E-ISSN: 2664-6773
P-ISSN: 2664-6765
Impact Factor: RJIF 5.6
IJCBS 2022; 4(1): 36-42
www.chemicaljournal.org
Received: 05-05-2022
Accepted: 09-06-2022

Mohammad Asif
Glocal School of Pharmacy, Glocal University, Mirzapur Pole, Saharanpur, Uttar Pradesh, India

Abdul Hafeez
Glocal School of Pharmacy, Glocal University, Mirzapur Pole, Saharanpur, Uttar Pradesh, India

Corresponding Author:
Mohammad Asif
Glocal School of Pharmacy, Glocal University, Mirzapur Pole, Saharanpur, Uttar Pradesh, India

A brief study of synthetic, chemical and pharmacological activities of naphthyridine derivatives: A mini review

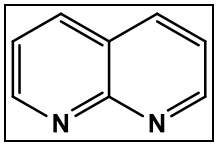
Mohammad Asif and Abdul Hafeez

DOI: https://doi.org/10.33545/26646765.2022.v4.i1a.46

Abstract
Heterocyclic compounds are of fundamental importance to biological process and are wide spread of natural products. Heterocyclic compounds are finding an increasing use as intermediates in organic synthesis. Heterocyclic compounds are organic compounds that contain a ring structure containing atom in addition to carbon, as part of the ring. Many of the heterocyclic ring systems are of fundamental importance to living systems. Naphthyridine is the name commonly given to the fused-ring system resulting from the fusion of two pyridine rings through two adjacent carbon atoms, each ring thus containing only one nitrogen atom. Many heterocyclic have important pharmaceutical properties and have a wide range of applications: they are predominant among the types of compounds used as pharmaceuticals, as agro chemicals and as veterinary products. The 1, 8-Naphthyridine derivatives are reported to possess a wide spectrum of biological activities such as antibacterial, antimalarial, anti-inflammatory, antitumor, antiviral, and other useful biological and chemical applications.

Keywords: Heterocyclic compounds, Naphthyridine, biological activities

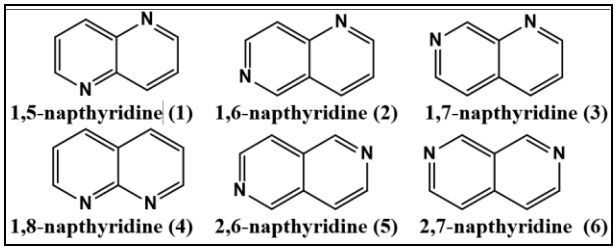
Introduction
Inrecent years, Naphthyridine with fused rings liked ibenzo, benzopyrido, diazanaphtho and benzoquino-lino have been widely reported. These naphthyridines display characteristic properties in multifarious pharmacological and chemotherapeutic activities. The 3-formylquinolin-2(1*H*) ones are the unique starting precursors for further [b]and [c] annelation for various ring systems and for many functional group interconversions. Many derivatives of naphthyridines and quinolines could be prepared out of them and several of them possess diverse biological properties [1, 5]. It is also known that when one biologically active compound is fused with another ring system, there will be enhanced biological activity. Recently there has been increased interest in the synthesis of Naphthyridine derivatives and their application in medicinal chemistry as quinoline bioisosteres. 1, 8-Naphthyridine and there. Derivatives represent one of the most active classes of compound possessing as wide spectrum of biological activities [6, 7]. 1, 8-Naphthyridine derivatives acquired a special place in the heterocyclic field because of their diversified activities such as antimicrobial [8-12], antiviral, anti-HIV [13, 15], anticancer, cytotoxic [16, 18], antiinflammatory [19], antimalarial [20, 21], antithrombotic [22] and anticipated biological activities [23, 30].
The first representative of the series, since 1, 8-naphthyridine was considered to be the naphthalene analogue of pyridine. Six possible naphthyridines are

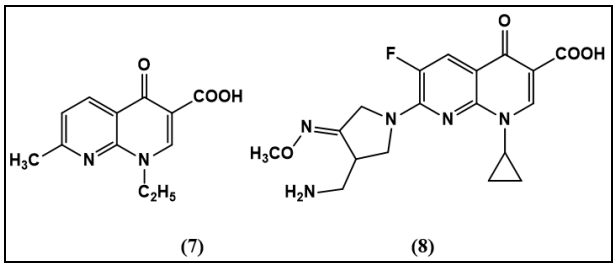


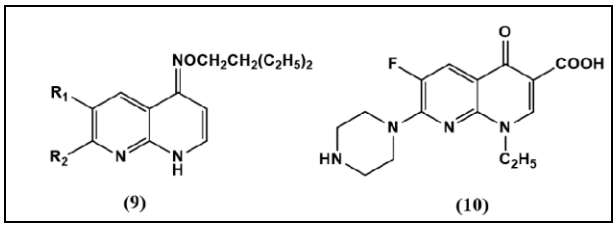
1.8: napthyridine (1)

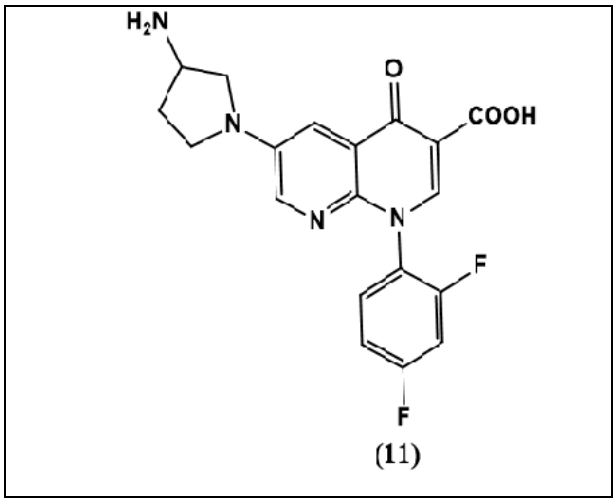
1, 8-Naphthyridine derivatives are reported to possess a wide spectrum of biological activities such as diuretic, antimalarial, anti-inflammatory, antitumor, antihypertensive and antibacterial activites.

