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SYNTHESIS OF SOME EFFECTIVE NOVEL HETEROCYCLIC COMPOUNDS AND THEIR CHARACTERIZATION

Dr.Sonal S.Mundhada,

Assistant Professor ,
Department of Chemistry
Brijlal Biyani Science College , Amravati ,India

Abstract - This study include preparation and characterization of the chalcone compound which were prepared from reaction of Aromatic aldehyde and aromatic ketone which is a one step reaction and also prepared a number of heterocyclic compounds from the chalcone derivative with Thiourea, urea, hydrazine hydrate ,these derivatives are (Thiazine, Oxazine, Pyrazole). All the prepared compounds were Characterized by means of the FT-IR spectra and the proton ^{1}H.NMR spectra. Then the bio-activity of these compounds and their effect on two types of bacteria (staphylococcus, Escherichia coli) were studied some compounds were identified that have a strong inhibitory effect.

Keywords- **Green synthesis , Chalcone, Thiazine,Oxazine, Pyrazol**

Introduction- Green chemistry is defined as environmentally benign chemical synthesis. It focused on the process that reduces the use and generation of hazardous substance or byproducts whether reactions are carried out in industry or chemical laboratory. The chemists all over the globe are motivated not only for the environmentally benign synthesis of new products but also to develop green synthesis for existing chemicals. This has been possible by the replacement of the organic solvents, which are hazardous by water or eliminate the use of solvent altogether. Heterocyclic nuclei play a vital role in various activities of biosphere. Heterocyclic compounds offer a high degree of structural diversity and have proven to be broadly and economically useful as therapeutic agents. The information on the most active oxazine derivatives have been showed substantial pharmacological activities like antimicrobial, antitubercular, anti-diabetic, anti-hypolipidaemic and antidepressant. It is used as an important tool for chemists to develop new and effective oxazine derivatives that may prove to be better compounds in efficacy[1]and safety [2]. 1,3-thiazine and its derivatives contains wonderful properties like antitumor, insecticide, and fungicidal. 1,3thiazines and its derivatives have been reported to exhibit a variety of biological activities like Antibacterial, Antifungal, Antitubercular[3], Anti-inflammatory [4], Analgesic, Sedative-hypnotic, Immunosuppressive agents, etc. Some derivatives of Thiazine are cannabinoid receptor agonists; also they can act as an anti-hypotensive. Moreover, Thiazine derivatives can be used for gastrointestinal disorders or diabetes prevention. Condensed heterocyclic systems possessing thiazine ring have been reported as antioxidants, and calcium channel modulators. Pyrazole drugs are found in medicines, and displayed anticonvulsant, antidepressant [5], antihyperglycemic 6 and antimicrobial [7]. These heterocyclic compounds like pyrazole comprise an important class due to their wide range of biological activity such as in their biological properties [8] such as anti-inflammatory [9], antibacterial [10], antioxidant activity [11], antifungal [12], antitumor [13], anticancer [14], anticonvulsant [15].

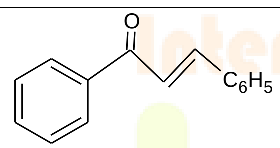
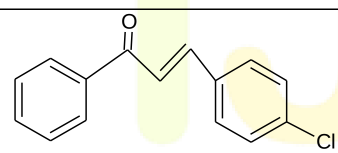
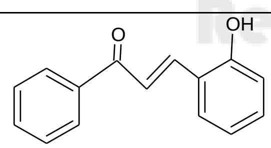
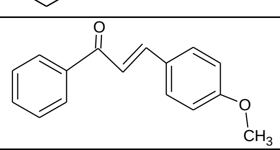
Material and Methods---

