Med Chem Res (2013) 22:3688–3697
DOI 10.1007/s00044-012-0369-3

MEDICINAL CHEMISTRY RESEARCH

ORIGINAL RESEARCH

Antibacterial and antifungal screening of newly synthesized benzimidazole-clubbed chalcone derivatives

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Received: 20 July 2012 / Accepted: 14 November 2012 / Published online: 30 November 2012

Abstract Different derivatives of chalcone-possessing benzimidazole as a prime motif were synthesized by the authors by acid catalyzed aldol condensation reaction. The synthesis of the desired compounds was initiated by undertaking two parallel reactions: (i) synthesis of 2-mercaptobenzimidazole and (ii) synthesis of N-(4-acetylphenyl)-2-chloroacetamide from 4-aminoacetophenone. The two intermediates so prepared were condensed to yield 2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-acetylphenyl)acetamide (II) using acetone as solvent and K_2CO_3 as a scavenger. The resultant product was further reacted with differently substituted aldehydes to produce the titled compounds using thionyl chloride ($SOCl_2$) in catalytic amount. The synthesized compounds were confirmed for their structure by means of various spectrometric techniques like IR, ^{1}H NMR, ^{13}C NMR, Mass spectra, and Elemental analysis. Thus-obtained chalcone derivatives were tested for their antibacterial and antifungal activities and were reported in form of minimum inhibitory concentration values.

Keywords Chalcones · Benzimidazole · Antimicrobial activity · MIC

Introduction

Chalcones demonstrate extensive applicability in medicinal science due to their wide range of biologic activities. Chalcones are found to be potent analgesics, antioxidants, and anti-inflammatory agents (Iwalewa *et al*., 2008). The multiple pharmacological actions of chalcones prove it to be highly efficacious as they can be used extensively as antifungal (Sarma *et al*., 2007), antiplasmodial (Mei-Lin Go *et al*., 2004), antiprotozoal (Azam *et al*., 2011), and antibacterial (Bandgar *et al*., 2010). Some of the substituted vinyl chalcones have proved to be TNF-α and IL-6 inhibitors (Bandgar *et al*., 2010). Chalcones are potent hydrophobic modulators of P-glycoprotein-mediated multidrug resistance (Boumendjel *et al*., 1999). Chalcones derived from the condensation between different acetophenones and aldehydes make them a potent motif as they exhibit a wide variety of biological activities including antimitotic (Ducki *et al*., 1998), anticancer (Barnard *et al*., 1993, De Meyer *et al*., 1991), Cardiovascular (Furman *et al*., 2001), and anti-tubercular (Linn *et al*., 2002). Similarly derived chalcones have also proved to be hyperglycemic agents (Satyanarayana *et al*., 2004).

Chalcones on incorporation with different biologically active scaffolds have always shown comparative more potent activities; like benzfuran chalcones have exhibited both antioxidant and antibacterial activity (Patil *et al*., 2010). Benzimidazole–"a heterocyclic scaffold" is a widely used medicinal component due to its broad spectrum of biological activities. Benzimidazoles are the class of compounds exhibiting excellent antiparasitic activity (Castilloa *et al*., 2002), anticancer activity (Reffat, 2011), antidiabetic, and anticonvulsant activity (Hosamani *et al*., 2010). Benzimidazole derivatives have proved to be potent analgesics (Dixit *et al*., 2012) and chemotherapeutic agents (Youssef *et al*., 2012). Benzimidazole derivatives on combining with chalcones have resulted in formation of compounds possessing antiviral properties (Tebbe and Spiyzer, 1997). Benzimidazole chalcones have proved to

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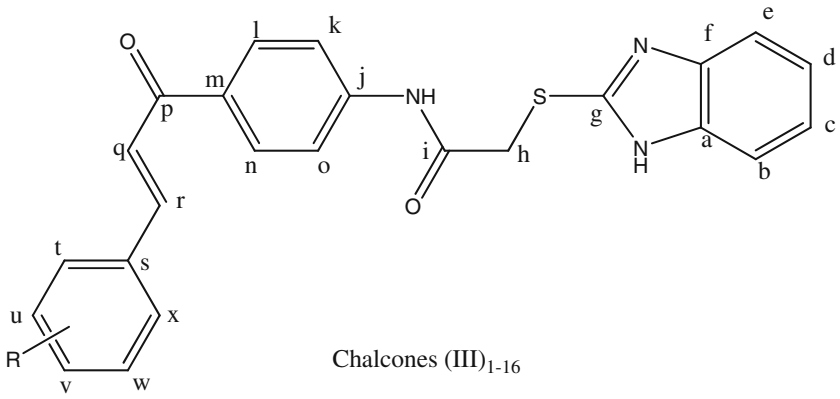