1, 8-Naphthyridine derivatives have attracted considerable attention because the 1, 8-naphthyridine skeleton is present in many compounds that have been isolated from natural substances, with various biological activities. Nalidixic acid (7), for example, possesses strong antibacterial activity and used mainly for the treatment of urinary tract infections with gram negative pathogens. In addition, Gatifloxacin (8) is antimicrobial and antibacterial. It is known that (*E*)- and (*Z*)-*O*-(diethyl amino)ethyl oximes of 1,8-naphthyridine series (9) are potential drugs for local anaesthesia8, and 1-(2-fluorobenzyl)-3-(2-tolyl)-1,8-naphthyridin-2(1*H*)-one (10) is used for the treatment of memory disorders, in particular, Alzheimer's disease. 2-Amino-*N*-hydroxy-1, 8-naphthyridine-3-carboxamidine (11) possesses herbicidal properties and used for the selective control of weeds in barley, wheat, maize, sorghum and rice crops.









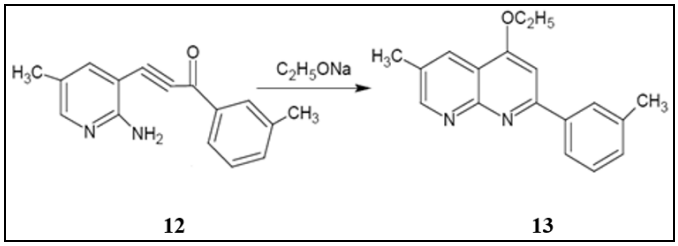
Halogeno-1,8-naphthyridine have proved to be valuable intermediates, halogeno1,8-napthyridine shows different antimicrobial activities. Examples are Enoxacin, Tosufloxacin, Trovafloxaxin etc. 1,8-Naphthyridine derivatives also react with adenosine receptors of subtypes A1 and A2. The important biological properties just described stimulated studies on the synthesis of various functionalized (particularly, at positions 2, 4 and 7) 1, 8-naphthyridines, with the goal of designing new drugs for oral administration. Some 3-phenyl-1,8-naphthyridines which carry piperidyl, piperazinyl or morpholinyl groups or an *N*-diethanolamine side-chain in the 2- or 7- and 2,7- positions have been reported to show significant activity as inhibitors of human platelets aggregation induced by arachidonate and collagen. In addition, 4-(*N*-methylenecyclo alkylamino)-1, 8-naphthyridine derivatives substituted in positions 2 and 7 are effective as anti-hypertensive agents. The 7-Amino-2-(4-carbethoxypiperazin-1-yl)-4-phenyl-1,8-naphthyridine has been synthesized and reported to have marked activity against *Mycobacterium tuberculosis*.

Synthesis of 1,8-naphthyridine

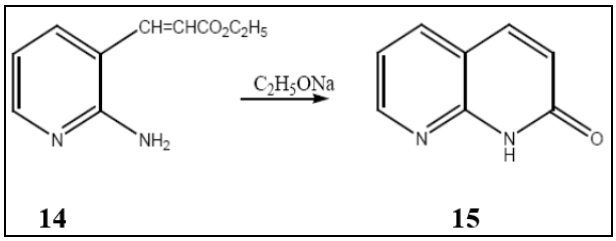
Primary synthesis of 1,8-naphthyridines may be done by cylization of appropriate aliphatic substrates, with or without auxiliary synthons, by cyclization of appropriate substituted pyridines with or without sythons or from other heterocyclic substrates by several process [31-35].

From a single pyridine substrate

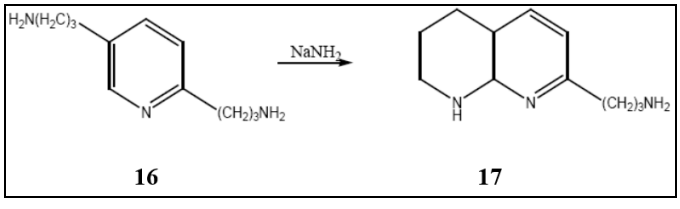
5-Methyl-3-(m-tolylethynyl)-2-pyridinamine (**12**) on treatment with sodium ethoxide in the presence of ethanol on cyclisation produced 4-ethoxy-6-methyl-2-m-tolyl-1, 8-naphthyridine (**13**).



The 3-(2-Ethoxycarbonylvinyl)-2-pyridinamine (14) on treatment with sodium ethoxide underwent cyclisation to form 1, 8-naphthyridin-2(1*H*)-one (15) in ethanol

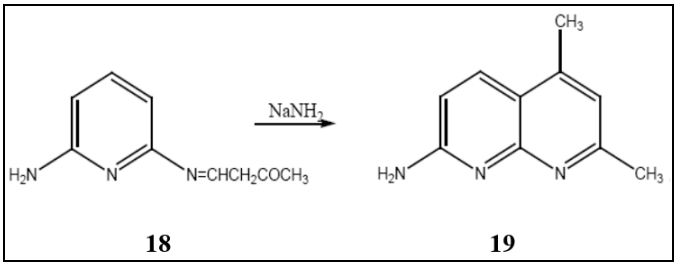


The 2,5-Bis (3-aminopropyl)pyridine (**16**) on treatment with NaNH2 in toluene after cyclisation gave 2-(3-aminopropyl)-1,2,3,4-tetrahydro-1,8-naphthyridine(**17**).



