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Design, green synthesis and reactions of 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6 sulfonohydrazide derivatives

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2,3-Dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonohydrazide and its derivatives were synthesized and characterize by IR, ^{1}H-NMR, ^{13}C-NMR and mass spectrometry analytical methods. The 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazide (compound 1), was synthesized from the reaction of o-phenylenediamine with oxalic acid to obtain quinoxaline-2,3-dione, which was subjected to chlorosulfonation with chlorosulfonic acid to give 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl chloride. The 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl chloride was reacted with hydrazine hydrate to afford 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazide (compound 1). The quinoxaline-6-sulfonohydrazone derivatives were synthesized by reacting compound 1 with substituted benzaldehydes or aromatic ketones. The chemical structures of the compounds prepared were confirmed by spectral data. The synthetic methodology was efficient and environmentally friendly; this was due to the fact that the work-up stage was carried out in water.

Key words: 2,3-Dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazide, quinoxaline-2,3-dione, synthesis, substituted benzaldehydes, isatin, infrared, spectroscopy.

INTRODUCTION

Heterocyclic compounds represent an important class of biologically active molecules (Sakata et al., 1998; Michael et al., 2002; Jaso et al., 2003; Zeb et al., 2014). Specifically, those containing quinoxaline derivatives have evoked considerable attention in recent years. Quinoxaline, or 1,4-benzo[pyrazine] is an important structural unit among nitrogen-containing heterocyclic compounds. Quinoxalines are, in general, easy to prepare. Hydrazone containing azomethine-NHN=CH protons constitutes an important class of compounds for novel drug development (Rollas and Kuçukguzel, 2007; Kaurase et al., 2011). It plays an essential role in biologically active compounds (Rangisetty et al., 2001; Salgin-Goksen et al., 2007; Ragavendran et al., 2007; Mehta et al., 2006; Bijev, 2006) and hence, represents an interesting template for medicinal chemistry (Rowan et al., 2002; Chang et al., 2003; Dongsheng et al., 2014). Many techniques have been employed in the synthesis of hydrazone frameworks (Sridharan et al., 2007; Abd-Elhafez et al., 2003; Vicini et al., 2003; Sridhar Ramesh, 2001; Beheshtiha et al., 2010; Asegbeloyin et al., 2015) and quinoxaline moieties (Srinivas et al., 2007;

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Taiwo et al., 2008; Zhenjiang et al., 2008; Olayiwola et al., 2007; Obafemi and Akinpelu, 2005; Urquiola et al., 2006; Nasr, 2002).

Microwave-assisted reactions have been intensely investigated since the earliest publication of Gedye et al. (1986) and Giguerre et al. (1986). It is fast becoming unavoidable technique for the accelerated synthesis of both organic compounds (Sha et al., 2001) and inorganic (Vanetsev et al., 2005), most importantly in the synthesis of different biologically active heterocycles (Abdellatif et al., 2008; Qingqing et al., 2008; Rodrigo et al., 2008; Outirite et al., 2008; Tinh and Stadlbauer, 2008; Muscia et al., 2008). Chemists have discovered that, microwave enhanced chemical reaction time and can be faster than those of conventional heating methods by as much as a thousand-fold (Hayes, 2004). This present work was designed to develop a series of novel 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazone using microwave irradiation technique and also compare it with traditional method of conventional heating approach.

MATERIALS AND METHODS

General

Melting points were determined with open capillary tube on a Gallenkamp (variable heater) melting point apparatus and were uncorrected. Infrared spectra were recorded as KBr pellets on a Buck Spectrometer. The ^{1}H and ^{13}C NMR were run on a Bruker 600 MHz spectrometer (δ in ppm relative to Me_4Si). Mass spectra were taken on a high-resolution (m/Δm = 30 000). Thermo Scientific LTQ-Orbitrap Discovery mass spectrometer (San Jose, CA) equipped with an electrospray ionization source at the Department of Chemistry, Portland State University, Portland U.S.A. The purity of the compounds were routinely checked by TLC on silica gel G plates using n-hexane/ethyl acetate (1:1, v/v) solvent system and the developed plates were visualized by UV light. All reagents used were obtained from Sigma-Aldrich Chemical Ltd, except glacial acetic acid, ethanol, oxalic acid and vanillin which were obtained from BDH Chemical Limited.

Preparation of quinoxaline-2,3-(1H,4H)-dione-6-sulfonohydrazide (compound 1)

To hydrazine dihydrate (20 ml, 0.460 mmol) in absolute methanol (400 ml) was added quinoxaline-6-sulfonylchloride (30 g, 0.115 mmol) portion wise with constant stirring for 15 min. The reaction mixture was stirred at room temperature for 24 h. The mixture obtained was refluxed at 80°C for 1 h. The solution was cooled and poured into cold water to give compound 1.

IR Spectra (KBr): 3347 cm^{-1} (N-H), 3139 cm^{-1} (N-H), 3050 cm^{-1} (N-H), 3039 cm^{-1} (N-H), 1669 cm^{-1} (C=O),1595 cm^{-1} (C=N), 1391 (SO_2), 1159 cm^{-1} (SO_2). ^{1}H NMR (DMSO-d_6): 3.37 (br s, 1H, NH, D_2O exchangeable), 4.12 (br s, 1H, NH, D_2O exchangeable), 12.10 (br s, 1H, NH, D_2O exchangeable), 8.37 (br s, 1H, NH, D_2O exchangeable), 7.60 (d, 1H, ArH), 7.49-7.50 (dd, 1H, ArH), 7.27 (d, 1H, ArH). ^{13}C NMR (DMSO-d_6): 154.86 (C=O), 131.98 (Aromatic), 128.95 (Aromatic), 125.50 (Aromatic), 122.33 (Aromatic), 115.27 (Aromatic), 114.96 (Aromatic). MS (m/z, %): 257 (M+1, 25), 227 ([M - CHO]$^+$, 100), 200 ([M – C_2O_2]$^+$,14), 135 ([M – $C_2H_4N_2O_2SH$]$^+$, 10), 111 (15).

