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Solid acidic $FeCl_3$/Bentonite catalyzed solvent-free condensation: synthesis, spectral studies and antimicrobial activities of some aryl hydrazine Schiff's bases

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Some aryl hydrazide derivatives have been synthesized including 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines by $FeCl_3$/Bentonite catalyzed solvent-free condensation of substituted phenyl hydrazine and aldehydes under microwave irradiation. The yields of the hydrazides are more than 70%.

The synthesized hydrazides are characterized by the physical constants, micro analysis and spectroscopic data. Effect of catalyst, solvent effect substituent effect and optimization of the catalyst was studied by the percentage of isolated yields. From the catalyst optimization, the present study catalyst gave the better yield of products.

The antimicrobial activities of all synthesized of 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines have been evaluated using Bauer-Kirby disc diffusion method.

Keywords: Aryl hydrazides, substituted phenyl hydrazines, $FeCl_3$/Bentonite, Solvent-free synthesis, Antimicrobial activities.

1. INTRODUCTION

Azines are nitrogenous compounds and they had azomethine >N–N= moieties in their structures. Moreover in addition they possess the skeletons of amido –CO–NH–N= imines –CO–NH–N=CH– and carbothioamides –CS–NH–N=CH–. These hydrazines were prepared by condensation of carbonyl compounds and hydrazine hydrates in presence of base or acid in organic medium or solvent-free methods. The geometry of these azines was confirmed by spectroscopic techniques such as UV-Visible, FT-IR [1], NMR [2], Mass and XRD [3–8].

Numerous synthetic methods including conventional and solvent-free methods were available for the synthesis of hydrazine derivatives. Desai et al. [9] studied the synthesis of some new azetidin and thiazolidin based hydrazine derivatives by conventional refluxation of azetidin and thiazolidin ketones with Schiff's bases using piperidine as catalyst. Some 2-(alkyl-, akylaryl, aryl-, hetaryl-)[1,2,4]triazolo[1,5-c]quinazozlzine based hydrazine derivatives were synthesized by conventional method in propanol/dioxane medium [10].

Patil et al. [11] have reported some thiophene-2-carboxylic acids N′-(3-acyl/substituted aryl/hetroaryl-acrylo-lyl)-hydrazide derivatives by refluxation method using NaOH as catalyst in ethanol medium at 20-25°C. Synthesis of some substituted benzylidene hydrazine acetyl mercapto-5-methyl-1,3,4-thiazole derivatives using conventional method in ethanol medium was reported by Dua and Srivatsava [12]. Solvent-free microwave irradiation method [13] was reported for the synthesis of some novel N-aryl hydrazines by the condensation of the hydrazide with carbonyl compounds in presence of con.H_2SO_4. Synthesis and X-ray diffraction study of (*E*)-1-(2,4-dinitrophenyl)-2-(2-fluoro benzylidene) hydrazine was reported by Jasinski et al. [7]. These azine derivatives are important in medicinal and pharmaceutical fields. They show important biological activities due to presence of polar groups in azomethine units in their structure.

The important biological activities are antimicrobial[2–5], anticonvulsant [1], anticancer, antitubercular, CNS activity, pesticidal, antihyperlipidenic [14], antidepressant, aantiinfalmmatory, vasoldilaror[10], anti- analgesic, antianxiety [15], antioxidant, HIV-1inhibitors [16], antiplatelet [11], antimalarial, antiviral, antischistosomiasis, antiepileptic, cardiovascular [17], antimycobacterial [18], antitumoural [19], antihypertensive, antidiabatic [20], herbicidal [21], and nematicidal [22]. Desai et al. [9] have evaluated the antimicrobial activities of some

Azetidine and thiozolidene based hydrazines using *Escherichia coli, Bacillus cirroflagellosus, Aspergillus niger* and *Colletotrichum capsici microbe strains.* Anticancer activity of some aryl hydrazines were studied using GI_{50} values and reported by Kovalenko et. al. [10].

The anticonvulsant activity of some novel semicarbazide derivatives was studied by Nain et al. [23]. The *in-vitro* anticancer activities of some thiophen-2-carboxylic acid N′-(3-aryl/substituted aryl/hetaryl-acrolyl)-hydrazine derivatives was evaluated by Patil et al. [11].

The antibacterial and antifungal activities of some novel hydrazeno-acetyl derivatives was evaluated using *Bacillus substilis, Escherichia coli. Klebsiella pneumoniae* and *Streptococcus aureus* bacterial strains and antifungal activity against *Aspergillus niger, Aspergillus flavus, Fusarium oxisporium* and *Trichoderma viride* fungi strains by Dua et al. [12]. The antimicrobial screening study of pyrimidine based hydrazine derivatives was reported by Hussein et. al. [24]. The mycobacterium tuberculosis H_{37}RV-microplate alaman blue assay (MABA) study of 2-phenylthio-benzoylaryl hydrazine derivatives was reported by Almasirad et. al. [25].

Prasanna Kumar and his co-workeres[26] employed the antimicrobial strains *Bacillus subtilis, Staphylococcus aureus, Xanthomonas campestris, Escherichia coli* and *Fusarium oxysporum* for evaluation of antimicrobial activities of (*E*)-2-(arylbenzylidene)-2-((4-methoxyphenyl)amino) acetohydrazide derivatives. Recently, Vijayakumkar et al. [27] investigated the synthesis, spectral studies and evaluation of antimicrobial activities of some hydrazone derivatives. At present the similar study with 1-(3-chloro-4-nitrophenyl)-2-(3-substituted benzylidene) hydrazines were not known in the literature survey.

Therefore the authors have taken efforts to synthesize above hydrazines and recorded their infrared, ^1H and ^{13}C NMR spectra with a view to seek characteri-zations. The antimicrobial activity synthesized hydrazines have been analyzed using Bauer-Kriby [28] disc diffusion method.

2. EXPERIMENTAL

2.1. General

Chemicals used in this investigations were purchased from Himedia (99% purity), S D Fine-Chem (97–99.3% purity) and Sigma-Aldrich (99.99% purity) Chemical Companies. The melting points of all compounds were measured in Raga melting point apparatus using

capillary tube and are uncorrected. IR spectra of all hydrazines under investigation were recorded using the SHIMADZU 8400 FT-IR spectrophotometer The ^{1}H and ^{13}C NMR Spectra of all α, β-unsaturated ketones under investigation were recorded using the BRUKER, 400MHz model spectrometer operating at 400 MHz has been utilized for recording ^{1}H NMR spectra and 100 MHz for ^{13}C NMR spectra in CDCl3 and DMSO solvent using TMS as internal standard.