Fig. 1 Carbon numbering of the synthesized compounds $(III)_{1–16}$

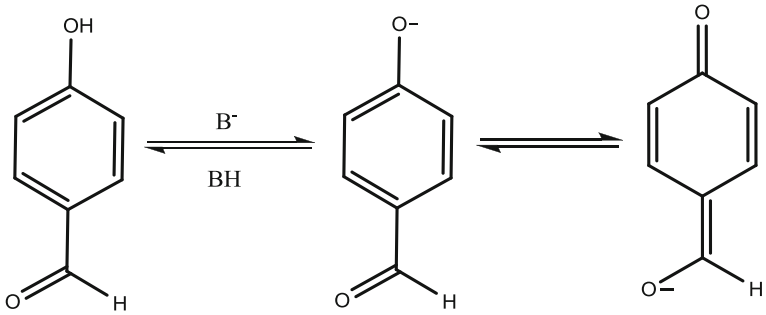


Fig. 2 Anionic delocalization of aldehydic component in presence of base

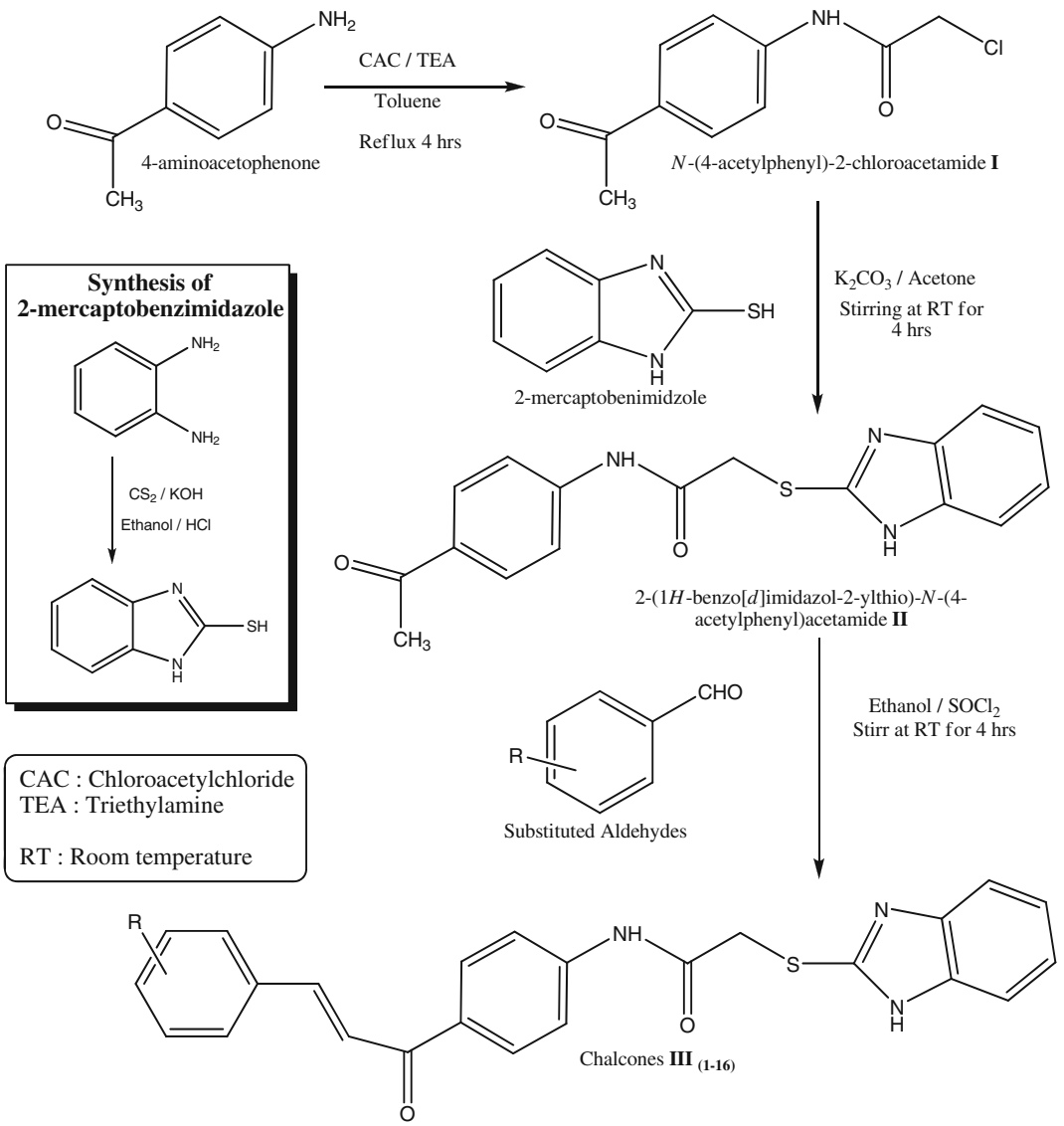
be good antimicrobials in recent times (Baviskar *et al*., 2009). 2-mercaptobenzimidazole a very good antioxidant, inhibitor, and antiseptic; is used as a precursor for the synthesis of titled compounds (Goodman, 1975; Saxena *et al*., 1982; Scherhag *et al*., 1974). Esomeprazole and lansoprazole possessing benzimidazole skeletal are widely used for treatment of gastric problems (Gatta *et al*., 2003).

Authors have tried to demonstrate the synthesis of chalcones via acid catalyzed aldol condensation method using acetophenone-bearing benzimidazole and various substituted aldehydes. There are several methods reported for the synthesis of chalcones viz. Base catalyzed condensation of chalcones is a very popular and the widely used method (Solankee *et al*., 2010), Catalyst like BF_3-Etherate (Narender and Reddy, 2007), natural phosphate modified with sodium nitrate (Sebti *et al*., 2003), Zinc (L-proline)$_2$ and water in combination are also used for the synthesis of chalcones (Siddiqui and Musthafa, 2011). The prominent method of acid catalyzed aldol condensation resulting chalcones in the shortest time and maximum yield reported by utilizing thionyl chloride and ethanol in combination was adapted by the researchers for the synthesis of the titled compounds as shown in Fig. 1 (Petrov *et al*., 2008, Jayapal and Sreedhar, 2010). The use of $SOCl_2$ as an acid catalyst in aldol condensation helps to overcome the error of decrease in the activity of aldehydes due to use of basic catalysts resulting in delocalization of anion formed. The delocalization phenomena discussed here is shown in Fig. 2.

Result and discussion

Chemistry

The synthetic methods adapted for the formation of the benzimidazole-based chalcone synthesis are depicted in Scheme 1. Two parallel reactions were undertaken simultaneously, of which the formation of heterocyclic structure benzimidazole was made possible by a reported procedure reacting o-phenylenediamine with carbon disulfide and KOH (Wang and Liu, 2007). On the other hand 4-aminoacetophenone was reacted with chloroacetyl chloride to form an intermediate N-(4-acetylphenyl)-2-chloroacetamide, which on reaction with 2-mercapto benzimidazole resulted in the formation of 2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-acetylphenyl)acetamide (II). This product (II) on reaction with different aldehydes via acid-catalyzed aldol condensation resulted in the formation of titled compounds $(III)_{1–16}$ in a good yield. The minimum inhibitory concentration (MIC) values of the synthesized compounds are indicated in Table 1. The retardation factor (R_f) value of compounds $(III)_{1–16}$ is indicated in Table 2.



Scheme 1 Synthesis of Compounds $(III)_{1-16}$

Characterization

IR data

Considering a particular compound from the series of derivatives synthesized, let us try to focus on the interpretation of spectral data. IR spectra obtained at 3236 and 3359 cm^{-1} indicated the presence of secondary amine in vicinity to carbonyl group and in the benzimidazole nucleus, respectively. A weak absorption stretching vibration band observed at 2750 cm^{-1} confirmed the presence of methylene group in the final motif. A sharp intensified band at 1640 cm^{-1} proved the presence of carbonyl group in the structure. The presence of C=C double bond in the aromatic ring was proved by the absorption band observed at 1413 cm^{-1}.

^1H NMR data

^1H NMR spectrum observed for the compound under investigation exhibited several absorption peaks corresponding to desired protons. Proton of secondary amine appearing at $\delta = 9.97$ confirmed its presence on nitrogen attached to aromatic ring by single bond, whereas the absorption peak at $\delta = 11.17$ indicated the presence of proton attached to the secondary nitrogen of the benzimidazole nucleus. A peak appearing particularly at $\delta = 4.65$ confirmed the protons of methylene group in the final structure. The protons of aromatic rings corresponded to the δ values between $\delta = 6.62$–8.10. The protons appearing in the chalcone formation confirmed its position at $\delta = 7.67$ and $\delta = 7.82$. The geometry of each proton

Table 1 Results for antibacterial and antifungal screening of compounds $(III)_{1–16}$