General procedure for the reaction of quinoxaline-6-sulfonohydrazide with substituted benzaldehydes and aromatic ketones

Quinoxaline-6-sulfonohydrazide (1.0 g, 39 mmol) and substituted benzaldehydes or aromatic ketones (39 mmol) were added to glacial acetic acid (25 ml) in a round bottom flask and refluxed at 120°C for 3 h. The reaction mixture was cooled and poured into crushed ice with continuous stirring to obtain a solid product which was filtered and dried. Recrystallization from DMF/water afforded N-(E)-(phenylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione)sulfonamide compounds 2 to 13. Completion of the reaction was monitored by TLC.

N-(E)-(4-hydroxybenzylideneamino)–6-(quinoxaline-2,3-(1H,4H)-dione) sulfonamide (compound 2)

Reagents: Compound 1 (1.00 g, 39 mmol) 4-hydroxybenzaldehyde (0.47 g, 39 mmol), glacial acetic acid (25 ml). IR Spectra (KBr): 3324 cm^{-1} (OH), 3239 cm^{-1} (N-H), 3100 cm^{-1} (C-H aromatic), 1684 cm^{-1} (C=O), 1599 cm^{-1} (C=N), 1344 ($\nu_{max}SO_2$), 1155 cm^{-1} ($\nu_{max}SO_2$), 1036 cm^{-1} (N-N). ^{1}H NMR (DMSO-d_6): 12.14 (br s, 1H, NH, D_2O exchangeable), 12.17 (br s, 1H, NH, D_2O exchangeable), 11.19 (br s, 1H, NH, D_2O exchangeable), 7.66 (d, 1H, ArH), 7.55-7.57 (dd, 1H, ArH), 7.24-7.25 (d, 1H, ArH), 7.40-7.42 (dd, 2H, ArH), 6.76-6.78 (d, 2H, ArH), 7.79 (s, 1H, N=CH). ^{13}C NMR (DMSO-d_6): 159.35 (C-O), 155 (C=O), 154 (C=N), 147.65 (Aromatic), 132.86 (Aromatic), 130.16 (Aromatic), 129.36 (Aromatic), 128.60 (Aromatic), 125.76 (Aromatic), 124.64 (Aromatic), 122 (Aromatic), 115.74 (Aromatic), 115.56 (Aromatic), 115.35 (Aromatic), 114.35 (Aromatic).

N-(E)-(4-Chlorobenzylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione) sulfonamide (compound 3)

Reagents: Compound 1 (1.00 g, 39 mmol) 4-chlorobenzaldehyde (0.55 g, 39 mmol), glacial acetic acid (25 ml). IR Spectra (KBr): 3239 cm^{-1} (N-H), 3216 cm^{-1} (N-H), 3042 cm^{-1} (CH aromatic), 1692 cm^{-1} (C=O), 1603 cm^{-1} (C=N), 1371 ($\nu_{max}SO_2$), 1163 cm^{-1} (SO_2). ^{1}H NMR (DMSO-d_6): 12.12- 12.18 (br s, 2H, NH, D_2O exchangeable), 11.61 (br s, 1H, NH, D_2O exchangeable), 7.89- 7.91 (s, 1H, ArH), 7.66-7.67 (d, 1H, ArH), 7.24-7.25 (d, 1H, ArH), 7.44-7.47 (m, 2H, ArH), 7.56-7.61 (m, 2H, ArH), 8.72 (s, 1H, N=CH). ^{13}C NMR (DMSO-d_6): 160.58 (C=O), 155.18 (C=O), 154.92 (C=N), 145.79, 134.54 (Aromatic), 132.53 (Aromatic), 132.66 (Aromatic), 130.00 (Aromatic), 129.52 (Aromatic), 129.07 (Aromatic), 128.84 (Aromatic), 128.45 (Aromatic), 125.85 (Aromatic), 121.97 (Aromatic), 115.42 (Aromatic), 114.20 (Aromatic). MS (m/z, %): 378 (M^+, 5), 254 ([M- (C_7H_5Cl)]$^+$ (10), 130 (100), 123 (83).

N-(E)-(2-nitrobenzylideneamino)-6-(quinoxaline-2, 3-(1H, 4H)-dione) sulfonamide (compound 4)

Reagents: Compound 1 (1.00 g, 39 mmol) 2-nitrobenzaldehyde (0.59 g, 39 mmol), glacial acetic acid (25 ml). IR Spectra (KBr): 3247 cm^{-1} (N-H), 3239 cm^{-1} (N-H), 3077 cm^{-1} (CH aromatic), 1680 cm^{-1} (C=O), 1599 cm^{-1} (C=N), 1341 cm^{-1} ($\nu_{max}SO_2$), 1151 cm^{-1} (SO_2). ^{1}H NMR (DMSO-d_6): 12.20 (br s, 1H, NH, D_2O exchangeable), 12.13 (br s, 1H, NH, D_2O exchangeable), 12.00 (br s, 1H, NH, D_2O exchangeable), 8.27 (d, 1H, ArH), 8.15-8.17 (dd, 2H, ArH), 7.58-7.59 (dd, 1H, ArH), 7.26-7.28 (d, 1H, ArH), 7.66-7.68 (m, 1H, ArH), 6.76-6.78(m, 1H, ArH) , 8.97 (s, 1H, N=CH). ^{13}C NMR (DMSO-d_6): 158.65 (C=O), 155.19 (C=O), 154.91 (C=N), 148.85 (Aromatic), 147.85 (Aromatic), 133.91 (Aromatic), 133.75 (Aromatic), 132.14 (Aromatic), 129.63 (Aromatic), 129.41 (Aromatic), 127.94 (Aromatic), 127.79 (Aromatic), 125.93

(Aromatic), 124.76 (Aromatic), 124.65 (Aromatic), 115.55 (Aromatic), 114.20 (Aromatic). MS (m/z, %): 342.43 ($[M - NO_2]^+$, 3), 287.22 (8), 185.04(25), 116 (90), 107.04 (100).

