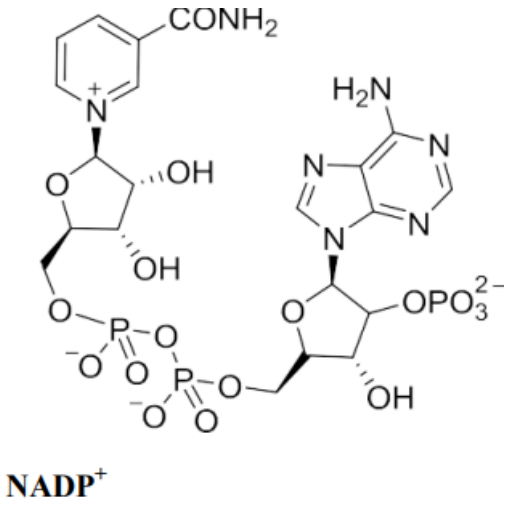


Figure 4: Structure of NADP+

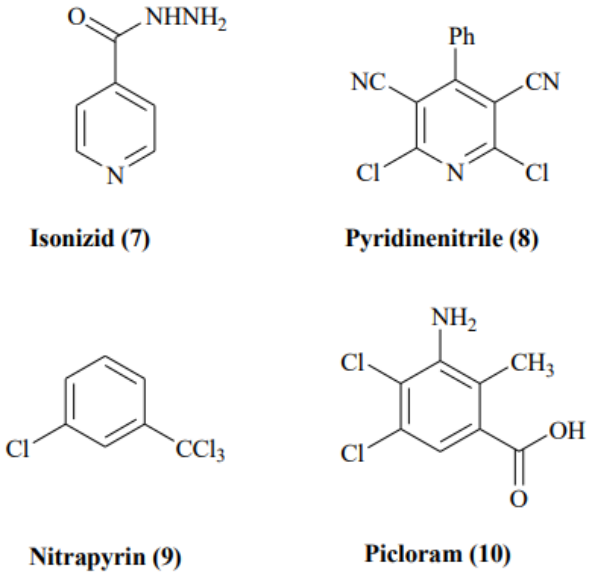


Figure 5: Pyridine containing pharmaceutical and agrochemicals drugs.

Pyridine is a very important heterocyclic class of chemistry, as pyridine moiety is observed in a wide range of molecules. In the modern pharmaceutical world, the pyridine moiety is very common; with more than thousands of currently marketed drugs, containing this vital unit (Goetz 2013)15. The majority of items found in nature contain the pyridine group. Niacin (11) and pyridoxine (12) are vitamins B3 & B6, respectively, and the alkaloid nicotine (13) is also present (Figure 6). Referenced in Henry (2004), 16.

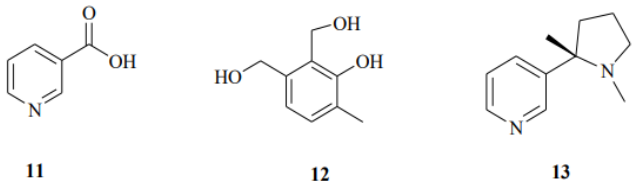


Figure 6: Pyridine moiety is present in several natural products.

Pyridine structure was normally found in natural products as a pharmaceutical agent. When it came to treating bacterial pneumonia in 1942, sulfapyridine was among the first antibiotics employed (Goetz 2013:15). The blockbuster drug Omeprazole (15) containing pyridine motif is currently used in the market (Figure 7).

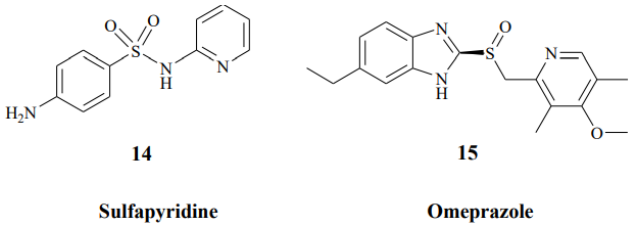


Figure 7: Pyridine in pharmaceutical agents.

In organic and inorganic chemistry, pyridines have also been used as ligands. For instance, 2,2'-Bipyridine, or bipy, is utilised as a chelating ligand in the rhenium catalysed reduction of carbon dioxide (Smieja 2010).