The 6-(2-acetyl-1-methylethylidene) amino-2-pyridinamine (**18**) gives 5, 7-dimethyl-1,8-naphthyridin-2-amine (**19**) after cyclisation on treatment with $NaNH_2$ in presence of

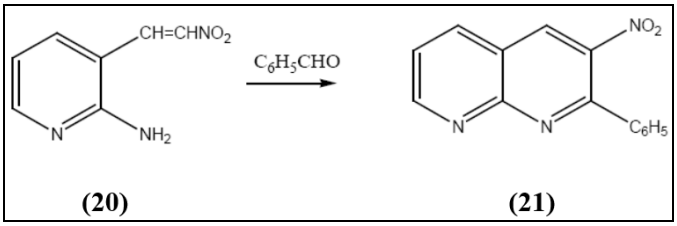
phosphoric acid at 100 °C.



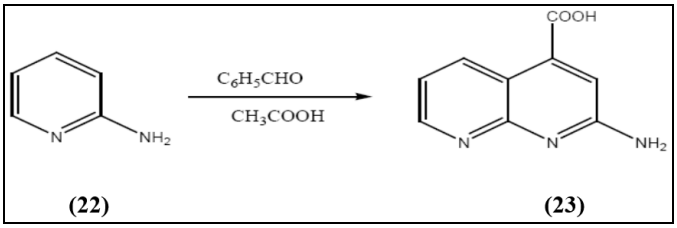
18 **19**

From pyridine substrate and synthon(S)

The 3-(2-Nitrovinyl)-2-pyridinamine (20) underwent condensation with benzaldehyde (Ph CHO) in xylene and gave 3-nitro-2-phenyl-1,8-naphthyridine (21). The 2-Pyridinamine (22) on treatment with benzaldehyde and subsequently with acetic acid produced 2-phenyl-1,8-naphthyridine-4-carboxylic acid (23) in ethanol.

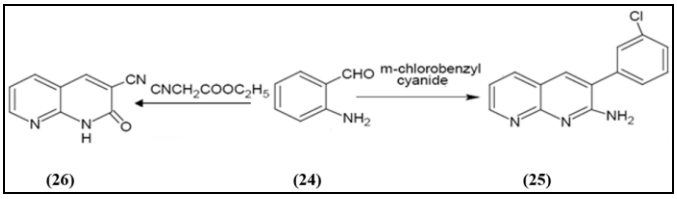


(20) **(21)**



(22) **(23)**

The 2-Amino-3-pyridinecarbonitrile (24) on treatment with m-chlorobenzyl cyanide, KOH/H2O on microwave irradiation produced 3-m-chlorophenyl-1,8 naphthyridin-2-amine (25). The same substrate (24) with ethyl cyano acetate in ethanol and trace amounts of piper dine gave 2-oxo-1, 2-dihydro-1,8-naphthyridine-3-carbonitrile (26).

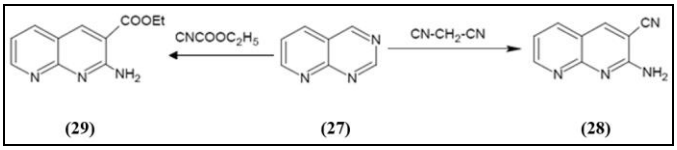


(26) **(24)** **(25)**

From other heterocyclic substrates

Pyrido [2, 3-d] pyrimidine's as substrates

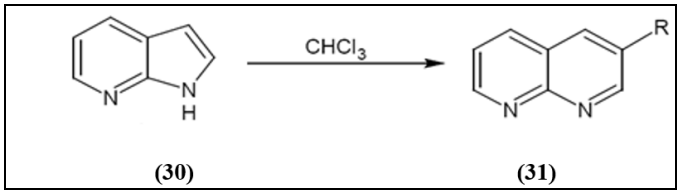
Pyrido [2, 3-d] pyrimidine (27) with malononitrile in methanol, gave 2-amino-1, 8-naphthyridine-3-carbonitrile (28) and with ethyl cyano acetate gave ethyl 2-amino-1, 8-naphthyridine-3-carboxylate.



(29) **(27)** **(28)**

Pyrrolo [2, 3-b] pyridines as substrates

Prolog [2, 3-b] pyridines (30) underwent pyrolysis in chloroform to give a separable mixture of 1, 8-naphthyridine (R=H) and 3-chloro-1, 8-naphthyridine (31) (R= Cl)

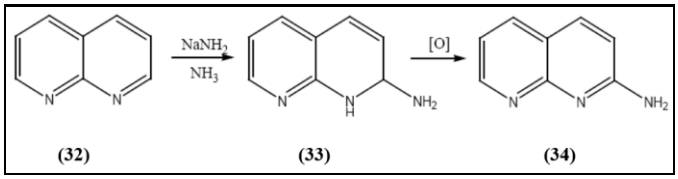


(30) **(31)**

Reactions of 1,8-napthyridines

C-Amination

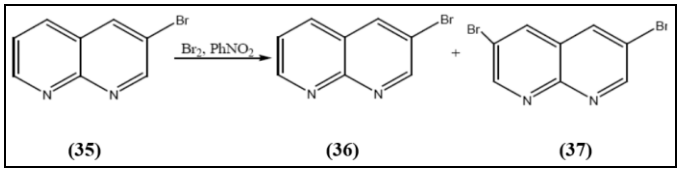
The 1,8-Naphthyridine (**32**) on treatment with $NaNH_2$ in NH_3 and then $KMnO_4$ gave 1,8-naphthyridin-2-amine (**34**) the intermediate dihydro adduct (**33**) was clearly involved