N-(E)-(benzylideneamino)-6-(quinoxaline-2,3-(1H, 4H)dione)sulfonamide (compound 5)

Reagents: Compound 1 (1.00g, 39 mmol) benzaldehyde (0.41 g, 39 mmol), glacial acetic acid (25 ml). IR Spectra (KBr): 3239 cm^{-1} (N-H), 3131 cm^{-1} (N-H), 3066 cm^{-1} (CH aromatic), 1680 cm^{-1} (C=O), 1607 cm^{-1} (C=N), 1322 (S=O), 1140 cm^{-1} (S=O). ^{1}H NMR (DMSO-d_6): 12.16 (br s, 2H, NH, D_2O exchangeable), 12.51 (br s, 2H, NH, D_2O exchangeable), 11.19 (br s, 1H, NH, D_2O exchangeable), 7.68 (s, 1H, ArH), 7.58-7.59 (m, 1H, ArH), 7.26 (d, 1H, ArH), 7.89-7.91 (m, 2H, ArH), 6.40 (m, 3H, ArH), 8.72 (s, 1H, N=CH). ^{13}C NMR (DMSO-d_6): 161.45 (C=O), 155.18 (C=O), 154.93 (C=N), 147.09 (Aromatic), 133.75 (Aromatic), 133.58 (Aromatic), 132.72 (Aromatic) 131.34 (Aromatic), 130.09 (Aromatic), 129.48 (Aromatic), 128.88 (Aromatic), 128.73 (Aromatic), 128.32 (Aromatic), 126.80 (Aromatic), 125.82 (Aromatic), 121.98 (Aromatic), 115.39 (Aromatic), 114.27 (Aromatic).

N-(E)-(4-methoxybenzylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione)sulfonamide (compound 6)

Reagents: Compound 1 (1.00 g, 39 mmol) 4-methoxybenzaldehyde (0.53 g, 39 mmol), glacial acetic acid (25 ml). IR Spectra (KBr): 3668 cm^{-1} (N-H), 3459 cm^{-1} (N-H), 3050 cm^{-1} (CH aromatic), 1684 cm^{-1} (C=O), 1599 cm^{-1} (C=N), 1395 cm^{-1} (C-O), 1322 (SO_2), 1151 cm^{-1} (SO_2). ^{1}H NMR (DMSO-d_6): 12.18 (br s, 1H, NH, D_2O exchangeable), 12.13 (br s, 1H, NH, D_2O exchangeable), 11.30 (br s, 1H, NH, D_2O exchangeable), 7.77 (d, 1H, ArH), 7.67 (d, 1H, ArH), 7.24-7.26 (dd, 1H, ArH), 7.52-7.54 (d, 2H, ArH), 6.94-6.96 (d, 2H, ArH), 8.64 (s, 1H, N=CH), 3.75 (s, 3H, -OCH_3). ^{13}C NMR (DMSO-d_6): 160.77 (C=O), 160.46 (C=O), 155.19, 154.94 (C=N), 147.17 (Aromatic), 132.81 (Aromatic), 129.94 (Aromatic), 129.40 (Aromatic), 128.43 (Aromatic), 126.51 (Aromatic), 126.19 (Aromatic), 125.77 (Aromatic), 122.01 (Aromatic), 115.35 (Aromatic), 114.35 (Aromatic), 114.31 (Aromatic), 114.19 (Aromatic), 55.23 (CH_3), 55.34 (CH_3).

N-(E)-(3-methoxybenzylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione)sulfonamide (compound 7)

Reagents: Compound 1 (1.00 g, 39 mmol) 3-methoxybenzaldehyde (0.53 g, 39 mmol), glacial acetic acid (25 ml). IR Spectra (KBr): 3486 cm^{-1} (N-H), 3212 cm^{-1} (N-H), 3062 cm^{-1} (CH aromatic), 1684 cm^{-1} (C=O), 1586 cm^{-1} (C=N), 1387 cm^{-1} (C-O), 1310 (SO_2), 1155 cm^{-1} (SO_2). ^{1}H NMR (DMSO-d_6): 12.18 (br s, 2H, NH, D_2O exchangeable), 11.52(br s, 1H, NH, D_2O exchangeable), 7.88 (d, 1H, ArH), 7.58 (dd, 1H, ArH), 7.17 (d, 1H, ArH), 7.12 (m, 1H, ArH), 7.27 (dd, 1H, ArH), 7.32 (t, 1H. ArH), 6.96-6.98(m, 1H, ArH) 7.68 (s, 1H, N=CH), 3.78 (s, 3H, -OCH_3). ^{13}C NMR (DMSO-d_6):159.39 (C=O), 155.20 (C=O), 154.95 (C=N), 146.97 (Aromatic), 134.97 (Aromatic), 132.66 (Aromatic), 130.30 (Aromatic), 129.87 (Aromatic), 129.50 (Aromatic), 125.81 (Aromatic), 125.58 (Aromatic), 122.41 (Aromatic), 122.02 (Aromatic), 119.36 (Aromatic), 115.85 (Aromatic), 115.42 (Aromatic), 114.31 (Aromatic), 112.87 (Aromatic), 111.61 (Aromatic), 55.10 (CH_3). MS (m/z, %): 374 (M+1), 15) 371.10 ($[M - H_2]^+$, 100), 262.98 (55), 239(25), 200.94 (90).

N-(E)-(2-hydroxybenzylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione)sulfonamide (compound 8)

Reagents: Compound 1 (1.00 g, 39 mmol) 2-hydroxybenzaldehyde (0.47 g, 39 mmol), glacial acetic acid (25 mL). IR Spectra (KBr): 3482 cm^{-1} (OH), 3208 cm^{-1} (N-H), 3050 cm^{-1} (CH aromatic), 1684 cm^{-1} (C=O), 1615 cm^{-1} (C=C) 1576 cm^{-1} (C=N), 1322 (SO_2), 1150 cm^{-1} (SO_2). ^{1}H NMR (DMSO-d_6): 12.15 (br s, 1H, NH, D_2O exchangeable), 11.51 (br s, 1H, NH, D_2O exchangeable), 10.16 (br s, 1H, NH, D_2O exchangeable) 9.01 (m, 1H, ArH), 7.50-7.56 (m, 1H, ArH), 7.66-7.71 (m, 1H, ArH), 7.41 (m, 1H, ArH), 6.98-6.99 (q, 2H, ArH), 7.22-7.27 (m, 1H. ArH), 8.17 (s, 1H, N=CH). ^{13}C NMR (DMSO-d_6): 162.79 (C-O), 158.60 (C=O), 156.40 (C=O), 155.18 (C=N), 154.92 (Aromatic), 145.81 (Aromatic), 133.21 (Aromatic), 132.49 (Aromatic), 131.45 (Aromatic), 130.82 (Aromatic), 129.56 (Aromatic), 127.23 (Aromatic), 125.89 (Aromatic), 121.93 (Aromatic), 119.57 (Aromatic), 119.38 (Aromatic), 119.11 (Aromatic), 118.13 (Aromatic), 116.49 (Aromatic) 116.12 (Aromatic), 115.48 (Aromatic), 114.19 (Aromatic). MS (m/z, %): 361 (M+1), 268.01 (M-$C_6H_5O^+$, 37), 243.00(45), 262.98 (55), 239(25), 227.01 (100), 123.04(33).