❖ Pharmacological significance

The pharmacological uses of pyridine derivatives are diverse. The following are a few of the most significant biological functions of pyridine compounds:

- Antiallergic (Nohara 1985) 18
- Antioxidant (Helal 2015) 17
- Anti-tubercular (Lu2017) 19
- Antibacterial and Anticancer (Alam 2020, Gouda 2018) 20-21
- Anti-inflammatory and Analgesic (Al-Omar 2010, Hamdy 2012) 22-23
- Anticonvulsant (Tripathi 2011) 24
- Antifungal (Wei 2019, Zhang 2019) 25-66

❖ Biological Significances

Antimicrobial and Antifungal activity

Pyridine containing piperazinyl oxazolidinone (compound 16) was prepared by J. Tucker et al (Tucker 1998)27 and evaluated for potential antimicrobial activities. Similarly, G. El-Nabawia and F. Alexandria (El-Nabawia 2000) synthesized novel derivatives of 2-aminonicotinitrile (17) and evaluated their antimicrobial potential (Figure 8).

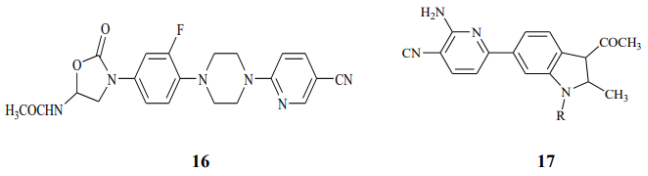


Figure 8: Pyridine containing (compound 16 & 17)

R. Patel and K. Parikh (Parikh 2009)28 synthesized novel derivatives of cyanopyridine, and evaluated their antimicrobial and antifungal activities (Figure 9).

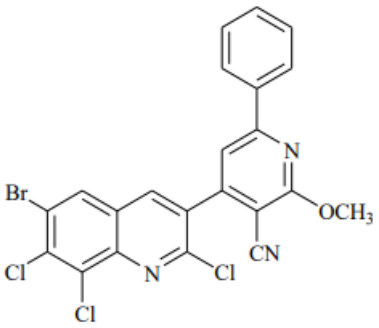


Figure 9: Amino pyridine derivatives

2-amino-3-cyano-4,6-substituted aryl derivatives were synthesized by V. Bhadani (Bhadani 2015)29

and evaluated their antimicrobial activities. The following synthetic chemical outperforms its peers in terms of antibacterial & antifungal efficacy. To test for antibacterial properties, Konda et al. (Konda 2010)30 produced a new amino pyridine with a naphthyl amine motif. Figure 10 shows that the chemical below has good antibacterial characteristics.

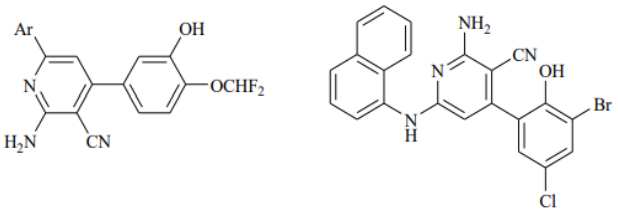
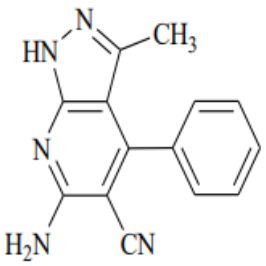


Figure 10: 2-Amino-3-cyano-4,6-substituted aryl derivatives.

El-Hashashet al. (El-Hashash 2014)31 synthesized various analog and derivatives of pyridine. They screened these compounds 21, pyrazolecyanopyridine was found to exhibit very good antimicrobial activity (Figure 11).



21

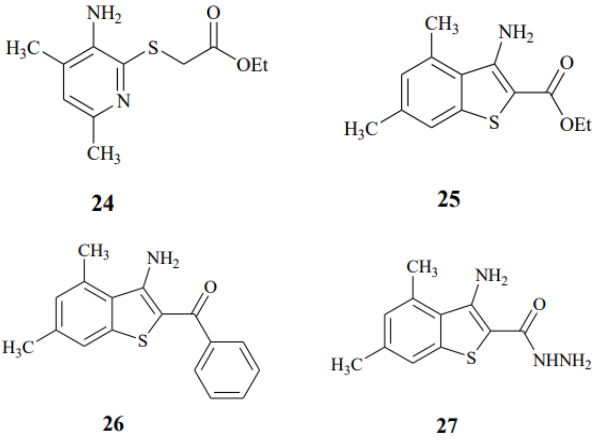
Figure 11: Novel amino pyridines

Acyl and Di-acylhydrazine (Compound 22 & 23) containing pyridine derivatives exhibit good antimicrobial activities against S. albus and E. coli as compared to standard drug streptomycin. Compounds (22 & 23) show antifungal activities against A. teniussiama as compared to reference drug Griseofulvin (Chavan 2006)32.