-R (Derivatives)	Minimum inhibitory concentration (MIC) in μg/ml					
	Gram-positive bacteria		Gram-negative bacteria		Fungi	
	S. aureus	*E. faecalis*	*E. coli*	*P. aeruginosa*	*C. albicans*	*A. niger*
-H	250	250	125	250	250	125
-4-Cl	125	250	62.5	125	250	125
-3,4-dimethoxy	62.5	250	31.25	125	125	62.5
-4-NO_2	62.5	125	62.5	125	125	62.5
-N,N-dimethyl	125	125	31.25	125	125	125
-4-Br	125	125	31.25	125	250	125
-3-Cl	31.25	125	62.5	125	250	125
-3-Br	31.25	250	62.5	125	250	250
-3,4,5-trimethoxy	31.25	250	31.25	125	125	250
-2-NO_2	31.25	250	31.25	250	250	250
-2,5-dimethoxy	31.25	125	31.25	125	250	125
Vanillin	15.62	250	62.5	250	62.5	125
-2-Hydroxy-1-napthaldehyde	62.5	250	62.5	62.5	125	62.5
-2-OH	62.5	125	31.25	31.25	62.5	125
-4-OCH_3	31.25	250	62.5	250	125	125
-4-OH	31.25	125	62.5	250	125	125
Fluconazole	–	–	–	–	**125**	**62.5**
Ciprofloxacin	**62.5**	**125**	**125**	**125**	**–**	**–**

MIC minimum inhibitory concentration, Std :standard drug Fluconazole for antifungal and Ciprofloxacin for antibacterial tests

Table 2 Retardation factor (R_f) value of compounds $(III)_{1–16}$

Compounds	Substitutions	Rf value
$(III)_1$	-H	0.57
$(III)_2$	-4-Cl	0.48
$(III)_3$	-3,4-dimethoxy	0.62
$(III)_4$	-4-NO_2	0.43
$(III)_5$	-N,N-dimethyl	0.43
$(III)_6$	-4-Br	0.49
$(III)_7$	-3-Cl	0.47
$(III)_8$	-3-Br	0.47
$(III)_9$	-3,4,5-trimethoxy	0.41
$(III)_{10}$	-2-NO_2	0.40
$(III)_{11}$	-2,5-dimethoxy	0.38
$(III)_{12}$	-Vanillin	0.36
$(III)_{13}$	-2-Hydroxy-1-napthaldehyde	0.37
$(III)_{14}$	-2-OH	0.50
$(III)_{15}$	-4-OCH_3	0.35
$(III)_{16}$	-4-OH	0.34

Retardation Factor= Distance travelled by analyte/Distance travelled by solvent

Mobile phase: Toluene/Acetone = 7/3

attached with C = C double bond of chalcone indicated to be Trans (E) as the coupling constant values for the two were 15.5 and 15.6 Hz, respectively.

^{13}C NMR data

The ^{13}C NMR spectral data helped to confirm the formation of desired structure. The δ values for the spectral study was seen to vary between δ = 39.2 to δ = 191. The carbon atoms "i" and "p" in contact to the electronegative element oxygen in the carbonyl group appeared downfield, nearly at 161.0 and 191.0, respectively, of which the carbon in the environment of secondary amine and methylene was seen to appear a bit up field (i.e. 161.0) than the one near to α, β-unsaturation. The carbon indicated as "g" present in benzimidazole nucleus between to nitrogen atoms and attached to sulfur was observed at δ = 148. The two carbons of chalcone linkage, i.e., carbon-q appeared at δ = 121.0 and carbon-r appeared at δ = 146.0. When the spectra of final product possessing nitro at ortho position to "s" carbon was observed, the δ value was seen to be shifting at δ = 127.3. Similar shift was seen in the spectra of 2, 5-dimethoxy substitution as the δ value shifted to 117.3. The carbon numbering to the structure is given in Fig. 1.

Antimicrobial activity

The compounds $(III)_{1–16}$ were tested for their antimicrobial activities against gram-positive bacteria, gram-negative bacterial, and fungal strains. The resulting MIC (μg/ml) values are indicated in the Table 1. It was observed that more than half of the compounds exhibited excellent activity in

comparison to the standards used, while the remaining were good and one or two of them were poor in comparison to the standards. The standards used for antifungal activity screening was Fluconazole and Ciprofloxacin was used as standard for anti bacterial assay. The MIC value for Fluconazole (standard) against *Candida albicans* was recorded to be 125 μg/ml where as against *Aspergillus niger* was 62.5 μg/ml. Similarly, the MIC values for Ciprofloxacin used as a standard against gram-positive bacteria *S. aureus* and *E. faecalis* were 62.5 μg/ml and 125 μg/ml, respectively. When the same standard drug Ciprofloxacin was used against gram-negative bacterial strains *E. coli* and *P. aeruginosa*; MIC value was observed to be 125 μg/ml. Some of the compounds showing excellent activity against particular bacteria and fungi are represented separately and in detail in the discussion of antibacterial and antifungal section below.

Antibacterial activity

The newly synthesized compounds $(III)_{1–16}$ were screened for their antibacterial activity against gram-positive bacteria *S. aureus* (ATCC No. 25923) and *E. faecalis* (ATCC No. 29212) and the gram-negative bacterial strain *E. coli* (ATCC No. 25922) and *P. aeruginosa* (ATCC No. 27853). The samples were tested by standard protocols like Micro dilution/Broth titer method. The screening for antibacterial activity was carried out by diluting the solution and preparing the sets consecutively from 1000, 500, 250, 125, 62.5, 31.25, 15.62 up to 7.8 μg/ml. Among all the synthesized derivatives, compound $(III)_{12}$ exhibited the best MIC value up to 15.62 μg/ml against gram-positive bacteria *S. aureus*. Other compounds showing higher activity than standard but less than compound $(III)_{12}$ against the bacterial strain *S. aureus* included compounds $(III)_7$, $(III)_8$, $(III)_9$, $(III)_{10}$, $(III)_{11}$, $(III)_{15}$, and $(III)_{16}$. Also, derivatives $(III)_3$, $(III)_4$, and $(III)_{13}$ possessed MIC value equivalent to that of the reference. When *E. faecalis* strain was used for conducting the MIC tests with the same standard Ciprofloxacin, compounds $(III)_4$, $(III)_5$, $(III)_6$, $(III)_7$, $(III)_{11}$, $(III)_{14}$, and $(III)_{16}$ exhibited MIC value similar to the standard used. In general, the derivatives with substitutions like p-NO_2 $(III)_4$, m-Cl $(III)_7$, 2,5-diOCH_3 $(III)_{11}$, o-OH $(III)_{14}$, and p-OH $(III)_{16}$ exhibited good activity against gram-positive bacteria when tested and compared with standard drug. The rest of the derivatives were showing moderate or lower activity than reference drug. Compound $(III)_1$ showed poor MIC value among all screened compounds against gram-positive bacterial strains. The same synthesized compounds when tested against gram-negative bacterial strains *E. coli*, Compounds with substitutions 3,4-diOCH_3 $(III)_3$, N,N-diCH_3 $(III)_5$, p-Br $(III)_6$, 3,4,5-triOCH_3 $(III)_9$, o-NO_2 $(III)_{10}$, 2,5-diOCH_3 $(III)_{11}$, and o-OH $(III)_{14}$ showed excellent activity near to MIC value 31.25 μg/ml. Compounds with substitutions p-Cl $(III)_2$, p-NO_2 $(III)_4$, m-Cl $(III)_7$, m-Br $(III)_6$, 3-$OCH_3$4-OH $(III)_{12}$, 2-OH-1-napthaldehyde $(III)_{13}$, and p-OH $(III)_{16}$ too exhibited good activity in comparison to the standard but were less than the one exhibiting 31.25 μg/ml. Only one compound from the series showed equivalent activity to the standard. The compounds when tested against another gram-negative bacteria *P. aeruginosa* did show few excellent results, especially compound $(III)_{13}$ 2-OH-1-napthaldehyde substituent and compound $(III)_{14}$ o-OH substituent showed excellent activity. All other substituents were equivalent in activity with the standard. Overall, most of the derivatives were more effective on *E. coli* than the other bacterial strains.

