Archive of SID.ir

Received: 25 November 2021 | Revised: 08 January 2022 | Accepted: 15 January 2022
DOI: 10.22034/ecc.2022.316819.1270
Eurasian Chemical Communications
SAMI

FULL PAPER

Anticancer activity of new 3-secondary amine derivatives containing fused rings of the imidazopyridine

Ahmed Zamil Hattab*[a] |Naeemah Al-Lami[a] |Jaafar Suhail Wadi[b]

[a]*Department of Chemistry, College of Sciences, University of Baghdad, Baghdad, Iraq*

[b]*Department of Pharmacology, College of Pharmacy, Al-Rafidain University, Baghdad, Iraq*

I_2 promoted one-pot protocol was suggested previously for the synthesis of 2-aryl-3-(pyridine-2-ylamino)imidazo[1,2-*a*]pyridine from 2-aminopyridine with different substituted acetophenone for the synthesis of secondary amine derivatives (a1-a6) compounds. After that, the secondary amine derivatives are reacted with propargyl bromide producing propargylamines (b1-b6) compounds. All synthesized compounds were characterized via FT-IR spectroscopy, some of which were characterized by ^{1}H-NMR spectroscopy and ^{13}C-NMR spectroscopy. Two of imidazo(1,2-a) pyridine derivatives were tested for cytotoxic activity against leukaemia cancer using MTT assay.

***Corresponding Author:**
Ahmed Zamil Hattab
Email: ahmedzamel90@gmail.com
Tel.: 07901749547

KEYWORDS

One-pot; sec.amine imidazo(1,2-a)pyridine; propargyl derivatives; anti-cancer activity.

Introduction

Heterocyclic compounds are of main interest in medicinal chemistry. The most complex branches of chemistry are normally heterocyclic chemistry. Most synthetic heterocyclic compounds act as a drug and are used as anticonvulsants, hypnotics, antineoplastic, antiseptics, antihistaminic, antiviral, anti-tumor. Every year many heterocyclic drugs are being introduced in the pharmacopoeia [1-2]. Among the various medical applications, heterocyclic compounds have a significant active role as antiviral [3], antibacterial [4-5], anti-inflammatory [6], anti-fungal [7], and anti-tumor drugs [8-10]. propargyl amines were synthesized by the reaction of disubstituted imidazo[1,2-a]pyridine (2-aryl-3-pyridine-2-ylamino imidazo(1,2-a)pyridine) derivatives with propargyl bromide. Propargylamines are widely used in organic synthesis to form diverse heterocyclic compounds [11], natural products, and bioactive compounds [12-14]. These compounds have a significant role in many pharmaceutical and biological applications, such as anti-cancer [15], antibacterial [16], anti-fungal [17], antiproliferative [18]. Conventional synthesis methods of propargyl amines involve amination of propargylic halides, phosphates, or triflates [19-21] and the reaction of lithium acetylides or Grignard reagents with imines or their derivatives [22,23]. Multi-component reactions are significant and desired because they produce several bonds in a one-pot, have a high atom economy, are gentle and simple

Archive of SID.ir

Archive of SID.ir

to perform, and are ecologically friendly. The Strecker reaction, which was discovered in 1850 and was the first multicomponent reaction (MCR), was one of the most important reactions, especially in the life science perspective [24].

Materials and methods

Experimental Instruments

A. Melting point was recorded using electrothermal melting point apparatus.
B. The (^{1}H and ^{13}C NMR) spectra were recorded on Bruker ultra-shield 500MHz spectrometer using DMSOd6 as solvent as an internal standard.
C. Chemical shift values are listed in δ scale. The IR spectra were recorded on
Schimadzu FTIR spectrophotometer by using potassium bromide discs.
D. Cytotoxic effect of some compounds on HL-60 cell line (human leukemia cell line) in Vitro Using MTT Assay.

Synthesis of 2-aryl-3-(pyridine-2-ylamino)imidazo[1,2-*a*]pyridines (General procedure) (Figure 1)[25].

A mixture of acetophenones (0.005 mol) and I_2 (0.01 mol) in DMSO (25 mL) was heated under reflux at 100 °C for 3 h. After that, 2- aminopyridine (0.0075 mol) was added and then heated for an additional 3 h. The resulting solution was cooled and poured to crushed ice. The formed precipitate was filtered and purified with the water for 3 h and dry precipitate after that purified by ethanol to obtain compounds. The characterization data of the compounds are given below (Table 1).

2-Phenyl-N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine (a1)

Elemental analysis was as follows: $C_{18}H_{14}N_4$ IR (KBr /cm^{-1}): 3145(N-H), 3060 (Ar-H), 1600(C=N) imidazo, 1573(C=C). ^{1}H-NMR (DMSO,500 MHZ) δ (ppm): 6.78-8.45 (m, Ar-H), δ 10.18(s,1H, NH) ^{13}C-NMR (DMSO, 500 MHZ) δ(ppm):154.1-134.8 (C=N) 129.2-107.1 (C=C).