22 23

Figure 12: Acyl and Di-acylhydrazine

Pyridine and thienopyridine derivatives (24-27) (Figure 13) exhibit good antimicrobial activities have shown against P. vulgaris, E. coli, and S. aureus (Zavyalova 1939-1940)33.

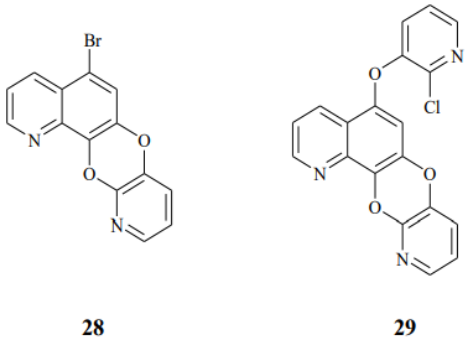


24 25 26 27

Figure 13: Thienopyridine and other pyridine derivatives (compounds 24-27)

Anti-Malarial Agents

Pyridine containing quinoline derivatives (Compounds 28 & 29) were observed as anti-malarial agents against a strain of Plasmodium falciparum and these compounds have shown a moderate anti-malarial activity. Although these compounds are moderately active but give a clue for designing novel anti-malarial drugs (Acharya 2008)34 (Figure 14).



28 29

Figure 14: Anti-malarial Agents

Anti-Inflammatory Agents

Marquez-Flores et al. has synthesized a novel imidazo[1,2-a]pyridine derivatives (Figure 15). These derivatives tested for anti-inflammatory activities (MarquezFlores 2011)35.

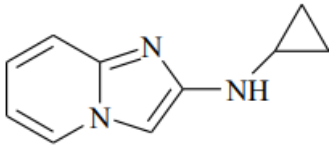


Figure 15: Imidazo[1,2-a]pyridine as anti-inflammatory agents

Analgesic Potency

Nigade et al. has synthesized some novel pyridine containing heterocyclic compounds & verified them for analgesic activity. Out of these compounds, compounds 30-32 showed good analgesic activity

as compared to standard drug pentazocine (Nigade 2010)36 (Figure 16).

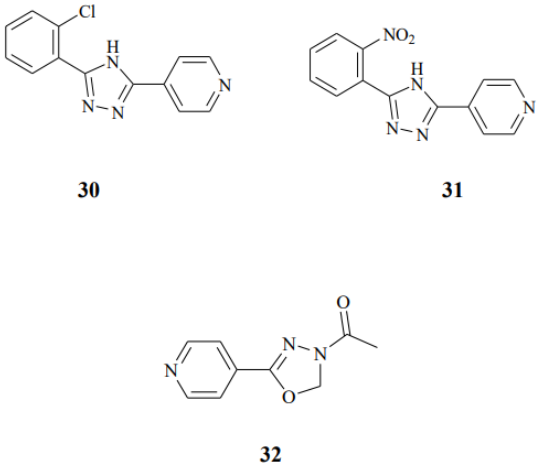


Figure 16: Anti-analgesic Agents

Enzyme Inhibition

Several imidazo[1,2-a] compounds have been synthesised by Lopez-Martinez & Jin. In comparison to other derivatives, compounds 33–34 inhibit acyl-CoA (cholesterol acyltransferase) (Jin 2009, Lopez-Martinez 2010) 37–38. Also, pyridine containing benzoimidazole derivatives show gastric H+/K+-ATPase inhibitory activity (Cho 2001)39 (Figure 17).