The mass spectra of all compounds recorded as electron impact (70 eV) and chemical ionization mode FAB+ mass spectrum in VARIAN-SATURN 2200 GC-MS spectrometer (Varian Medical Systems, Palo Alto, CA, USA). Microanalyses of all the hydrazines were performed in Thermofinnigan CHN analyzer.

2.2. Preparation of $FeCl_3$/Bentonite catalyst

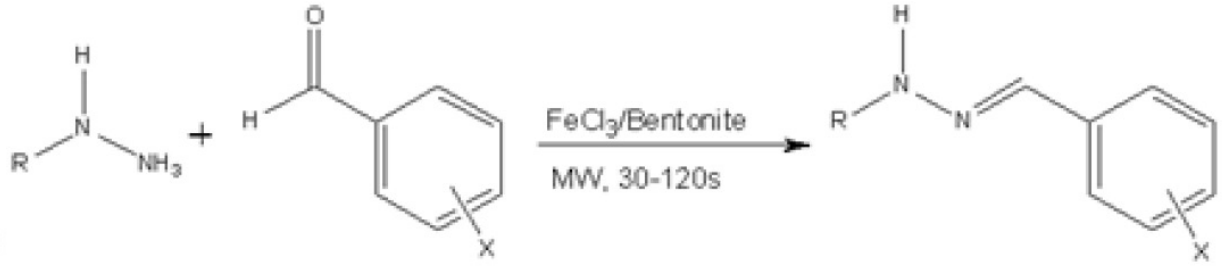
The solid acidic $FeCl_3$/Bentonite catalyst was prepared and characterized by literature method [29] (*See supplementary data for preparation and characterization of the catalyst*).

2.3. Synthesis of (E)1-(substituted benzylidene)-2-(substituted phenyl) hydrazines

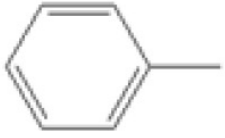
An appropriate mixture of equimolar quantities of substituted hydrazine (0.01mol), substituted benzaldehyde (0.01 mol) and 0.2g of $FeCl_3$/Bentonite catalyst were taken in a round bottomed flask, thoroughly mixed. Then these contents were subjected to microwave irradiation in a scientific microwave oven at 120°C with the regular interval time 30–120 s (Ragatech oven, RG31L Scientific Microwave oven, 230 V A/C, 50 Hz, 2450 Hz, 1200 rpm (beam reflector)) (Scheme 1). The completion of the reaction was monitored by Thin Layer Chromatogram.

The resultant mixture was cooled at room temperature. Then the precipitate obtained, was filtered at the filter pump and washed several times with cold water. The crude product was recrystallized from ethanol to afforded glittering red orange solids.

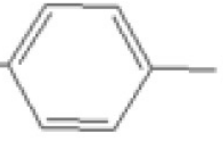
Scheme .1. Synthesis of 1-(substituted benzylidene)-2-(substituted phenyl) hydrazines.



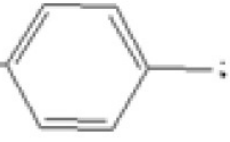
Where

R=  ;

Entry	1a	1b	1c	1d	1e	1f	1g	1h	1i	1j
X	H	4-Br	4-Cl	4-CH_3	2-NO_2	3-NO_2	4-NO_2	---	---	---

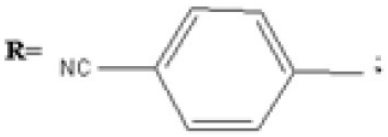
R= Br  ;

Entry	2a	2b	2c	2d	2e	2f	2g	2h	2i	2j
X	H	3-Br	4-Br	3-Cl	4-Cl	4-F	4-OCH_3	3-NO_2	4-NO_2	---

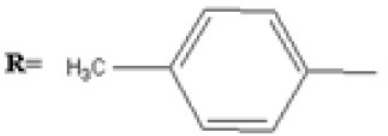
R= Cl  ;

Entry	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j
X	H	3-Br	4-Br	3-Cl	4-Cl	4-F	4-OCH_3	3-NO_2	4-NO_2	---

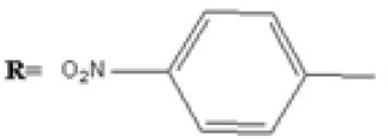
cont. Scheme 1.



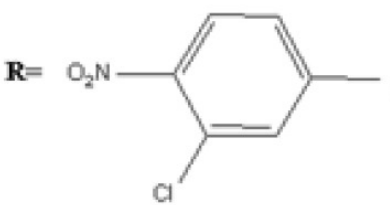
Entry	4a	4b	4c	4d	4e	4f	4g	4h	4i	4j
X	H	3-Br	4-Br	3-Cl	4-Cl	4-F	4-OCH_3	3-NO_2	4-NO_2	—



Entry	5a	5b	5c	5d	5e	5f	5g	5h	5i	5j
X	H	3-Br	4-Br	3-Cl	4-Cl	4-F	4-OCH_3	3-NO_2	4-NO_2	—



Entry	6a	6b	6c	6d	6e	6f	6g	6h	6i	6j
X	H	3-Br	4-Br	3-Cl	4-Cl	4-F	4-OCH_3	3-NO_2	4-NO_2	—



Entry	7a	7b	7c	7d	7e	7f	7g	7h	7i	7j
X	H	3-Br	4-Br	3-Cl	4-Cl	4-F	4-OCH_3	3-CH_3	3-NO_2	4-NO_2