Antifungal activity

The same synthesized motifs were tested for their antifungal activity against two different fungal strains. The method implemented for the MIC tests was same as in antibacterial activity test. Only the strains used were *C. albicans* and *A. niger*. The standard drug used here for comparison was Fluconazole. The MIC values for the standard against both the strains appeared to be 125 μg/ml. Compounds $(III)_{12}$ and $(III)_{14}$ with 3-OCH_3-4-OH and 2-OH substituent, respectively, showed excellent activity against *C. albicans*. When tested on *C. albicans*, Compounds $(III)_3$, $(III)_4$, $(III)_5$, $(III)_9$, $(III)_{13}$, $(III)_{15}$, and $(III)_{16}$ exhibited equivalent activity to that of standard drug Fluconazole. Compounds $(III)_1$, $(III)_2$, $(III)_6$, $(III)_7$, $(III)_8$, $(III)_{10}$, and $(III)_{11}$ exhibited poor activity as compared to standard when tested against *C. albicans* (ATCC No. 10231). The same compounds were tested against *A. niger* (ATCC 1015), where few compounds, viz., $(III)_3$, $(III)_4$, and $(III)_{13}$ resulted in equivalent MIC values with reference. Other compounds exhibited poor activity against *A. niger* in comparison to the standard drug used.

SAR study

The use of SAR study helped in concluding that the different substitutions on the aromatic ring exerted varied biological activity. The substitutions were so selected as to confer different electronic environments of the molecules. Both electron-withdrawing and electron-donating groups were chosen as substituents on the chemical structure of the targeted compound. In major, compounds with electron donating groups such as methoxy and hydroxy exhibited lower MIC value than the reference drug used. Compounds $(III)_{12}$ and $(III)_{14}$ with substitutions 3-OCH_3-4OH and 2-OH showed lower MIC value against *S. aureus*, *E. coli*, and *C. albicans* as compared to the standards used for antimicrobial screening. Compounds with substituent from electron-donating groups like 3,4,5-trimethoxy $(III)_9$, 2,5-dimethoxy

$(III)_{11}$, 4-methoxy $(III)_{15}$, and 4-hydroxy $(III)_{16}$ also showed lower MIC value than the reference drug used, as described in Table 1. On the other hand, the derivatives with electron withdrawing group like chloro, bromo, and nitro did not execute lower MIC values as compared to the reference when treated with the fungal strains. From the above results, it can be concluded that the derivatives with electron-donating substitutions like hydroxy and methoxy are the most efficient compounds as antimicrobial agents. The results in Table 1 strongly support the report that the electron-donating group having the capacity to increase the electron density makes the compound more effective toward the microorganisms. Thus, It is inevitable for a compound to possess an optimum electron density to achieve a significant antimicrobial activity.

Experimental

Methods, materials and physical measurements

All the chemicals and solvents required for the synthesis were purchased from Merck ltd., sdfine chemicals, LOBA Chemie, and HIMEDIA. Melting points reported here are obtained by open end capillary method and are uncorrected. TLC plates used for monitoring the completion of reaction were purchased from Merck (TLC Silica gel 60 F_{254}). The IR spectral data were measured using Bruker FT-IR alpha-t (ATR). The ^{1}H NMR and ^{13}C NMR were obtained using Bruker Spectrophotometer-400 MHz where DMSO-d_6 was used as solvent and TMS as Reference. The mass spectral analysis was conducted on Shimadzu mass spectrophotometer. The elemental analysis was carried out on Perkin-Elmer 2400 CHN Analyzer.

Synthesis and physical data

Synthesis of N-(4-acetylphenyl)-2-chloroacetamide I

The titled compound I was obtained by reacting 4-aminoacetophenone (0.01 mol, 135gm/mol, 1.35gm) with chloroacetylchloride (0.015 mol, 113gm/mol, 1.19 ml) and Triethylamine (3–4drops) using toluene (25 ml) as solvent. The reaction mixture was refluxed for 4 h. The completion of reaction was monitored by TLC with mobile phase Toluene: Acetone (7:3). The obtained intermediate was buff in color and solid by state. Crystallization was carried in toluene.

Compound I: Solid light brown crystals; Yield: 87 %; M.P.: 154 °C; IR (ATR, cm^{-1}): 740 (C–Cl str.), 1413 (C=C str. aromatic ring), 1640 (C=O str.), 2750 (CH_2 str. methylene), 3049 (CH str. aromatic ring), 3232 (NH str.); ^{1}H NMR (400 MHz, $DMSOd_6$, δ, ppm): 2.56 (3H, s, -C<u>H</u>$_3$), 4.89 (2H, s, -C<u>H</u>$_2$), 7.77–8.10 (4H, d, Ar–<u>H</u>), 9.97 (1H, s, -N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 27.2 (q), 43.2 (h), 121.0 (k), 121.0 (o), 129.2 (l), 129.2 (n), 137.2 (m), 142.2 (j), 166.0 (i), 198.2 (p); (MS (m/z): 212 (M^+).

Synthesis of 2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-acetylphenyl)acetamide II

N-(4-acetylphenyl)-2-chloroacetamide I (0.01 mol, 211.5gm/mol, 2.11gm) obtained was further reacted with 2-mercatobenzimidazole (0.01 mol, 150.2gm/mol, 1.50gm). The reaction was stirred for 4 h at room temperature in the presence of K_2CO_3 (0.02 mol, 138gm/mol, 2.76gm) and acetone (20 ml) was used as reaction medium. After the completion of reaction monitored on TLC using Toluene: Acetone (8:2) as mobile phase, product was poured into water and stirred vigorously for 1 h. The separated precipitates were collected and dried. The product was recrystallized from methanol.

Compound II: Solid white; Yield: 85 %; M.P.: 210 °C; IR (ATR, cm^{-1}): 1413 (C=C str. aromatic ring), 1640 (C=O str.), 2750 (CH_2 str. methylene), 3049 (CH str. aromatic ring), 3232 (NH str.), 3359 (NH str. benzimidazole); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 2.56 (3H, s, -C<u>H</u>$_3$), 4.65 (2H, s, -C<u>H</u>$_2$), 7.30–8.10 (8H, d, Ar–<u>H</u>), 9.97 (1H, s, -N<u>H</u>), 11.17 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 27.2 (q), 39.2 (h), 116.2 (b), 116.2 (e), 121.0 (k), 121.0 (o), 124.0 (c), 124.0 (d), 129.2 (l), 129.2 (n), 137.2 (m), 140.0 (a), 140.0 (f), 142.2 (j), 148.0 (g), 166.0 (i), 198.2 (p); MS (m/z): 326 (M^+).