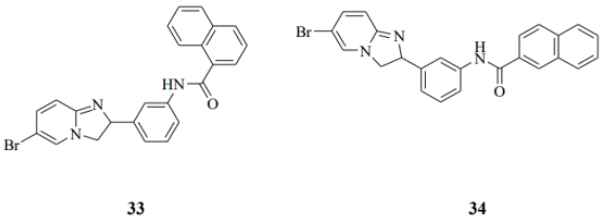


Figure 17: Pyridine containing benzoimidazole derivatives

❖ **Introduction to 4-Thiazolidinones derivatives**

Heterocyclic compounds having sulphur and nitrogen in a 5- member ring is called thiazolidine. It is an important class of heterocyclic compound. 4-Thiazolidinones are the subclass of thiazolidine in which a carbonyl group at 4-position. These are solid and normally melt with decomposition. Thiazolidines are prepared by a number of different methods with different reagents (Brown1961)40. Thiazolidines are essential moiety from researchers and chemists due to different types of biological activities (antimicrobial, anticancer, anti-inflammatory, etc).

➢ **Pharmacological uses of 4-thiazolidinones**

Anti-HIV activities

A novel series of substituted diaryl derivatives of 1,3-thiazolidin-4-ones prepared by Barreca and Rao et al. and these derivatives shown anti-HIV activity against standard drugs. A further study new class of antiviral agents acting as NNRTIs with least cytotoxicity (Monforte 2001)41

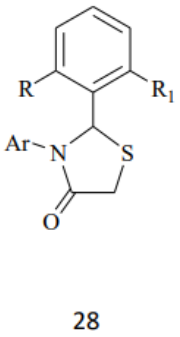


Figure 18: Substituted diaryl derivatives of thiazolidin-4-ones as Anti-HIV agent

A novel series of substituted-(2,6-dibromophenyl)-1,3-thiazolidin-4-one derivatives (Figure 19) have been reported by Rawal et al. and these derivatives showed good anti-HIV activity as compared to a standard drug (Rawal 2007)42.

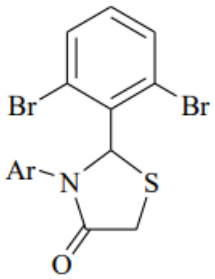


Figure 19: Substituted-(2,6-dibromophenyl)-1,3-thiazolidin-4-one derivatives

Anticonvulsant activity

Archana, Kumar A. has synthesized novel thiazolidinonyl quinazolin-4(3H)-ones derivatives (Srivastava 2002)43. These compounds have shown excellent anticonvulsant activity when compared with reference drugs (Phenytoin sodium, Lamotrigine, etc). Shiradkar et al. has prepared a thiazolidinone derivatives containing triazole. (Shiradkar 2007)44 (Figure 20).

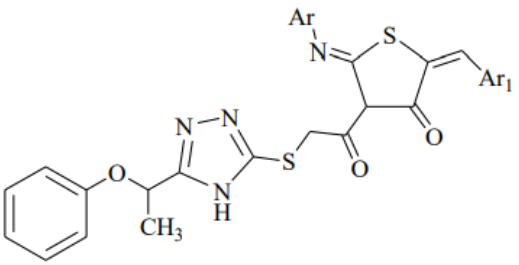


Figure 20: Anticonvulsant agent

Follicle stimulating hormone (FSH) receptor agonist activity

Yanofsky et al. has prepared thiazolidinone derivatives and these derivatives activate the

allosteric side of FSH receptor (Yanofsky 2006)45 (Figure 21).

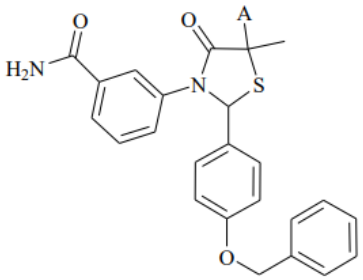


Figure 21: Thiazolidinone derivatives FSH receptor agonist

Anticancer activity

Recently Gawrońska-Grzywacz et al. (Gawrońska-Grzywacz 2018)46 evaluate the antitumor activity by 3-disubstituted 1,3-thiazolidin-4-one derivatives and which is very promising for the renal cell adenocarcinoma (Figure 22).

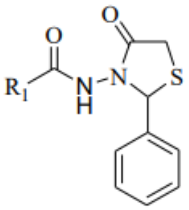


Figure 22: 3-disubstituted 1,3-thiazolidin-4-one derivatives as anticancer agents

Anti-inflammatory activity

Vazzana et al. has synthesized aromatic substituted-1,3-thiazolidin-4-one derivatives (Figure 23). These derivatives have shown good anti-inflammatory activity as compared to standard compounds (Vazzana 2004)47.

