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MEDICINAL CHEMISTRY RESEARCH

ORIGINAL RESEARCH

Microwave-assisted synthesis of some novel and potent antibacterial and antifungal compounds with biological screening

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Abstract Hydantoins have widely been used as antiarrythmic, anticonvulsant and antitumor agents but recent research has shown a different and novel cytotoxic activity of hydantoins and its derivatives, i.e. anti HIV, antibacterial and antifungal. The following research article deals with the synthesis of hydantoins and their derivatives by Mannich reaction viz., 3-(substituted)-5,5-diphenylimidazolidine-2,4-dione and 1-(substituted)-3,5,5-triphenylimidazolidine-2,4-dione. The synthesised compounds are novel and some of the compounds showed good antibacterial and antifungal activity equivalent to the standards used. All synthetic procedures were carried out in a microwave and not by conventional methods, which led to speedy process and high yield for the same.

Keywords Microwave · Hydantoins · Mannich bases · Antibacterial and antifungal

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Introduction

Human beings have always thrived to do something new in their scientific approach. Pharmaceutical Chemistry is one such branch where this particular idea is being fulfilled and continuing with this idea of search for a new compound with therapeutic effects was being effected. Microorganisms have the ability to mutate and produce a new strain which is resistant to the existing drugs. Be it a human error or environmental factors, every decade there are new stains of viruses, bacteria and to an extent fungi.

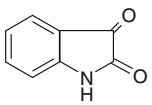
The aim is to generate a new compound having potent antifungal and antibacterial property and which, in future gives protection against wide range of microorganisms including HIV.

Rational design

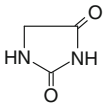
A lot of synthetic research and biological activity determination was carried out on substituted isatin heterocyclic derivatives, when tested for activity; it was found that they were cytotoxic (Islam *et al*., 2001a, b; Lingcon *et al*., 2001). This gave a pathway for synthesis of isatin like compounds viz. hydantoins and thiohydantoins (Muccioli and Pupaert, 2003). The imidazoline-2,4-dione or hydantoin nucleus is a common 5-membered ring containing a reactive cyclic urea core. The heterocyclic is present in a wide range of biologically active compounds including antiarrythmic, anticonvulsant and antitumor agents.

Hydantoins and thiohydantoins posseses antiarrythmic, anticonvulsant and antitumor activity but recent research has shown a different and novel cytotoxic activity for both these compounds, i.e. anti HIV, antibacterial and antifungal (Kashemliton and Islam, 2006; Patel *et al*., 2006).

The basic requirement for any medicinal substance is that it should be potent. For this purpose, N-Mannich bases of hydantoins were synthesized which were supposed to posses antifungal and antibacterial property. To improve the efficiency of the synthetic procedure microwave was used in place of conventional apparatus (Wen-Ben *et al.*, 2003; Bausera *et al.*, 1998; Keiko *et al.*, 2007).



ISATIN



HYDANTOIN

Chemistry

Synthesis of 5,5-diphenylimidazolidine-2,4-dione and 3,5,5-triphenylimidazolidine-2,4-dione is a base catalyzed condensation of benzil, urea or monophenyl urea in DMSO. The formation of theses products follows pinacol–pinacoline type rearrangement. Synthesis of N-Mannich bases involves reaction of 5,5-diphenylhydantoin having active hydrogen atom attached to nitrogen, undergoing amino-methylation reaction in microwave oven in presence of formaldehyde, secondary amines as well as primary amines such as morpholine, 1-methylpiperazine, 1H-benzo[d]imidazole, 1*H*-benzo[d][1,2,3]triazole, diethylamine and 2-aminothiazole. The different substituted products have been successfully synthesized in domestic microwave oven. The amino methylated products have been tested for antibacterial and antifungal activity. The structure of these synthesized compounds has been elucidated on the basis of their elemental analysis and spectral data. The synthetic scheme is given in Scheme 1.