(32) **(33)** **(34)**

Halogenation

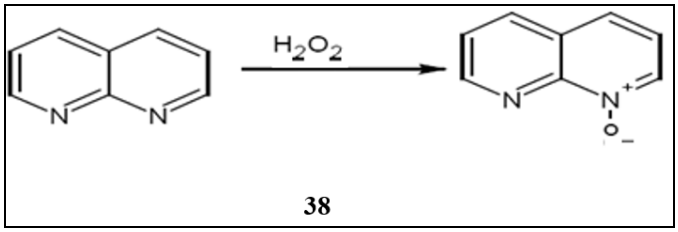
The 1, 8-Naphthyridine hydro bromide (35) gave a separable mixture of 3-bromo-1, 8-naphthyridine (36) and 3, 6-dibrimo-1, 8-naphthyridine (37) on treatment with Br_2 in $PhNO_2$ at 175°C yield was 30% each



(35) **(36)** **(37)**

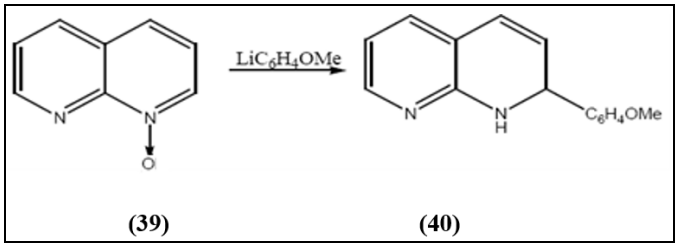
N-oxidation

The 1, 8-napthyridine undergo oxidation in the presence of H_2O_2 and benzoic acid to form its 1-oxide derivative (**38**)



38

The 1, 8-Naphthyridine-1-oxide (39) with o-methoxyphenyllithium gave 2-o-methoxyphenyl-1,8-naphthyridine (40) in diethylether30.



(39) **(40)**

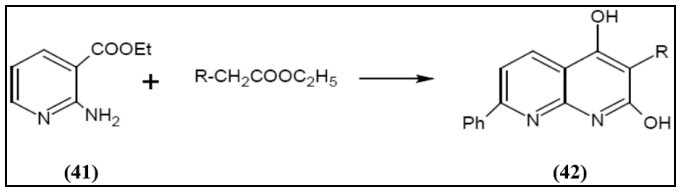
Synthetic routes of 1, 4-napthyridine nucleus

Four routes involved in synthesis of 1, 8-napthyridine ring a) Niementowski synthesis b) Friedlander synthesis c) Reductive cyclization d) Intramolecular nucleophilic cyclization

Niementowski synthesis

In the first route Hitherto31 described was an extension of the

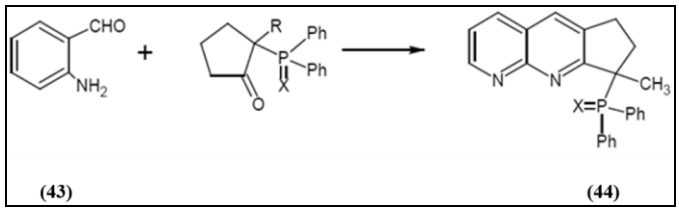
Niementowski synthesis to the preparation of 1, 8-napthyridine-2, 4-diols. 7-phenyl-1, 8-napthyridine-2, 4-diols (42) by the condensation of ethyl-2-amino-6-phenyl nicotianae (41) with simple esters in the presence of sodium.



(41) (42)

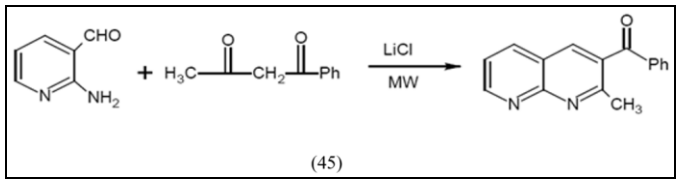
Friedlander synthesis

In the second route Friedlander was described. For the synthesis of [1, 8] naphthyridine derivatives containing phosphorus. The first 2, 3 alkene substituted [1, 8] naphthyridine (44) bearing a phosphorus moiety have been synthesized by the Fried lander annulations of 2-aminonicotinaldehyde (43) with diphenyl phosphoryl cyclopentanones.



(43) (44)

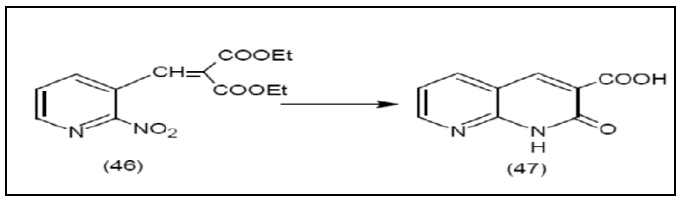
The Friedlander condensation of 2-amino nicotinaldehyde with active methylene compounds in the presence of catalyst Lithium chloride under the two non- conventional methods like microwave Irradiation and by grinding in a mortar afforded the corresponding 1,8-Naphthyridines (45). Both these methodologies are attractive as they are relatively nontoxic, economical and highly effective. The results shows that microwave procedure as slightly superior to the solid-state methods in terms of reduced time period and better yields.



(45)

Reductive cyclization

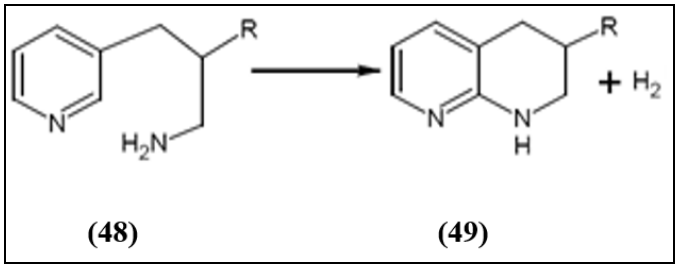
The third route was investigated for synthesis of 1,2-dihydro-1-hydroxy 2-oxo-1,8-napthyridine-3-carboxylate (47) by reductive cyclization of B-(3-nitro-4-pyridyl) acrylic acid (46).



