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Synthesis, Characterization And Study Of Oxadiazole Derivatives For Potent Antimicrobial Activity

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ABSTRACT: Four new oxadiazole derivatives, 5-(2-chlorophenyl)-1, 3, 4-oxadiazole-2-amine, 5-(3-nitrophenyl)-1, 3, 4-oxadiazole-2-amine, 4-(5-amino-1, 3, 4-oxadiazole-2-yl)phenol, 5-(3,4-dimethoxyphenyl)-1, 3, 4-oxadiazole-2-amine have been synthesized, characterized and studied for in-vitro antimicrobial activities. The antibacterial studies is carried out against bacteria E.coli, Bacillus subtilis, Micrococcus letteus and the anti-fungal studies is carried out against fungus candida albicans, Sacromyces cervesiae at concentrations 50µg/ml, 100 µg/ml and 150µg/ml. The potency of the derivatives is analysed against standard antibiotic drug ampicillin at 100µg/ml. Compounds 5-(2-chlorophenyl)-1, 3, 4-oxadiazole-2-amine and 5-(3,4-dimethoxyphenyl)-1, 3, 4-oxadiazole-2-amine are found more effective than ampicillin, which may be explored as new analogues in antibiotic category.

Keywords: oxadiazole, anti-microbial, anti-bacterial, anti-fungal, heterocycles.

INTRODUCTION: It is well known in the literature that nitrogen and oxygen containing compounds are essentially used in medicine for the treatment of different kinds of fungal and bacterial infections. The organic moiety having nitrogen atom results towards higher efficiency against various diseases [1]. There are four types of isomers of oxadiazole in which 1, 3, 4-oxadiazole ring is associated with many types of biological properties such as anti-inflammatory anti-fungal and anti-bacterial activities [2]. The first effective chemotherapeutic agents of oxadiazole drug were employed systemically for the prevention and cure of bacterial infection in human beings in 1955. The first mono-substituted 1, 3, 4-oxadiazoles were reported by two independent laboratories along with its characteristics as per **Table 1** [3].

Table 1: Characteristics of 1, 3, 4-oxadiazoles

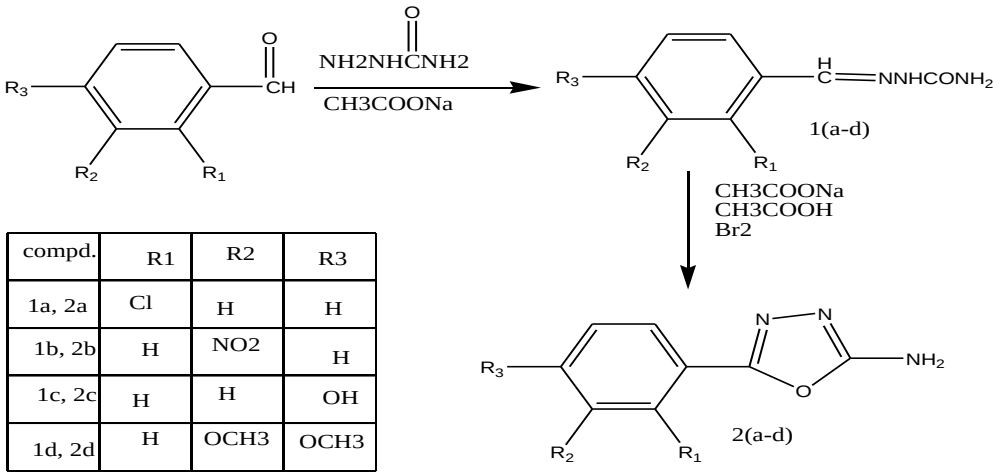
Characteristics	**Values**
Physical state	Colourless liquid
Boiling point	150^{o}C
Hydrogen bond acceptors	3
IR spectra	1640-1650 cm (C=N) and at 1020 cm(C=O)

The oxadiazole is important heterocyclic ring present in large number of biologically active molecules of different pharmacological classes. Oxdiazole derivtives containing the di hydro pyrimidine ring have been reported to demonstrate a wide range of pharmacological activities, which include antibacterial, antifungal, antitubercular, antimicrobial, analgesic and anti-hypersensitive activity [4]. The nitrogen and oxygen containing compounds like oxadiazoles are used in medicine for the treatment of gastric ulcer, cancer [5-6]. Literature review reveals that oxdizole derivatives possess a wide spectrum of antimicrobial profile like antibacterial activity against *Mycobacterium tuberculosis* [7-10], antibacterial and antifungal activities against *E.coli* and *Stayphyllococcus aureus*, *Aspergillus niger* and *Aspergillus oryzae* [11, 12], antibacterial and antimicrobial activities against *Stayphylococcus aureus, Bacillus subtilis* and *Pseudomonas aeruginosa, E.coli* [13], antibacterial and antifungal activities against *P.aeruginosa* and *C. albicans* [10], antimicrobial activity against *B.Subtilis* and *S. aureusķ* [14], antibacterial activity against *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus epidermidis*, and *Staphylococcus aureus* [15], antimicrobial activities against *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa, Candida albicans, C. krusei* and *C. parapsilosis* [16]. Therefore it was decided to synthesize, characterize few oxadiazole derivatives and to check its anti-bacterial activity against *E.coli, Bacillus subtilis, Micrococcus letteus* and the anti-fungal activity against *Candida albicans, Sacromyces cervesiae* [17].