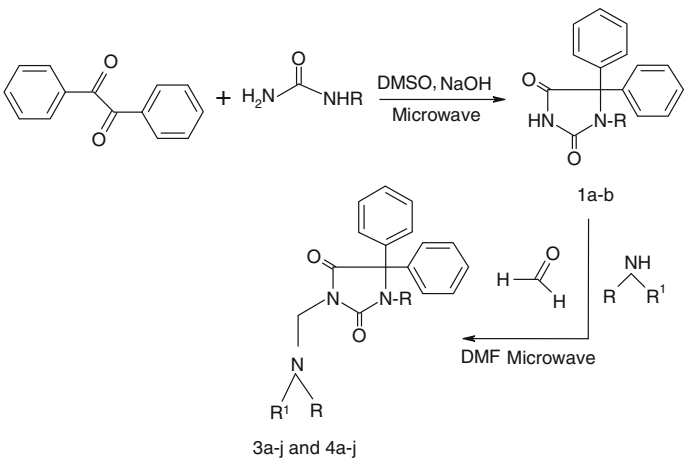
Experimental

Step-1: general procedure for synthesis of 5,5-diphenylimidazolidine-2,4-dione (**1a**) and 3,5,5-triphenylimidazolidine-2,4-dione (**1b**)

Benzil and urea were taken in molar ratio of 1:2, and were dissolved in sufficient quantity of DMSO. To this solution, 10 g of potassium hydroxide solution was added so that the solution becomes basic. Following a 90 s 750 W pulse, the mixture was stirred for 5 min, cooled and then 30 s pulse were applied at 6, 9, 12, 15, 18, 24 and 30 min. It was then poured into cold water acidified with HCl and the precipitate so obtained was filtered, dried and washed with water. The product was then recrystallized with ethanol.

Step-2: general procedure for synthesis of 3-(substituted)-5,5-diphenylimidazolidine-2,4-dione (**3a–j**) and 1-(substituted)-3,5,5-triphenylimidazolidine-2,4-dione (**4a–j**)

Previously synthesized derivative of hydantoin and formaldehyde were dissolved in DMF and to it substituted amine was added. The mixture was then activated by two pulses of 15 s each at 20% power. The mixture was then stirred for 5 min and cooled. The whole mixture was then microwaved with a pulse of 15 s for a total of 3–5 min with some stirring and cooling time in between each pulse. It was then poured into cold water and ice mixture, acidified with HCl and the precipitate so obtained was filtered, dried and washed with water. The product was then recrystallized with methanol Structures (**3a–j** and **4a–j**).



Scheme 1 Synthesis of 3-(substituted)-5,5-diphenylimidazolidine-2,4-dione and 1-(substituted)-3,5,5-triphenylimidazolidine-2,4-dione

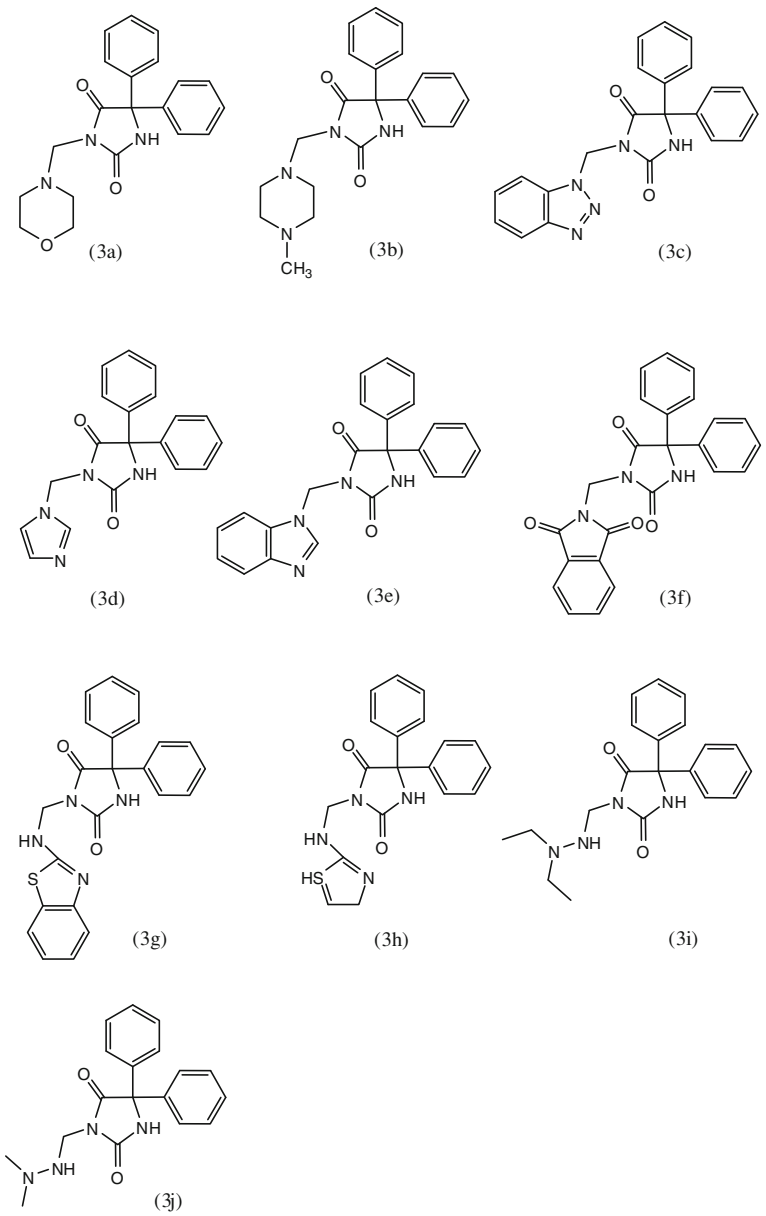
*(**3a**) 3-(Morpholinomethyl)-5,5-diphenylimidazolidine-2,4-dione*