2.4. Measurement of Antimicrobial activities

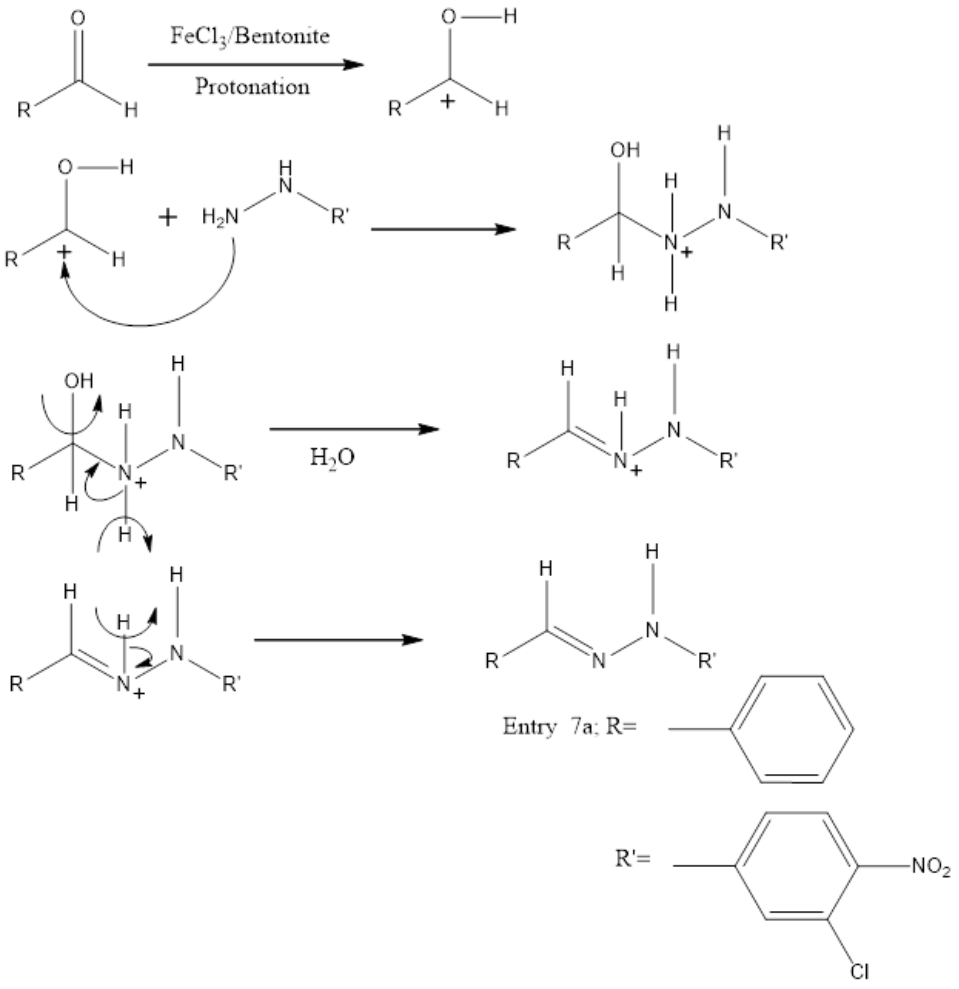
The antimicrobial activities such as antibacterial and antifungal activities of synthesized 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines were evaluated using disc diffusion method from the literature procedure [28, 30]. In this method the maximum zone of inhibition of hydrazines against their bacterial and fungi strains. This disc-diffusion experiment was conducted with the dilution of 250mg/cm^3, Ampicillin and Micanazole were standard drug and DMSO was the control solvent.

In the present investigation there are two gram positive *B.subtilis* and *M.luteus* strains and two gram negative bacterial *E.coli* and *P.aeruginosa* strains were employed for evaluation of antibacterial and antifungal activities of synthesized hydrazine derivatives. The fungal strains *A. niger* and *T.viride* were used for evaluation of antifungal activities of synthesized hydrazine derivatives (*see supplementary data for detailed experimental procedure*).

3. RESULTS AND DISCUSSION

We have reported our earlier work for the synthesis of various organic substrates by condensation reaction with various catalysts from our research laboratory [2–5, 27, 29, 30]. In continuation of our work, we attempts to synthesize some hydrazine based Schiff's base derivatives by condensation of substituted hydrazines and various benzaldehydes in presence of solid acidic $FeCl_3$/Bentonite catalyst by microwave irradiation. All hydrazines gave more than 75% yields. The 3-chloro-4-nitrophenyl hydrazine gave more than 92% yield (Entry7a). This condensation proceeds through acid catalyzed mechanism. The first step consists of protonation of aryl aldehyde from acidic $FeCl_3$/Bentonite catalyst to form the carbocation. Second step is the nucleophilic addition of phenyl hydrazine amino nitrogen to carbo cation of aldehydic carbon. Then the nitrogen carry's positive charge. The third step consists of the removal of water by elimination of –OH from aldehydic carbon and H from the imine nitrogen atom leads to formation of C=N bond with positive charge. The fourth step is the removal of proton from C=NH+ moiety leads to neutralized the positive charge on nitrogen atom leads to formation of hydrazine (Scheme 2). The electron donating substituents in the aldehydes gave higher yields than electron withdrawing substituents. The effect of catalyst was studied the condensation of 3-chloro-4-

nitrophenylhydrazine (0.01 mol) and benzaldehyde (0.01 mol) with $FeCl_3$/Bentonite catalyst. The physical constants, analytical and mass spectral data of hydrazines are presented in Tables 1–7. The infrared and NMR spectral data of all synthesized 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl)hydrazines were compiled in Table 8. The NMR spectra parent compound (Entry 7a) is shown in Figs. 1 and 2.



Scheme 2. The mechanism of $FeCl_3$/Bentonite catalyzed condensation of aryl aldehyde and aryl hydrazine by microwave irradiation under solvent-free conditions.

Table 1. The physical constants, analytical and mass fragment (m/z) of synthesized 1-(substituted benzylidene)-2-(3-substituted phenyl) hydrazines

Entry	M.F.	Time [s]	Yield [%]	m.p. [°C]	M.W.	Micro analysis [%]			Mass [m/z]
						C	H	N	
1a	$C_{13}H_{12}N_2$	90	90	157–158 (157–158) [31]	196	–	–	–	196[M^+]
1b	$C_{13}H_{11}BrN_2$	60	85	103–104 (103–104) [32]	275	–	–	–	275[M^+]
1c	$C_{13}H_{11}ClN_2$	60	88	113–114 (111–113) [32]	231	–	–	–	231[M^+]
1d	$C_{13}H_{14}N_2$	90	85	149–150 (148–149) [33]	210	–	–	–	210[M^+]
1e	$C_{13}H_{11}N_3O_2$	90	80	151–152 (151–152) [32]	241	–	–	–	241[M^+]
1f	$C_{13}H_{11}N_3O_2$	60	85	116–117 (116–117) [32]	241	–	–	–	241[M^+]
1g	$C_{13}H_{11}N_3O_2$	60	80	188–189 (186–188) [33]	241	–	–	–	241[M^+]

Table 2. The physical constants, analytical and mass fragment (m/z) of synthesized 1-(substituted benzylidene)-2-(4-bromophenyl) hydrazines.