MATERIALS AND METHODS: Melting points of the synthesized compounds were determined by open capillary and are uncorrected. The purity of the compounds was checked using TLC plates (glass) coated with silica gel. The developed chromatographic plates were visualized under iodine chamber. All the reaction were done by refluxing method and the identification of the synthesized compound were done by IR spectroscopy using KBr on Shimadzu FTIR model 8400 spectrophotometer and 1H NMR from Bruker Avance II 400 NMR spectrometer. The antimicrobial activity was carried out by disk diffusion test method [18].

EXPERIMENTAL WORK:

SCHEME 1:



compd.	R1	R2	R3
1a, 2a	Cl	H	H
1b, 2b	H	NO2	H
1c, 2c	H	H	OH
1d, 2d	H	OCH3	OCH3

Synthesis of 1-(2-chlorobenzylidene) semicarbazide, 1a: A mixture of 0.1mol of semicarbazide hydrochloride, 0.2mol sodium acetate and 30ml distilled water were taken in

RB flask followed by addition of mixture of 0.1mol of 2-chloro benzaldehyde and 20ml ethyl alcohol. This reaction mixture was stirred continuously for 1 hr, which resulted the formation of product. The product was further washed, dried and recrystallized with ethanol to give compd. 1a as per **SCHEME 1.** The yield analysis data is given in **TABLE 2. FT-IR (KBrνmax cm^{-1}):** 3462 cm^{-1} (NH_2), 1687 cm^{-1} ($O=CNH_2$), 724 cm^{-1} (Cl), 3195 cm^{-1} (=CH).

Synthesis of 5-(2-chlorophenyl)-1, 3, 4-oxadiazole-2-amine, 2a: A mixture of 0.1mol of compd. 1a, 0.2mol of Sodium acetate and 30ml glacial acetic acid were taken into a RB flask. To this mixture a solution of 1.6ml bromine into 8ml glacial acetic acid was added with continuous stirring for 1hr. The product obtained in this process was washed, dried and recrystallize with ethanol to give compd. 2a as per **SCHEME 1.** The yield analysis data is given in **Table 2. FT-IR (KBrνmax cm^{-1}):** 3460cm^{-1} (NH_2), 3157cm^{-1} (=C-H) , 1157cm^{-1} (C-O-C), 1658cm^{-1} (C=C), 734cm^{-1} (Cl ortho position), 2613cm^{-1} (C=N), 1707cm^{-1} (N=C-NH_2).**NMR (400 MHz, DMSO, ppm): δ** 6.5-7.00ppm (d, 2H, S, 2H, Ar-4H), **δ** 7.2-7.5ppm (s, 2H, NH_2),

Synthesis of 1-(3-nitrobenzylidene) semicarbazide, 1b: A mixture of 0.1mol of semicarbazide hydrochloride, 0.2mol sodium acetate and 30ml distilled water were taken in RB flask followed by addition of mixture of 0.1mol of 3-nitro benzaldehyde and 20ml ethyl alcohol. This reaction mixture was stirred continuously for 1 hr, which resulted the formation of product. The product was further washed, dried and recrystallized with ethanol to give compd. 1b as per **SCHEME 1.** The yield analysis data is given in **Table 2. FT-IR (KBrνmax cm^{-1}):**: 3458 cm^{-1} (NH_2), 1708 cm^{-1} ($O=CNH_2$), 729 cm^{-1} (NO_2), 3230 cm^{-1} (=CH).

Synthesis of 5-(3-nitrophenyl)-1, 3, 4-oxadiazole-2-amine, 2b : A mixture of 0.1mol of compd. 1b, 0.2mol of Sodium acetate and 30ml glacial acetic acid were taken into a RB flask. To this mixture a solution of 1.6ml bromine into 8ml glacial acetic acid was added with continuous stirring for 1 hr. The product obtained in this process was washed, dried and recrystallize with ethanol to give compd. 2b as per **SCHEME 1.** The yield analysis data is given in **Table 2. FT-IR (KBrνmax cm^{-1}**): 3462cm^{-1} (NH_2), 3165cm^{-1} (=C-H), 1710cm^{-1} (N=C-NH_2), 1141cm^{-1} (C-O-C), 2820cm^{-1} (C=N), 725cm^{-1} (NO_2 meta aubstituted). **NMR (400 MHz, DMSO, ppm): δ** 6.5-8.4ppm, (d, 2H, s, 2H Ar-4H), **δ** 8.5-10.8ppm (s, 2H, NH_2).

Synthesis of 1-(4-hydroxybenzylidene) semicarbazide, 1c: A mixture of 0.1mol of semicarbazide hydrochloride, 0.2mol sodium acetate and 30ml distilled water were taken in RB flask followed by addition of mixture of 0.1mol of parahydroxy benzaldehyde and 20ml ethyl alcohol. This reaction mixture was stirred continuously for 1 hr, which resulted the formation of product. The product was further washed, dried and recrystallized with ethanol to give compd. 1c as per **SCHEME 1.** The yield analysis data is given in **Table 2. FT-IR (KBrνmax cm^{-1}):** 3471 cm^{-1} (NH_2), 1687 cm^{-1} ($C=NH_2$), 823 cm^{-1} (OH), 3244 cm^{-1} (=CH).