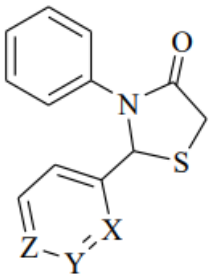


Figure 23: Substituted-1,3-thiazolidin-4-one derivatives

2-[(substituted 6-bromoquinazolin thiazolidin-4-one (Figure 24) have synthesized by Kumar A and tested for anti-inflammatory activity (Kumar A 2007)48.

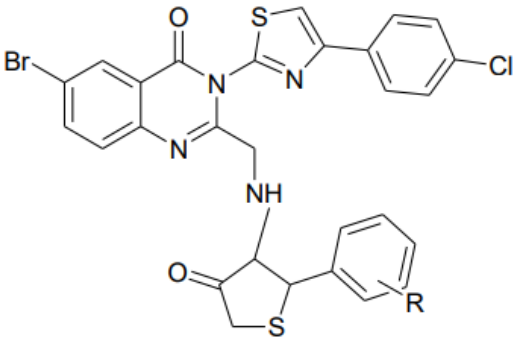


Figure 24: Substituted thiazolidin-4-one an anti-inflammatory agent

Antimicrobial activity

Substituted 2-[(4-carbethoxymethylthiazol-2-yl)imino]-4-thiazolidinones derivatives have prepared by Altintas et al.(Figure 25). These derivatives were screened for their in-vitro antibacterial activity against S. aureus, E. coli, (Altintas 2005)49.

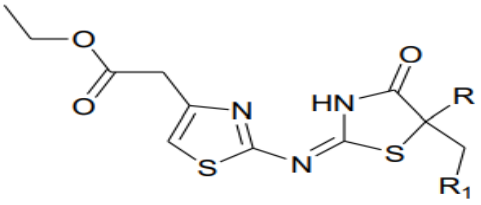


Figure 25: 4-Thiazolidinones derivatives an antibacterial

Novel derivatives (benzothiazolylthio)-acetamidyl]-4-oxo-thiazolidines synthesized by Desai KG and Desai KR (Figure 26). The synthesized derivatives have shown excellent antimicrobial activity against E. coli, S.aureus, and B. substilis (Desai 2006)50.

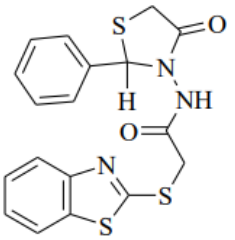


Figure 26: (Benzothiazolylthio)-acetamidyl]-4-oxo-thiazolidine derivative

CONCLUSION

In conclusion, this comprehensive review has delved into the intricate realm of synthetic strategies for pyridine derivatives, offering a thorough exploration of the complexities inherent in the construction of these vital heterocyclic composite compounds. The multifaceted nature of pyridine, with its widespread applications in medicinal chemistry, agrochemicals, and materials science, underscores the importance of continually advancing and refining synthetic methodologies. he significance of heterocyclic composites in

influencing the selectivity and efficiency of these synthetic pathways has been a focal point, emphasizing the pivotal role played by nitrogen-containing building blocks. The application of pyridine derivatives in drug discovery, agrochemicals, and materials science was explored, showcasing the practical implications of synthetic strategies in tailoring the properties of these compounds for specific purposes.

REFERENCES

1. Pizzarello, S.; Huang,Y.; Becker, L.; Poreda, R.J.; Nieman, R.A.; Cooper G.; Williams, M. Science, 2001, 293,2236.

2. Ashry, E.S.H.; Ramadan, E, Kassem, A.A, Adv. Heterocycl. Chem., 2005,88, 1-3.

3. Ohnmacht, S.; West, R.; Parker, R.; Atkinson, J. Bioorg. Med. Chem., 2008, 16(16), 7631-7631.

4. Naidu, K. A. Nutrition Journal, 2003, 2, 1.

5. Padayatty, S. J.; Katz, A.; Wang, Y.; Eck, P.; Kwon, O.; Lee, J. H.; Chen, S.; Corpe, C.; Dutta, A.; Dutta, S. K.; Levine, M. J. Am. Coll. Nutr. 2003, 22, 18-35

6. Phillips, A.P., Hantzsch's Pyridine Synthesis, Journal of the American Chemical Society 1949, 71, 4003-4007

7. Baumann, M.; Baxendale, I. R., An overview of the synthetic routes to the best selling drugs containing 6-membered heterocycles, Beilstein J. Org. Chem. 2013, 9, 2265–2319.