Entry	M.F.	Time [s]	Yield [%]	m.p. [°C]	M.W.	Micro analysis [%]			Mass [m/z]
						C	H	N	
2a	$C_{13}H_{11}N_2Br$	90	87	84-85 (84-85) [4]	221	–	–	–	221[M^+], 223[M^{2+}]
2b	$C_{13}H_{10}N_2Br_2$	90	82	115-116 (114-115) [4]	354	–	–	–	354[M^+], 356[M^{2+}], 358[M^{4+}]
2c	$C_{13}H_{10}N_2Br_2$	90	86	97-98 (98-99) [4]	354	–	–	–	354[M^+], 356[M^{2+}], 358[M^{4+}]
2d	$C_{13}H_{10}N_2ClBr$	90	87	117-118 (117-118) [4]	309	–	–	–	309[M^+],311[M^{2+}], 313[M^{4+}]
2e	$C_{13}H_{10}N_2ClBr$	90	84	110-111 (110-111) [4]	309	–	–	–	309[M^+],311[M^{2+}], 313[M^{4+}]
2f	$C_{13}H_{10}N_2FBr$	90	76	98-99 (99-100) [4]	293	–	–	–	293[M^+],295[M^{2+}], 297[M^{4+}]
2g	$C_{14}H_{13}N_2OBr$	90	86	113-114 (114-115) [4]	305	–	–	–	305[M^+],307[M^{2+}]
2h	$C_{13}H_{10}N_3O_2Br$	90	89	128-129 (126-127) [4]	320	–	–	–	320[M^+],322[M^{2+}]
2i	$C_{13}H_{10}N_3O_2Br$	90	93	155-156 (154-155) [4]	266	–	–	–	320[M^+],322[M^{2+}]

Table 3. The physical constants, analytical and mass fragment (m/z) of synthesized 1-(substituted benzylidene)-2-(4-chloro phenyl)hydrazines

Entry	M.F.	Time [s]	Yield [%]	m.p. [°C]	M.W.	Micro analysis [%]			Mass [m/z]
						C	H	N	
3a	$C_{13}H_{11}N_2Cl$	90	80	103–104 (103–104) [34]	230	–	–	–	230[M^+],232[M^{2+}]
3b	$C_{13}H_{10}N_2BrCl$	90	82	81–82 (80–81) [34]	309	–	–	–	309[M^+],311[M^{2+}], 313[M^{4+}]
3c	$C_{13}H_{10}N_2BrCl$	90	84	110–11 (108–109) [34]	309	–	–	–	309[M^+],311[M^{2+}], 313[M^{4+}]
3d	$C_{13}H_{10}N_2Cl_2$	90	86	81–82 (79–80) [34]	265	–	–	–	265[M^+],267[M^{2+}], 269[M^{4+}]
3e	$C_{13}H_{10}N_2Cl_2$	90	83	101–102 (101–102) [34]	265	–	–	–	265[M^+],267[M^{2+}], 269[M^{4+}]
3f	$C_{13}H_{10}N_2FCl$	90	86	105–106 (104–105) [34]	248	–	–	–	248[M^+],250[M^{2+}], 252[M^{4+}]
3g	$C_{14}H_{13}N_2OCl$	60	85	152–153 (151–152) [34]	260	–	–	–	260[M^+],262[M^{2+}]
3h	$C_{13}H_{10}N_3O_2Cl$	90	87	123–124 (123–124)[34]	275	–	–	–	275[M^+],277[M^{2+}]
3i	$C_{13}H_{10}N_3O_2Cl$	90	81	153–154 (153–154)[34]	275	–	–	–	275[M^+],277[M^{2+}]

Table 4. The physical constants, analytical and mass fragment (m/z) of synthesized 1-(substituted benzylidene)-2-(4-cyano phenyl)hydrazines.

Entry	M.F.	Time [s]	Yield [%]	m.p. [°C]	M.W.	Micro analysis [%]			Mass [m/z]
						C	H	N	
4a	$C_{14}H_{11}N_3$	90	87	131-132 (131-32) [3]	221	–	–	–	221[M^+]
4b	$C_{14}H_{10}N_3Br$	90	88	178-179 177-178 [3]	299	–	–	–	299[M^+],301[M^{2+}]
4c	$C_{14}H_{10}N_3Br$	90	85	165-166 (166-167) [3]	299	–	–	–	299[M^+],301[M^{2+}]
4d	$C_{14}H_{10}N_3Cl$	90	86	171-172 (172-73) [3]	255	–	–	–	255[M^+], 257[M^{2+}]
4e	$C_{14}H_{10}N_3Cl$	90	88	170-171 (169-170) [3]	255	–	–	–	255[M^+], 257[M^{2+}]
4f	$C_{14}H_{10}N_3F$	90	80	191-192 (192-193) [3]	239	–	–	–	239[M^+], 241[M^{2+}]
4g	$C_{15}H_{13}N_3$	60	80	158-159 (157-58) [3]	235	–	–	–	235[M^+]
4h	$C_{15}H_{13}N_3O$	60	89	135-136 (136-137) [3]	251	–	–	–	251[M^+]
4i	$C_{14}H_{10}N_4O_2$	90	90	216-217 (216-217) [3]	266	–	–	–	251[M^+]

Table 5. The physical constants, analytical and mass fragment (m/z) of synthesized 1-(substituted benzylidene)-2-(4-methyl phenyl)hydrazines.

Entry	M.F.	Time [s]	Yield [%]	m.p. [°C]	M.W.	Micro analysis [%]			Mass [m/z]
						C	H	N	
5a	$C_{14}H_{14}N_2$	90	94	93–94 (93–94)[5]	210	–	–	–	210[M^+]
5b	$C_{14}H_{13}N_2Br$	90	92	135–136 (134–135)[5]	289	–	–	–	289[M^+], 291[M^{2+}]
5c	$C_{14}H_{13}N_2Br$	90	90	151–152 (151–152)[5]	289	–	–	–	289[M^+], 291[M^{2+}]
5d	$C_{14}H_{13}N_2Cl$	90	95	138–139 (139–140)[5]	244	–	–	–	244[M^+], 246[M^{2+}]
5e	$C_{14}H_{13}N_2F$	90	91	119–120 (119–120)[5]	228	–	–	–	228[M^+], 246[M^{2+}]
5f	$C_{15}H_{16}N_2$	90	90	128–129 (129–130)[5]	224	–	–	–	244[M^+], 246[M^{2+}]
5g	$C_{15}H_{16}N_2O$	90	93	161–162 (162–163)[5]	240	–	–	–	240[M^+], 242[M^{2+}]
5h	$C_{14}H_{13}N_3O_2$	90	95	138–139 (137–138)[5]	255	–	–	–	255[M^+]
5i	$C_{14}H_{13}N_3O_2$	90	96	127–128 (127–128)[5]	286	–	–	–	286[M^+]

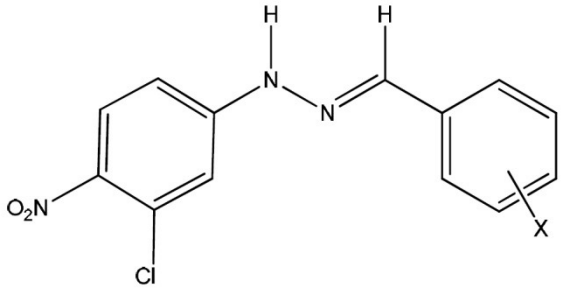
Table 6. The physical constants, analytical and mass fragment (m/z) of synthesized 1-(substituted benzylidene)-2-(4-nitro phenyl)hydrazines.