Synthesis of 2-mercaptobenzimidazole

2-mercaptobenzimidazole required for the formation of compound II was prepared by literature procedure (Castilloa et al., 2002). Yield: 70 %; M.P. : 286 °C; IR (ATR, cm^{-1}): 1413 (C=C str. aromatic ring), 1640 (C=O str.), 2750 (CH_2 str. methylene), 3049 (CH str. aromatic ring), 3232 (NH str.), 3359 (NH str. benzimidazole); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 7.30–8.10 (4H, d, Ar–<u>H</u>), 11.17 (1H, s, benzimidazole-N<u>H</u>), 11.69 (1H, s, -S<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 116.2 (b), 116.2 (e), 124.0 (c), 124.0 (d), 140.0 (a), 140.0 (f), 158.0 (g); MS (m/z): 151 (M^+).

General procedure for the synthesis of chalcones III $_{1\text{-}16}$

Acid-catalyzed aldol condensation (Jayapal and Sreedhar, 2010) was implemented for the synthesis of final derivatives $(III)_{1–16}$ of benzimidazole-clubbed chalcones. *2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-acetylphenyl)acetamide* II (0.01 mol, 325gm/mol, 3.25gm) was further treated with different substituted aldehydes (0.01 mol) in the presence of ethanol and $SOCl_2$ (in catalytic amount). This reaction was carried out at room temperature for 4 h with constant

stirring and then poured onto crushed ice. The product obtained is filtered and washed with water periodically and dried. The final products thus obtained were crystallized from alcohol and melting points of each synthesized heterocyclic chalcones were measured.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-cinnamoylphenyl)acetamide (III)$_1$ Solid brown; Yield: 68 %; M.P.: 180 °C; IR (ATR, cm^{-1}): 1359 (C–N str. sec. amine), 1413 (C=C str. aromatic ring), 1596 (C=C str. conjugated to carbonyl group), 1660 (C=O str. α,β-unsaturation), 2750 (CH_2 str. methylene), 3049 (CH str. aromatic ring), 3236 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 4.65 (2H, s, -C<u>H</u>$_2$), 6.62–8.10 (13H, d, Ar–<u>H</u>), 7.67(1H, d, <u>H</u>C = C<u>H</u>, J = 15.7 Hz), 7.82 (1H, d, <u>H</u>C = C<u>H</u>, J = 15.5 Hz), 9.97 (1H, s, -N<u>H</u>), 11.17 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 116.2 (b), 116.2 (e), 121.0 (k), 121.0 (o), 121.9 (q), 124.0 (c), 124.0 (d), 127.6 (v), 128.8 (t), 128.8 (x)128.9 (u), 128.9 (w), 129.2 (n), 129.2 (l), 136.0 (s), 137.2 (m), 140.0 (a),, 140.0 (f), 142.2 (j), 146.0 (r), 148.0 (g), 166.0 (i), 191.1 (p); MS (m/z): 414 (M^+). For $C_{24}H_{19}N_3O_2S$: C, 69.71 %; H, 4.63 %; N, 10.16 %; S, 7.75 %. Found: C, 69.75 %; H, 4.59 %; N, 10.21 %; S, 7.71 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(4-chlorophenyl)acryloyl)phenyl)acetamide (III)$_2$ Solid dark brown; Yield: 71 %; M.P.:184 °C(D); IR (ATR, cm^{-1}): 1352 (C–N str. sec. amine), 1421 (C=C str. aromatic ring), 1591 (C=C str. conjugated to carbonyl group), 1662 (C=O str. α,β-unsaturation), 2763 (CH_2 str. methylene), 3032 (CH str. aromatic ring), 3234 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 4.63 (2H, s, -C<u>H</u>$_2$), 6.92–8.10 (12H, d, Ar–<u>H</u>), 7.69(1H, d, <u>H</u>C = C<u>H</u>, J = 15.6 Hz), 7.83 (1H, d, <u>H</u>C = C<u>H</u>, J = 15.4 Hz), 9.97 (1H, s, -N<u>H</u>), 11.20 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 116.2 (b), 116.2 (e), 121.0 (k), 121.0 (o), 121.9 (q), 124.0 (c), 124.0 (d), 128.5 (u), 128.5(w), 129.2 (n), 129.2 (l), 129.8 (t), 129.8 (x), 133.6 (v), 134.4 (s), 137.2 (m), 140.0 (f), 140.0 (a), 142.2 (j), 146.0 (r), 148.0 (g), 166.0 (i), 191.1 (p); MS (m/z): 448(M^+). For $C_{24}H_{18}N_3O_2SCl$: C, 64.35 %; H, 4.05 %; N, 9.38 %; S, 7.16 %. Found: C, 64.39; H, 4.03; N, 9.43; S, 7.19 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(3,4-dimethoxyphenyl)acryloyl)phenyl)acetamide (III)$_3$ Solid chrome yellow; Yield: 64 %; M.P.:136 °C; IR (ATR, cm^{-1}): 1347 (C–N str. sec. amine), 1403 (C=C str. aromatic ring), 1589 (C=C str. conjugated to carbonyl group), 1661 (C=O str. α,β-unsaturation),), 2756 (CH_2 str. methylene), 3041 (CH str. aromatic ring, 3242 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 3.75 (3H, s, OC<u>H</u>$_3$), 3.81 (3H, s, OC<u>H</u>$_3$),4.61 (2H, s, -C<u>H</u>$_2$), 7.01–8.19 (11H, d, Ar–<u>H</u>), 7.73(1H, d, <u>H</u>C = C<u>H</u>, J = 15.4 Hz), 7.83 (1H, d, <u>H</u>C = C<u>H</u>, J = 15.5 Hz), 9.93 (1H, s, -N<u>H</u>), 11.18 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 112.8(w), 112.8 (t), 116.2 (b), 116.2 (e), 121.0 (k), 121.0 (o), 121.9 (q), 123.7 (x), 124.0 (c), 124.0 (d), 127.4 (s), 129.2 (n), 129.2 (l), 137.2 (m), 140.0 (f), 140.0 (a), 142.2 (j), 146.0 (r), 148.0 (g), 150.7 (u), 150.7(v), 166.0 (i), 191.1 (p); MS (m/z): 474(M^+). For $C_{26}H_{23}N_3O_4S$: C, 65.94; H, 4.90 N, 8.87; S, 6.77 %. Found: C, 65.90; H, 4.93; N, 8.91; S, 6.82 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(4-nitrophenyl)acryloyl)phenyl)acetamide (III)$_4$ Solid cream yellow; Yield: 60 %; M.P.:148 °C; IR (ATR, cm^{-1}): 1360 (C–N str. sec. amine), 1411 (C=C str. aromatic ring), 1599 (C=C str. conjugated to carbonyl group), 1656 (C=O str. α,β-unsaturation), 2753 (CH_2 str. methylene), 3053 (CH str. aromatic ring), 3247 (NH str. sec. amine); ^{1}H NMR (400 MHz, Dmso-d_6, δ, ppm): 4.69 (2H, s, -C<u>H</u>$_2$), 6.82–8.03 (12H, d, Ar–<u>H</u>), 7.59(1H, d, <u>H</u>C=C<u>H</u>, J=15.5 Hz), 7.81 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.5 Hz), 10.01 (1H, s, -N<u>H</u>), 11.21 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 116.2 (b), 116.2 (e), 121.0 (k), 121.0 (o), 121.9 (q), 123.9 (u), 123.9 (w), 124.0 (c), 124.0 (d), 128.8 (t), 128.8 (x), 129.2 (n), 129.2 (l), 137.2 (m), 140.0 (f), 140.0 (a), 140.9 (s), 142.2 (j), 146.0 (r), 147.6 (v), 148.0 (g), 166.0 (i), 191.1 (p); MS (m/z): 459(M^+). For $C_{24}H_{18}N_4O_4S$: C, 62.87; H, 3.96; N, 12.22; S, 6.99 %. Found: C, 62.90; H, 4.01; N, 12.30; S, 7.03 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(4-(dimethylamino)phenyl)acryloyl)phenyl)acetamide (III)$_5$ Solid light orange; Yield: 65 %; M.P.:188 °C; IR (ATR, cm^{-1}): 1369 (C–N str. sec. amine), 1423 (C=C str. aromatic ring), 1600 (C=C str. conjugated to carbonyl group), 1671 (C = O str. α,β-unsaturation), 3053 (CH str. aromatic ring), 2759 (CH_2 str. methylene), 3247 (NH str. sec. amine); ^{1}H NMR (400 MHz, Dmso-d_6, δ, ppm): 3.16 (6H, s, -C<u>H</u>$_3$ N,N-dimethyl group), 4.59 (2H, s, -C<u>H</u>$_2$), 6.69–8.10 (12H, d, Ar–<u>H</u>), 7.71(1H, d, <u>H</u>C=C<u>H</u>, J = 15.5 Hz), 7.79 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.8 Hz), 10.07 (1H, s, -N<u>H</u>), 11.13 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 116.2 (b), 112.9 (u), 112.9 (w), 116.2 (e), 121.0 (o), 121.0 (k), 121.9 (q), 124.0 (c), 124.0 (d), 124.9 (s), 129.2 (l), 129.2 (n), 129.8 (x), 129.8 (t), 137.2 (m), 140.0 (a), 140.0 (f), 142.2 (j), 146.0 (r), 148.0 (g), 166.0 (i), 150.6 (v), 191.1 (p); MS (m/z): 460(M^+). For $C_{26}H_{24}N_4O_2S$: C, 68.40; H, 5.30; N, 12.27; S, 7.02 %. Found: C, 68.36; H, 5.34; N, 12.30; S, 7.16 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(4-bromophenyl)acryloyl)phenyl)acetamide (III)$_6$ Solid dark brown; Yield: 57 %; M.P.:190 °C; IR (ATR, cm^{-1}): 1361