2-(4-Bromophenyl)-N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine (a2)

Elemental analysis was as follows: $C_{18}H_{13}BrN_4$ IR (KBr/cm^{-1}): 3251(N-H), 3070(Ar-H), 1631(C=N)imidazo, 1595(C=C), 754(C-Br), ^{1}H-NMR (DMSO,500 MHZ) δ(ppm): 6.77-8.46 (m, Ar-H), δ 10.18(s,1H, NH) ^{13}C-NMR (DMSO, 500MHZ) δ(ppm):154.5-134.8(C=N), 132.1-107.8(C=C),123.1(C-Br)

2-(4-Nitrophenyl)-N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine (a3)

Elemental analysis was as follows: $C_{18}H_{13}N_5O_2$ IR (KBr/cm^{-1}): 3236(NH-), 3072(Ar-H), 1600(C=N) imidazo, 1575(C=C), 1519 and 1344(NO2). ^{1}H-NMR (DMSO,500 MHZ) δ(ppm): 6.71-8.41 (m, Ar-H), δ 10.18(s,1H, NH) and ^{13}C-NMR (DMSO, 500 MHZ) δ(ppm): 134.8-154.8(C=N), 107.3-138.3 (C=C), 147.9(C-NO2).

2-(4-Chlorophenyl)-N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine (a4)

Chemical Formula: $C_{18}H_{13}ClN_4$ IR (KBr/cm^{-1}): 3245(N-H), 3099(Ar-H), 1623(C=N)imidazo, 1591(C=C), 744(C-Cl), ^{1}H-NMR (DMSO,500 MHZ) δ(ppm): 6.72-8.43 (m, Ar-H), δ 10.18(s,1H, NH), ^{13}C-NMR (DMSO, 500 MHZ) δ(ppm): 134.8-154.8(C=N), 107.3-138.3 (C=C), 134.3(C-Cl).

2-(4-Aminophenyl)-N-(pyridin-2-yl) imidazo[1,2-a]pyridin-3-amine (a5)

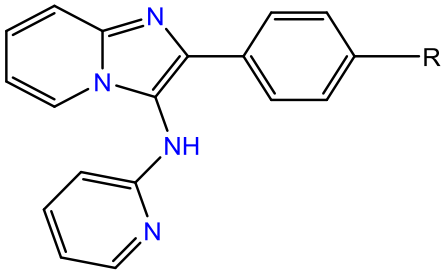
Elemental analysis was as follows: $C_{18}H_{15}N_5$ IR (KBr/cm^{-1}): 3396 and 3332 (NH2), 3226(NH), 3064(Ar-H), 1620(C=N)imidazo, 1593 and 1566(C=C) ^{1}HNMR (DMSO,500 MHZ) δ(ppm): 6.51-8.60 (m, Ar-H), δ 10.18(s,1H, NH), δ 5.41(s, 2H, NH2). ^{13}C-NMR (DMSO, 500 MHZ) δ(ppm): 134.8-153.8(C=N), 108.3-138.3 (C=C), 142.6(C-NH_2).

Archive of SID.ir

Archive of SID.ir

4-(3-(Pyridin-2-ylamino)imidazo[1,2-a]pyridin-2-yl)phenol (a6)

Elemental analysis was as follows: $C_{18}H_{14}N_4O$ IR (KBr/cm^{-1}): 3429(OH), 3114(NH), 3080(Ar-H), 1604(C=N)imidazo, 1579(C=C); ^{1}H-NMR (DMSO,500 MHZ) δ(ppm): 6.82-8.26 (m, Ar-H), δ 10.18(s,1H, NH), δ 9.71 (s, OH). ^{13}C-NMR (DMSO, 500 MHZ) δ(ppm): 134.8-158.8(C=N), 107.3-138.3 (C=C), 158.5(C-OH).



(a1- a6)

FIGURE 1 structural of 2-aryl-3-(pyridine-2-ylamino)imidazo[1,2-*a*]pyridine (a1-a6)

TABLE 1 Physical properties of compounds (a1-a6)

Compound .No.	R	Molecular Formula	Melting point (C^0)	Color	Yield (%)
a1	-H	$C_{18}H_{14}N_4$	160-163	Brown dark	60
a2	-Br	$C_{18}H_{13}BrN_4$	154-157	brown	70
a3	-NO_2	$C_{18}H_{13}N_5O_2$	128-130	brown	75
a4	-Cl	$C_{18}H_{13}ClN_4$	150-154	Brown dark	50
a5	-NH2	$C_{18}H_{15}N_5$	172-175	olive dark	80
a6	-OH	$C_{18}H_{14}N_4O$	130-133	brown	80

Synthesis of propargylamines compounds (General procedure) (b1-b6) (Figure 2) [26]

To a mixture of compounds (a1-a6) (0.003 mol) and K_2CO_3 (0.003 mol) in DMF (25 mL) solvent for (1/2 – 1) h, propargylbromide no. of moles (2-3 mL) and add from toluene (1.5-2.5 mL) in that same time was added at (40 - 50) C^0 temperature. The reaction mixture was refluxed for 24 h. After the reaction ended, the mixture was poured into crushed ice and stirred for 15 minutes. The formed precipitate was filtered and purified by diethyl ether to obtain compounds, yield 60% and m.p 128-130C^0 properties. The characterization data of the compounds are given below **(**Table 2).