Synthesis of 4-(5-amino-1, 3, 4-oxadiazol-2-yl)phenol, 2c : A mixture of 0.1mol of compd. 1c, 0.2mol of Sodium acetate and 30ml glacial acetic acid were taken into a RB flask. To this mixture a solution of 1.6ml bromine into 8ml glacial acetic acid was added with continuous stirring for 1 hr. The product obtained in this process was washed, dried and recrystallize with ethanol to give compd. 2c as per **SCHEME 1.** The yield analysis data is given in **Table 2. FT-IR (KBrνmax cm^{-1}):** 3481cm^{-1} (NH_2), 3254cm^{-1} (=C-H), 1685cm^{-1} (N=C-NH_2), 1051cm^{-1} (C-O-C), 1685cm^{-1} (C=C), 2609cm^{-1} (C=N), 825cm^{-1} (OH para

substituted). **NMR (400 MHz, DMSO):** **δ** 6.3-7.9ppm (d, 4H, Ar-H), **δ** 8.4-10.2ppm (s, 2H, NH_2), **δ** 2.5ppm (s, 1H, OH).

Synthesis of 1-(3,4-dimethoxybenzylidene)semicarbazide, 1d: A mixture of 0.1mol of semicarbazide hydrochloride, 0.2mol sodium acetate and 30ml distilled water were taken in RB flask followed by addition of mixture of 0.1mol of 3,4 dimethoxy benzaldehyde and 20ml ethyl alcohol. This reaction mixture was stirred continuously for 1 hr, which resulted the formation of product. The product was further washed, dried and recrystallized with ethanol to give compd. 1d as per **SCHEME 1.** The yield analysis data is given in **Table 2. FT-IR (KBrνmax cm^{-1}):** 3470 cm^{-1} (NH_2), 3161 cm^{-1} (=CH), 1163 cm^{-1} (OCH_3), 1691 cm^{-1} ($O=CNH_2$).

Synthesis of 5-(3, 4-dimethoxyphenyl)-1, 3, 4-oxadiazole-2-amine, 2d: A mixture of 0.1mol of compd. 1d, 0.2mol of Sodium acetate and 30ml glacial acetic acid were taken into a RB flask. To this mixture a solution of 1.6ml bromine into 8ml glacial acetic acid was added with continuous stirring for 1 hr. The product obtained in this process was washed, dried and recrystallize with ethanol to give compd. 2d as per **SCHEME 1.** The yield analysis data is given in **Table 2. FT-IR (KBrνmax cm^{-1}):** 3468 cm^{-1}(NH_2), 3192cm^{-1}(=CH), 1678cm^{-1}(N=C-NH_2), 1166cm^{-1}(C-O-C), 1136cm^{-1} (OCH_3). **NMR (400 MHz, DMSO, ppm**): δ 6.8-7.5ppm (d, 2H, S, 1H Ar-3H), δ 7.5-10.4ppm (s, 2H, NH_2), δ 3.6-6.5ppm, (s, 3H, OCH_3).

Table 2: Yield analysis of synthesized compounds 2(a-d)

Compound	Molecular formula	Recrystallization solvent	Yield (%)	m.p. (°C)	R_f
1a	$C_8H_8N_3OCl$	Ethanol	88.5	215	0.87
1b	$C_8H_8N_4O_3$	Ethanol	92.5	115	0.86
1c	$C_8H_9N_3O_2$	Ethanol	97.0	115	0.88
1d	$C_{10}H_{13}N_3O_3$	Ethanol	89.0	58	0.93
2a	$C_8H_6N_3OCl$	Ethanol	61.0	110	0.91
2b	$C_8H_6N_4O_3$	Ethanol	58.6	210	0.93
2c	$C_8H_7N_3O_2$	Ethanol	96.0	160	0.86
2d	$C_{10}H_{11}N_3O_3$	Ethanol	92.0	40	0.83

ANTIMICROBIAL ACTIVITY:

Procedure for preparing anti-bacterial and anti-fungal strains: 0.78 grams ampules present in powder form (nutrient broth) is dissolved in 60ml water and divided in two test tubes. Both test tubes were autoclaved for one hour. Inoculation (addition of pure culture) was done in one test tube in laminar for 5-10min. and other was used as control. Both test tubes were kept in incubator for 24hrs at 37°C. The growth of strains was checked with control test tube. The test tube with strain was found in different phases, while control test

tube was found in similar phase. 0.5ml anti-bacterial or anti-fungal strain was used for each petri plate.

Different strains such as anti-bacterial like *Bacillus subtilis, E.coli, Micrococcus Letteus* and antifungal like *Candida albicans, Sacromyces cervesiae* were used for antimicrobial activities.

2.8gm of nutrient agar powder, 3gms of agar agar powder and 100 ml water were taken in 250ml conical flask and mixed vigorously for anti-bacterial strain. This mixture along with well dried petri plate was autoclaved for 1hr. The same process was repeated with 5.6grm yped agar powder, 3gms of agar agar powder and 100ml water for anti-fungal strain. Thereafter, the mixture from conical flask was spread onto petri plates with the help of spreader and kept for 5min., the whole process was carried out in laminar. Already prepared anti-bacterial or anti-fungal strain was introduced in this petri plate.

Each compound was dissolved in DMSO at 50µg/ml, 100µg/ml and 150µg/ml and one filter paper disc was added in each solution and kept for 2hrs. Antibiotic ampicillin (Control) was dissolved in DMSO at 100µg/ml and one filter paper disc was added in it. These discs were administered in petri plate one for control and three for tests. The petri plate was covered with the help of paraffin and kept in incubator for 24hrs. Thereafter, the antimicrobial activity was analysed in term of zone of inhibition in millimetre.