(C–N str. sec. amine), 1409 (C=C str. aromatic ring), 1586 (C=C str. conjugated to carbonyl group), 1656 (C=O str. α,β-unsaturation), 2747 (CH_2 str. methylene), 3059 (CH str. aromatic ring), 3242 (NH str. sec. amine); ^{1}H NMR (400 MHz, Dmso-d_6, δ, ppm): 4.60 (2H, s, -C<u>H</u>$_2$), 6.72–8.00 (12H, d, Ar–<u>H</u>), 7.72(1H, d, <u>H</u>C=C<u>H</u>, J = 15.7 Hz), 7.85 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.5 Hz), 9.92 (1H, s, -N<u>H</u>), 11.12 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 116.2 (b), 116.2 (e), 120.6 (v), 121.0 (k), 121.0 (o), 121.9 (q), 124.0 (c), 124.0 (d), 128.3 (x), 128.3 (t), 129.2 (n), 129.2 (l), 131.9 (u), 131.9 (w), 133.9 (s), 137.2 (m), 140.0 (a), 140.0 (f), 142.2 (j), 146.0 (r), 148.0 (g), 166.0 (i), 191.1 (p); MS (m/z): 492(M^+). For $C_{24}H_{18}N_3O_2SBr$: C, 58.54 H, 3.68; N, 8.53; S, 6.51 %. Found: C, 58.58; H, 3.71; N, 8.57; S, 6.54 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(3-chlorophenyl)acryloyl)phenyl)acetamide (III)$_7$ Solid light yellow; Yield: 77 %; M.P.: 126 °C; IR (ATR, cm^{-1}): 1361 (C–N str. sec. amine), 1411 (C=C str. aromatic ring), 1591 (C=C str. conjugated to carbonyl group), 1661 (C=O str. α,β-unsaturation), 2747 (CH_2 str. methylene), 3053 (CH str. aromatic ring), 3239 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 4.61 (2H, s, -C<u>H</u>$_2$), 6.79–8.17 (12H, d, Ar–<u>H</u>), 7.77(1H, d, <u>H</u>C=C<u>H</u>, J = 15.7 Hz), 7.89 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.8 Hz), 9.89 (1H, s, -N<u>H</u>), 11.15 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 116.2 (b), 116.2 (e), 121.0 (o), 121.0 (k), 121.9 (q), 124.0 (c), 124.0 (d), 126.3 (x), 126.3 (t), 128.6 (v), 129.2 (n), 129.2 (l), 130.9 (w), 134.9 (u), 136.9 (s), 137.2 (m), 140.0 (a), 140.0 (f), 142.2 (j), 146.0 (r), 148.0 (g), 166.0 (i), 191.1 (p); MS (m/z): 448(M^+). For $C_{24}H_{18}N_3O_2SCl$: C, 64.35; H, 4.05; N, 9.38; S, 7.16 %. Found: C, 64.39; H, 4.09; N, 9.34; S, 7.22 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(3-bromophenyl)acryloyl)phenyl)acetamide (III)$_8$ Solid light brown; Yield: 80 %; M.P.:110 °C; IR (ATR, cm^{-1}): 1352 (C–N str. sec. amine), 1416 (C=C str. aromatic ring), 1582 (C=C str. conjugated to carbonyl group), 1653 (C=O str. α,β-unsaturation), 2759 (CH_2 str. methylene), 3056 (CH str. aromatic ring), 3239 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 4.57 (2H, s, -C<u>H</u>$_2$), 6.62–8.10 (12H, d, Ar–<u>H</u>), 7.72(1H, d, <u>H</u>C=C<u>H</u>, J = 15.5 Hz), 7.82 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.5 Hz), 9.91 (1H, s, -N<u>H</u>), 11.23 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 116.2 (b), 116.2 (e), 121.0 (k), 121.0 (o), 121.9 (q), 123.9 (u), 124.0 (c), 124.0 (d), 127.3 (x), 129.2 (n), 129.2 (l), 129.5 (w), 130.6 (v), 133.7 (t), 137.2 (m), 137.9 (s), 140.0 (f), 140.0 (a), 142.2 (j), 146.0 (r), 148.0 (g), 166.0 (i), 191.1 (p); MS (m/z): 492(M^+). For $C_{24}H_{18}N_3O_2SBr$: C, 58.54; H, 3.68; N, 8.53 ; S, 6.51 %. Found: C, 58.59; H, 3.72; N, 8.55; S, 6.56 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(3,4,5-trimethoxyphenyl)acryloyl)phenyl)acetamide (III)$_9$ Solid light yellow; Yield: 78 %; M.P.:148 °C; IR (ATR, cm^{-1}): 1352 (C–N str. sec. amine), 1423 (C=C str. aromatic ring), 1593 (C=C str. conjugated to carbonyl group), 1667 (C=O str. α,β-unsaturation), 2759 (CH_2 str. methylene), 3059 (CH str. aromatic ring), 3249 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 4.59 (2H, s, -C<u>H</u>$_2$), 6.69–7.99 (10H, d, Ar–<u>H</u>), 7.70(1H, d, <u>H</u>C = C<u>H</u>, J = 15.7 Hz), 7.80 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.5 Hz), 9.91 (1H, s, -N<u>H</u>), 11.21(1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 103.7 (t), 103.7 (x), 116.2 (b), 116.2 (e), 121.0 (k), 121.0 (o), 121.9 (q), 124.0 (c), 124.0 (d), 127.9 (s), 129.2 (l), 129.2 (n), 137.2 (m), 138.7 (v), 140.0 (a), 140.0 (f), 142.2 (j), 146.0 (r), 148.0 (g), 153.9 (u), 153.9 (w), 166.0 (i), 191.1 (p); MS (m/z): 504(M^+). For $C_{27}H_{25}N_3O_5S$: C, 64.40; H, 5.00; N, 8.34; S, 6.37 %. Found: C, 64.35; H, 5.03; N, 8.39; S, 6.69 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(2-nitrophenyl)acryloyl)phenyl)acetamide (III)$_{10}$ Solid off white; Yield: 78 %; M.P.:202 °C; IR (ATR, cm^{-1}): 1352 (C–N str. sec. amine), 1410 (C=C str. aromatic ring), 1586 (C=C str. conjugated to carbonyl group), 1652 (C=O str. α,β-unsaturation), 2747 (CH_2 str. methylene), 3062 (CH str. aromatic ring), 3249 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 4.59 (2H, s, -C<u>H</u>$_2$), 6.53–7.89 (12H, d, Ar–<u>H</u>), 7.73(1H, d, <u>H</u>C=C<u>H</u>, J = 15.7 Hz), 7.80 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.7 Hz), 9.97 (1H, s, -N<u>H</u>), 11.19 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 116.2 (b), 116.2 (e), 121.0 (o), 121.0 (k), 121.9 (q), 123.9 (u), 124.0 (c), 124.0 (d), 127.3 (s), 127.3 (x), 128.7 (v), 129.2 (l), 129.2 (n), 134.9 (w), 137.2 (m), 140.0 (a), 140.0 (f), 142.2 (j), 146.0 (r), 148.7 (t), 148.0 (g), 166.0 (i), 191.1 (p); MS (m/z): 459(M^+). Anal. calc. For $C_{24}H_{18}N_4O_4S$: C, 62.87; H, 3.96; N, 12.22; S, 6.99 %. Found: C, 62.93; H, 3.87; N, 12.18; S, 6.94 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(2,5-dimethoxyphenyl)acryloyl)phenyl)acetamide (III)$_{11}$ Solid lemon yellow; Yield: 82 %; M.P.:168 °C; IR (ATR, cm^{-1}): 1361 (C–N str. sec. amine), 1421 (C=C str. aromatic ring), 1589 (C=C str. conjugated to carbonyl group), 1659 (C=O str. α,β-unsaturation), 2756 (CH_2 str. methylene), 3051 (CH str. aromatic ring), 3231 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 3.56 (6H, s, -OC<u>H</u>$_3$), 4.69 (2H, s, -C<u>H</u>$_2$), 6.62–8.10 (11H, d, Ar–<u>H</u>), 7.62(1H, d, <u>H</u>C=C<u>H</u>, J = 15.7 Hz), 7.79 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.7 Hz), 9.91 (1H, s, -N<u>H</u>), 11.21 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 112.3 (x), 116.2 (b), 116.2 (e), 116.7 (v), 117.3 (s), 117.9 (u), 121.0 (k), 121.0 (o), 121.9 (q), 124.0 (c), 124.0 (d), 129.2 (l), 129.2 (n), 137.2 (m), 140.0 (a), 140.0 (f),