Spectroscopy of prepared compounds was as follows:

2-Phenyl-N-(prop-2-yn-1-yl)-N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine (b1)

$C_{21}H_{16}N_4$ IR (KBr/cm^{-1}): 3303(C≡C-H), 2123(C≡C), 1593(C=N) imidazo, 1508(C=C) ^{1}H-NMR (DMSO,500 MHZ) δ(ppm): 8.83-6.67(m, Ar-H), 4.67(s,2H, CH2), 3.08(s,1H, C≡C-H). ^{13}C-NMR (DMSO, 500 MHZ) δ(ppm): 161.3-134.4(C=N), 138.6-109.3(C=C), 78, 73(C≡C), 43.3(CH2).

2-(4-Bromophenyl)-N-(prop-2-yn-1-yl)-N-(pyridin-2-yl) imidazo[1,2-a] pyridin-3-amine .....(b2)

Elemental analysis was as follows: $C_{21}H_{15}BrN_4$ IR (KBr/cm^{-1}): 3285(C≡C-H), 2123 (C≡C), 1637(C=N) imidazo, 1587 (C=C), 754 (C-Br) ^{1}H-NMR (DMSO,500 MHZ) δ(ppm): 8.43-6.95(m. Ar-H), 4.69(s.2H, CH2), 3.02(s,1H, C≡C-H), ^{13}C-NMR (DMSO, 500 MHZ) δ(ppm): 162.2- 134.3(C=N), 138.7-109.4(C=C), 78.4,73.1(C≡C), 43.3(CH2),123(C-Br).

Archive of SID.ir

Archive of SID.ir

2-(4-Nitrophenyl)-N-(prop-2-yn-1-yl)-N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine……(b3)

Elemental analysis was as follows: $C_{21}H_{15}N_5O_2$ IR(KBr/cm^{-1}): 3267(C≡C-H), 2125(C≡C), 1635(C=N)imidazo, 1598(C=C), 1431,1344(NO_2), ^{1}H-NMR (DMSO,500 MHZ) δ(ppm): 8.83-6.87(m. Ar-H), 4.67(s, 2H, CH2), 3.09(s. 1H, C≡C-H), ^{13}C NMR (DMSO, 500 MHZ) δ(ppm): 161.5-134.4(C=N), 137.9109.7(C=C), 77.9,73.3(C≡C),148.5(C-NO_2).

2-(4-Chlorophenyl)-N-(prop-2-yn-1-yl)-N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine …….(b4)

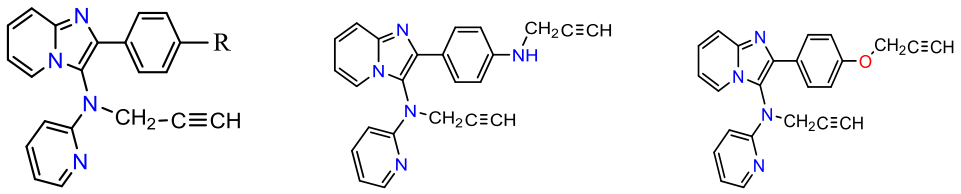
Elemental analysis was as follows: $C_{21}H_{15}ClN_4$ IR (KBr/cm-1): 3245(C≡C-H), 2183 (C≡C), 1616(C=N)imidazo, 1556,1514(C=C) 743(C-Cl), ^{1}H-NMR (DMSO,500 MHZ) δ(ppm): 8.44-6.59(m. Ar-H), 4.68(s.2H, CH2), 3.08(s,1H, C≡C-H), ^{13}C-NMR (DMSO, 500 MHZ) δ(ppm): 161.2-134.3(C=N), 138.7-109.4(C=C), 78.4,73.1(C≡C), 43.3(CH2),134.1(C-Cl).

N-(prop-2-yn-1-yl)-2-(4-(prop-2-yn-1-ylamino)phenyl)-N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine (Equation 1)……..*(b5)*

Elemental analysis was as follows: $C_{27}H_{21}N_5$ IR (KBr/cm-1): 3284,(C≡C-H), 2123(C≡C), 1610(C=N)imidazo, 1581 (C=C). ^{1}H-NMR (DMSO, 500 MHZ) δ(ppm): 8.35 - 6.51(m, Ar-H), 4.68(s, 2H, CH2), 3.9(s, 2H, CH2), 3.09(s, 1H, C≡C-H). ^{13}C-NMR (DMSO, 500 MHZ) δ(ppm): 161.3-134.4(C=N), 138.2-109.3(C=C), 76.5 75,70.3(C≡C), 48.3, 32.5(2CH2),149(C-NH).

N-(prop-2-yn-1-yl)-2-(4-(prop-2-yn-1-yloxy)phenyl)-N-(pyridin-2-yl)imidazo[1,2-a]pyridin-3-amine ……(b6)

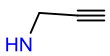
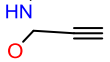
Elemental analysis was as follows: $C_{24}H_{18}N_4O$ IR(KBr/cm-1): 3280(C≡C-H), 2119(C≡C), 1637(C=N)imidazo, 1595(C=C). ^{1}H-NMR (DMSO,500 MHZ) δ(ppm): 8.42-6.20(m, Ar-H), 4.66(s, 2H, CH2) 3.52-3.09(s, 1H, C≡C-H). ^{13}C-NMR (DMSO, 500 MHZ) δ(ppm): 161.3-139.2(C=N), 137.9-110(C=C), 78.7-71.3(C≡C), 53.3,40.3(CH2).