Anti-bacterial activity against *E. coli*: The compounds 2(a-d) were tested at three different concentrations- 50µg/ml, 100µg/ml and 150µg/ml along with antibiotic ampicillin at 100µg/ml against E. coli. All four synthesized compounds were found active as shown in **Fig. 2** and data for zone of inhibition is given in **Table 3.**

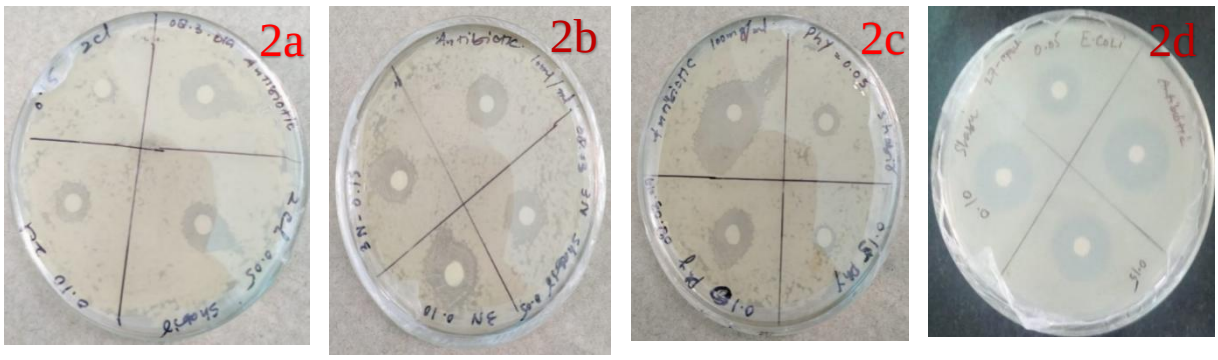


FIG. 2: Antibacterial activity result of compounds. 2(a-d) against the bacteria *E. coli*

Anti-bacterial activity against *Bacillus subtilis*: The compounds 2(a-d) were tested at three different concentrations- 50µg/ml, 100µg/ml and 150µg/ml along with antibiotic ampicillin at 100µg/ml against *Bacillus subtilis*. All four compounds were found active as shown in **Fig. 3** and data for zone of inhibition is given in **Table 3.**

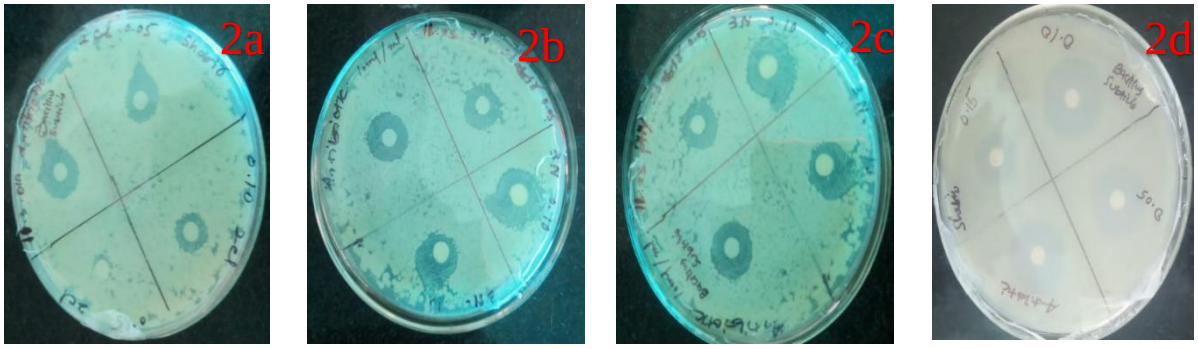


FIG. 3: Antibacterial activity result of compounds 2(a-d) against the bacteria *Bacillus subtilis*

Anti-bacterial activity against *Micrococcus luteus*: The compounds 2(a-d) were tested at three different concentrations- 50µg/ml, 100µg/ml and 150µg/ml along with antibiotic ampicillin at 100µg/ml against *Micrococcus luteus*. All four synthesized compounds

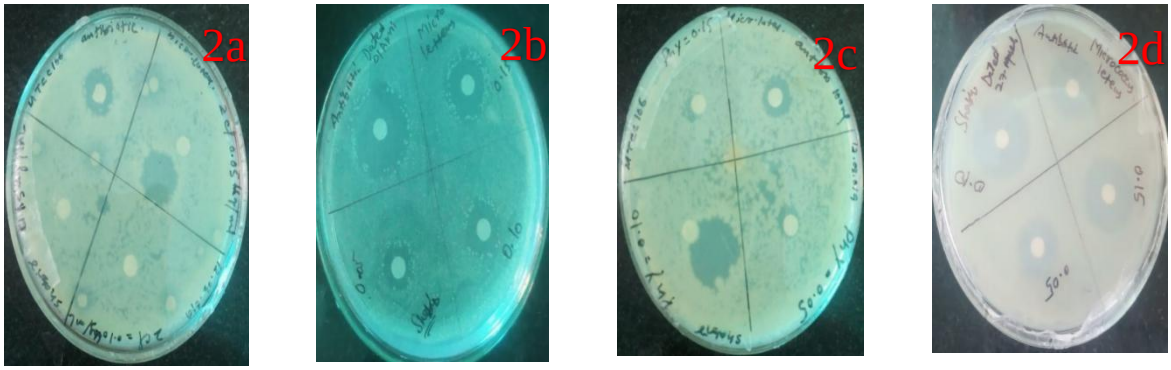


FIG. 4: Antibacterial activity result of compounds 2(a-d) against the bacteria *Micrococcus Letteus*

were not found active as shown in **Fig. 4** and the data for zone of inhibition is given in **Table 3.**