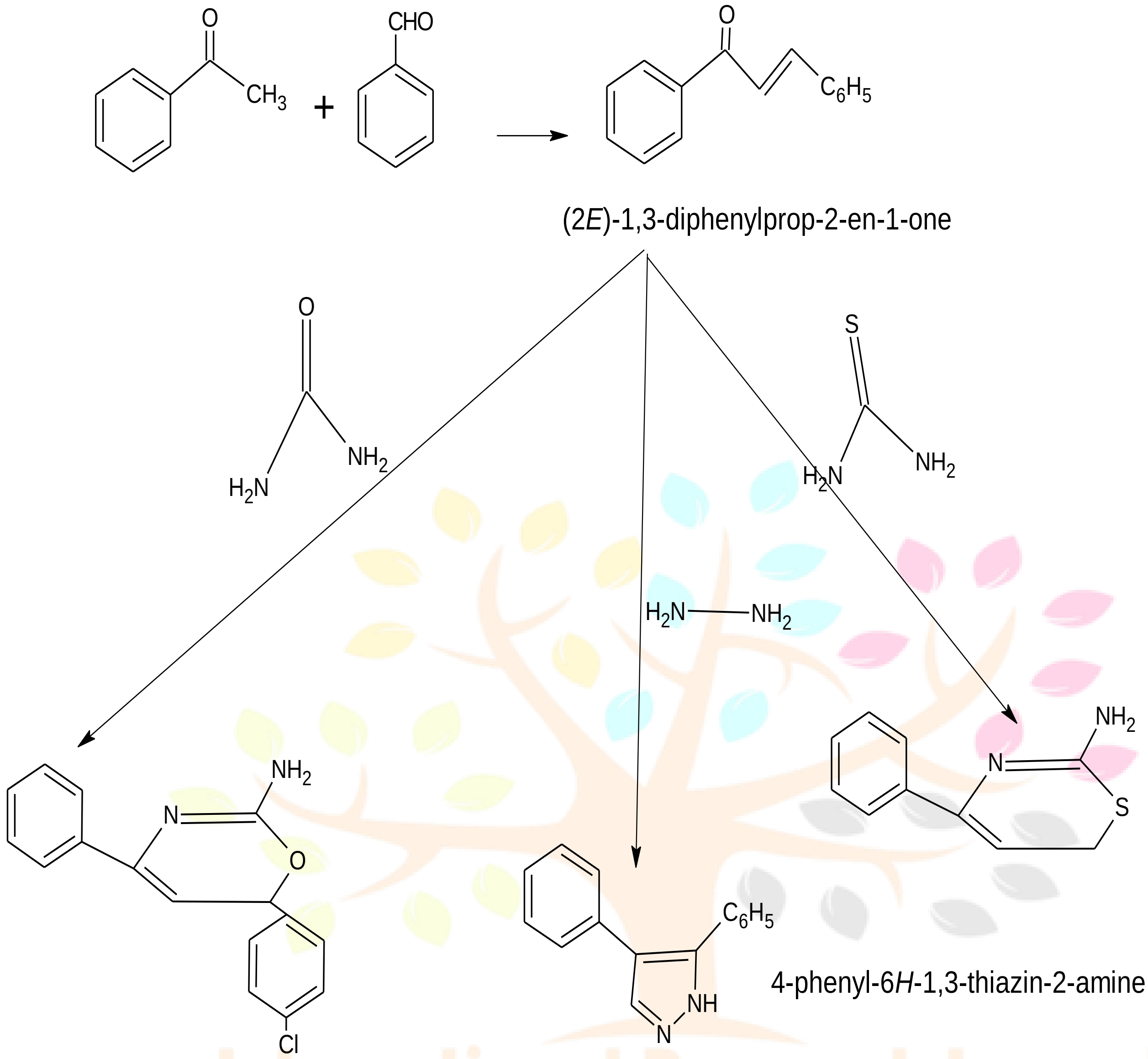
Synthesis of 1,3-diphenylprop-2-ene-1-one :-

In a 250ml three necked flask, a solution containing 0.005M of benzaldehyde and 0.005M of acetophenone was dissolved in 40% sodium hydroxide. This mixture is placed in microwave for 1min and then the mixture is cooled for 5min.The product was filtered and washed with alcohol. Then we will recyrstallize the product with the help of methanol and hence the product benzaldehyde chalcone was formed.