(1b - 4b) (5b) (6b)

FIGURE 2 Chemical structures of propargyl derivativs of imidazo pyridine

TABLE 2 Physical properties of compounds (b1-b6)

Compound .No.	R	Molecular Formula	Melting point (C⁰)	Color	Yield (%)
b1	-H	$C_{21}H_{16}N_4$	**130-128**	black	60
b2	-Br	$C_{21}H_{15}BrN_4$	**234-232**	brown	65
b3	-NO_2	$C_{21}H_{15}N_5O_2$	**179-175**	Dark brown	80
b4	-Cl	$C_{21}H_{15}ClN_4$	oily	brown	50
b5		$C_{27}H_{21}N_5$	**295-293**	brown	80
b6		$C_{24}H_{18}N_4O$	**184-182**	brown	79

Results and discussion

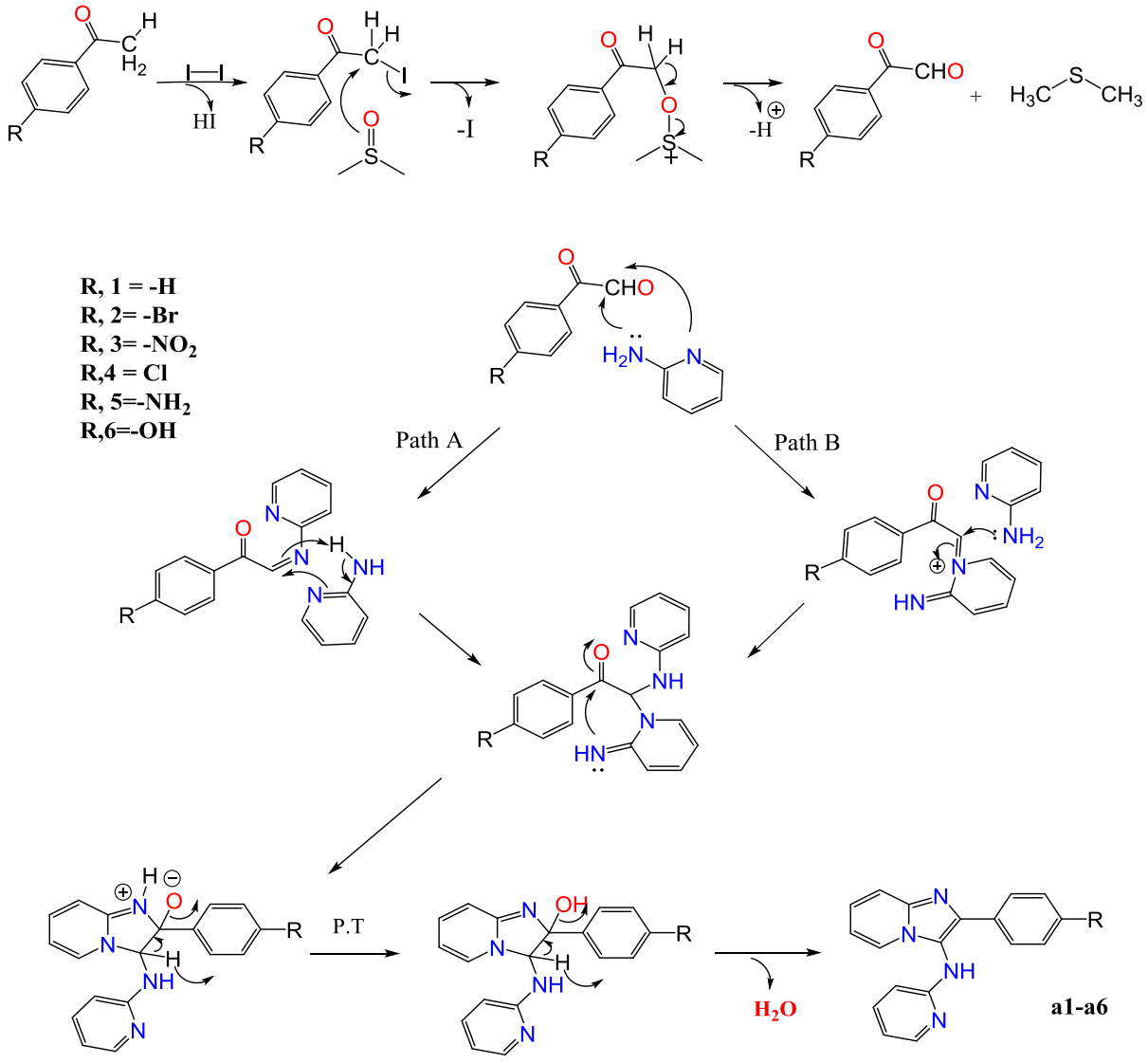
One-pot reaction was performed for synthesis 2-aryl-3-(pyridine-2-ylamino)imidazo[1,2- a]pyridine derivatives (a1-a6) from the reaction of 2-aminopyridine with different substituted acetophenones in the prescience of I_2 and DMSO (Scheme 1).