N-(E)-(3-hydroxybenzylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione)sulfonamide (compound 9)

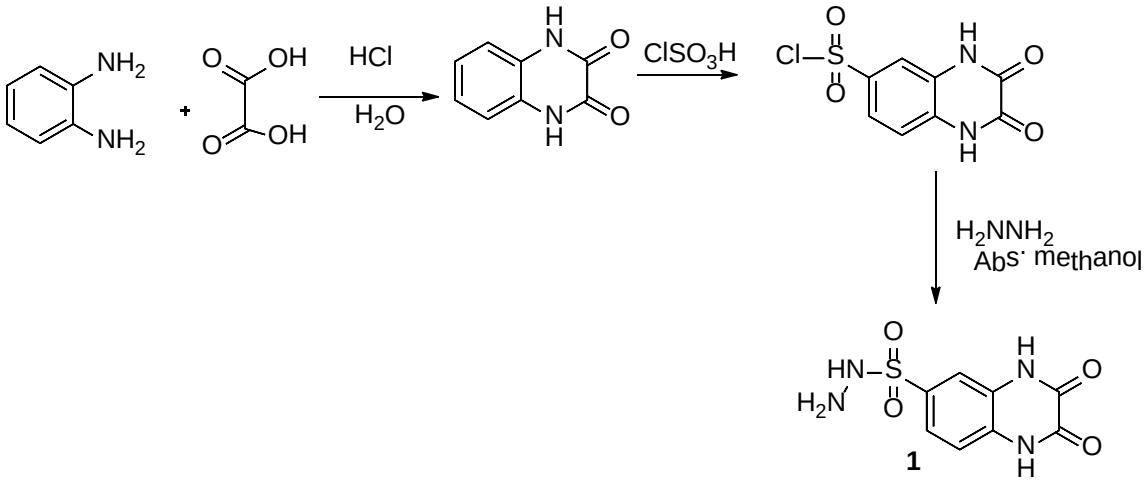
Reagents: Compound 1 (1.00 g, 39 mmol) 3-hydroxybenzaldehyde (0.47 g, 39 mmol), glacial acetic acid (25 ml). IR Spectra (KBr): 3355 cm^{-1} (OH), 3143 cm^{-1} (N-H), 3042 cm^{-1} (CH aromatic), 1676 cm^{-1} (C=O), 1603 cm^{-1} (C=N), 1322 ($v_{max}SO_2$), 1155 cm^{-1} (SO_2). ^{1}H NMR (DMSO-d_6): 12.16 (br s, 2H, NH, D_2O exchangeable), 9.72 (br s, 1H, NH, D_2O exchangeable), 9.59 (s, 1H, ArH) 8.59 (d, 1H, ArH), 7.65 (d, 1H, ArH), 7.81 (s, 2H, ArH), 7.18 (t, 1H. ArH), 7.59 (d, 1H. ArH), 8.36 (s, 1H, N=CH). ^{13}C NMR (DMSO-d_6): 157.41 (C-O), 157.26 (C=O), 155.13 (C=O), 154.89 (C=N), 147.24 (Aromatic), 138.61 (Aromatic), 137.54 (Aromatic), 134.75 (Aromatic), 132.72 (Aromatic), 129.76 (Aromatic), 125.73 (Aromatic), 121.93 (Aromatic), 118.22 (Aromatic), 117.81 (Aromatic), 116.54 (Aromatic), 115.38 (Aromatic), 114.63 (Aromatic), 114.15 (Aromatic), 112.59 (Aromatic), 111.25 (Aromatic). MS (m/z, %): 361 (M+1), 268.01 (M-$C_6H_5O^+$, 23) 243.01 (28), 161.00 (24), 144.99 (100), 123.04 (47).

N-(E)-((1-(4-dimethylamino)phenyl)methylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione)sulfonamide (compound 10)

Reagents: Compound 1 (1.00 g, 39 mmol) dimethylaminobenzaldehyde (0.58 g, 39 mmol), glacial acetic acid (25 ml). IR Spectra (KBr): 3193 cm^{-1} (N-H), 3135 cm^{-1} (N-H), 3035 cm^{-1} (CH aromatic), 1676 cm^{-1} (C=O), 1584 cm^{-1} (C=N), 1318 (SO_2), 1159 cm^{-1} (SO_2). ^{1}H NMR (DMSO-d_6): 12.13 (br s, 1H, NH, D_2O exchangeable), 11.92 (br s, 1H, NH, D_2O exchangeable), 10.04 (br s, 1H, NH, D_2O exchangeable), 7.76 (s, 1H, ArH), 7.74 (d, 2H, ArH), 7.55 (ddd, 1H, ArH), 7.38-7.44 (dd, 2H, ArH), 7.23-7.32 (ddd, 1H, ArH), 8.61 (s, 1H, N=CH), 2.50 (s, 6H, CH_3). ^{13}C NMR (DMSO-d_6): 155.18 (C=O), 154.92 (C=O), 137.27 (Aromatic), 132.79 (Aromatic), 132.05 (Aromatic), 129.72 (Aromatic), 129.40 (Aromatic), 129.02 (Aromatic), 128.40 (Aromatic), 128.34 (Aromatic), 126.44 (Aromatic), 126.01 (Aromatic), 125.66 (Aromatic), 125.58 (Aromatic), 122.40 (Aromatic), 14.67 (CH_3), 14.27 (CH_3)