Yield 80%, Mp 230°C, IR (KBr) cm^{-1}: 3270 (–NH, amide), 3030 (CH, str., aromatic), 2325 (CH_2, str.) 1750, 1740 (C=O, str.), 1280 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.0–7.50 (m, 10H, Ar–H), 8.801 (s, 1H, NH), 4.15 (m, 2H, CH_2), 2.80–3.68 (m, 8H, morpholine ring). Anal. Calcd for $C_{20}H_{21}N_3O_3$: C, 68.36; H, 11.02; N, 11.96. Found C, 68.66; H, 11.58; N, 1154. LCMS: m/z $[M+1]^+$ 352.4.

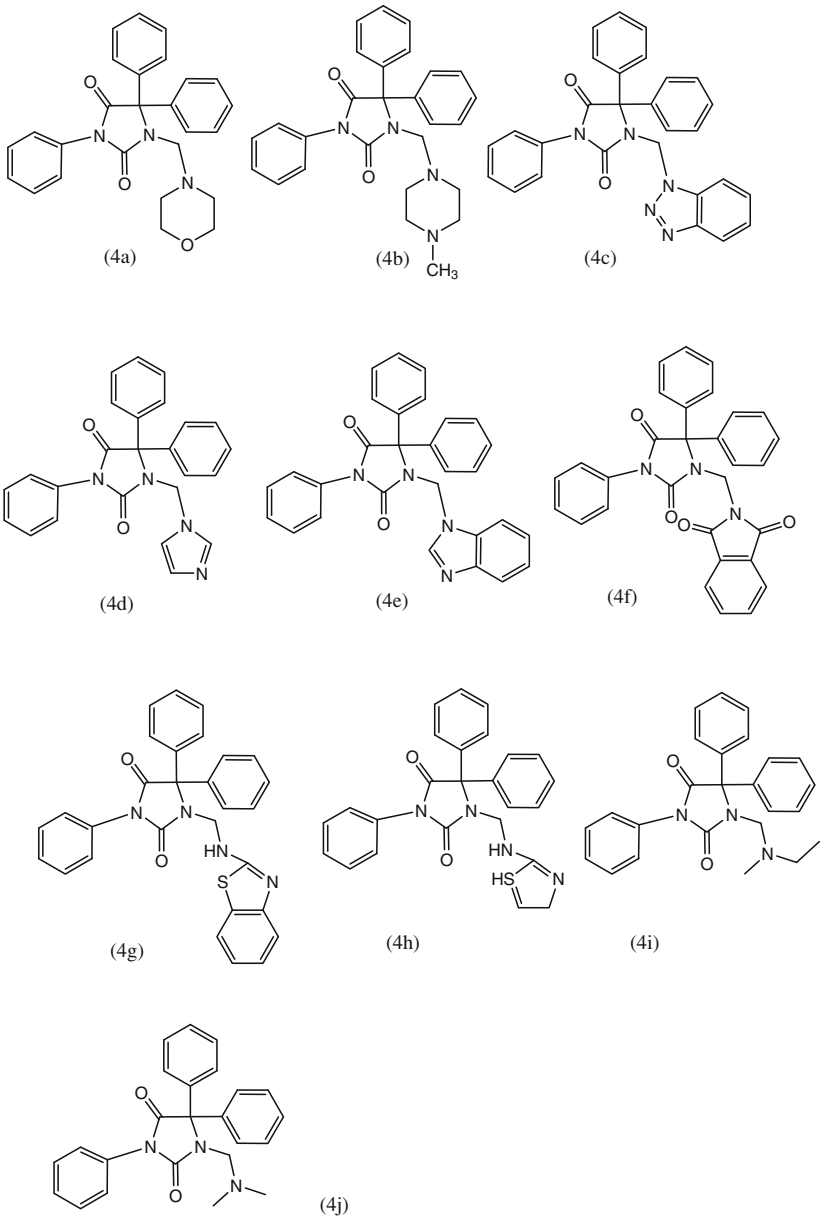
*(**3b**) 3-((4-Methylpiperazin-1-yl) methyl)-5,5-diphenylimidazolidine-2,4-dione*