Archive of SID.ir

Archive of SID.ir

These compounds were identified by the absence of the characteristic bands in the FT-IR spectrum for one carbonyl group and one NH_2 group and the appearance of new peaks at (1600-1631 cm^{-1}) for (C=N) imidazo and at (3100-3300 cm^{-1}) for (NH) group. ^{1}HNMR spectrum showed multiple signals for (Ar-H, NH) protons at (8.83-6.5 ppm) and for(s,1H,OH) for (a6) compound 9.71 ppm. Also, these compounds' synthesis was identified by ^{13}CNMR spectrum that showed signals at 169.3-147.1 ppm (C=N) and at 138.1-109.3 ppm(C=C).

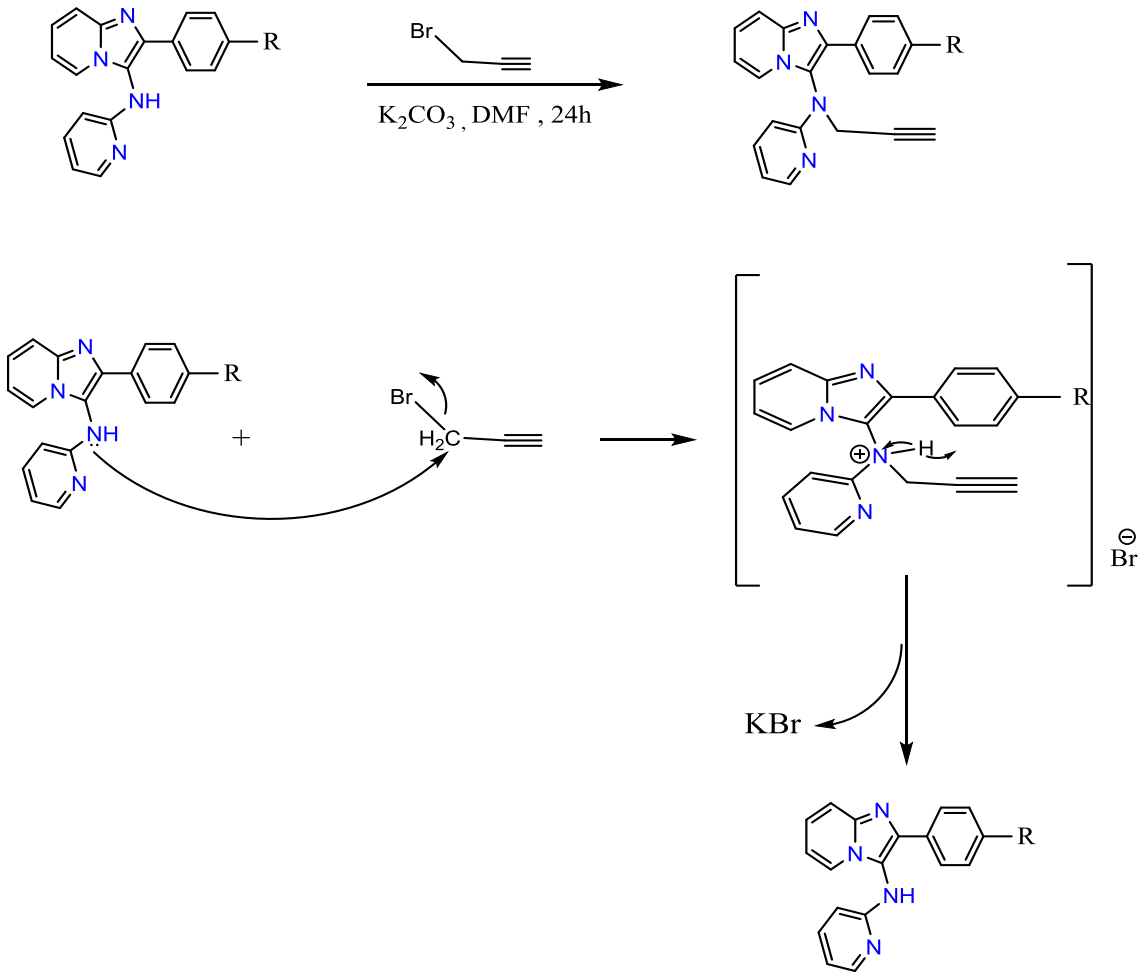
The second step was the synthesis of propargylamines by the reaction of (a1-a6) compounds with propargylbromide as SN2 reaction (Scheme 2). The absorption characteristic peaks of these propargylamines compounds in the FT-IR spectrum were at (2183- 2119 cm^{-1}) owing to (C≡C) and at (3277- 3224 cm-1) owing to (C≡C-H). ^{1}HNMR signals at 3.8-3.02 ppm (s, 1H, C≡C-H). ^{13}CNMR showed new signals at 78.4, 73, 72 ppm for (C≡C), 56.3, 43.3, 30.5 ppm for (CH_2).



SCHEME 1 synthesis mechanism of compounds (a1-a6)

Archive of SID.ir

Archive of SID.ir



SCHEME 2 synthesis mechanism of compounds (b1 – b6)

Cytotoxic effect of (5a,5b) compound on HL-60 cell line (human leukemia cell line) in Vitro Using MTT Assay

The test of 3-(dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) was accomplished to evaluate the cytotoxic effect of (5a and 5b) compound on leukemia cancer cell line (HL-60). MTT assay was performed to calculate the cell viability and inhibition rate on the tumor cell line using different concentrations of (5a, 5b) compounds. The percentage viability of treated cells was calculated compared with normal cell line WPL-68. The cytotoxic effect of (5a,5b) compounds in concentration ranged from 6.25- 400 µg/mL on HL-60 cells (Tables 3 and 4), which showed a decreased in cell viability in a dose-dependent pattern. The cell viability was reduced by increasing the concentration of (5a,5b) compounds.