142.2 (j), 143.0 (r), 148.0 (g), 152.7 (t), 152.9 (w), 166.0 (i), 191.1 (p); MS (m/z): 474(M^+). Anal. calc. For $C_{26}H_{23}N_3O_4S$: C, 65.94 %; H, 4.90; N, 8.87; S, 6.77 %. Found: C, 65.91; H, 4.87; N, 9.78; S, 6.80 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(4-hydroxy-3-methoxyphenyl)acryloyl)phenyl)acetamide (III)$_{12}$ Solid lemon yellow; Yield: 76 %; M.P.:158 °C; IR (ATR, cm^{-1}): 1356 (C–N str. sec. amine), 1421 (C=C str. aromatic ring), 1599 (C=C str. conjugated to carbonyl group), 1662 (C = O str. α,β-unsaturation), 2752 (CH_2 str. methylene), 3056 (CH str. aromatic ring), 3241 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 3.78 (3H, s, -OC<u>H</u>$_3$), 3.19 (1H, s, -O<u>H</u>), 4.59 (2H, s, -C<u>H</u>$_2$), 6.89–8.00 (11H, d, Ar–<u>H</u>), 7.70(1H, d, <u>H</u>C=C<u>H</u>, J = 15.7 Hz), 7.83 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.5 Hz), 9.89 (1H, s, -N<u>H</u>), 11.14 (1H, s, benzimidazole-N<u>H</u>),; ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 112.7 (t), 116.2 (b), 116.2 (e), 116.9 (w), 121.0 (k), 121.0 (o), 121.9 (q), 122.3 (x), 124.0 (c), 124.0 (d), 127.3 (s), 129.2 (n), 129.2 (l), 137.2 (m), 140.0 (a), 140.0 (f), 142.2 (j), 146.0 (r), 146.7 (v), 147.9 (u), 148.0 (g), 166.0 (i), 191.1 (p); MS (m/z): 460(M^+). Anal. calc. For $C_{25}H_{21}N_3O_4S$: C, 65.34; H, 4.61; N, 9.14; S, 6.98 %. Found: C, 65.39; H, 4.63; N, 9.18; S, 6.94 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(2-hydroxynaphthalen-1-yl)acryloyl)phenyl)acetamide (III)$_{13}$ Solid purple; Yield: 76 %; M.P.:186 °C; IR (ATR, cm^{-1}): 1359 (C–N str. sec. amine), 1413 (C = C str. aromatic ring), 1596 (C = C str. conjugated to carbonyl group), 1660 (C = O str. α,β-unsaturation), 2750 (CH_2 str. methylene), 3049 (CH str. aromatic ring), 3236 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 3.09 (1H, s, -O<u>H</u>), 4.65 (2H, s, -C<u>H</u>$_2$), 6.63–8.10 (14H, d, Ar–<u>H</u>), 7.67(1H, d, <u>H</u>C=C<u>H</u>), 7.82 (1H, d, <u>H</u>C=C<u>H</u>), 9.97 (1H, s, -N<u>H</u>), 11.17 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 21.0 (k), 39.2 (h), 116.2 (b), 116.2 (e), 117.9 (u), 121.0 (o), 121.9 (w), 121.9 (q), 123.3 (s), 124.0 (c), 124.0 (d), 128.3 (x), 129.2 (l), 129.2 (n), 129.7 (v), 137.2 (m), 140.0 (a),140.0 (f), 142.0 (r), 142.2 (j), 148.0 (g), 158.7 (t), 166.0 (i), 191.1 (p); MS (m/z): 430(M^+). Anal. calc. For $C_{28}H_{21}N_3O_3S$: C, 70.13; H, 4.41; N, 8.76; S, 6.69 %. Found: C, 70.16; H, 4.47; N, 8.80; S, 6.74 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(2-hydroxyphenyl)acryloyl)phenyl)acetamide (III)$_{14}$ Solid light brown; Yield: 56 %; M.P.:186 °C; IR (ATR, cm^{-1}): 1352 (C–N str. sec. amine), 1429 (C=C str. aromatic ring), 1589 (C=C str. conjugated to carbonyl group), 1663 (C=O str. α,β-unsaturation), 2751 (CH_2 str. methylene), 3053 (CH str. aromatic ring), 3239 (NH str. sec. amine); ^{1}H NMR (400 MHz, dmso, δ, ppm): 3.06 (1H, s, -OH), 4.59 (2H, s, -CH_2), 6.59–8.03 (11H, d, Ar), 7.72(1H, d, C=C, J = 15.5 Hz), 7.88 (1H, d, C = C, J = 15.7 Hz), 10.02 (1H, s, -NH), 11.24 (1H, s, benzimidazole-NH); ^{13}C NMR (400 MHz, dmso, δ, ppm): 21.0 (k), 39.2 (h), 116.2 (b), 116.2 (e), 117.9 (u), 121.0 (o), 121.9 (w), 121.9 (q), 123.3 (s), 124.0 (c), 124.0 (d), 128.3 (x), 129.2 (l), 129.2 (n), 129.7 (v), 137.2 (m), 140.0 (a),140.0 (f), 142.0 (r), 142.2 (j), 148.0 (g), 158.7 (t), 166.0 (i), 191.1 (p); MS (m/z): 430(M^+). Anal. calc. For $C_{24}H_{19}N_3O_3S$: C, 67.12; H, 4.46; N, 9.78; S, 7.47 %. Found: C, 67.14; H, 4.43; N, 9.74; S, 7.46 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(4-methoxyphenyl)acryloyl)phenyl)acetamide (III)$_{15}$ Solid light yellow; Yield: 86 %; M.P.:164 °C; IR (ATR, cm^{-1}): 1351 (C–N str. sec. amine), 1429 (C=C str. aromatic ring), 1599 (C=C str. conjugated to carbonyl group), 1653 (C=O str. α,β-unsaturation), 2759 (CH_2 str. methylene), 3051 (CH str. aromatic ring), 3249 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 3.79 (3H, s, -OC<u>H</u>$_3$), 4.61 (2H, s, -C<u>H</u>$_2$), 6.79–8.06 (12H, d, Ar–<u>H</u>), 7.77(1H, d, <u>H</u>C=C<u>H</u>, J = 15.6 Hz), 7.83 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.5 Hz), 9.99 (1H, s, -N<u>H</u>), 11.23 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 114.9 (w), 114.9 (u), 116.2 (b), 116.2 (e), 121.0 (o), 121.0 (k), 121.9 (q), 124.0 (c), 124.0 (d), 128.3 (s), 129.2 (l), 129.2 (n), 130.3 (x), 130.7 (t), 137.2 (m), 140.0 (a),140.0 (f), 142.2 (j), 146.0 (r), 146.0 (r), 148.0 (g), 166.0 (i), 191.1 (p); MS (m/z): 444(M^+). Anal. calc. For $C_{25}H_{21}N_3O_3S$: C, 67.70; H, 4.77; N, 9.47; S, 7.23 %. Found: C, 67.74; H, 4.73; N, 9.42; S, 7.26 %.