Yield 88%, Mp 210°C, IR (KBr) cm^{-1}: 3280 (–NH amide), 3035 (CH, str., aromatic), 2325 (CH_2, str.), 1755, 1743 (C=O, str.), 1278 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.0–7.60 (m, 10H, Ar–H), 7.70 (s, 1H, NH), 4.28 (m, 2H, CH_2), 2.90–3.10 (8H, piperzine), 2.30 (s, 3H, N–CH_3). Anal. Calcd for $C_{21}H_{24}N_4O_2$: C, 69.21; H, 6.64; N, 15.37; Found C, 69.52; H, 6.20; N, 14.90. LCMS: m/z $[M]^+$ 364.3.

Structure 1



Structure 2



*(**3c**) 3-((1H-benzo[d][1,2,3]triazol-1-yl)methyl)-5,5-diphenylimidazolidine-2,4-dione*

Yield 82%, Mp 221°C, IR (KBr) cm^{-1}: 3265 (NH, amide), 3122 (CH str., aromatic), 2310 (CH_2, str.), 1736, 1743 (C=O, str.), 1265 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.10–8.10 (m, 14H, Ar–H, –C=C–Ar and benzotrizol 5H), 6.50 (s, 1H, NH), 5.70 (s, 2H, N–CH_2–N). Anal. Calcd for $C_{22}H_{17}N_5O_2$: C, 68.92; H, 4.47; N, 18.27. Found C, 67.22; H, 4.78; N, 18.50. LCMS: m/z $[M\text{-}1]^+$ 382.4.

*(**3d**) 3-((1H-imidazol-1-yl) methyl)-5,5-diphenylimidazolidine-2,4-dione*

Yield 79%, Mp 195°C, IR (KBr) cm^{-1}: 3278 (NH, amide), 3100 (CH str., aromatic), 2315 (CH_2, str.), 1748, 1755 (C=O, str.), 1282 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 6.70–7.60(m, 13H, Ar–H, –C=C–Ar and imidazole 3H), 6.70 (s, 1H, NH), 5.80 (s, 2H, N–CH_2–N). Anal. Calcd for $C_{19}H_{16}N_4O_2$: C, 68.66; H, 4.84; N, 16.89. Found C, 68.43; H, 5.14; N, 17.10. LCMS: m/z $[M+1]^+$ 333.4.

*(**3e**) 3-((1H-benzo[d]imidazol-1-yl)methyl)-5,5-diphenylimidazolidine-2,4-dione*

Yield 88%, Mp 205°C, IR (KBr) cm^{-1}: 3260 (NH, amide), 3127 (CH str., aromatic), 2300 (CH_2, str.), 1746, 1763 (C=O, str.), 1275 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.10–8.30 (m, 15H, Ar–H, –C=C–Ar and benzimidazole 5H), 6.70 (s, 1H, NH), 5.60 (s, 2H, N–CH_2–N). Anal. Calcd for $C_{23}H_{18}N_4O_2$: C, 72.24; H,4.74; N, 14.65. Found C,72.24; H, 5.08; N, 5.05. LCMS: m/z $[M]^+$ 382.4.