(46) (47)

Intramolecular nucleophilic cyclization

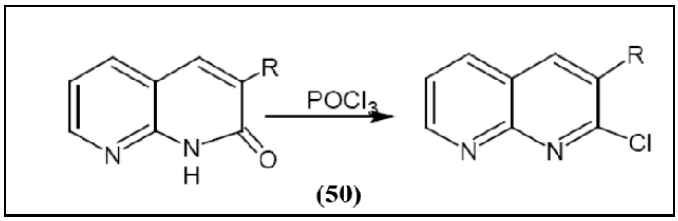
The fourth route was investigated for synthesis of 1, 2.3, 4-Tetrahydro-3-phenyl-1, 8- napthyridine (49) by intramolecular nucleophilc cyclization of a 3-(3-pyridyl)-propylamine (48) in the presence of sodium.



(48) (49)

Preparation of halogeno-1, 8-napthyridine Halogenolysis of 1, 8-naptyridinones

The 1, 8-napthyridine-2-one reacts with phosphoryl chloride in microwave Irraidation forms 2-chloro-3-substituted-1,8-naphthyridine(50).35

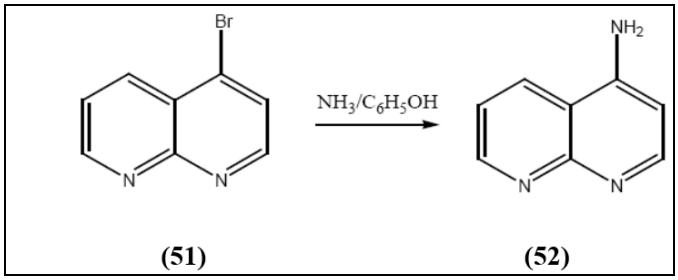


(50)

Reactions of halogeno-1, 8-napthyridine

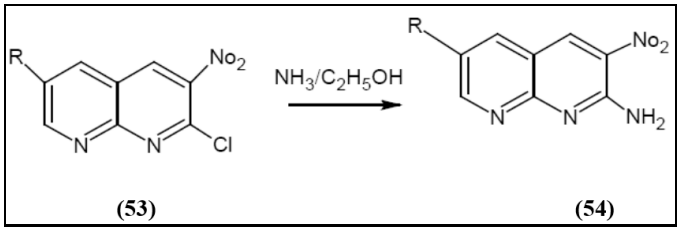
Aminolysis

The 4-Bromo-1, 8-naphthyridine (51) gave 1, 8-naphthyridin-4-amine (52) on treatment with NH_3 in phenol at 170 °C.



(51) (52)

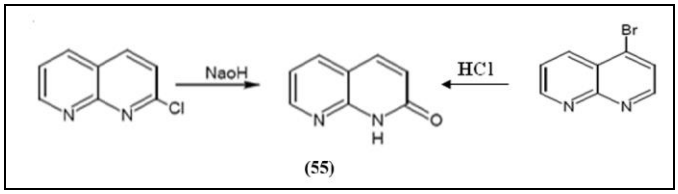
The 2-chloro-3-nitro-1,8-naphthyridine (**53**) gave 3-nitro-1,8-naphthyridin-2-amine (54) on treatment with NH3 in ethanol at 110 °C.



(53) (54)

Hydrolysis

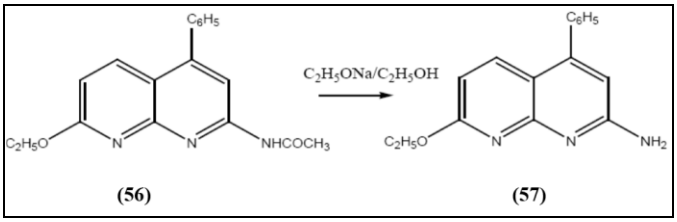
In alkaline hydrolysis 2-chloro-1,8-napthyridine reacts with NaOH to from 1,8-napthyridine-2-(1H)-one (55). In acidic condition 4-bromo-1, 8-napthyridine with Hcl to from 1,8-napthyridine-2(1H)-one.



(55)

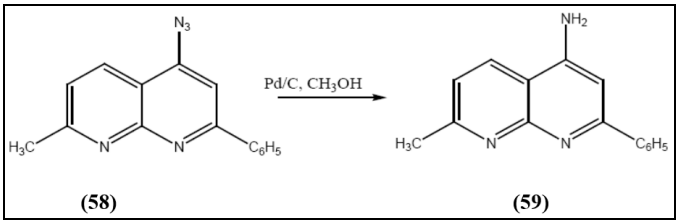
1.4 Preparation of amino-1,8-naphthyridine
From Acylamino-1,8-naphthyridine

The 2-Acetamido-7-ethoxy-4-phenyl-1,8-naphthyridine (56) reflux with sodium ethoxide in ethanol gave 7-ethoxy-4-phenyl-1,8-naphthyridin-2-amine (57).



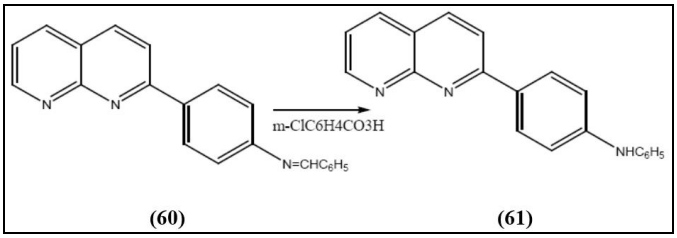
Conversion of a zido to amino naphthyridine

The 4-Azido-7-methyl-2-phenyl-1, 8-naphthyridine (**58**) gave 7-methyl-2-phenyl-1,8-naphthyridin-4-amine (**59**) with Pd/C in methanol, H_2O at 20°C.