(E)-2-(1H-benzo[d]imidazol-2-ylthio)-N-(4-(3-(4-hydroxyphenyl)acryloyl)phenyl)acetamide (III)$_{16}$ Solid chrome yellow; Yield: 63 %; M.P.:168 °C; IR (ATR, cm^{-1}): 1351 (C–N str. sec. amine), 1419 (C=C str. aromatic ring), 1591 (C=C str. conjugated to carbonyl group), 1658 (C=O str. α,β-unsaturation), 2763 (CH_2 str. methylene), 3055 (CH str. aromatic ring), 3249 (NH str. sec. amine); ^{1}H NMR (400 MHz, DMSO-d_6, δ, ppm): 3.16 (1H, s, -O<u>H</u>), 4.67 (2H, s, -C<u>H</u>$_2$), 6.82–8.17 (12H, d, Ar–<u>H</u>), 7.62(1H, d, C<u>H</u>=C<u>H</u>, J = 15.6 Hz), 7.79 (1H, d, <u>H</u>C=C<u>H</u>, J = 15.7 Hz), 9.92 (1H, s, -N<u>H</u>), 11.25 (1H, s, benzimidazole-N<u>H</u>); ^{13}C NMR (400 MHz, DMSO-d_6, δ, ppm): 39.2 (h), 115.9 (u), 115.9 (w), 116.2 (b), 116.2 (e), 121.0 (k), 121.0 (o), 121.9 (q), 124.0 (c), 124.0 (d), 127.3 (s), 129.2 (l), 129.2 (n), 130.7 (x), 130.7 (t), 137.2 (m), 140.0 (a), 140.0 (f), 142.2 (j), 146.0 (r), 148.0 (g), 156.7 (v), 166.0 (i), 191.1 (p); MS (m/z): 430(M^+). Anal. calc. For $C_{24}H_{19}N_3O_3S$: C, 67.12; H, 4.46; N, 9.78; S, 7.47 %. Found: C, 66.09; H, 4.43; N, 9.82; S, 7.46 %.

Conclusion

In the present research work, we have synthesized benzimidazole-clubbed chalcone derivatives as microorganism growth inhibitors. The antifungal and antibacterial data displayed significant activity of the synthesized compounds.

Some of the derivatives showed higher bacterial and fungal growth inhibition, even higher than the standard drugs. It can be concluded that there is a wide scope in developing these compounds as potent lead molecules.

Acknowledgments The authors are thankful to Sheth M. N. Science College, Patan for providing laboratory facilities and to SAIF Chandigarh, for providing analytical and instrumentation facilities. We are also thankful to the Department of Science and Technology-INDIA for awarding one of the author DSJ with DST-JRF (INSPIRE fellowship).

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