N-(E)-((1-(5-methoxy-4-hydroxyl-)phenyl)ethylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione)sulfonamide (compound 11)

Reagents: Compound 1 (1.00 g, 39 mmol) vanillin (0.59 g, 39 mmol), glacial acetic acid (25 ml). IR Spectra (KBr): 3363 cm^{-1} (OH), 3239 cm^{-1} (N-H), 3054 cm^{-1} (CH aromatic), 1680 cm^{-1} (C=O), 1588 cm^{-1} (C=N), 1391 cm^{-1} (C-O), 1333 (SO_2), 1156 cm^{-1} (SO_2). ^{1}H NMR (DMSO-d_6) :12.13 (br s, 2H, NH, D_2O exchangeable), 11.20



Scheme 1. Synthesis of 2,3-dioxo-1,2,3,4-tetrahhydroquinoxaline-6-sulfonylhydrazide.

(br s, 1H, NH, D_2O exchangeable), 9.50 (s, 1H, ArH), 7.56-7.57 (dd, 1H, ArH), 7.66 (d, 1H, ArH), 6.98 (dd, 1H, ArH), 7.24-7.26 (d, 1H, ArH), 7.10 (d, 1H, ArH), 7.77 (s, 1H, N=CH), 3.78 (s, 6H, OCH_3). ^{13}C NMR (DMSO-d_6): 154.89 (C=O), 148.79 (C=N), 147.73 (C-O), 132.72 (Aromatic), 129.32 (Aromatic), 125.68 (Aromatic), 124.96 (Aromatic), 121.99 (Aromatic), 121.08 (Aromatic), 115.35 (Aromatic), 115.29 (Aromatic), 114.31 (Aromatic), 109.50 (Aromatic), 55.47 (CH_3). MS (m/z, %): 390 (M^+), 254.01 ((M-$C_8H_8O_2$]$^+$ 3), 160.04 (4), 148.04(100), 132.04 (90).

N-(E)-(2-oxoindole-3-ylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione)sulfonamide (compound 12)

Reagents: Compound 1 (1.00 g, 39 mmol) isatin (0.55 g, 39 mmol), glacial acetic acid (25 ml). IR Spectra (KBr): 3324 cm^{-1} (N-H), 3104 cm^{-1} (N-H), 1680 cm^{-1} (C=O), 1595 cm^{-1} (C=N), 1383 cm^{-1} (C-O), 1322 (SO_2), 1163 cm^{-1} (SO_2). ^1H NMR (DMSO-d_6): 12.21 (br s, 1H, NH, D_2O exchangeable), 12.17 (br s, 1H, NH, D_2O exchangeable), 10.73 (br s, 1H, NH, D_2O exchangeable), 7.72 (d, 1H, ArH), 7.87 (d, 1H, ArH), 7.63-7.65 (dd, 1H, ArH), 6.85-6.86 (d, 1H, ArH), 7.27-7.29 (d, 1H, ArH), 7.37 (t, 1H, ArH), 7.06 (t, 1H, ArH). ^{13}C NMR (DMSO-d_6): 171.93 (C=O), 163.61 (C=O), 155.16 (C=O), 154.86 (C=N), 143.84 (Aromatic), 141.84 (Aromatic), 133.07 (Aromatic), 131.58 (Aromatic), 129.86 (Aromatic), 126.58 (Aromatic), 125.67 (Aromatic), 122.75 (Aromatic), 121.60 (Aromatic), 115.36 (Aromatic), 115.12 (Aromatic), 115.02 (Aromatic) 110.50 (Aromatic). MS (m/z, %): 254.01 (3), 160.04 (4), 148.04 (100), and 132.04 (90).

N-(E)-(-1-phenylethylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione)sulfonamide (compound 13)

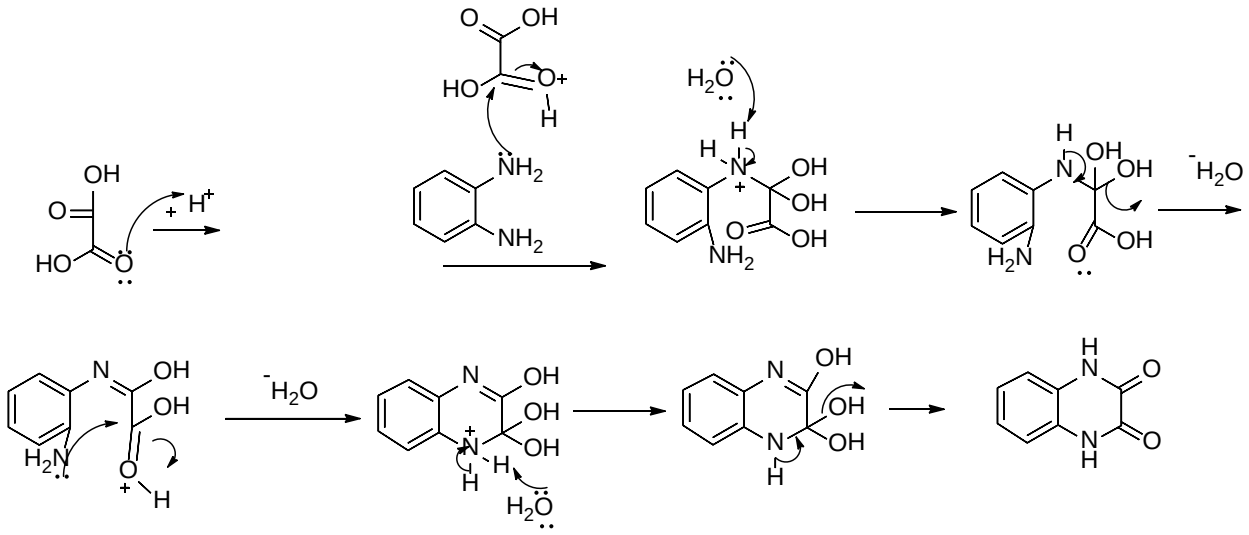
Reagents: Compound 1 (1.00 g, 39 mmol) acetophenone (0.50 g, 39 mmol), glacial acetic acid (40 ml). IR Spectra (KBr): 3347 cm^{-1} (N-H), 3139 cm^{-1} (N-H), 3039 cm^{-1} (CH aromatic), 2927 cm^{-1} (CH aliphatic) 1676 cm^{-1} (C=O), 1595 cm^{-1} (C=N), 1314 (SO_2), 1167 cm^{-1} (SO_2). ^1H NMR (DMSO-d_6): 12.17 (br s, 2H, NH, D_2O exchangeable), 8.36 (br s, 1H, NH, D_2O exchangeable), 8.35 (s, 1H, ArH), 7.91 (m, 1H, ArH), 7.25 (d, 1H, ArH), 7.60 (d, 1H, ArH), 7.46 (m, 3H, ArH), 2.50 (s, 3H, CH_3). ^{13}C NMR (DMSO-d_6): 158.56 (C=O), 155.12 (C=O) 154.88 (C=N), 151.13, 148.17 (Aromatic), 143.28 (Aromatic), 132.89 (Aromatic), 129.23 (Aromatic), 128.09 (Aromatic), 125.65 (Aromatic), 124.58 (Aromatic), 121.96 (Aromatic), 120.51 (Aromatic), 115.23 (Aromatic), 114.31 (Aromatic), 111.93 (Aromatic) 111.84 (Aromatic), 20.95 (CH_3). MS (m/z, %): 243.03 (18), 163.06 (20), 129.13 (33), 111.1 (100).