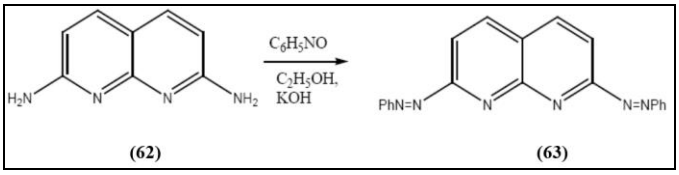


Reactions of amino-1,8-naphthyridine

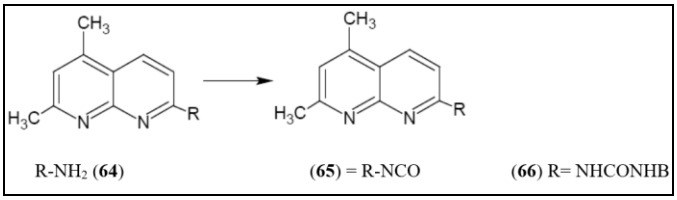
The 2-p-(Benzylideneamino) phenyl-1,8-naphthyridine (**60**) underwent oxidation to give 2-p-benzamidophenyl-1,8-naphthyridine (**61**) on treatment with m-$ClC_6H_4CO_3H$.



The 1, 8-Naphthyridine-2,7-diamine (62) with nitrobenzene gave 2,7-bis phenyl azo-1,8-naphthyridine (63) on treatment with alcoholic KOH in H_2O.

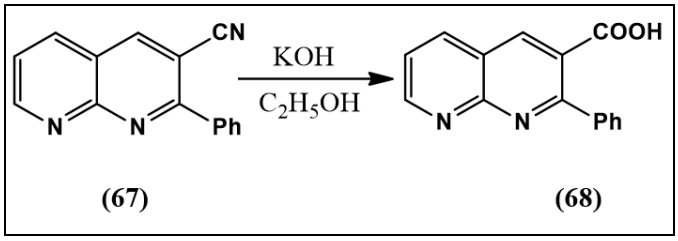


The 5,7-Dimethyl-1,8-naphthyridin-2-amine (64, R=NH_2) gave 2-isocyanato-5,7-dimethyl-1,8-naphthyridine (65, R=NCO) as a minor product (7%) via an imidazole[1,2-a][1,8]naphthyridine intermediate. The same substrate (64, R=NH_2) with butyl is ocyanate afforded 2-N-butylureido-5,7-dimethyl-1,8-naphthyridine (66, R=NHCONHBu) on reflux with toluene.



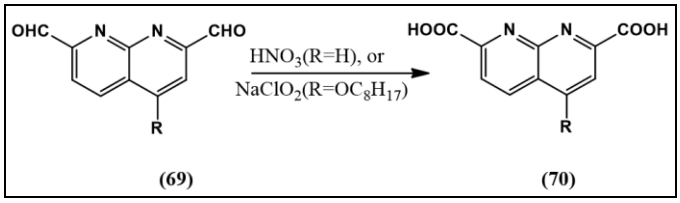
Preparation of 1, 8-naphthyridine carboxylic acid
By hydrolysis of 1, 8-naphthyridinecarbonitriles

The 2-Phenyl-1,8-naphthyridine-3-carbonitrile (67, R=CN) gave the corresponding 3-carboxylic acid (68, R= CO2H) on reflux with alcoholic KOH in water for 14 h at 70 °C, the yield was found to be 76%.



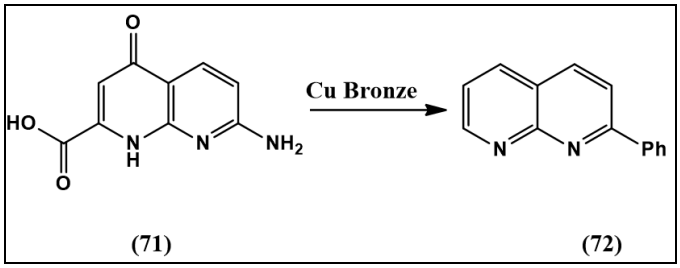
By oxidation of 1,8-naphthyridinecarbaldehydes

The 1,8-Naphthyridine-2,7-dicarbaldehyde (69, R=H) gave 1,8-naphthyridine-2,7-dicarboxylic acid (70, R=H) on refluxing with 80% HNO_3.



Reaction of 1, 8-naphthyridine carboxylic acid Decarboxylation

The 7-Amino-4-oxo-1, 4-dihydro-1,8-naphthyridine-2-carboxylic acid (71) gave 2-phenyl-1,8-naphthyridine (72) on treating with Cu bronze at 260 °C.



Conclusion

Drug discovery research is a highly creative and stimulating work environment where people are driven to succeed by personal and scientific objectives. Many heterocycles have important pharmaceutical properties and biological applications like used as pharmaceuticals, agro chemicals and veterinary products. They are also used as optical brightening agents, as antioxidants, as copolymers, solvents, photographic sensitizers, corrosion inhibitors and additives with a variety of other functions [36-40]. Many dye stuffs and pigments have heterocyclic structures.