Table 3: Antibacterial activity of synthesized compounds 2(a-d)

Compound	**Concentration (µg/ml)**	**Zone of inhibition (mm)**		
		E.coli	***Bacillus subtilis***	***Micrococcus lettus***
2a	50	05	04	00
	100	07	03	00
	150	08	02	00
2b	50	04	04	02
	100	03	06	03
	150	02	05	04
2c	50	04	05	04

	100	06	04	08
	150	03	06	02
2d	50	05	06	05
	100	07	08	08
	150	06	05	06
Standard (Ampicillin)	100	5.12	5.0	5.0

Anti-fungal activity against *Candida albicans*: The compounds 2(a-d) were tested at three different concentrations- 50µg/ml, 100µg/ml and 150µg/ml along with antibiotic ampicillin at 100µg/ml against *Candida albicans*. All four synthesized compounds were not found active as shown in **Fig. 5** and data for zone of inhibition is given in **Table 4.**

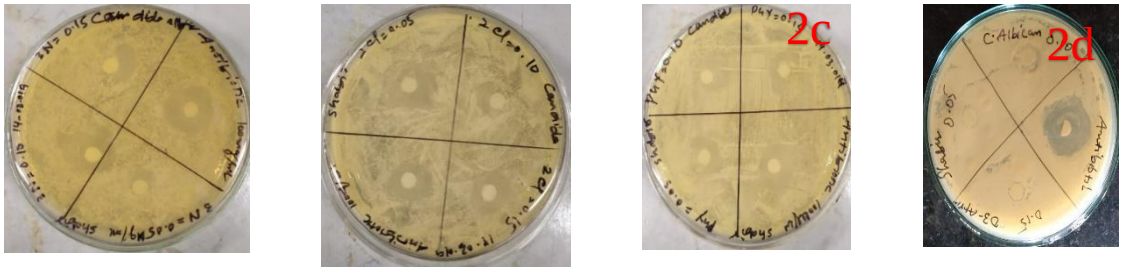


Fig. 5: Antifungal activity result of compounds (2a-d) against fungi *candida albicans*.

Anti-fungal activity against *Saccharomyces cerevisiae*: The compounds 2(a-d) were tested at three different concentrations- 50µg/ml, 100µg/ml and 150µg/ml along with antibiotic ampicillin at 100µg/ml against *Saccharomyces cerevisiae*. All four

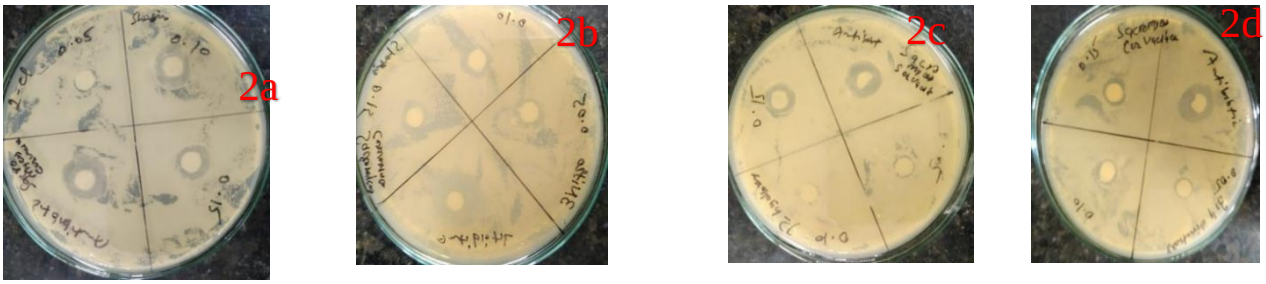


Fig. 6: Antifungal activity result of compounds (2a-d) against fungi S*acromyces cervesicae*

compounds were not found active as shown in **Fig. 6** and data for zone of inhibition is given in **Table 4**.

Table 4: Antifungal activity of synthesized compounds 2(a-d)

Compound	**Concentration (µg/ml)**	**Zone of inhibition (mm)**	
		Candida albicans	***Sacromyces cervesiae***

2a	50	05	01
	100	03	02
	150	04	03
2b	50	02	01
	100	04	02
	150	03	02
2c	50	03	01
	100	04	01
	150	03	03
2d	50	00	01
	100	01	02
	150	01	02
Standard (Ampicillin)	100	05	04

DISCUSSION: The comparative graphical analysis of antimicrobial activities gives more clarity about the impact of synthesized compounds for in-vitro studies against bacterial and fungal species. The analysis has been discussed through **Figures 7-11.**

The antibacterial activity of synthesized compounds 2(a-d) and standard drugs Ampicillin against *E. coli* is shown by **Fig. 7.** Ampicillin at 100µg/ml gives inhibition zone at 5mm while synthesized compounds 2a, 2c and 2d give 7mm, 6mm and 7mm respectively which evolves better antibacterial agents. While at 50 µg/ml Ampicillin gives inhibition zone at 5mm and synthesized compounds 2a and 2d give 5mm and 5mm respectively which evolves poor antibacterial agents. At 150µg/ml the Ampicillin shows zone of inhibition at 5mm and synthesized compounds 2a and 2d give 8mm and 6mm respectively which evolves better antibacterial agents.