RESULTS

The 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonohydrazide 1 was synthesized starting from the reaction of 1,2,3,4-tetrahydroquinoxaline-2,3-dione with excess chlorosulfonic acid to obtain the corresponding 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl chloride, which was then reacted with hydrazine hydrate in methanol to give the expected 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonohydrazide, 1. The sequence of reactions is shown in Scheme 1.

The reactions of 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazide 1 with some aromatic aldehydes under refluxing condition in glacial acetic acid afforded the hydrazones 2-13 as shown in Scheme 2. Furthermore, N-(E)-(2-oxoindole-3-ylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione) sulfonamide 12 was prepared by the reaction of 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazide, 1 with isatin as shown in Scheme 2. The reaction of 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazide 1 with acetophenone under refluxing condition in glacial acetic acid afforded the hydrazone 13. The sequence of this reaction is shown in Scheme 2. All the synthesized compounds were observed to exhibit sharp melting points. The melting points ranged between 233 and 330°C. The colour of most of the hydrazones 2 to 13 was yellow except compounds 10 and 12 which are purple and red, respectively (Table 1).

Generally, the infrared spectra of the compounds showed absorption bands due to the stretching vibrations of N-H and OH between 3135 and 3390 cm^{-1}, C=O



Scheme 2. Mechanism of the reaction for the synthesis of quinoxaline-2, 3-dione.

Table 1. Physical properties of the 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazones 1 to 13.

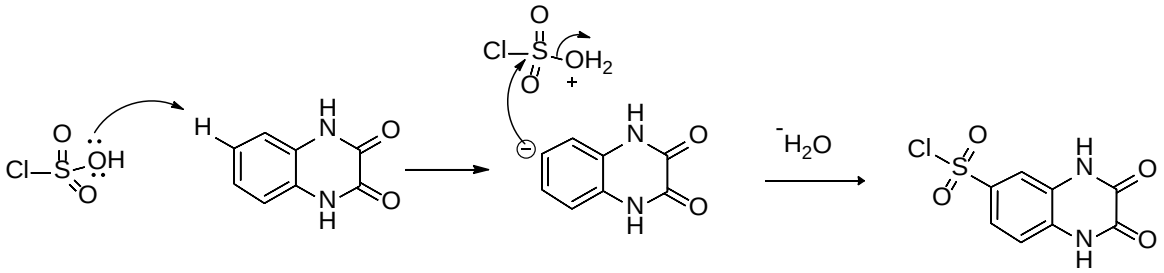
S/N	Molecular formula/Mass	Reaction time (h)	Yield (%)	Colour	Melting point (°C)
1	$C_8H_8N_4O_4S$ (256.24)	6	90	White	> 330
2	$C_{15}H_{12}N_4O_5S$ (360.34)	3	65	Yellow	249-250
3	$C_{15}H_{11}ClN_4O_4S$ (378.79)	3	73	Yellow	241-243
4	$C_{15}H_{11}N_5O_6S$ (389.34)	3	80	Yellow	250 (Decomposed)
5	$C_{15}H_{12}N_4O_4S$ (344.35)	3	57	Yellow	274-276
6	$C_{16}H_{14}N_4O_5S$ (374.37)	3	58	Yellow	240-242
7	$C_{16}H_{14}N_4O_5S$ (374.37)	3	72	Yellow	262-263
8	$C_{15}H_{12}N_4O_5S$ (360.34)	3	43	Yellow	238-240
9	$C_{15}H_{12}N_4O_5S$ (360.34)	3	56	Yellow	>310
10	$C_{17}H_{17}N_5O_4S$ (387.41)	3	70	Purple	270-272
11	$C_{16}H_{14}N_4O_6S$ (390.37)	3	80	Yellow	233 (Decomposed)
12	$C_{16}H_{11}N_5O_5S$ (385.35)	3	88	Red	273-274
13	$C_{16}H_{14}N_4O_4S$ (358.37)	3	63	Yellow	290-292

between 1676 and 1692 cm^{-1}, C=C and C=N between 1607 and 1580 cm^{-1}, SO_2 at 1310 to 1391 cm^{-1} and 1140 to 1167 cm^{-1} for asymmetric and symmetric vibrations. Generally, the ^{1}H-NMR spectral data of compounds 2 to 13 in DMSO-d6 showed signal for NH between 8.37 and 12.51 ppm, the signals for CH=N between 7.68 and 9.59 ppm, the signals for aromatic protons were observed between 6.40 and 9.50 ppm, the signals for methyl protons (CH_3) were seen at 2.50 ppm and the signals for methoxy protons (OCH_3) were observed between 3.75 and 3.78 ppm. In general, the compounds 2 to 13 showed signal for C-O between 159.3 and 162.79 ppm, the signals for C=O between 154.86 and 171.93 ppm, the signals for C=N were observed between 148.79 and 155.98 ppm, the signals for aromatic carbons were seen between 109.50 and 154.92 ppm, while the signals for methoxy carbom (OCH_3) were observed between 55.10 and 55.47 ppm and methyl carbon appeared between 14.27 and 20.97 ppm.