(2*E*)-1,3-diphenylprop-2-en-1-one

Table -1 Synthesis of Substituted Chalcones

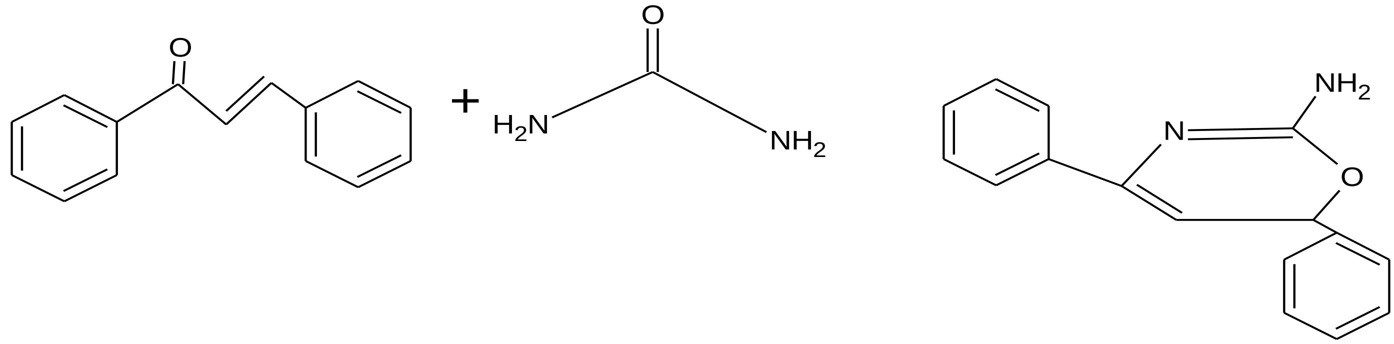
S.No.	Structure	Molecular Formula	Melting Point	Aldehyde used
1(Ia)		$C_{15}H_{12}O$	57^0C	Benzaldehyde
2(Ib)		$C_{15}H_{11}ClO$	87^0C	4-Chlorobenzaldehyde
3(Ic)		$C_{15}H_{12}O_2$	58^0C	Salicyaldehyde
4(Id)		$C_{16}H_{14}O_2$	63^0C	Anisaldehyde



6-(4-chlorophenyl)-4-phenyl-6*H*-1,3-oxazin-2-amine

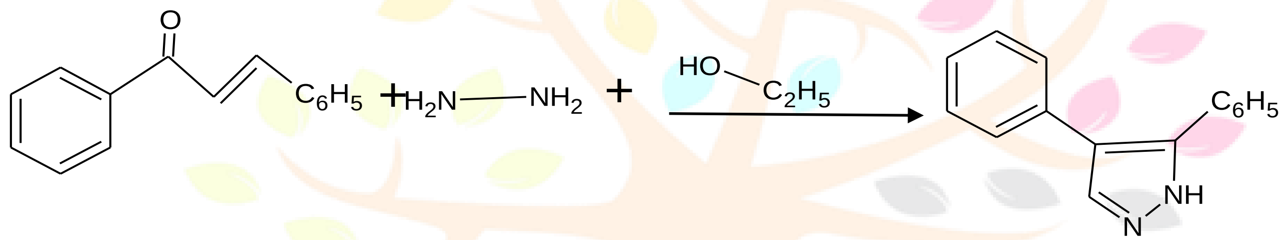
Synthesis of Oxazine from Chalcones

A mixture of chalcone (0.2mol), urea (0.02) were dissolved in ethanolic sodium hydroxide (10ml) was stirred about 2-3 hours. this was then poured into 400 ml of cold water with continuous stirring recystallized for on hour and then kept in refrigerator for 24 hours. the precipitate obtained was filtered, washed and from ethanol. the product of oxazine was formed.



Synthesis of pyrazole from chalcone

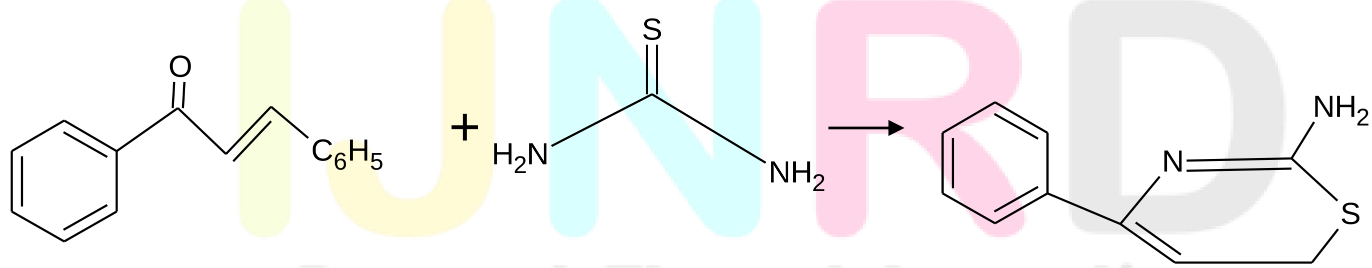
A mixture of chalcone (5mmol), hydrazine (20 mmole) and 5 ml acetic acid and add some flex of potassium hydroxide. Then the mixture is placed in microwave for 1 min and let it cool for 5min. recrystallize the mixture with methanol with the help of scratching. The product of pyrazole was formed then filtered and dried.