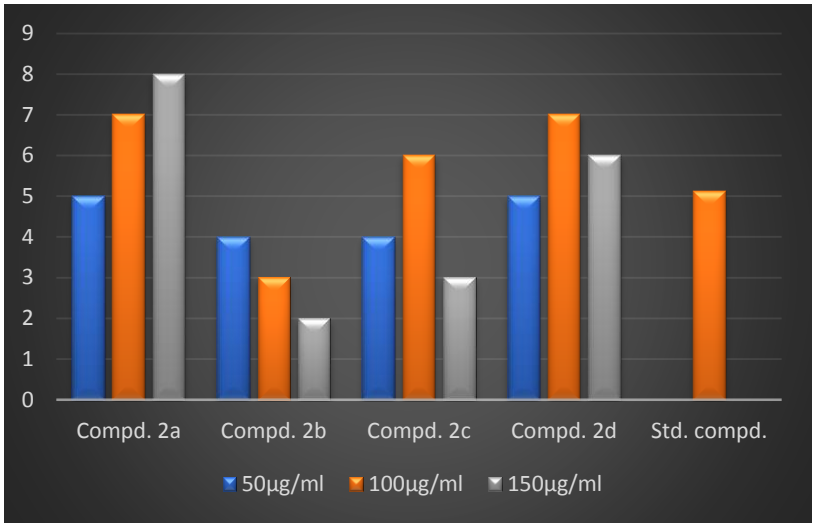


Fig.7: Comparative antibacterial activity of compounds 2(a-d) on E. *coli*

The antibacterial activity of synthesized compounds 2a-d and standard drugs Ampicillin against *Bacillus subtilis* is shown by **Fig. 8.** Ampicillin at 50 µg/ml gives inhibition zone at 5mm while synthesized compounds 2a, 2b, 2c and 2d give 4mm, 4mm, 5mm and 6mm respectively which evolve better antibacterial agents. At 100µg/ml Ampicillin shows zone of inhibition 5mm and synthesized compounds 2a and 2d give 6mm and 8mm respectively which evolves better antibacterial agents and At 150 µg/ml Ampicillin shows zone of inhibition at 5mm and synthesized compounds 2b, 2c and 2d give 5mm, 6mm, and 5mm respectively which evolve better antibacterial agents.

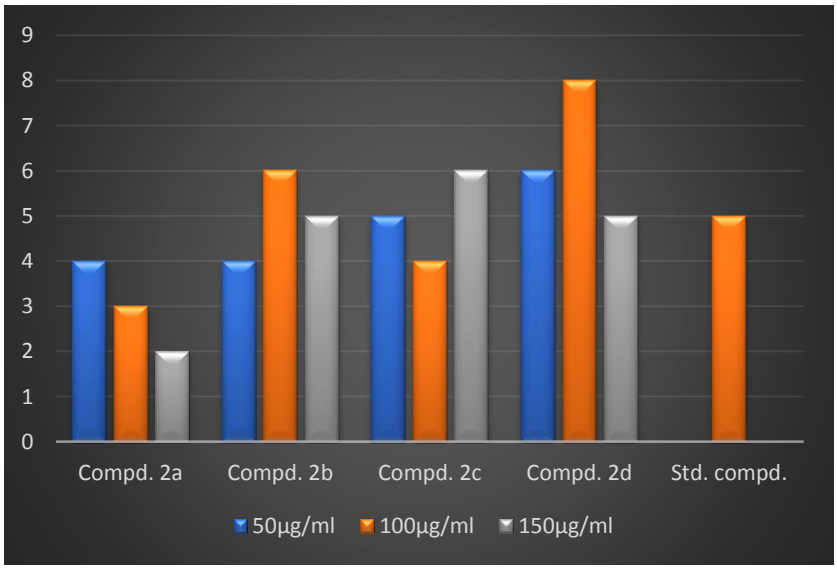


Fig. 8: Comparative antibacterial activity of compounds 2(a-d) on *Bacillus subtilis*

The antibacterial activity of synthesized compounds 2a-d and standard drugs Ampicillin against *Micrococcus letteus* is shown by **Fig. 9.** Ampicillin at 50 µg/ml gives inhibition zone at 5mm while synthesized compounds 2c and 2d give 4mm and 5mm respectively which evolve poor antibacterial agents. . At 100µg/ml Ampicillin shows zone of inhibition 5mm and synthesized compounds 2c and 2d give 8mm and 8mm respectively which evolve better

antibacterial agents and At 150 µg/ml Ampicillin shows zone of inhibition at 5mm and synthesized compounds 2b and 2d are poor antibacterial agents.