8. Koehn, C.J.; Elvehjem, C.A., Further Studies on the Concentration of the Anti-pellagra Factor, J. Biol. Chem., 1937, 118, 693

9. Farhanullah; Agarwal, N.; Goel, A.; Ram, V. J., Synthesis of aminonicotinonitriles and diaminopyridines through base-catalyzed ring transformation of 2H-pyran-2-ones, J. Org. Chem. 2003, 68, 2983.

10. Matolcsy, G.; Nádasy, M.; Andriska, V., Pesticide Chemistry, ElsevierAmsterdam 1988, 388

11. Henkel, T.; Brunne, R. M.; Müller, H.; Reichel, F., Statistical investigation into the structural complementarity of natural products and synthetic compounds, Angew. Chem., Int. Ed. Engl., 1999, 38, 643.

12. Santos, V. A. F. F. M.; Regasini, L. O.; Nogueira, C. R.; Passerini, G. D.; Martinez, I.; Bolzani, V. S.; Graminha, M. A. S.; Cicarelli, R. M. B.; Furlan M., J. Nat. Prod., 2012, 75, 991. Antiprotozoal Sesquiterpene Pyridine Alkaloids from Maytenus ilicifolia. J Nat Prod.; 2012, 75, 991–995.

13. Bull, J. A.; Mousseau, J. J.; Pelletier, G.; Charette, A. B., Synthesis of pyridine and dihydropyridine derivatives by regio- and stereoselective addition to Nactivated pyridines, Chem. Rev. 2012, 112, 2642.

14. Goetz, A. E.; Garg, N. K., Regioselective reactions of 3,4-pyridynes enabled by the aryne distortion model, Nature Chem., 2013, 5, 54

15. Henry, G. D., De novo synthesis of substituted pyridines, Tetrahedron, 2004, 60, 6043

16. Helal, M.; El-Awdan, S.; Salem, M.; Abd-elaziz, T.A.; Moahamed, Y.A.; ElSherif, A.A.; Mohamed, G.A.M., Synthesis, biological evaluation and molecular modeling of novel series of pyridine derivatives as anticancer, antiinflammatory and analgesic agents, Spectrochim Acta Part A Mol Biomol Spectrosc., 2015, 135, 764.

17. Nohara, A.; Ishiguro, T.; Ukawa, K.; Sugihara, H,; Maki, Y,; Sanno, YStudies on Antianaphylactic Agents. Synthesis of Antiallergic 5-Oxo-5H- [1]benzopyrano[2,3-b]pyridines.; . J. Med. Chem., 1985, 28, 559.

18. Lu, X.; Tang, J.; Cui, S.; Wan, B.; Franzblauc, S. G.; Zhang, T.; Zhang, X.; Ding, K., Pyrazolo[1,5-a]pyridine-3-carboxamide hybrids: Design, synthesis and evaluation of anti-tubercular activity, European J. Med. Chem., 2017, 125, 41.

19. Alam, M.N.; Yu, J.Q.: Beale, P.; Turner, P.; Proschogo, N.; Huq, F. Crystal Structure, Antitumour and Antibacterial Activity of Imidazo[1, 2-α]pyridine Ligand Containing Palladium Complexes, Chem. Select, 2020, 5, 668.

20. Gouda, M. A.; Attia, E.; Helal, M. H.; and Salem, M. A., Recent Progress on Nicotinonitrile Scaffold-based Anticancer, Antitumor, and Antimicrobial Agents: A Literature Review, J. Heterocyclic Chem., 2018, 55, 2224.

21. Al-Omar, M.A.; Amr, A.E.-G.E.; Al-Salahi, R.A., Anti-inflammatory, Analgesic, Anticonvulsant and Antiparkinsonian Activities of Some Pyridine Derivatives Using 2,6-Disubstituted Isonicotinic Acid Hydrazides, Arch. Pharm. Med. Chem., 2010, 343, 648.

22. Hamdy, N.A.; Kamel, G.M., Potent anti-inflammatory and analgesic activities of new derivatives of chalcone, pyridine, pyrazole,

and isoxazole incorporated into 5,6,7,8-tetrahydronaphthalene, Egypt Pharmaceut J., 2012, 11, 22.