4,5-diphenyl-1*H*-pyrazole

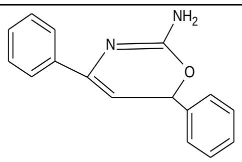
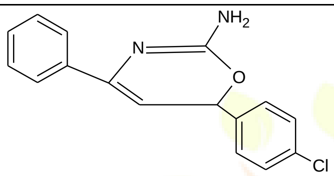
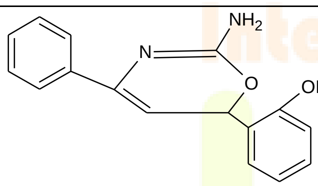
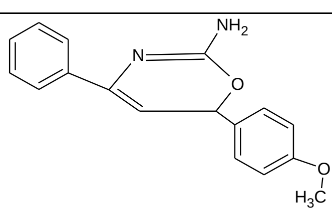
Synthesis of Thiazine from Chalcone

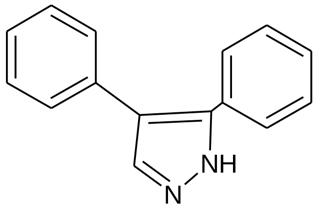
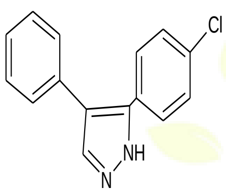
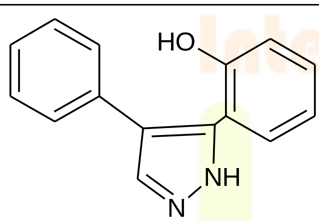
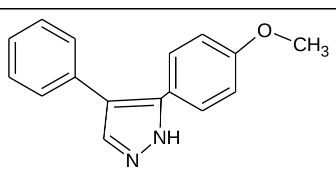
A mixture of Chalcone (0.02mol), and Aromatic aldehyde (0.02 mol) and Thiourea were dissolved in ethanol and kept in microwave for 1 min. This was then poured into 100 ml of Methanol with continuous stirring . The precipitate obtained was filtered and washed with ethanol. The product thiazine was formed.

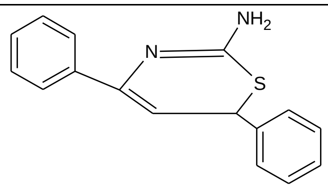
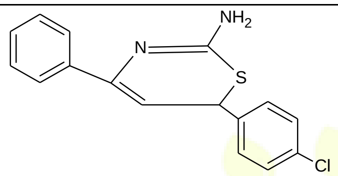
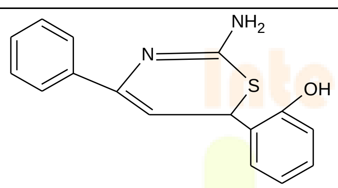
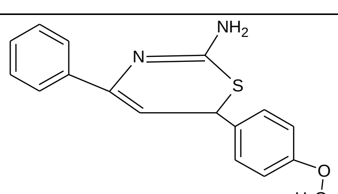


4-phenyl-6*H*-1,3-thiazin-2-amine

TABLE-II (SPECTRAL DATA)