Entry	M.F.	Time [s]	Yield [%]	m.p. [°C]	M.W.	Micro analysis [%]			Mass [m/z]
						C	H	N	
6a	$C_{13}H_{11}N_3O_2$	90	90	198–199 (198–199) [35]	241	–	–	–	241[M^+]
6b	$C_{13}H_{10}N_3O_2Br$	90	88	124–125 (124–125) [35]	320	–	–	–	320[M^+], 232[M^{2+}]
6c	$C_{13}H_{10}N_3O_2Br$	90	92	145–146 (144–145) [35]	320	–	–	–	320[M^+], 232[M^{2+}]
6d	$C_{13}H_{10}N_3O_2Cl$	90	95	122–123 (120–121) [35]	275	–	–	–	375[M^+], 277[M^{2+}]
6e	$C_{13}H_{10}N_3O_2Cl$	90	91	124–125 (124–125) [35]	275	–	–	–	375[M^+], 277[M^{2+}]
6f	$C_{13}H_{10}N_3O_2F$	60	94	121–122 (122–123) [35]	259	–	–	–	259[M^+], 261[M^{2+}]
6g	$C_{14}H_{13}N_3O_2$	90	89	124–125 (123–124) [35]	255	–	–	–	255[M^+]
6h	$C_{14}H_{14}N_3O_3$	60	87	127–128 (126–127) [35]	271	–	–	–	271[M^+]
6i	$C_{13}H_{10}N_4O_4$	90	93	168–169 (168–169) [35]	286	–	–	–	286[M^+]
6j	$C_{13}H_{11}N_4O_2$	60	92	172–173 (172–173) [35]	286	–	–	–	286[M^+]

Table 7. The physical constants, analytical and mass fragment (m/z) of synthesized 1-(substituted benzylidene)-2-(3-chloro-4-nitro phenyl)hydrazines.

Entry	M.F.	Time [s]	Yield [%]	m.p. [°C]	M.W.	Micro analysis [%]			Mass [m/z]
						C	H	N	
7a	$C_{13}H_{10}ClN_3O_2$	120	92	116–117	275	56.66 (56.64)	3.60 (3.66)	15.22 (15.24)	275[M^+], 277[M^{2+}]
7b	$C_{13}H_9BrClN_3O_2$	120	94	103–104	352	43.05 (43.03)	2.48 (2.56)	11.79 (11.85)	352[M^+],355[M^{2+}], 357[M^{4+}]
7c	$C_{13}H_9BrClN_3O_2$	120	93	115–116	352	43.06 (43.03)	2.50 (2.56)	15.81 (11.85)	352[M^+],355[M^{2+}], 357[M^{4+}]
7d	$C_{13}H_9Cl_2N_3O_2$	90	92	102–103	310	50.38 (50.53)	2.88 (2.92)	13.49 (13.55)	310[M^+],312[M^{2+}], 314[M^{4+}]
7e	$C_{13}H_9Cl_2N_3O_2$	120	93	117–118	310	50.56 (50.53)	2.90 (2.92)	13.51 (13.55)	310[M^+],312[M^{2+}], 314[M^{4+}]
7f	$C_{13}H_9ClFN_3O_2$	120	93	121–122	294	53.17 (53.17)	3.06 (3.09)	14.29 (14.31)	294[M^+],298[M^{2+}], 312[M^{4+}]
7g	$C_{13}H_{12}ClN_3O_3$	120	95	117–118	306	55.04 (55.01)	3.92 (3.96)	13.71 (13.74)	306[M^+],308[M^{2+}]
7h	$C_{13}H_{12}ClN_3O_2$	120	94	124–125	290	58.06 (58.04)	4.13 (4.17)	14.58 (14.50)	290[M^+], 292[M^{2+}]
7i	$C_{13}H_9ClN_4O_4$	120	91	113–114	230	48.71 (48.69)	2.79 (2.83)	17.43 (17.47)	230[M^+], 232[M^{2+}]
7j	$C_{13}H_9ClN_4O_4$	120	91	125–126	230	48.70 (48.69)	2.81 (2.83)	17.44 (17.47)	230[M^+], 232[M^{2+}]

Table 8. The infrared and NMR spectral data of synthesized 1-(substituted benzylidene)-2-(3-chloro-4-nitro-phenyl) hydrazines.



Entry	X	IR(ν, cm^{-1})		^{1}H NMR(δ, ppm)				^{13}C NMR(δ, ppm)		
		C=N	NH	NH(1H, s)	CH(1H, s)	Ar-H(m)	X	CH	Ar-C	X
7a	H	1543.05	3300.20	7.943	7.841	7.260–7.719(8H)	–	145.39	107.41–138.22	–
7b	3–Br	1523.76	3331.07	7.945	7.843	7.264–7.123(7H)	–	148.84	105.18–146.41	–
7c	4–Br	1544.98	3294.42	7.968	7.924	7.244–7.822(7H)	–	147.80	111.58–144.94	–
7d	3–Cl	1539.20	3309.85	7.973	7.934	7.264–7.729(7H)	–	147.75	104.44–144.92	–

cont. Table 8.

7e	4–Cl	1544.98	3300.20	7.945	7.847	7.259–7.720(7H)	–	149.43	107.41–145.45	–
7f	3–F	1537.27	3311.78	7.949	7.844	7.081–7.745(7H)	–	147.85	104.36–145.30	–
7g	4–OCH_3	1517.98	3325.28	7.930	7.720	6.925–7.671(7H)	3.850	149.40	124.35–141.12	63.26
7h	3–CH_3	1546.91	3304.06	7.939	7.866	7.201–7.738(7H)	2.385	143.42	107.28–145.81	21.44
7i	3–NO_2	1527.62	3296.35	8.279	8.258	7.266–8.240(7H)	–	147.78	102.13–139.02	–
7j	4–NO_2	1527.62	3300.20	7.939	7.720	6.866–7.681(7H)	–	145.57	104.07–138.15	–

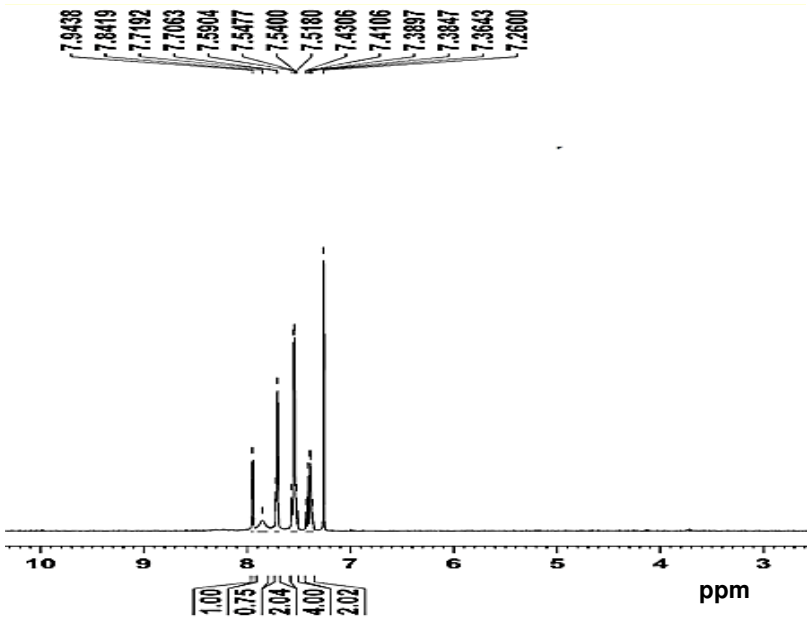


Fig. 1. [1]H NMR spectra of (*E*)-1-benzylidene-2-(3-chloro-4-nitrophenyl)hydrazine.