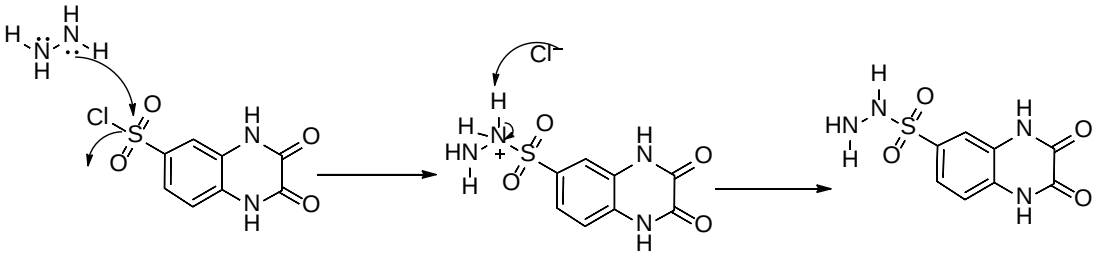
DISCUSSION

1,2,3,4-Tetrahydroquinoxaline-2,3-dione was prepared by the modified procedure of Obafemi and Pfleiderer (1994) by reacting o-phenylenediarnine with oxalic acid dehydrate thermally or by microwave irradiation in acidified water (Scheme 1).

The mechanism of the reaction between oxalic acid and the 1, 2-diaminobenzene is acid catalyzed condensation reaction involving the protonation of the carbonyl oxygen atom of the oxalic acid by the acid used



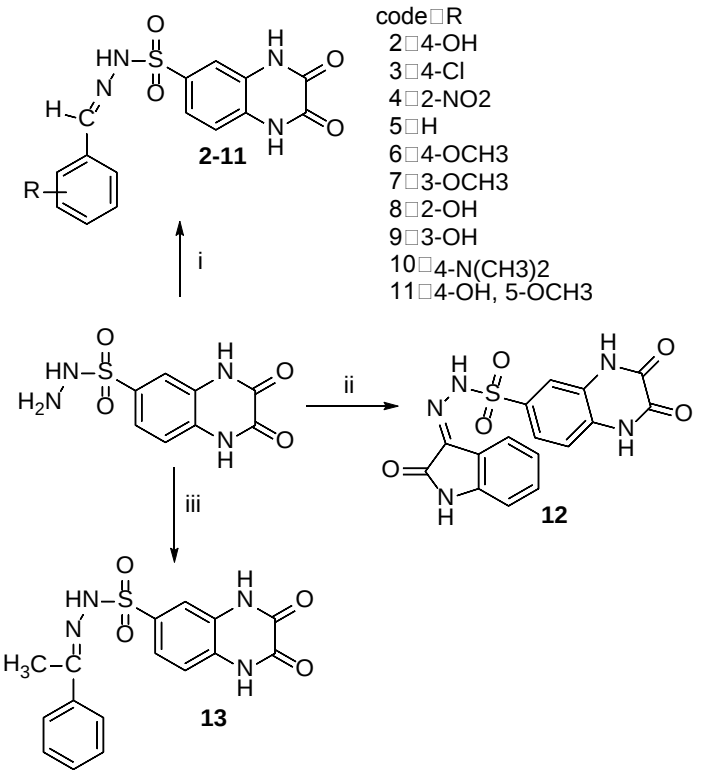
Scheme 3. Mechanism of reaction of quinoxaline-2,3-dione with chlorosulfonic acid.



Scheme 4. Mechanism of reaction of hydrazine hydrate with 2,3-dioxo-1,2,3,4-tetrahydro-quinoxaline-6-sulfonyl chloride.