23. Tripathi, L.; Singh, R.; Stables, J.P., Design & synthesis of N"-[substituted] pyridine-4-carbohydrazides as potential anticonvulsant agents", Eur. J. Med. Chem., 2011, 46,

24. Wei, L.; Tan, W.; Zhang, J.; Mi, Y.; Dong, F.; Li, Q.; Guo, Z., Synthesis, Characterization, and Antifungal Activity of Schiff Bases of Inulin Bearing Pyridine ring. Polymers, 2019, 11, 371.

25. Zhang, J.; Tan, W.; Mi, Y.; Luan, F.; Wei, L.; Li, Q.; Dong, F.; Guo, Z., Synthesis and Characterization of Inulin Derivatives Bearing Urea Groups with Promising Antifungal Activity; Starch, 2019, 71, 1800058

26. Tucker, J.A.; Allwine, D.A.; Grega, K.C.; Barbachyn, M.R.; Klock, J.L.; Adamski, J.L.; Brickner, S.J.; Hutchinson, D.K.; Ford, C.W.; Zurenko, G.E.; Conradi, R.A.; Burton, P.S.; Jensen, R.M., Piperazinyl oxazolidinone antibacterial agents containing a pyridine, diazene, or triazene heteroaromatic ring J. Med. Chem., 1998, 41, 3727.

27. Parikh, K.; Patel, R., Synthesis and Characterization of Some Cyanopyridine Compounds in Therapeutic Interest.; Int. J. ChemTech Res., 2009, 1, 581.

28. Bhadani, V.; Patel, P.; Purohit, H.; Purohit, D., Synthesis and Antimicrobial Screening 6-Aryl-2-(Amino/Methoxy)-4-[(4′-Difluoro Methoxy) (3′-Hydroxy) Phenyl] Nicotinonitrile, Int. Lett. Chem. Physics and Astronomy, 2015, 50, 35

29. Konda, S.G.; Khedkar, V.T.; Dawane, B.S.; Synthesis of some new 2-amino3-cyano-4-aryl-6-(1-napthyl amino)-pyridines as antibacterial agents, J. Chem. Pharm. Res., 2010, 2, 187.

30. El-Hashash, M.A.; Sherif, S.M.; Badawy, A.; Rashdan, H., Facial synthesis of some new pyrazolopyridine, barbituric and thiobarbituric acid derivatives with antimicrobial activities, Inter. J. Adv. Res., 2014, 2, 900.

31. Chavan, V.; Sonawane, S.; Shingare, M.; Karale, B., Synthesis, characterization, and biological activities of some 3,5,6-trichloropyridine derivatives, Chem. Heterocycl. Comp., 2006, 42, 625

32. Zav"yalova, V.K.; Zubarev, A.A.; Shestopalov, A.M., Synthesis and reactions of 3-acetyl-6-methyl-2-(methylthio)pyridine. Russ Chem. Bull ., 2009, 58, 1939–1944.

33. Acharya, B.N.; Thavaselvam, B.D.; Kaushik, M.P., Synthesis and antimalarial evaluation of novel pyridine quinoline hybrids, Med Chem Res., 2008, 17, 487.

34. Marquez-Flores, Y.K., Campos-Aldrete, M.E., Salgado-Zamora, H., Acute and chronic anti-inflammatory evaluation of imidazo[1,2-a]pyridine carboxylic acid derivatives and docking analysis, Med. Chem. Res., 2012, 21, 3491.

35. Nigade, G.; Chavan, P.; Deodhar, M., Synthesis and analgesic activity of new pyridine-based heterocyclic derivatives.; Med. Chem. Res., 2010, 21.

36. Jin, Y.; Rho, M.C.; Gajulapati, K.; Jung, H.Y.; Boovanahalli, S.K;, Lee, J.H.; Song, G.Y.; Choi, J.H.; Kim, Y.K.; Lee, K.; Choi, Y.,Synthesis of a Novel Series of Imidazo[1,2-α]pyridines as Acyl-CoA: Cholesterol Acyltransferase (ACAT) Inhibitors,Bull. Korean Chem. Soc., 2009, 30, 1297.

37. López-Martínez, M.; Salgado-Zamora, H.; San-Juan, E. R.; Zamudio, S.; Picazo, O.; Campos, M. E.; Naranjo-Rodriguez, E. B.,Anti-anxiety and sedative profile evaluation of imidazo[1,2-a]pyridine derivatives, Drug Dev. Res., 2010, 71, 371.