*(**3f**) 2-((2,5-Dioxo-4,4-diphenylimidazolidin-1-yl)methyl)isoindoline-1,3-dione*

Yield 80%, Mp 212°C, IR (KBr) cm^{-1}: 3255 (NH, amide), 3132 (CH str., aromatic), 2320 (CH_2, str.), 1736, 1743, 1720, 1680 (C=O, str.), 1255(3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.06–8.10 (m, 19H, Ar–H, –C=C–Ar and phthalamide 4H), 6.15 (s, 1H, NH), 5.60 (s, 2H, N–CH_2–N–). Anal. Calcd for $C_{24}H_{17}N_3O_4$: C,70.07; H, 4.16; N, 10.21. Found C, 70.34; H, 4.50; N, 10.42. LCMS: m/z $[M-1]^+$ 410.2.

*(**3g**) 3-((Benzo[d]thiazol-2-yl amino)methyl)-5,5-diphenylimidazolidine-2,4-dione*

Yield 85%, Mp 222°C, IR (KBr) cm^{-1}: 3240, 3130 (NH, amide), 3132 (CH str., aromatic), 2320 (CH_2, str.), 1742, 1760 (C=O, str.), 1225 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.06–8.30(m, 14H, Ar–H, –C=C–Ar and benothiozole), 6.10(s, 1H, HN–$COCPh_2$), 4.92 (s, 2H, N–CH_2–N–), 4.20(s, 1H, NH). Anal. Calcd for $C_{23}H_{18}N_4O_2S$: C, 66.65; H, 4.38; N, 13.52. Found C, 67.02; H, 4.68; N, 13.10. LCMS: m/z $[M-1]^+$ 413.5.

*(**3h**) 5,5-Diphenyl-3-((thiazol-2-yl amino)methyl)imidazolidine-2,4-dione*

Yield 79%, Mp 208°C, IR (KBr) cm^{-1}: 3255, 3120(NH, amide), 3132 (CH str., aromatic), 2310(CH_2, str.), 1730, 1743 (C=O, str.), 1235 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.06–8.10(m, 12H, Ar–H, –C=C–Ar and aminothiozole), 6.15(s, 1H, N–$COCPh_2$), 4.80 (s, 2H, N–CH_2–N–), 4.10 (s, 1H, NH). Anal. Calcd for: $C_{19}H_{16}N_4O_2S$: C, 63.02; H, 4.64; N, 15.67. Found C, 62.62; H, 4.43; N, 15.37. LCMS: m/z $[M+1]^+$ 367.3.

*(**3i**) 3-((Diethyl amino)methyl)-5,5-diphenylimidazolidine-2,4-dione*

Yield 80%, Mp 217°C, IR (KBr) cm^{-1}: 3220 (NH, amide), 3120 (CH, str., aromatic), 2330 (CH_2, str.), 1732, 1750 (C=O, str.), 1235 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.10–7.60(m, 10H, Ar–H, –C=C–Ar), 6.00(s, 1H, N–H.), 4.38 (s, 2H, N–CH_2–N), 2.40 (s, 4H, CH_2, CH_2), 1.20(s, 6H, dimethyl group). Anal. Calcd for $C_{20}H_{23}N_3O_2$: C,71.19; H, 6.87; N, 12.45. Found C, 69.90; H, 7.02; N, 12.45. LCMS: m/z $[M]^+$ 352.4.

*(**3j**) 3-((Dimethyl amino)methyl)-5,5-diphenylimidazolidine-2,4-dione*

Yield 81%, Mp 218°C, IR (KBr) cm^{-1}: 3230 (NH, amide), 3130 (CH str., aromatic), 2325 (CH_2, str.), 1742, 1760 (C=O, str.), 1245 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.06–8.30 (m, 10H, Ar–H, –C=C–Ar), 6.00 (s, 1H, NH), 4.38 (s, 2H, N–CH_2–N), 2.30 (s, 6H, dimethyl). Anal. Calcd for $C_{18}H_{19}N_3O_2$: C, 69.88; H, 6.19; N, 13.58. Found C, 70.09; H, 6.40; N, 13.20. LCMS: m/z $[M+1]^+$ 325.2.