S.No.	Structure	Molecular Formula	Compound Name	NMR	CMR
1	 (IIa)	$C_{16}H_{14}$ N_2O	4,6-diphenyl-6*H*-1,3-oxazin-2-amine	^{1}H NMR: δ 5.50 (1H, d, *J* = 1.7 Hz), 6.26 (1H, d, *J* = 1.7 Hz), 7.21-7.53 (6H, 7.27 (tt, *J* = 7.2, 1.2 Hz), 7.35 (tt, *J* = 7.5, 1.3 Hz), 7.37 (dddd, *J* = 8.1, 7.2, 1.8, 0.5 Hz), 7.46 (dddd, *J* = 8.1, 7.5, 1.5, 0.6 Hz)), 7.78 (2H, dddd, *J* = 8.1, 1.3, 1.0, 0.6 Hz), 8.22 (2H, dtd, *J* = 8.1, 1.2, 0.5 Hz	^{3}C NMR: δ 75.7 (1C, s), 117.4 (1C, s), 126.5 (2C, s), 126.8 (2C, s), 127.8-127.8 (2C, 127.8 (s), 127.8 (s)), 128.3-128.5 (4C, 128.4 (s), 128.4 (s)), 133.7 (1C, s), 137.0 (1C, s), 137.9 (1C, s), 160.3 (1C, s).
2	 (IIb)	$C_{16}H_{13}ClN_2O$	6-(4-chlorophenyl)-4-phenyl-6*H*-1,3-oxazin-2-amine	5.50 (1H, d, *J* = 2.1 Hz), 5.98 (1H, d, *J* = 2.1 Hz), 7.21-7.62 (7H, 7.27 (tt, *J* = 7.2, 1.2 Hz), 7.37 (dddd, *J* = 8.1, 7.2, 1.8, 0.5 Hz), 7.49 (ddd, *J* = 8.3, 1.2, 0.5 Hz), 7.56 (ddd, *J* = 8.3, 1.4, 0.5 Hz)), 8.22 (2H, dtd, *J* = 8.1, 1.2, 0.5 Hz).	δ 75.7 (1C, s), 117.4 (1C, s), 126.8 (2C, s), 127.2 (2C, s), 127.8 (1C, s), 128.4 (2C, s), 128.7 (2C, s), 133.6-133.8 (2C, 133.7 (s), 133.7 (s)), 137.0 (1C, s), 137.9 (1C, s), 160.3 (1C, s).
3	 (IIc)	$C_{16}H_{14}$ N_2O_2	2-(2-amino-4-phenyl-6*H*-1,3-oxazin-6-yl)phenol	δ 5.49 (1H, d, *J* = 1.9 Hz), 5.92 (1H, d, *J* = 1.9 Hz), 6.66 (1H, ddd, *J* = 8.3, 1.2, 0.5 Hz), 7.00 (1H, ddd, *J* = 7.9, 7.6, 1.2 Hz), 7.20-7.45 (5H, 7.27 (ddd, *J* = 8.3, 7.6, 1.3 Hz), 7.27 (tt, *J* = 7.2, 1.2 Hz), 7.32 (ddd, *J* = 7.9, 1.3, 0.5 Hz), 7.37 (dddd, *J* = 8.1, 7.2, 1.8, 0.5 Hz)), 8.22 (2H, dtd, *J* = 8.1, 1.2, 0.5 Hz)	δ 75.7 (1C, s), 116.8 (1C, s), 117.4 (1C, s), 121.6 (1C, s), 126.8 (2C, s), 127.4 (1C, s), 127.8 (1C, s), 128.3-128.5 (3C, 128.4 (s), 128.4 (s)), 129.4 (1C, s), 133.7 (1C, s), 137.0 (1C, s), 154.0 (1C, s), 160.3 (1C, s).
4		$C_{17}H_{16}N_2O_2$	6-(4-methoxyphenyl)-4-phenyl-6*H*-1,3-oxazin-2-amine	δ 3.75 (3H, s), 5.51 (1H, d, *J* = 1.9 Hz), 5.94 (1H, d, *J* = 1.9 Hz), 6.89 (2H, ddd, *J* = 8.2, 1.1, 0.6 Hz), 7.21-7.45 (5H, 7.27 (tt, *J* = 7.2,	δ 56.0 (1C, s), 75.7 (1C, s), 114.3 (2C, s), 117.4 (1C, s), 126.8 (2C, s), 127.8 (1C, s), 128.0 (2C, s), 128.4 (2C, s),