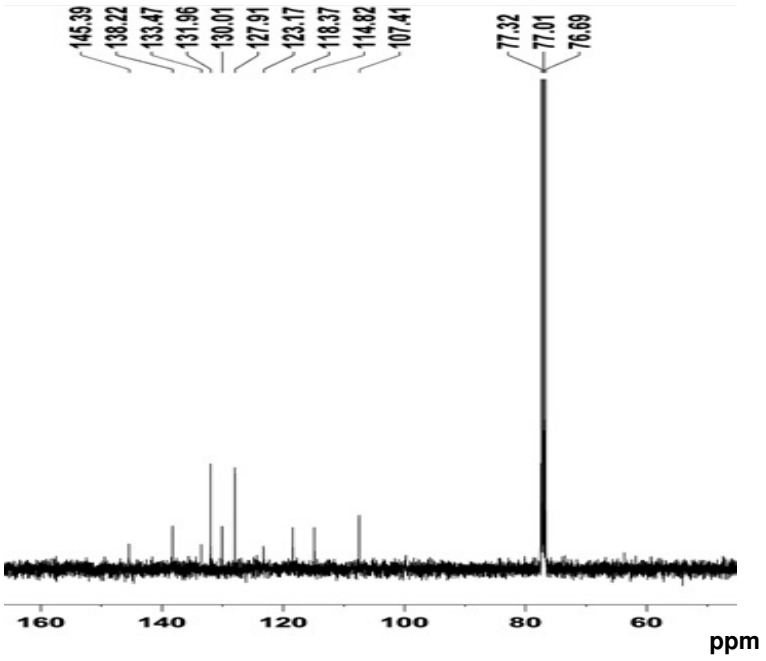


Fig. 2. [1]H NMR spectra of (*E*)-1-benzylidene-2-(3-chloro-4-nitrophenyl)hydrazine.

In this condensation, the quantity of catalyst was increases from 0 to 0.3 g by the increment of 0.05 g. The obtained yield of hydrazines are 89 to 92% up to 0.2g of the catalyst quantity. Beyond the catalyst quantity of 0.2g, there is no increment in the yield. This effect of catalyst loading was shown in Fig. 3.

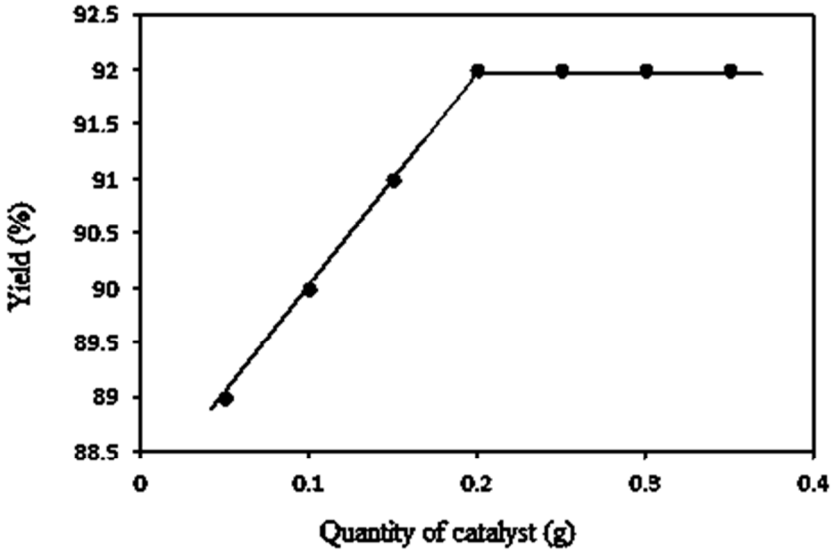


Fig. 3. The effect of catalyst loading.

Further the authors have studied the optimization of catalyst for this condensation with various zeolite and non-zeolite based catalysts in the same reaction conditions. In this experiment the $FeCl_3$/Bentonite catalyzed condensation gave better yield(92%) than other catalysts. The effects of different catalyst on the synthesis of the hydrazine Schiff's bases are presented in Table 9.

The effect of solvents on the yield of the reaction was studied with methanol, ethanol, tetrahydro furon, dioxane, ethyl acetate, dichloromethane and dimethyl sulphoxide solvents under conventional heating(Entry 7a). From this experiment the isolated yield was 78% only. The influence of solvent on the yield of this condition retain was given in Table 10.

The effect of substituent on the benzaldehyde moiety was investigated in these reactions by the quantity of isolated yields. The electron-donating groups such as methoxy and methyl were gave higher yield than electron with-drawing halogens and nitro substituents.

Table 9. The effect of various zeolite and non-zeolite based catalysts on the condensation of 3-chloro-4-nitrophenylhydrazine (0.01 mol) and benzaldehyde(0.01 mol) under solvent-free conditions (Entry 7a).

Catalyst[a]	Time [s]	Yield [%][b]
SiO_2	160	62
Al_2O_3(basic)	60	65
$SiO_2.H_2SO_4$	60	61
$SiO_2.H_3PO_4$	60	60
$SiO_2.HClO_4$	45	63
Fly-ash	180	60
Fly-ash.H_2SO_4	150	78
Fly-ash.H_3PO_4	120	80
Fly-ash.$HClO_4$	120	72
Hydroxyapatite	180	78
TiO_2SO_4	90	80
Cu^{2+}/Zeolite	120	82
$FeCl_3$/Bentonite	90	92

[a]Catalyst quantity = 0.2g; Solvent-free microwave irradiation;
[b]Isolated yield,

Table 10. The influence of solvent on the yield for the condensation of 3-chloro-4-nitrophenylhydrazine(0.01 mol) and benzaldehyde (0.01 mol) with $FeCl_3$/Bentonite catalyst.