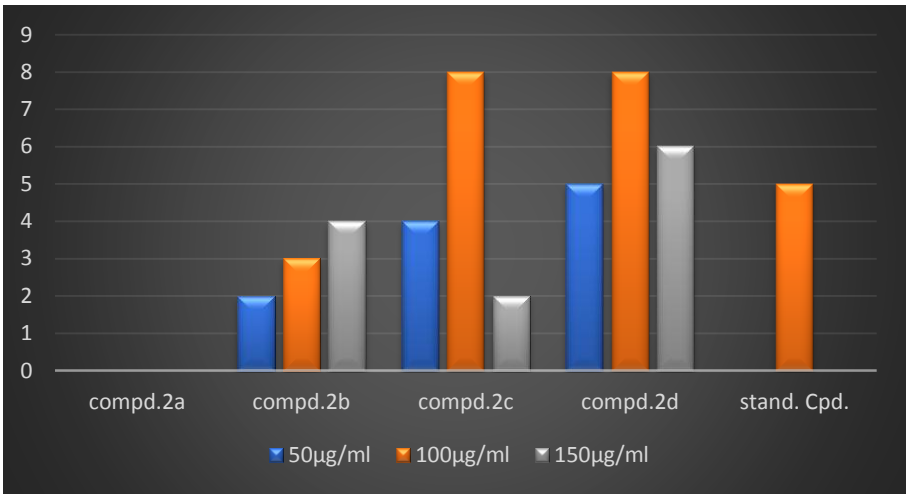


Fig.9: Comparative antibacterial activity of compounds 2(a-d) against M*icrococcus letteus*

The antifungal activity of synthesized compounds 2(a-d) and standard drugs Ampicillin against *Candida albicans* is shown by **Fig. 10.** Ampicillin at 50 µg/ml gives inhibition zone at 5mm while synthesized compounds 2a give 5mm and at 100µg/ml Ampicillin shows zone of inhibition 5mm and synthesized compounds 2b, 2c give 4mm, 4mm and at 150 µg/ml Ampicillin shows zone of inhibition at 5mm and synthesized compounds 2a give 4mm respectively evolve better antifungal agents.

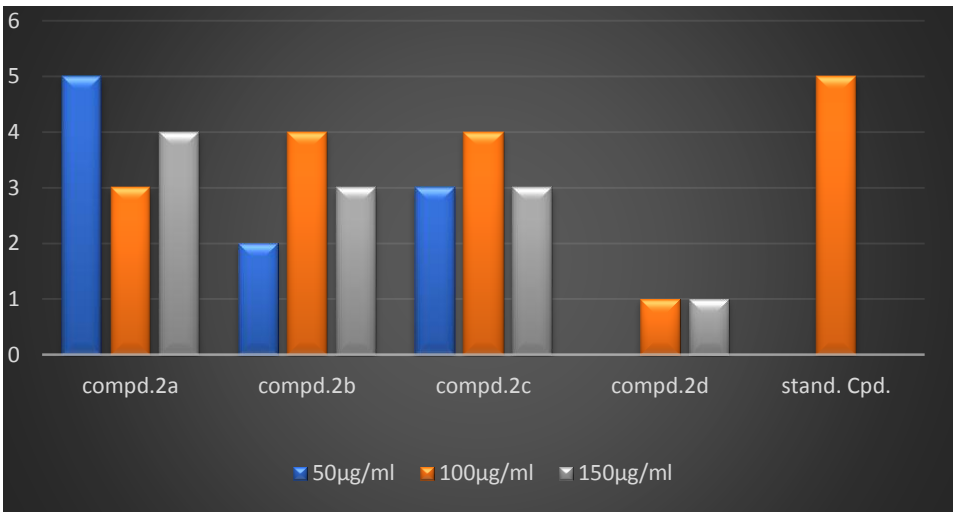


Fig. 10: Comparative antifungal activity of compounds 2(a-d) on *Candida albicans*

The antifungal activity of compounds 2(a-d) and standard drugs Ampicillin against *Sacromyces cervesiae* is shown by **Fig. 11.** Ampicillin at 50 µg/ml gives inhibition zone at 4mm while synthesized compounds 2a, 2b, 2c, and 2d give 1mm, 1mm, 1mm, and 1mm and at 100µg/ml Ampicillin shows zone of inhibition 4mm and synthesized compounds 2a, 2b, 2c, and 2d give 2mm, 2mm, 1mm, and 2mm and at 150 µg/ml Ampicillin shows zone of inhibition at 4mm and synthesized compounds 2a and 2c give 3mm and 3mm respectively evolve better antifungal agents.

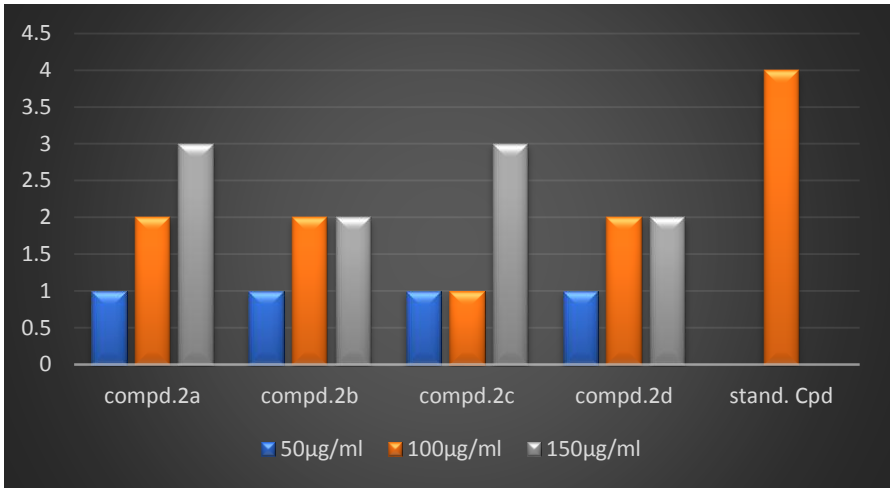


Fig.11: Comparative antifungal activity of compounds 2(a-d) on *Sacromyces cervesiae*

RESULT: The synthesized compounds 2(a-d) gave comparatively more yield and require less time to complete the reaction. In the present study, all synthesized compounds showed moderate Antimicrobial activities. The synthesized compounds 5-(2-chlorophenyl)-1, 3, 4-oxadiazole-2-amine, 2a and 5-(3,4-dimethoxyphenyl)-1, 3, 4-oxadiazole-2-amine, 2d showed good anti-bacterial as well as anti-fungal activities in terms of zone of inhibition in mm. The newly synthesized oxadiazole derivatives had good anti-bacterial and anti-fungal activities and might be used for the development of new drugs and for the treatment of bacterial and fungal diseases.