	(IId)			1.3 Hz), 7.36 (ddd, *J* = 8.2, 1.1, 0.6 Hz), 7.37 (dddd, *J* = 8.1, 7.2, 1.8, 0.5 Hz)), 8.22 (2H, dtd, *J* = 8.1, 1.3, 0.5 Hz).	133.7 (1C, s), 137.0 (1C, s), 137.9 (1C, s), 159.8 (1C, s), 160.3 (1C, s)
5	 (IIIa)	$C_{15}H_{12}N_2$	4,5-diphenyl-1*H*-pyrazole	δ 7.41-7.62 (4H, 7.47 (tdd, *J* = 7.5, 1.5, 1.4 Hz), 7.51 (ddd, *J* = 7.9, 7.3, 1.1 Hz), 7.55 (dddd, *J* = 7.9, 7.5, 1.3, 0.5 Hz)), 7.62-7.88 (2H, 7.69 (ddd, *J* = 7.9, 7.3, 1.5 Hz), 7.82 (ddd, *J* = 7.9, 1.1, 0.5 Hz)), 7.93-8.07 (3H, 8.00 (ddd, *J* = 7.9, 1.5, 0.5 Hz), 8.01 (dtd, *J* = 7.9, 1.5, 0.5 Hz))	δ 110.4 (1C, s), 120.1 (1C, s), 125.9 (1C, s), 127.3 (2C, s), 127.8 (1C, s), 128.2 (1C, s), 128.3-128.5 (3C, 128.4 (s), 128.4 (s)), 132.1 (1C, s), 140.8 (1C, s), 151.7 (1C, s
6	 (IIIb)	$C_{15}H_{11}N_2Cl$	5-(4-chlorophenyl)-4-phenyl-1*H*-pyrazole	δ 7.36-7.90 (8H, 7.43 (ddd, *J* = 7.8, 7.4, 1.1 Hz), 7.56 (ddd, *J* = 8.7, 1.5, 0.5 Hz), 7.65 (ddd, *J* = 7.9, 7.4, 1.5 Hz), 7.71 (ddd, *J* = 8.7, 1.6, 0.5 Hz), 7.81 (ddd, *J* = 7.9, 1.1, 0.5 Hz), 7.84 (ddd, *J* = 7.8, 1.5, 0.5 Hz))	δ 110.4 (1C, s), 120.1 (1C, s), 125.9 (1C, s), 128.2 (1C, s), 128.3-128.6 (3C, 128.4 (s), 128.5 (s)), 128.7 (2C, s), 132.1 (1C, s), 133.7 (1C, s), 140.8 (1C, s), 151.7 (1C, s).
7	 (IIIc)	$C_{15}H_{12}N_2O$	2-(4-phenyl-1*H*-pyrazol-5-yl)phenol	δ 7.17 (2H, ddd, *J* = 8.9, 1.4, 0.4 Hz), 7.48-7.63 (2H, 7.55 (ddd, *J* = 7.8, 7.5, 1.2 Hz), 7.56 (ddd, *J* = 8.1, 7.5, 1.6 Hz)), 7.74 (2H, ddd, *J* = 8.9, 1.6, 0.4 Hz), 7.86-8.08 (2H, 7.92 (ddd, *J* = 8.1, 1.2, 0.4 Hz), 8.02 (ddd, *J* = 7.8, 1.6, 0.4 Hz)).	δ 71.7 (1C, s), 110.4 (1C, s), 114.8 (1C, s), 120.1 (1C, s), 125.9-126.0 (2C, 125.9 (s), 125.9 (s)), 128.2 (1C, s), 128.4 (1C, s), 128.9 (1C, s), 132.1 (1C, s), 140.8 (1C, s), 151.7 (1C, s), 153.2 (1C, s).
8	 (IIId)	$C_{16}H_{14}N_2O$	5-(4-methoxyphenyl)-4-phenyl-1*H*-pyrazole	3.78 (3H, s), 7.21 (2H, ddd, *J* = 8.9, 1.4, 0.5 Hz), 7.46-7.62 (2H, 7.53 (ddd, *J* = 7.8, 7.6, 1.2 Hz), 7.55 (ddd, *J* = 8.1, 7.6, 1.6 Hz)), 7.73 (2H, ddd, *J* = 8.9, 1.6, 0.5 Hz), 7.91 (1H, ddd, *J* = 8.1,	δ 56.0 (1C, s), 71.7 (1C, s), 110.4 (1C, s), 114.8 (1C, s), 120.1 (1C, s), 125.9-126.0 (2C, 125.9 (s), 125.9 (s)), 128.2 (1C, s), 128.4 (1C, s), 128.9 (1C, s), 132.1 (1C, s),