Solvents	MeOH	EtOH	THF	DO	EAT	DCM	DMSO	MW
Yield [%]	62	72	70	60	75	78	74	92

MeOH = methanol; EtOH = ethanol; THF = terahydro furon; DO = dioxane;
EAT = ethylacetate; DCM = dichloromethane; DMSO = dimethylsulphoxide;
MW = microwave.

3.1. Antimicrobial activities

3.3.1. Antibacterial activity

The observed antibacterial activity of synthesized hydrazines by means of measurement of mm of zone of inhibition was presented in Table 11.

Table 11. Zone of inhibition (mm) values of antibacterial activity of 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines.

Entry	X	Zone of inhibition (mm)			
		Gram positive bacteria		Gram negative bacteria	
		B.subtilis	*M.luteus*	*E.coli*	*P.aeruginosa*
7a	H	8	8	10	10
7b	3-Br	9	11	9	9
7c	4-Br	8	9	12	11
7d	3-Cl	10	10	13	12
7e	4-Cl	11	10	13	13
7f	4-F	9	8	11	10
7g	4-OCH_3	6	8	9	9
7h	3-CH_3	7	6	8	10
7i	3-NO_2	8	9	9	10
7j	4-NO_2	8	7	8	9
Standard	Ampicillin	12	12	14	14
Control	DMSO	–	–	–	–

The disc diffusion zone of inhibition of plates are illustrated in Figure 4 (Plates 1–8) and the correlation-clustered column chart was shown in Figure 5. From the table 5, the hydrazine derivatives 7d and 7e showed good antibacterial activities against *B.subtilis strains.* The hydrazine derivatives 7a-c, 7f, 7i and 7j were shows satisfactory antibacterial activities against *B.subtilis strains.* The hydrazines 7g and 7h

shows least bacterial activity against *B.subtilis strains.* The hydrazine compounds 7b, 7d and 7e shows good antibacterial activities against *M.luteus* bacterial strains.

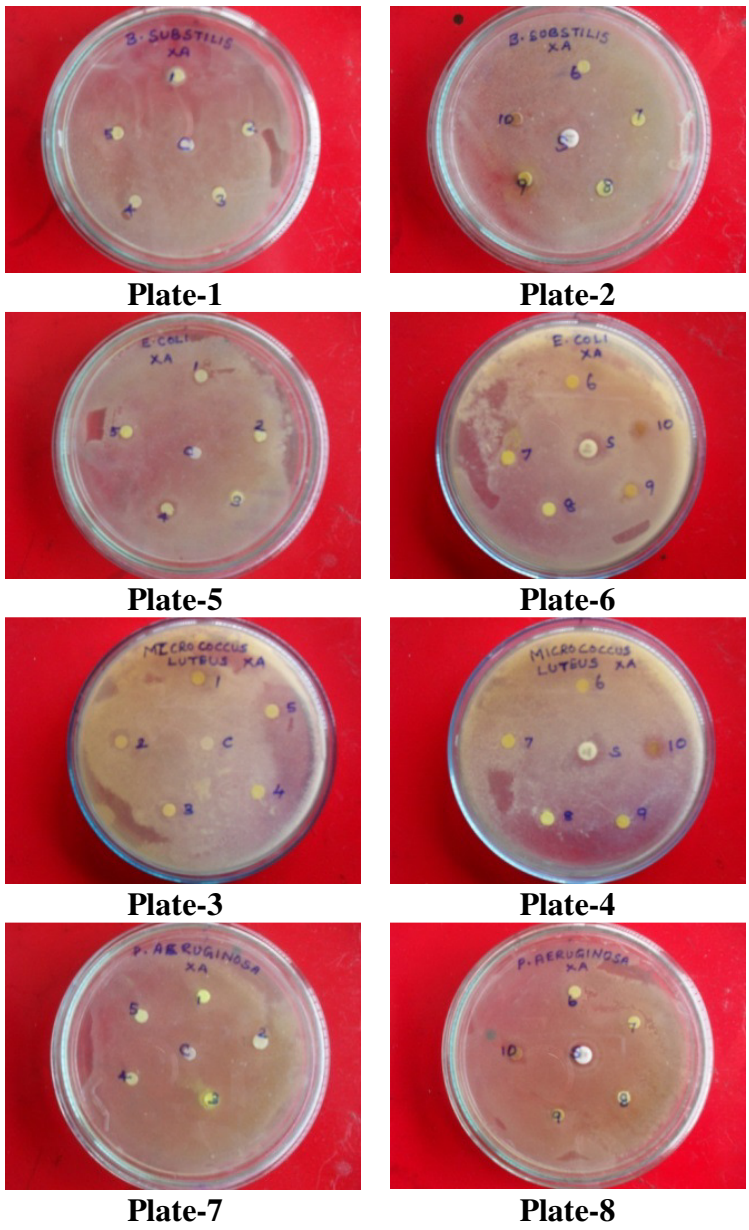


Fig. 4. Antibacterial Activities of 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines-Petri plates

Compounds 7a, 7c, 7f, 7g and 7i were showed satisfactory antibacterial activities against *M.luteus* bacterial strain. The hydrazines 7h and 7j shows least antibacterial activity against *M.luteus* bacterial strain. Hydrazines 7a and 7c-g shows good antibacterial activities against *E.coli* bacterial strain. The hydrazine derivatives 7b, and 7g-i were shown satisfactory antibacterial activities against *E.coli* bacterial strain. Compounds 7a, 7c-f, 7i and 7j shows good antibacterial activities against *P.aeruginosa* bacterial strain. The remaining hydrazine compounds shows satisfactory antibacterial activities against *P.aeruginosa* bacterial strain.

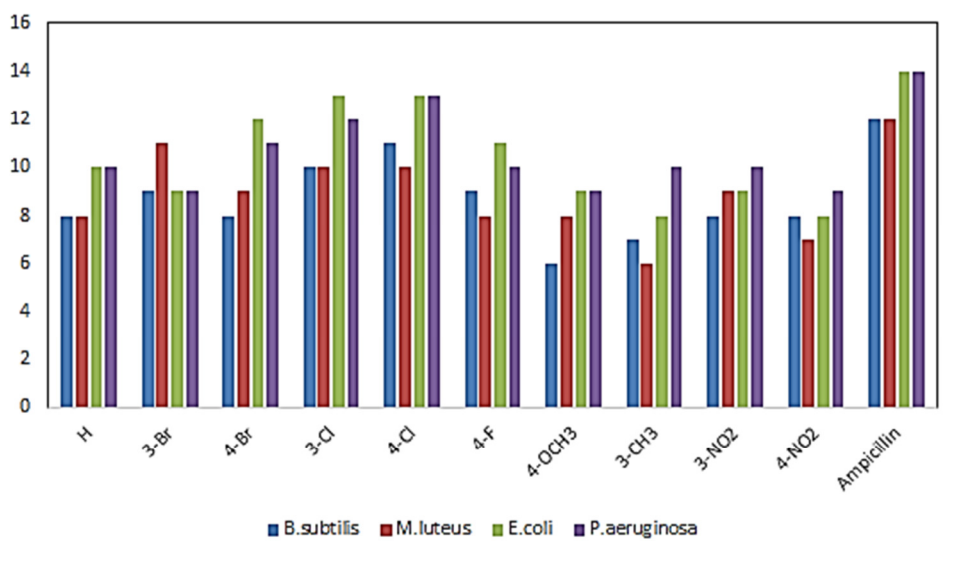


Fig.5. Antibacterial activities of 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines-Clustered column chart.