38. Cho, S. Y.; Kang, S. K.; Kim, S. S.; Cheon, H. G.; Choi, J. K.;Yum, E. K. Synthesis and SAR of benzimidazolederivatives containing oxycyclicpyridineas a gastric H+/K+-ATPase inhibitors, Bull. Korean Chem. Soc., 2001, 22, 1217.

39. Brown, F.C., 4-Thiazolidinones, Chem. Rev.1961, 61, 463.

40. Rao, A.; Balzarini, J.; Carbone, A.; Chimirri, A.; De Clercq, M., Synthesis of new 2,3-diaryl-1,3-thiazolidin-4-ones as anti-HIV agents.; Farmaco, 2004, 59, 33.

41. Rao, A.; Carbone, A.; Chimirri. A.; De Clercq. E.; Monforte, A.M.; Monforte, P.; Pannecouque, C.; Zappalà M., Farmaco., 2002, 57, 747. Synthesis and anti-HIV activity of 2,3-diaryl-1,3-thiazolidin-4-(thi)one derivatives. Il Farmaco, 2002, 57(9): 747–751

42. Rawal, R.K.; Tripathi, R.; Katti, S.B.; Pannecouque, C.; Synthesis and evaluation of 2-(2,6-dihalophenyl)-3-pyrimidinyl-1,3-thiazolidin-4-one analogues as anti-HIV-1 agents. Bioorganic & Medicinal Chemistry, 2007, 15(9): 3134–3142

43. Srivastava A.V.K.; Kumar, A., Synthesis of newer thiadiazolyl and thiazolidinonyl quinazolin-4(3H)-ones as potential

anticonvulsant agents Eur. J. Med. Chem., 2002, 37, 873

44. Shiradkar, M.; Ghodke, M.; Bothara, K.; Bhandari, S. V.; Nikalje, A.; Kalyan, C.; Chakravarthy, A.; Desai, N.; Burange, P., Synthesis and anticonvulsant activity of clubbed thiazolidinone–barbituric acid and thiazolidinone–triazole derivatives.; Arkivoc, 2007, 14, 58.

45. Yanofsky, S. D.; Shen, E. S.; Holden, F.; Whitehorn, E.; Aguilar, B.; Tate, E.; Holmes, C. P.; Scheuerman, R.; MacLean, D.; Wu, M. M.; Frail, D. E.; López, F. J.; Winneker, R.; Arey, B. J.; Barrett, R. W., Allosteric Activation of the Follicle-stimulating Hormone (FSH) Receptor by Selective, Nonpeptide Agonists.; J. Biol. Chem., 2006, 19, 281

46. Gawrońska-Grzywacz, M.; Popiołek, Ł.; Natorska-Chomicka, D.; Piątkowska-Chmiel, I.; Izdebska, M.; Herbet, M.; Iwan, M.; Korga, A.; Dudka, J.; Wujec, M., Novel 2,3-disubstituted 1,3-thiazolidin-4-one derivatives as potential antitumor agents in renal cell adenocarcinoma, Oncol. Rep. 2019, 41, 693

47. Vazzana I.; Terranova, E.; Mattioli, F.; Sparatore, F., Aromatic Schiff Bases and 2,3-Disubstituted-1,3-thiazolidin-4-one Derivatives as Anti-Inflammatory Agents., Arkivoc, 2004, 5, 364\

48. Kumar A.; Rajput, C.S.; Bhati, S.K., Synthesis of 3-[4′-(p-chlorophenyl)- thiazol-2′-yl]-2-[(substituted azetidinone/thiazolidinone)-aminomethyl]-6- bromoquinazolin-4-ones as anti-inflammatory agent, Bioorg. Med. Chem., 2007, 15, 3089.

49. Altintas, H.; Ateş, Ö.; Birteksöz, S.; Ötük, G.; Uzun, M.; Satana, D., Synthesis of Mannich bases of some 2,5-disubstituted 4-thiazolidinones and evaluation of their antimicrobial activities, Turk. J. Chem., 2005, 29, 425

50. Desai, K.G.; Desai, K.R., A facile microwave enhanced synthesis of sulfurcontaining 5-membered heterocycles derived from 2-mercaptobenzothiazole over ZnCl2/DMF and antimicrobial activity evaluation, J. Sulphur Chem., 2006, 27, 315.

Corresponding Author

Alok Kumar*

Research Scholar, Shri Krishna University, Chhatarpur. M.P.India

Email: alokkumar1990@live.com