				1.2, 0.4 Hz), 8.04 (1H, ddd, *J* = 7.8, 1.6, 0.4 Hz)	140.8 (1C, s), 151.7 (1C, s), 153.2 (1C, s).
9	 (IVa)	$C_{16}H_{14}N_2S$	4,6-diphenyl-6*H*-1,3-thiazin-2-amine	5.48-5.59 (2H, 5.53 (d, *J* = 4.1 Hz), 5.54 (d, *J* = 4.1 Hz)), 6.96 (2H, dddd, *J* = 7.9, 1.5, 1.2, 0.5 Hz), 7.19-7.49 (6H, 7.25 (tt, *J* = 7.7, 1.5 Hz), 7.27 (tt, *J* = 7.2, 1.3 Hz), 7.29 (dddd, *J* = 7.9, 7.7, 1.9, 0.5 Hz), 7.41 (dddd, *J* = 8.1, 7.2, 1.9, 0.5 Hz)), 8.18 (2H, dddd, *J* = 8.1, 1.7, 1.3, 0.5 Hz).	δ 47.9 (1C, s), 117.0 (1C, s), 126.8 (2C, s), 127.8-127.8 (4C, 127.8 (s), 127.8 (s), 127.8 (s)), 128.3-128.5 (4C, 128.4 (s), 128.4 (s)), 133.7 (1C, s), 135.8 (1C, s), 137.0 (1C, s), 159.2 (1C, s)
10	 (IVb)	$C_{16}H_{13}ClN_2S$	6-(4-chlorophenyl)-4-phenyl-6*H*-1,3-thiazin-2-amine	δ 5.35 (1H, d, *J* = 4.9 Hz), 5.57 (1H, d, *J* = 4.9 Hz), 7.27 (1H, tt, *J* = 7.2, 1.3 Hz), 7.34-7.54 (6H, 7.40 (ddd, *J* = 8.3, 1.5, 0.5 Hz), 7.41 (dddd, *J* = 8.1, 7.2, 1.9, 0.5 Hz), 7.47 (ddd, *J* = 8.3, 1.6, 0.5 Hz)), 8.35 (2H, dddd, *J* = 8.1, 1.7, 1.3, 0.5 Hz)	δ 47.9 (1C, s), 117.0 (1C, s), 126.8 (2C, s), 127.8-127.8 (3C, 127.8 (s), 127.8 (s)), 128.4 (2C, s), 128.7 (2C, s), 133.6-133.8 (2C, 133.7 (s), 133.7 (s)), 135.8 (1C, s), 137.0 (1C, s), 159.2 (1C, s)
11	 (IVc)	$C_{16}H_{14}N_2OS$	2-(2-amino-4-phenyl-6*H*-1,3-thiazin-6-yl)phenol	δ 5.24 (1H, d, *J* = 4.8 Hz), 5.55 (1H, d, *J* = 4.8 Hz), 6.67 (1H, ddd, *J* = 8.3, 1.3, 0.6 Hz), 6.91 (1H, ddd, *J* = 7.9, 7.5, 1.3 Hz), 7.17-7.49 (5H, 7.25 (ddd, *J* = 8.3, 7.5, 1.3 Hz), 7.27 (tt, *J* = 7.2, 1.3 Hz), 7.30 (ddd, *J* = 7.9, 1.3, 0.6 Hz), 7.41 (dddd, *J* = 8.1, 7.2, 1.9, 0.5 Hz)), 8.35 (2H, dddd, *J* = 8.1, 1.7, 1.3, 0.5 Hz).	δ 47.9 (1C, s), 116.8 (1C, s), 117.0 (1C, s), 126.8 (2C, s), 127.8-127.8 (2C, 127.8 (s), 127.8 (s)), 128.0 (1C, s), 128.3-128.5 (3C, 128.4 (s), 128.4 (s)), 129.4 (1C, s), 133.7 (1C, s), 137.0 (1C, s), 159.2 (1C, s), 160.0 (1C, s).
12	 (IVd)	$C_{17}H_{16}N_2OS$	6-(4-methoxyphenyl)-4-phenyl-6*H*-1,3-thiazin-2-amine	3.74 (3H, s), 5.20 (1H, d, *J* = 4.8 Hz), 5.57 (1H, d, *J* = 4.8 Hz), 6.95 (2H, ddd, *J* = 8.5, 1.1, 0.6 Hz), 7.21-7.33 (3H,	δ 47.9 (1C, s), 56.0 (1C, s), 114.3 (2C, s), 117.0 (1C, s), 126.8 (2C, s), 127.8 (1C, s), 128.4 (2C, s), 128.6 (2C, s),

				7.27 (ddd, *J* = 8.5, 1.1, 0.6 Hz), 7.27 (tt, *J* = 7.2, 1.3 Hz)), 7.41 (2H, dddd, *J* = 8.1, 7.2, 1.9, 0.5 Hz), 8.27 (2H, dddd, *J* = 8.1, 1.7, 1.3, 0.5 Hz).	133.7 (1C, s), 135.8 (1C, s), 137.0 (1C, s), 159.2 (1C, s), 159.8 (1C, s)

Preparation of wet disc for antibacteriall activity -

MATERIALS AND METHODS -

The punch discs of 6.25 m.m. diameter of Whatman filter paper No. 1 were prepared and dispensed in the batches of 100 each in screw-capped bottles. These were sterilized by dry heat at 140 ^{0}C for 60 minutes. The solutions of 1000 ppm and 100 ppm concentrations of test compounds were prepared in dimethyl formamide (DMF) solvent separately. The discs were soaked, in such way that each disc will contain approximately 0.01 ml of test solution and stored in wet conditions.

Table 5.2 - In vitro antibacterial screening of above tested compounds .