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CONFLICT OF INTEREST: The authors declare no conflict of interest.

REFERENCES:

1. Sun J, Makawana JA and Zhu HL: 1, 3, 4-Oxadiazole Derivatives as Potential Biological Agents. Mini-Reviews in Medicinal Chemistry 2013; 13(12): 1725-1743.

2. Sahin G, Palaska E, Ekizoglu M and Ozalp M: Synthesis and antimicrobial activity of some 1, 3, 4-oxadiazole derivatives. Farmaco 2002; 57(7): 539-542.

3. Grewal AS, and Redhu S: Synthesis, antibacterial and antifungal activity of 2, 5-disubstituted-1, 3, 4-oxadiazole derivatives. International Journal of Pharm Tech Research 2014; 6(7): 2015-2021.

4. Mishra MK, Gupta AK, Negi S and Bhatt M: Synthesis of some new oxadiazole with antimicrobial. International Journal of Pharma Sciences and Research 2010; 1(3): 172-177.

5. Mukherjee, R. (2020). Electrical, thermal and elastic properties of methylammonium lead bromide single crystal. Bulletin of Materials Science, *43*(1), 1-5.

6. Mukherjee, R., Huang, Z. F., & Nadgorny, B. (2014). Multiple percolation tunneling staircase in metal-semiconductor nanoparticle composites. Applied Physics Letters, *105*(17), 173104.

5. Husain A and Ajmal M: Synthesis of novel 1,3,4-oxadiazole derivatives and their biological properties. Acta pharmaceutica 2009; 59(2): 223-233.

6. Laha, S. S., Mukherjee, R., & Lawes, G. (2014). Interactions and magnetic relaxation in boron doped Mn3O4 nanoparticles. Materials Research Express, *1*(2), 025032.

7. Singh, S., Singh, N., Kumar, V., Datta, S., Wani, A. B., Singh, D., ... & Singh, J. (2016). Toxicity, monitoring and biodegradation of the fungicide carbendazim. Environmental chemistry letters, *14*(3), 317-329.

8. Roy PP, Bajaj S, Maity TK and Singh J: Synthesis and evaluation of anticancer activity of 1, 3, 4-oxadiazole derivatives against ehrlich ascities carcinoma bearing mice and their correlation with histopathology of liver. Indian Journal of Pharmaceutical Education and Research 2017; 51(2): 260-269.

9. Ali M and Shaharyar M: Oxadiazole mannich bases: synthesis and anti-microbacterial activity. Bioorganic and Medicinal Chemistry Letters 2007; I7(12): 3314-3316.

10. Modi V and Modi P: oxadiazole: synthesis, characterization and biological activities. Journal of Saudi chemical society 2012; 16(3): 327-332.

11. Gupta V, Kashaw SK, Jatav V and Mishra P: Synthesis and antimicrobial activity of some new 3-[5-(4-substituted) phenyl-1, 3, 4-oxadiazole-2yl]-2- styrylquinazoline-4(3H)-ones. Medicinal Chemistry Research 2008; 17; (2-7): 205-211.

12. Parikh PK, Marvaniya HM and Sen DJ: Synthesis and biological evaluation of 1, 3, 4-oxadiazole derivatives as potential antibacterial and antifungal agents. International Journal of Drug Development and Research 2011; 3(2): 248-255.

13. Mukherjee, R., Chuang, H. J., Koehler, M. R., Combs, N., Patchen, A., Zhou, Z. X., & Mandrus, D. (2017). Substitutional Electron and Hole Doping of WSe 2: Synthesis, Electrical Characterization, and Observation of Band-to-Band Tunneling. Physical Review Applied, *7*(3), 034011.

14. Mukherjee, R., Lawes, G., & Nadgorny, B. (2014). Enhancement of high dielectric permittivity in CaCu3Ti4O12/RuO2 composites in the vicinity of the percolation threshold. Applied Physics Letters, *105*(7), 072901.

15. Malhotra M, Sanduja M, Samad A and Deep A: New oxadiazole derivatives of isonicotinohydrazide in the search of antimicrobial agents: Synthesis and in vitro evaluation. Journal of Serbian Chemical Society 2012; 77(1): 9-16.

16. Bala S, Kamboj S, Kajal A, Saini V and Prasad DN: 1,3,4-Oxadiazole Derivatives: Synthesis, Characterization, Antimicrobial Potential, and Computational Studies. Biomed Research International 2014; 2014: 172791.

17. Sahin G, Palaska E, Ekizoglu M and Ozalp M: Synthesis and antimicrobial activity of some 1,3,4-oxadiazole derivatives. Il Farmaco 2002; 57(7):539-42.

18. Bauer AW, Kirby WM, Sherris JC and Turck M: Antibiotic susceptibility testing by a standardized single disk method. American Journal of Clinical Pathology 1966; 45(4): 493–6.