Conflict of Interest

Not available

Financial Support

Not available

References

1. Lowe PA. Comprehensive Heterocyclic Chemistry, Vol.II, (Pergamon Press Ltd, Oxford, Newyork); c1984, pp 581.

2. Badawneh M, Ferrarini PL, Calderone V, Manera C, Martinotti E, Mari C, *et al*. Synthesis and evaluation of antihypertensive activity of 1,8-naphthyridine derivatives. Part X. Eur. J. Med. Chem. 2001;36:925-934.
3. Bouzard D, DiCesare P, Essiz M, Jacquet JP, Ledoussa B, Remuzon P, *et al*. Fluoronaphthyridines as antibacterial agents. 4. Synthesis and structure-activity relationships of 5-substituted-6-fluoro-7-(cycloalkylamino)-1,4-dihydro-4-oxo-1,8 naphthyridine-3-carboxylicacids. J. Med. Chem., 1992; 35: 518-525.
4. Litvinov VP. Chemistry and biological activities of 1,8-naphthyridines. Russ. Chem. Rev. 2004;73:637-670.
5. Roma G, Braccio MD, Grassi G, Mattioh F, Ghai M. 1,8-Naphthyridines IV. 9-substituted N,N-dialkyl-5-(alkylaminoorcyclo alkylamino) [1,2,4]triazolo[4,3-a] [1,8] naphthyridine-6-carboxamides, new compounds with anti-aggressive and potent anti-inflammatory activities. Eur. J. Med. Chem. 2000;35:1021-1035.
6. Zhang SX, Bastow KF, Tachibana Y, Kuo SC, Hamel E, Mauger A, *et al*. Antitumoragents. 196. Substituted2-thienyl-1,8-naphthyridin-4-ones: their synthesis, cytotoxicity, and inhibition of tubulin polymerization. J. Med. Chem., 1999;42:4081-4087.
7. Thamaraiselvi SN. Solid-state synthesis and characterization of benzo[g][1,8]naphthyridin-2,4-diones. Int. J. Recent Sci. Res. 2013;4(1):71-73.
8. Suresh T, Dhanabal T, Kumar NR, Mohan PS. Synthesis, characterization and antimicrobial activities of fused 1,6-naphthyridines. Indian J. Chem., 2005;44B:2375-2379.
9. Cohen MA, Huband MD, Mailloux GB, Yoder SL, Roland GE, Domagala JM, *et al*. *In vitro* antibacterial activities of PD 131628, a new 1,8-naphthyridine anti-infective agent. Antimicrob Agents Chemother. 1991;35(1):141-146.
10. Guinea J, Gargallo-Viola D, Robert M, Tudela E, Xicota MA, Garcia J, *et al*. E-4695, a new C-7 azetidinyl fluoronaphthyridine with enhanced activity against gram-positive and anaerobic pathogens. Antimicrob. Agents Chemother. 1995;39(2):413-421.
11. Abbanat D, Webb G, Foleno B, Li Y, Macielag M, Montenegro D, *et al*. *In vitro* Activities of Novel 2-Fluoro-Naphthyridine-Containing Ketolides. Antimicrob. Agents Chemother. 2005;49(1):309-315.
12. Nagate T, Kurashige S, Mitsuhashi S. *In vitro* and *in vivo* antibacterial activity of AB206, a new naphthyridine derivative. Antimicrob Agents Chemother. 1980;17(2):203-208.
13. Bedard J, May S, L'Heureux L, Stamminger T, Copsey A, Drach J, *et al*. Antiviral Properties of a Series of 1,6-Naphthyridine and 7,8-Dihydroisoquinoline Derivatives Exhibiting Potent Activity against Human Cytomegalovirus. Antimicrob Agents Chemother. 2000;44(4):929-937.
14. Zhao XZ, Smith SJ, Métifiot M, Marchand C, Boyer PL, Pommier Y, *et al*. 4-Amino-1-hydroxy-2-oxo-1,8-naphthyridine-Containing Compounds Having High Potency against Raltegravir-Resistant Integrase Mutants of HIV-1. J. Med. Chem. 2014;57(15):6885.
15. Hombrouck A, Voet A, Remoortel BV, Desadeleer C, De Maeyer M, Debyser Z, *et al*. Mutations in Human Immunodeficiency Virus Type 1 Integrase Confer Resistance to the Naphthyridine L-870,810 and Cross-Resistance to the Clinical Trial Drug GS-9137. Antimicrob Agents Chemother. 2008;52(6):2069-2078.
16. Hwang YJ, Chung ML, Sohn UD, Im C. Cytotoxicity and Structure-activity Relationships of Naphthyridine Derivatives in Human Cervical Cancer, Leukemia, and Prostate Cancer. Korean J Physiol. Pharmacol. 2013;17(6):517-523.
17. Kiselev E, Dexheimer T, Pommier Y, Cushman M. Design, Synthesis and Evaluation of Dibenzo[c,h][1,6]naphthyridines as Topoisomerase I Inhibitors and Potential Anticancer Agents. J Med. Chem. 2010;53(24):8716-8726.
18. Ahmed NS, Alfooty KO, Khalifah SS. An Efficient Sonochemical Synthesis of Novel Schiff's Bases, Thiazolidine, and Pyrazolidine Incorporating 1,8-Naphthyridine Moiety and Their Cytotoxic Activity against HePG2 Cell Lines. Sci. World J. 2014;2014:587059.
19. Dianzani C, Collino M, Gallicchio M, Di Braccio M, Roma G, Fantozzi R. Effects of anti-inflammatory[1,2,4]triazolo[4,3-a][1,8]naphthyridine. Derivatives on human stimulated PMN and endothelial cells: an *in vitro* study. J Inflamm. (Lond). 2006;3:4.
20. Olepu S, Suryadevara PK, Rivas K, Yokoyama K, Verlinde CLMJ. Chakrabarti D. *et al*. 2-Oxo-tetrahydro-1,8-naphthyridines as Selective Inhibitors of Malarial Protein Farnesyltransferase Inhibitors and as Antimalarials. Bioorg. Med. Chem. Lett. 2008;18(2):494-497.
21. Zhu S, Zhang Q, Gudise C, Meng L, Wei L, Smith E. *et al*. Synthesis and Evaluation of Naphthyridine Compounds as Antimalarial Agents. Bioorg. Med. Chem. Lett. 2007;17(22):6101-6106.
22. Ott H, Smith GM. Anti-thrombotic activity of a benzo(c)(1,6)naphthyridine. Br. J Pharmacol. 1971;43(2):460P-461P.
23. Bernardino AMR, Azevedo AR, Pinheiro LCS, Borges JC, Paixão ICP, Mesquita M, *et al*. Synthesis and anti-HSV-1 evaluation of new 3H-benzo[b] pyrazolo[3,4-h]-1,6-naphthyridines and 3H-pyrido[2,3-b]pyrazolo[3,4-h]-1,6-naphthyridines. Org. Med. Chem. Lett. 2012;2:3.
24. Hagihara S, Kumasawa H, Goto Y, Hayashi G, Kobori A, Saito I. *et al*. Detection of guanine–adenine mismatches by surface plasmon resonance sensor carrying naphthyridine–azaquinolone hybrid on the surface. Nucleic Acids Res. 2004;32(1):278-286.
25. Dubost E, Dumas N, Fossey C, Magnelli R, Butt-Gueulle S, Ballandonne C. *et al*. Synthesis and Structure-Affinity Relationships of Selective High-Affinity 5-HT4 Receptor Antagonists: Application to the Design of New Potential Single Photon Emission Computed Tomography (SPECT) Tracers. J Med. Chem. 2012;55(22):9693-9707.
26. Almansour AI, Kumar RS, Arumugam N, Basiri A, Kia Y, Ali MA. An Expedient Synthesis, Acetylcholinesterase Inhibitory Activity, and Molecular Modeling Study of Highly Functionalized Hexahydro-1,6-naphthyridines. Biomed. Res. Int. 2015;2015:965987.
27. Parhi AK, Zhang Y, Saionz KW, Pradhan P, Kaul M, Trivedi K. *et al*. Antibacterial activity of quinoxalines, quinazolines, and 1,5-naphthyridines. Bioorg. Med. Chem. Lett. 2013;23(17):4968-4974.
28. Kiselev E, Empey N, Agama K, Pommier Y, Cushman M. Dibenzo [c,h] [1,5] naphthyridinediones as Topoisomerase I Inhibitors: Design, Synthesis and Biological Evaluation. J Org. Chem. 2012;77(11):5167-5172.
29. Zhao XZ, Smith SJ, Métifiot M, Marchand C, Boyer PL, Pommier Y, *et al*. Correction to 4-Amino-1-hydroxy-2-oxo-1,8-naphthyridine-Containing Compounds Having High Potency against Raltegravir-Resistant Integrase