Sr.No.	Tested Compounds	Bacteria (zone of inhibition in mm)			
		staphylococcus		*E.Coli*	
		100 ppm	1000 ppm	100 ppm	1000 ppm
1	IIa	8	10	6	11
2	IIb	-	10	12	12
3	IIc	8	10	11	13
4	IId	13	14	13	15
5	IIIa	19	22	21	22
6	IIIb	19	20	23	24
7	IIIc	16	17	15	18
8	IIId	16	17	15	14

9	IVa	8	9	12	13
10	IVb	17	20	28	21
11	IVc	18	18	19	21
12	IVd	13	14	16	19

DISCUSSION OF THE RESULTS

Antibacterial study of above test compounds on bacterial pathogens like Staphylococcus and E.Coli have been carried out for 18-24 hrs. at 37 ^{0}C for 100ppm and 1000ppm by using disc diffusion method. Screening of the test compounds showed following conclusion

1)It was found that compound (IV b) showed higher activity than other compound for bacteria. Both compounds IIIb,IVb had shown remarkable inhibitory activity against noted bacteria in higher concentration (1000ppm) than lower concentration (100ppm).

2)The solvent free conditioncontributes to saving in cost, time and diminishes the waste disposal problem and environmental pollution this work may bringresearch fraternity towards sustainable development.

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References

[1] N. Siddiqui, R. Ali, M. S. Alam, W. J. Ahsan, Chem. Pharm. Res., 2, 309 (2010).

[2] T. J. Sindhu, S. D. Arikkatt, G. Vincent, M. Chandran, A. R. Bhat, K. Krishna Kumar, Inter. J. Pharma. Sci. Res., 4, 134 (2013).

[3]. Aurelija Urbanaite. “Synthesis of 4H-thiazine”. Chemistry of Heterocyclic Compounds 52 (2016): 1.

[4]. Jupudi S. “An overview on versatile molecule 1, 3- thiazine”. Asian Journal of Research in Pharmaceutical Sciences 3.1 (2013): 170-177.

[5] N. Polish, M. Nesterkina, N. Marintsova, A. Karkhut, I. Kravchenko, V. Novikov, A. Khairulin, Acta Chim. Slov., 2020, 67, 934- 939. [crossref], [Google Scholar], [Publisher]

[6] V. Pogaku, K. Gangarapu, S. Basavoju, K.K. Tatapudi, S.B. Katragadda, Bioorg. Chem., 2019, 93, 103307. [crossref], [Google Scholar], [Publisher]

[7] G.M. Reddy, J.R. Garcia, G. Yuvaraja, M.V. Subbaiah, J.C. Wen, J. Heterocycl. Chem., 2020, 57, 2288-2296. [crossref], [Google Scholar], [Publisher]

[8] L. Emami, L. Zamani, R. Sabet, K. Zomorodian, Z. Rezaei, Z. Faghih, Y. Shahbazi, S. Khabnadideh, Trends in Pharmaceutical Sciences, 2020, 6, 113-120. [crossref], [Google Scholar], [Publisher]

[9] A. Masih, A.K. Agnihotri, J.K. Srivastava, N. Pandey, H.R. Bhat, U.P. Singh, J. Biochem. Mol. Toxicol., 2020, 35, e22656. [crossref], [Google Scholar], [Publisher]

[10] N.A.A .Elkanzi, H. Hrichi, R.B. Bakr, O. Hendawy, M.M. Alruwaili, E.D. Alruwaili, R. W. Almamtrfi, H.Kh. Alsharary, J. Iran. Chem. Soc., 2020, 18, 977–991. [crossref], [Google Scholar], [Publisher]

[11] Y. Kaddouri, F. Abrigach, E.l. Bekaye Yousfi, M. El Kodadi, R. Touzani, Heliyon, 2020, 6, e03185. [crossref], [Google Scholar], [Publisher]

[12] D.S. Zinad, A. Mahal, O.A. Shareef, IOP Conf. Ser.: Mater. Sci. Eng., 2020, 770, 012053. [crossref], [Google Scholar], [Publisher]

[13] N.E. Santos, A.R.F. Carreira, V.L.M. Silva, S.S. Braga, Molecules, 2020, 25, 1364. [crossref], [Google Scholar], [Publisher]

[14] F.E. Bennani, L. Doudach, Y. Cherrah, Y. RamLi, Kh. Karrouchi, M. Ansar, M.E.A. Faouzi, Bioorg. Chem., 2020, 97, 103470. [crossref], [Google Scholar], [Publisher]

[15] D.R. Kerzare, S.S. Menghani, N.R. Rarokar, P.B. Khedekar, Arch Pharm., 2021, 354, 2000100. [crossref], [Google Scholar], [Publisher]