*(**4a**) 1-(Morpholinomethyl)-3,5,5-triphenylimidazolidine-2,4-dione*

Yield 88%, Mp 230°C, IR (KBr) cm^{-1}: 3100 (CH str., aromatic), 2315 (CH_2, str.), 1746, 1756 (C=O, str.), 1288 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.00–7.50 (m, 15H, Ar–H, –C=C–Ar), 4.20 (m, 2H,–CH_2–), and 2.8–3.56 (m, 8H, morpholine ring). Anal. Calcd for $C_{26}H_{25}N_3O_3$: C, 73.05; H, 5.89; N, 9.83. Found C, 73.46; H, 6.23; N, 10.20. LCMS: m/z $[M-1]^+$ 426.6.

*(**4b**) 1-((4-Methylpiperazin-1-yl)methyl)-3,5,5-triphenylimidazolidine-2,4-dione*

Yield 80%, Mp 235°C, IR (KBr) cm^{-1}: 3065 (CH str., aromatic), 2335 (CH_2, str.) 1745, 1733 (C=O, str.), 1268 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7–7.60 (m, 15H, Ar–H, –C=C–Ar), 4.23 (m, 2H, –CH_2–) and 2.50–2.80 (m, 8H, piperzine), 2.28 (s, 3H, –NCH_3). Anal. Calcd for $C_{27}H_{28}N_4O_2$: C, 73.30; H, 6.41; N, 12.72. Found C, 72.02; H, 6.63; N, 13.05. LCMS: m/z $[M+1]^+$ 441.6.

*(**4c**) 1-((1H-benzo[d][1,2,3] triazol-1-yl)methyl)-3,5,5-triphenylimidazolidine-2,4-dione*

Yield 78%, Mp 248°C, IR (KBr) cm^{-1}: 3105 (CH str., aromatic), 2300 (CH_2, str.) 1723, 1737 (C=O, str.), 1255 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.08–8.10 (m, 19H, Ar–H, –C=C–Ar and benzotriazole 5H), 5.65 (s, 2H, N–CH_2–N). Anal. Calcd for $C_{28}H_{21}N_5O_2$: C, 73.19; H, 4.61; N, 15.24. Found C, 73.40; H, 4.42; N, 15.02. LCMS: m/z $[M]^+$ 459.6.

*(**4d**) 1-((1H-imidazol-1-yl)methyl)-3,5,5-triphenylimidazolidine-2,4-dione*

Yield 82%, Mp 228°C, IR (KBr) cm^{-1}: 3110 (CH str., aromatic), 2325 (CH_2, str.), 1738, 1743 (C=O, str.), 1272 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 6.70–7.60 (m, 18H, Ar–H, –C=C–Ar and imidazole 3H), 5.68 (s, 2H, N–CH_2–N). Anal. Calcd for $C_{25}H_{20}N_4O_2$: C, 73.51; H, 4.94; N, 13.72. Found C, 73.20; H, 5.21; N, 13.52. LCMS: m/z $[M-1]^+$ 407.4.

*(**4e**) 1-((1H-benzo[d] imidazol-1-yl) methyl)-3,5,5-triphenylimidazolidine-2,4-dione*

Yield 87%, Mp 252°C, IR (KBr) cm^{-1}: 3127 (CH str., aromatic), 2280 (CH_2, str.), 1730, 1746 (C=O, str.), 1265 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.00–8.10 (m, 20H, Ar–H, –C=C–Ar and benzimidazole 6H), 5.52 (s, 2H, N–CH_2–N). Anal. Calcd for $C_{29}H_{22}N_4O_2$: C, 75.97; H, 4.84; N, 12.22. Found C, 76.60; H, 5.02; N, 12.02. LCMS: m/z $[M+1]^+$ 459.6.

*(**4f**) 2-((2,5-Dioxo-3,4,4-triphenylimidazolidin-1-yl)methyl)isoindoline-1,3-dione*

Yield 78%, Mp 242°C, IR (KBr) cm^{-1}: 3126 (CH str., aromatic), 2314(CH_2, str.) 1730, 1740, 1715, 1675 (C=O, str.), 1245 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.06–8.15 (m, 19H, Ar–H, –C=C–Ar and phthalmide 4H), 5.50 (s, 2H, N–CH_2–N). Anal. Calcd for $C_{30}H_{21}N_3O_4$: C,73.91; H, 4.34; N, 8.62. Found C, 74.23; H, 4.02; N 8.90. LCMS: m/z $[M-1]^+$ 486.5.