In case (a5) compound, the decreasing in HL-60 cell line viability (%) was noticed at 400 µg/mL (39.35 ± 4.78%) while the highest HL-60 cell viability at 6.25 µg/mL reached (95.95±0.53%).

An (a5) compound exhibited cytotoxic activity with an IC50 value of 112.9 µg/mL from the compound's effect on the HL-60 cell line. However, an IC50 value of 245.7 µg/mL was obtained from the effect of (a5) compound on the WRI-68 normal cell line (Figure 3).

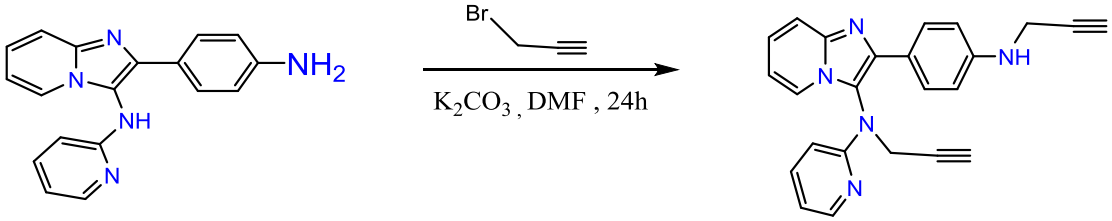
In case (b5) compound, the decreasing in HL-60 cell viability (%) was noticed at 400 µg/mL (41.01± 4.18%) while the highest HL-60 cell viability at 6.25 µg/mL reached (96.14±1.05%).

A (b5) compound exhibited cytotoxic activity with IC50 value of 104.3 µg/mL from the compound's effect on the HL-60 cell line.

Archive of SID.ir

Archive of SID.ir

However, an IC50 of 121.3 µg/mL was obtained from the effect of (b5) compound on WRI-68 normal cell line (Figure 4).



a5 b5

EQUATION 1 Synthesis of propargyl derivatives

TABLE 3 Cytotoxicity effect of (a5) compound on HL-60 and WRI-68 cells after 24 h incubation at 37 °C

Concentration of (5a) compound µg/mL	Viable cell count of HL-60 cell line Mean ± SD	Viable cell count of WRL-68 cell line Mean ± SD
400.00	39.35±4.78	70.41±2.86
200.00	48.03±2.55	84.80±1.20
100.00	71.49±3.40	93.60±2.10
50.00	90.70±3.18	94.17±1.57
25.00	95.72±0.81	95.22±0.82
12.50	95.18±1.28	95.18±0.41
6.25	95.95±0.53	95.29±1.05

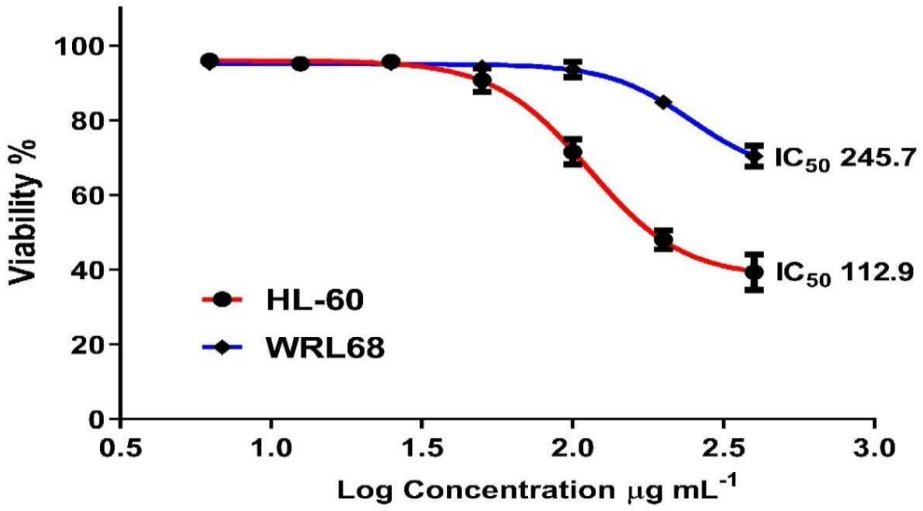


FIGURE 3 Cytotoxic effect of (a5) compound on HL-60 and WRL-68 cells after 24 h incubation at 37 °C

Archive of SID.ir

Archive of SID.ir

TABLE 4 Cytotoxicity effect of (b5) compound on HL-60 and WRI-68 cells after 24 h incubation at 37 °C

Concentration of (5b) compound µg/mL	Viable cell count of HL-60 cell line Mean ± SD	Viable cell count of WRL-68 cell line Mean ± SD
400.00	41.01±4.18	65.70±3.65
200.00	48.26±4.63	70.60±6.47
100.00	66.05±2.41	84.16±2.72
50.00	75.15±5.10	91.94±4.48
25.00	83.22±1.33	95.80±0.88
12.50	95.41±1.41	94.91±2.20
6.25	96.14± 1.05	96.10±0.48