Mutants of HIV-1. J. Med. Chem. 2014;57(12):5190-5202.
30. Hamilton PB, Rosi D, Peruzzotti GP, Nielson ED. Microbiological Metabolism of Naphthyridines. Appl. Microbiol. 1969;17(2):237-241.
31. Fadel S, Hajbi Y, Khouili M, Lazar S, Suzenet F, Guillaumet G. Synthesis of 3,4-dihydro-1,8-naphthyridin-2(1H)-ones via microwave-activated inverse electron-demand Diels–Alder reactions. Beilstein J Org. Chem. 2014;10:282-286.
32. Fang Y, Larock RC. Nucleophilic addition to 2,3-pyridyne and synthesis of benzo-naphthyridinones. Tetrahedron. 2012;68(13):2819-2826.
33. Woo GHC, Beeler AB, Snyder JK. 1,2,3,4-Tetrahydro-1,5-naphthyridines and related heterocyclic scaffolds: Exploration of suitable chemistry for library development. Tetrahedron. 2007;63(25):5649-5655.
34. Jiang B, Fan W, Sun MY, Ye Q, Wang SL, Tu SJ, *et al*. Domino Reaction of Arylglyoxals with Pyrazol-5-amines: Selective Access to Pyrazolo-Fused 1,7-Naphthyridines, 1,3-Diazocanes, and Pyrroles. J Org. Chem. 2014;79(11):5258-5268.
35. Zhang Y, Illarionov B, Bacher A, Fischer M, Georg GI, Ye QZ, *et al*. A Novel Lumazine Synthase Inhibitor Derived from Oxidation of 1,3,6,8-Tetrahydroxy-2,7-naphthyridine to a Tetraazaperylenehexaone Derivative. J Org. Chem. 2007;72(8):2769-2776.
36. Sato Y, Nishizawa S, Yoshimoto K, Seino T, Ichihashi T, Morita K, *et al*. Influence of substituent modifications on the binding of 2-amino-1,8-naphthyridines to cytosine opposite an AP site in DNA duplexes: thermodynamic characterization. Nucleic Acids Res. 2009;37(5):1411-1422.
37. Shen LL, Black-Schaefer C, Cai Y, Dandliker PJ, Beutel, BA. Mechanism of Action of a Novel Series of Naphthyridine-Type Ribosome Inhibitors: Enhancement of tRNA Footprinting at the Decoding Site of 16S rRNA. Antimicrob Agents Chemother. 2005;49(5):1890-1897.
38. Deeba F, Khan MA, Zia-ur-Rehman M, Şahin E, Çaylak N. N′-[(E)-Benzyl¬idene]-1-ethyl-7-methyl-4-oxo-1,4-dihydro-1,8-naphthyridine-3-carbohydrazide. Acta Crystallogr. Sect. E Struct. Rep. Online. 2009;65(Pt 12):o3152-o3153.
39. Liang F, Lindsay S, Zhang P. 1,8-Naphthyridine-2,7-diamine: A Potential Universal Reader of the Watson-Crick Base Pairs for DNA Sequencing by Electron Tunneling. Org. Biomol. Chem. 2012;10(43):8654-8659.
40. Malfitano AM, Laezza CD, Alessandro A, Procaccini C, Saccomanni G, *et al*. Effects on Immune Cells of a New 1,8-Naphthyridin-2-One Derivative and Its Analogues as Selective CB2 Agonists: Implications in Multiple Sclerosis. PLoS One. 2013;8(5):e62511.

How to Cite This Article
Asif M, Hafeez A. A brief study of synthetic, chemical and pharmacological activities of naphthyridine derivatives: A mini review. International Journal of Chemical and Biological Sciences. 2022;4(1):36-42.