*(**4g**) 1-((Benzo[d]thiazol-2-ylamino)methyl)-3,5,5-triphenylimidazolidine-2,4-dione*

Yield 76%, Mp 252°C, IR (KBr) cm^{-1}: 3130 (N–H amide), 3132 (CH str., aromatic), 2310(CH_2, str.) 1736, 1756 (C=O, str,), 1222 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.06–8.10 (m, 19H, Ar–H, –C=C–Ar and benothiozol 4H), 4.98 (s, 2H, N–CH_2–N), 4.10(s, 1H, N–H). Anal. Calcd for: $C_{29}H_{22}N_4O_2S$: C, 71.00; H, 4.52; N,11.42. Found C, 70.82; H, 4.62; N, 11.12. LCMS: m/z $[M-1]^+$ 489.6.

*(**4h**) 3,5,5-Triphenyl-1-((thiazol-2-yl amino)methyl)imidazolidine-2,4-dione*

Yield 80%, Mp 234°C, IR (KBr) cm^{-1}: 3128 (CH str., aromatic), 2308 (–CH_2, str.) 1728, 1740, (C=O, str.), 1230, (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.06–8.10 (m, 17H, Ar–H, –C=C–Ar and aminothiozol 2H), 4.60 (s, 2H, N–CH_2–N), 4.05 (s, 1H, NH). Anal. Calcd for $C_{25}H_{20}N_4O_2S$: C, 68.16; H, 4.58; N, 12.72. Found C, 68.42; H, 4.22; N, 12.54. LCMS: m/z $[M]^+$ 442.4.

*(**4i**) 1-((Diethyl amino)methyl)-3,5,5-triphenylimidazolidine-2,4-dione*

Yield 78%, Mp 252°C, IR (KBr) cm^{-1}: 3125 (CH str., aromatic), 2315 (CH_2 str.), 1730, 1747 (C=O, str.), 1222 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.10–7.60 (m, 15H, Ar–H, –C=C–Ar), 4.28 (s, 2H, N–CH_2–N), 2.35 (s, 4H, CH_2), 1.10(s, 6H, –dimethyl group). Anal. Calcd for: $C_{26}H_{27}N_3O_2$: C, 75.52; H, 6.58; N, 10.16. Found C, 75.70; H, 6.32; N, 10.34. LCMS: m/z $[M+1]^+$ 429.4.

*(**4j**) 1-((Dimethyl amino)methyl)-3,5,5-triphenylimidazolidine-2,4-dione*

Yield 80%, Mp 202°C, IR (KBr) cm^{-1}: 3130 (CH str., aromatic), 2320(CH_2, str.), 1732, 1750, (C=O, str.), 1240 (3°N, amine). ^1H NMR (δ ppm) ($CDCl_3$): 7.06–7.60(m, 15H, Ar–H, –C=C–Ar), 4.28 (s, 2H, N–CH_2–N), 2.25 (s, 6H, dimethyl). Anal. Calcd for: $C_{24}H_{23}N_3O_2$: C, 74.78; H, 6.01; N, 10.90. Found C, 75.08; H, 6.31; N, 11.20. LCMS: m/z $[M-1]^+$ 399.4.

Antibacterial and antifungal studies

All the synthesized compounds were evaluated for biological activity, i.e. antimicrobial and antifungal. Antibacterial activities of some selected compounds were determined against four different strains of two gram-positive bacteria (*Bacillus subtitis* and *Staphylococcus aureus*) and two gram-negative (*Pseudomonas aeruginosa and Escherichia coli*) bacteria. The inhibition of growth of bacteria was compared with the standard drug ampicillin. Synthesized compounds were also tested for their antifungal activity against *Candida albicans and Aspergillus niger* using Griseofulvin as a standard. Disc diffusion method was used for determining the biological activity using nutrient agar and potato dextrose agar to culture the bacteria and fungus, respectively. The plate was incubated for 24 h at 35°C for the bacteria and 48 h at 28°C for fungus to record the diameter of anti-bacterial and anti-fungal activity.

Procedure

The synthesized compounds were dissolved in DMF and screened for their antibacterial and antifungal activity at concentrations of 1000 and 500 μg/ml, respectively. A blank test was conducted to check the antimicrobial activity of DMF. The results are recorded in the form of primary screening. The synthesized compounds found active in the primary screening were further tested in a second set of dilution against all microorganisms for secondary screening.