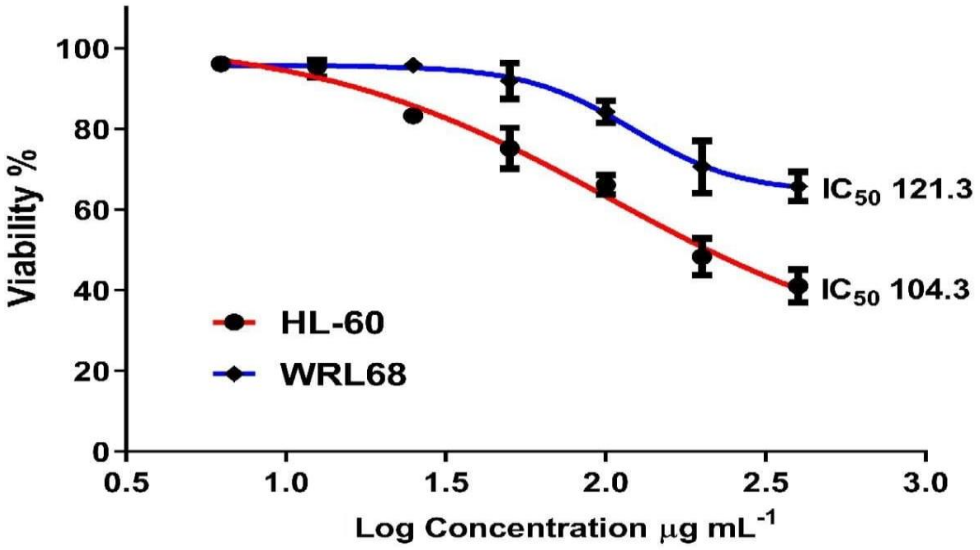


FIGURE 4 Cytotoxic effect of (b5) compound on HL-60 and WRL-68 cells after 24 hours incubation at 37 °C

Conclusion

In this work, a variety of imidazo [1,2- a] pyridine derivatives have been synthesized from 2-aminopyridine and different substituted acetophenones synthesized compounds (a1...a2...a3...a4...a5…a6)

As shown in the first scheme while in scheme two react 2-aryl-3-(pyridine-2-ylamino)imidazo[1,2-a]pyridines derivatives with propargylbromide synthesized compounds (b1...b2...b3...b4...b5...b6).

An (a5) compound exhibited cytotoxic activity with IC50 value of 112.9 µg/mL from the effect of the compound on the HL-60 cell line, While A (b5) compound exhibited cytotoxic activity with IC50 value of 104.3 µg/mL from the effect the compound on the HL-60 cell line.

An (a5) compound exhibited cytotoxic activity with IC50 value of 245.7 µg/mL from the effect of the compound on the WRL-68 cell line, While A (b5) compound exhibited cytotoxic activity with IC50 value of 121.3 µg/mL from the effect the compound on the WRL-68 cells cell line.

From the previous results, it was possible to conclude that the values of IC50 play a critical role in determining the effect of the compounds on cancer cells since compound (b5) has a lower IC50 value therefore it has the best Cytotoxic activity on cancer cells line compared to compound (a5) which has a higher IC50 value. Moreover, compound (a5) is considered less toxic to normal cells since it

Archive of SID.ir

Archive of SID.ir

gave a high value of IC50 compared to (b5). Based on these results, (a5) compound was considered better than (b5) as cytotoxic activity.

Acknowledgements

I'm grateful to Miss Muneera for doing FT-IR spectra, and also big thanks to my friends Thamer and Aqeel for scientific discussion.

Orcid:

Ahmed Zamil Hattab: https://orcid.org/0000-0003-0197-3720

Naeemah Al-Lami: https://orcid.org/0000-0002-8151-4227

Jaafar Suhail Wadi: https://orcid.org/0000-0002-8140-5426

References

[1] A. Gomtsyan, *Chem. Heterocycl. Compd.*, **2012**, *48*, 7-10. [crossref], [Google Scholar], [Publisher]

[2] H.B. Broughton, I.A. Watson, *J. Mol. Graph.*, **2004**, *23*, 51-58. [crossref], [Google Scholar], [Publisher]

[3] M.S. Salem, S.I. Sakr, W.M. El-Senousy, H.M.F. Madkour, *Arch. Pharm. Chem.*, **2013**, *346*, 766–773. [crossref], [Google Scholar], [Publisher]

[4] N.M.A. El-Salam, M.S. Mostafa, G.A. Ahmed, O.Y. Alothman, *J. Chem.*, **2013**, *2013*, 1-8. [crossref], [Google Scholar], [Publisher]

[5] M.E. Azab, M.M. Youssef, E.A. El-Bordany, *Molecules*, **2013**, *18*, 832-844. [crossref], [Google Scholar], [Publisher]

[6] E.R. El-Sawy, M.S. Ebaid, H.M. Abo-Salem, A.H. Al-Sehemi, A.G. Mandour, *Arab. J. Chem.*, **2014**, *7*, 914-923. [crossref], [Google Scholar], [Publisher]

[7] X. Cao, Z. Sun, Y. Cao, R. Wang, T. Cai, W. Chu, W. Hu, Y. Yang, *J. Med. Chem.*, **2014**, *57*, 3687-3706. [crossref], [Google Scholar], [Publisher]