3.2. Antifungal activity

The observed antifungal activity of synthesized hydrazines by means of measurement of mm of zone of inhibition was presented in Table 12. The disc diffusion zone of inhibition of plates are illustrated in Figure 6 (Plates 9–12) and the correlation-clustered column chart was shown in Figure 7.

From the table 8, the hydrazine derivatives 7a, 7d and 7g-j showed good antifungal activities against *A.niger* strain. The hydrazine derivatives 7b, 7c, 7e and 7f were shows least antifungal activities against *A.niger* strain. The hydrazine compounds 7a-c and 7g-i shows good antifungal activities against *T.viride* fungal strains. Compounds 4, 5 and 6 were showed least antifungal activity against *T.viride* fungal strains.

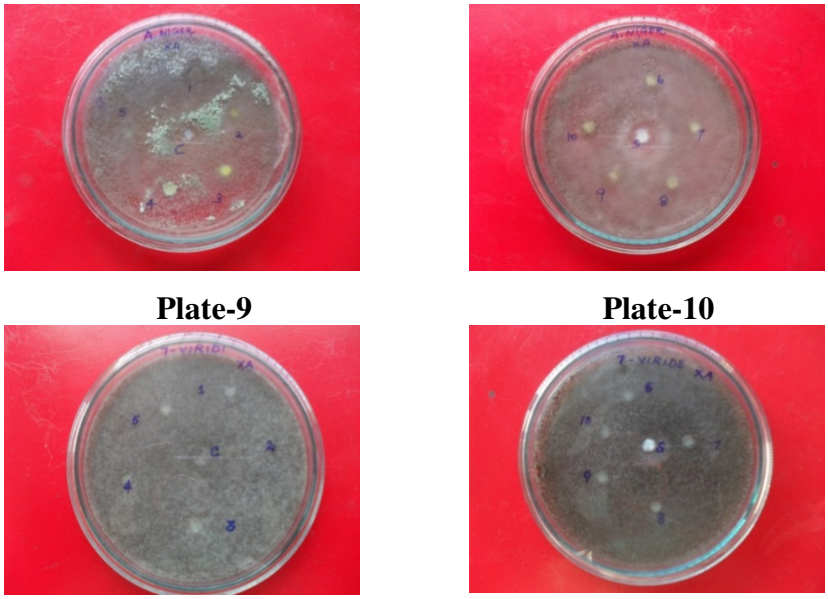


Fig. 6. Antifungal activities of 1-(substituted benzylidene)-2-(3-chloro-4-nitro-phenyl) hydrazines-Petri plates.

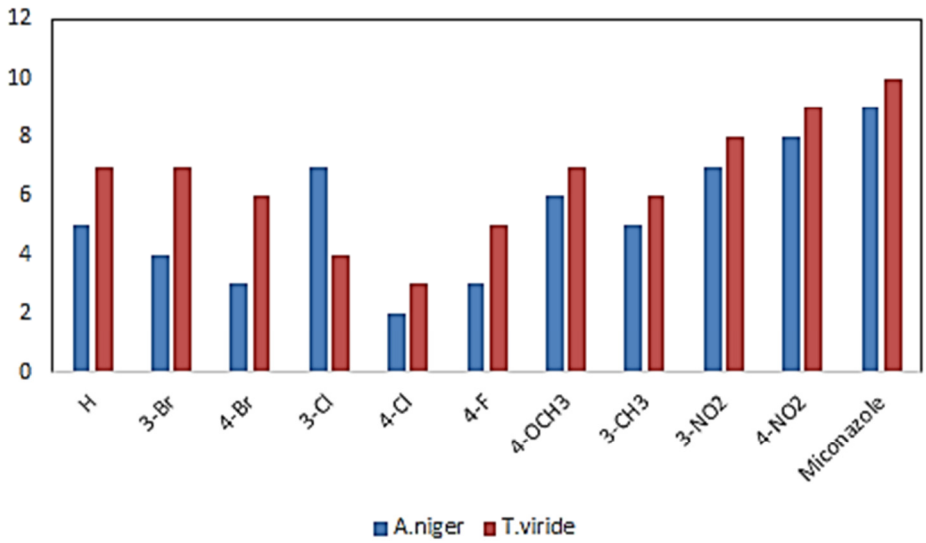


Fig. 7. Antifungal activities of 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines-Clustered column chart

Table 12. Zone of inhibition (mm) values of antifungal activity of 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines.

Entry	X	Zone of Inhibition (mm)	
		A.niger	*T.viride*
7a	H	5	7
7b	3-Br	4	7
7c	4-Br	3	6
7d	3-Cl	7	4
7e	4-Cl	2	3
7f	4-F	3	5
7g	4-OCH_3	6	7
7h	3-CH_3	5	6
7i	3-NO_2	7	8
7j	4-NO_2	8	9
Standard	Miconazole	9	10
Control	DMSO	–	–

4. CONCLUSIONS

Good yields of Some aryl hydrazide derivatives have been synthesized including 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines by $FeCl_3$/Bentonite catalyzed solvent-free condensation of substituted phenyl hydrazine and aldehydes under microwave irradiation. The synthesized hydrazides are characterized by the physical constants, micro analysis and spectroscopic data. The antimicrobial activities of all synthesized of 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines have been evaluated using Bauer-Kirby disc diffusion method. Most of the hydrazine derivatives show good and satisfactory antimicrobial activities against their microbial strains.

The 1-(substituted benzylidene)-2-(3-chloro-4-nitrophenyl) hydrazines 7d and 7e showed good antibacterial activities against *B.subtilis strains.* The hydrazine compounds 7b, 7d and 7e shows good antibacterial

activities against *M.luteus* bacterial strains. Hydrazines 7a and 7c-g shows good antibacterial activities against *E.coli* bacterial strain. Compounds 7a, 7c-f, 7i and 7j shows good antibacterial activities against *P.aeruginosa* bacterial strain. the hydrazine derivatives 7a, 7d and 7g-j showed good antifungal activities against *A.niger* strain. The hydrazine compounds 7a-c and 7g-i shows good antifungal activities against *T.viride* fungal strains.

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