Table 1 Antibacterial activity of compounds **3(a–j)**

Antibacterial activity (zone of inhibition in mm)												
C. no.	*E. coli*			*P. aeruginosa*			*B. subtitis*			*S. aureus*		
	50 μg/ml	100 μg/ml	200 μg/ml	50 μg/ml	100 μg/ml	200 μg/ml	50 μg/ml	100 μg/ml	200 μg/ml	50 μg/ml	100 μg/ml	200 μg/ml
3a	04	10	17	04	08	14	04	12	14	05	06	09
3b	06	13	16	04	06	10	04	12	19	06	12	20
3c	03	10	18	06	10	14	05	14	22	06	12	18
3d	06	16	22	06	10	20	05	11	15	06	11	20
3e	07	15	24	06	11	14	05	13	23	05	13	15
3f	05	12	20	05	08	10	04	12	16	04	06	09
3g	06	15	23	07	12	20	07	10	21	05	10	19
3h	06	15	24	04	12	20	05	11	19	04	10	21
3i	03	13	18	05	09	14	03	09	15	05	10	14
3j	05	13	22	06	10	17	05	10	22	04	09	12
Ampicillin	10	18	29	09	14	23	10	16	26	09	14	23

Table 2 Antibacterial activity of compounds **4(a–j)**

Antibacterial activity (zone of inhibition in mm)												
C. no.	*E. coli*			*P. aeruginosa*			*B. subtitis*			*S. aureus*		
	50 μg/ml	100 μg/ml	200 μg/ml	50 μg/ml	100 μg/ml	200 μg/ml	50 μg/ml	100 μg/ml	200 μg/ml	50 μg/ml	100 μg/ml	200 μg/ml
4a	04	08	15	04	06	11	04	09	11	05	06	09
4b	06	13	16	04	06	10	04	05	14	06	10	18
4c	03	08	14	06	10	12	05	12	18	04	10	14
4d	05	14	19	05	09	18	05	11	13	04	09	18
4e	06	12	18	04	08	12	05	13	18	05	10	12
4f	05	12	20	05	08	10	04	10	14	04	06	09
4g	06	15	17	07	12	20	07	10	18	05	10	17
4h	05	10	18	04	12	18	05	091	13	04	10	18
4i	03	13	18	05	09	14	03	09	13	05	10	14
4j	05	13	18	06	10	14	05	10	18	04	09	12
Ampicillin	10	18	29	09	14	23	10	16	26	09	14	23

Table 3 Antifungal activity of compound **3(a-j)**

Antifungal activity (zone of inhibition in mm)						
C. no.	*C. albicans*			*A. niger*		
	50 μg/ml	100 μg/ml	200 μg/ml	50 μg/ml	100 μg/ml	200 μg/ml
3a	10	12	15	10	11	12
3b	12	13	13	11	12	12
3c	11	12	13	11	11	11
3d	17	24	30	15	17	19
3e	16	24	32	16	19	32
3f	15	16	20	12	15	16
3g	17	18	32	16	19	31
3h	11	12	13	11	11	11
3i	09	10	11	08	10	12
3j	16	18	19	16	18	18
Griseofulvin	18	25	40	21	24	40

Table 4 Antifungal activity of compounds **4(a–j)**

Antifungal activity (zone of inhibition in mm)						
C. no.	*C. albicans*			*A. niger*		
	50 μg/ml	100 μg/ml	200 μg/ml	50 μg/ml	100 μg/ml	200 μg/ml
4a	10	12	15	10	11	12
4b	12	13	13	11	12	12
4c	11	12	13	11	11	11
4d	10	11	13	10	12	13
4e	16	24	32	16	19	32
4f	15	16	20	12	15	16
4g	13	15	20	16	16	20
4h	11	12	13	11	11	11
4i	09	10	11	08	10	12
4j	16	18	19	16	18	18
Griseofulvin	18	25	40	21	24	40

The active compounds were diluted to 200, 100 and 50 μg/ml concentrations. The results revealed that all the newly synthesized compounds exhibited promising antibacterial and antifungal activity against the test organisms. The data for all the compounds is reported in Tables 1, 2, 3, 4.

Conclusion

Most of the synthesized compounds were found to possess mild to moderate antibacterial and antifungal activity except a couple of compounds which showed excellent activity, almost equivalent to the given standards. In future, further processing of the compounds will take place which may lead to a potentially improved compound.

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