[8] Y. Chen, K. Yu, N.Y. Tan, R.H. Qiu, W. Liu, N.L. Luo, L. Tong, C.T. Au, Z.Q. Luo, S.F. Yin, *Eur. J. Med. Chem.*, **2014**, *79*, 391-398. [crossref], [Google Scholar], [Publisher]

[9] R. Goel, V. Luxami, K. Paul, *Curr. Top Med. Chem.*, **2016**, *16*, 3590-3616. [crossref], [Google Scholar], [Publisher]

[10] Y.N. Mabkhot, A. Barakat, A.M. Al-Majid, S. Alshahrani, S. Yousuf, M.I. Choudhary, *Chem. Cent. J.*, **2013**, *7*, 1-9. [crossref], [Google Scholar], [Publisher]

[11] K. Lauder, A. Toscani, N. Scalacci, D. Castagnolo, *Chem. Rev.*, **2017**, *117*, 14091-14200. [crossref], [Google Scholar], [Publisher]

[12] B.M. Nilsson, H.M. Vargas, B. Ringdahl, U. Hacksell, *J. Med. Chem.*, **1992**, *35*, 285-294. [crossref], [Google Scholar], [Publisher]

[13] K. Hattori, M. Miyata, H. Yamamoto, *J. Am. Chem. Soc.*, **1993**, *115*, 1151-1152. [crossref], [Google Scholar], [Publisher]

[14] M.A. Huffman, N. Yasuda, A.E. DeCamp, E.J. Grabowski, *J. Org. Chem.*, **1995**, *60*, 1590-1594. [crossref], [Google Scholar], [Publisher]

[15] D. Ma, T. Han, M. Karimian, N. Abbasi, H. Ghaneialvar, A. Zangeneh, *Int. J. Biol. Macromol.*, **2020**, *165*, 767-775. [crossref], [Google Scholar], [Publisher]

[16] N.S. Vatmurge, B.G. Hazra, V.S. Pore, F. Shirazi, P.S. Chavan, M.V. Deshpande, *Bioorg. Med. Chem. lett.*, **2008**, *18*, 2043-2047. [crossref], [Google Scholar], [Publisher]

[17] M.R. Aouad, *Molecules*, **2014**, *19*, 18897-18910. [crossref], [Google Scholar], [Publisher]

[18] M. Jeleń, K. Pluta, M. Zimecki, B. MorakMłodawska, J. Artym, M. Kocięba, I. Kochanowska, *J. Enzyme Inhib. Med. Chem.*, **2016**, *31*, 83-88. [crossref], [Publisher]

[19] I.E. Kopka, Z.A. Fataftah, M.W. Rathke, *J. Org. Chem.*, **1980**, *45*, 4616-4622. [crossref], [Google Scholar], [Publisher]

[20] S. Czernecki, J.M. Valéry, *J. Carbohydr. Chem.*, **1990**, *9*, 767-770. [crossref], [Google Scholar], [Publisher]

[21] Y. Imada, M. Yuasa, I. Nakamura, S.I. Murahashi, *J. Org. Chem.*, **1994**, *59*, 2282-2284. [crossref], [Google Scholar], [Publisher]

[22] a) D. Enders, U. Reinhold, *Tetrahedron:*

Archive of SID.ir

Archive of SID.ir

Asym., **1997**, *8*, 1895-1946. [crossref], [Google Scholar], [Publisher], b) R. Bloch, *Chem. Rev*., **1998**, *98*, 1407-1438. [crossref], [Google Scholar], [Publisher]

[23] a) T. Murai, Y. Mutoh, Y. Ohta, M. Murakami, *J. Am. Chem. Soc*., **2004**, *126*, 5968-5969. [crossref], [Google Scholar], [Publisher], b) C.W. Ryan, C. Ainsworth, *J. Org. Chem*., **1961**, *26*, 1547-1550. [crossref], [Google Scholar], [Publisher], c) M.E. Jung, A. Huang, *Org. lett*., **2000**, *2*, 2659-2661. [crossref], [Google Scholar], [Publisher]

[24] E. Ezzatzadeh, Z. Hossaini, *Nat. Prod. Res*., **2020**, *34*, 923-929. [crossref], [Google Scholar], [Publisher]

[25] Z. Fei, Y.P. Zhu, M.C. Liu, F.C. Jia, A.X. Wu, *Tetrahedron Lett*., **2013**, *54*, 1222-1226. [crossref], [Google Scholar], [Publisher]

[26] S. Pradhan, N. Chauhan, C.K. Shahi, A. Bhattacharyya, M.K. Ghorai, *Org. Lett*., **2020**, *22*, 7903-7908. [crossref], [Google Scholar], [Publisher]

How to cite this article: Ahmed Zamil Hattab*, Naeemah Al-Lami, Jaafar Suhail Wadi. Anticancer activity of new 3-secondary amine derivatives containing fused rings of the imidazopyridine. *Eurasian Chemical Communications*, 2022, 4(3), 222-231. **Link:** http://www.echemcom.com/article_144207.html

Copyright © 2022 by SPC (Sami Publishing Company) + is an open access article distributed under the Creative Commons Attribution License(CC BY) license (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Archive of SID.ir