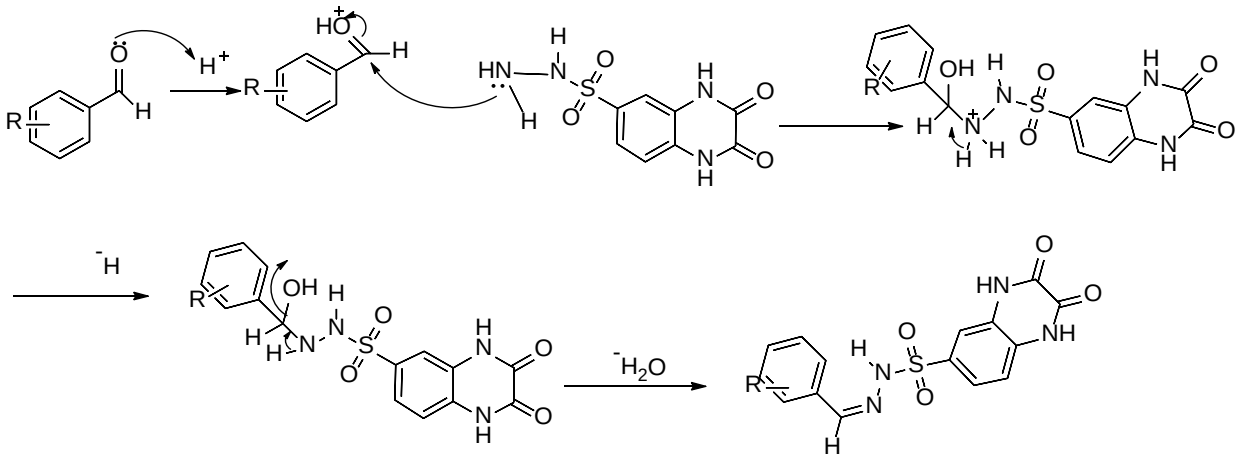
as the catalyst. This makes the carbonyl carbon more electrophilic and this can easily be attacked by the nucleophile. In this case the nucleophile is the amino group of the 1, 2-diaminobenzene. The acid is regenerated during the cyclization stage which is effected by the heat supplied into the system (Scheme 2). 1,2,3,4-tetrahydroquinoxaline-2,3-dione was allowed to react with excess of chlorosulfonic acid under reflux to obtain 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl chloride (Scheme 1). The proposed mechanism for the synthesis of 2,3-dioxo-1,2, 3, 4-tetrahydroquinoxaline-6-sulfonyl chloride is given in Scheme 3. The reaction of 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl chloride with hydrazine hydrate in absolute methanol afford afforded 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonylhydrazide, 1 (Scheme 1). The mechanism of the synthesis of 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazide is outlined in Scheme 4. The treatment of equimolar amount of 1 with some aromatic aldehydes under refluxing condition in glacial acetic acid afforded the hydrazones 2 to 11 (Scheme 5). The proposed general mechanism for the reactions of 2,3-dioxo-1,2,3,4-tetrahydro quinoxaline-6- sulfonyl hydrazide, 1′ with different benzaldehydes are given in Scheme 5. The mechanism of the reaction involves the protonation of the carbonyl carbon of the substituted benzaldehydes. This makes the carbon to be electron deficient and enables the centre to be more susceptible to Nucleophilic attack by the amino end of the hydrazide. The heat supplied serves as the driving force for the loose of water molecules to afford the hydrazones Scheme 6. Treatment of equimolar amount of compound 1 and isatin in glacial acetic acid led to the formation of N-(E)-(2-oxoindole-3-ylideneamino)-6-(quinoxaline-2,3-(1H,4H)-dione) sulfonamide 12. The proposed mechanism for the reaction of 2, 3-dioxo-1, 2, 3, 4- tetrahydroquinoxaline-6-sulfonyl hydrazide, 1 with isatin is highlighted in Scheme 5. The mechanism of the reaction involves the protonation of the ketonic carbonyl carbon of the isatin. This makes the carbon to be electron deficient and enables the centre to be more susceptible to nucleophilic attack by the amino end of the hydrazide. The heat supplied serves as the driving force for the loose of water molecules to afford the expected hydrazone Scheme 7. The synthesis of N-(E)-(phenylideneamino)-6-(quinoxaline-2-(1H,4H)-dione)sulfonamide 13 was achieved by the condensation of compound 1 and equimolar amount of acetophenone in glacial acetic acid. The mechanism of the reaction involves the protonation of the carbonyl carbon of the acetophenone. This makes the carbon to be electron deficient and enables the centre to be more susceptible to nucleophilic attack by the amino end of the hydrazide. The heat supplied serves as the driving force for the loose of water molecules to afford the hydrazone Scheme 8.

From the spectroscopic studies, the infrared spectra of compounds 2 to 13 showed two absorption bands at 3324 and 3221 cm^{-1} assigned to *v* (O-H) phenolic and *v* (N-H), respectively. There is a strong band of azomethine group (C=N) which occurred at 1599 cm^{-1}. This group



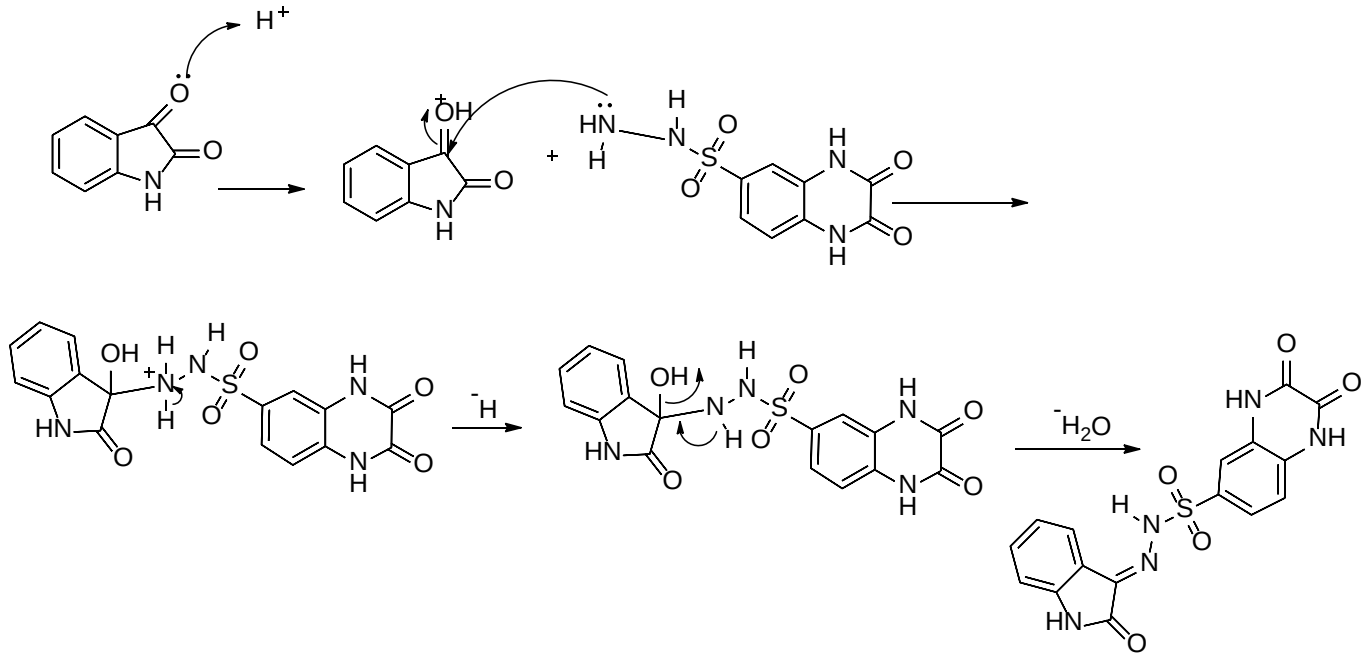
i. substituted benzaldehydes (**2-11**) ii). isatin(**12**) (iii).acetophenone (**13)**. Reaction condition: glatial acetic acid, reflux at 120 ^{0}C.

Scheme 5. Mechanism of reaction of 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazide with different substituted aromatic aldehydes and ketones.

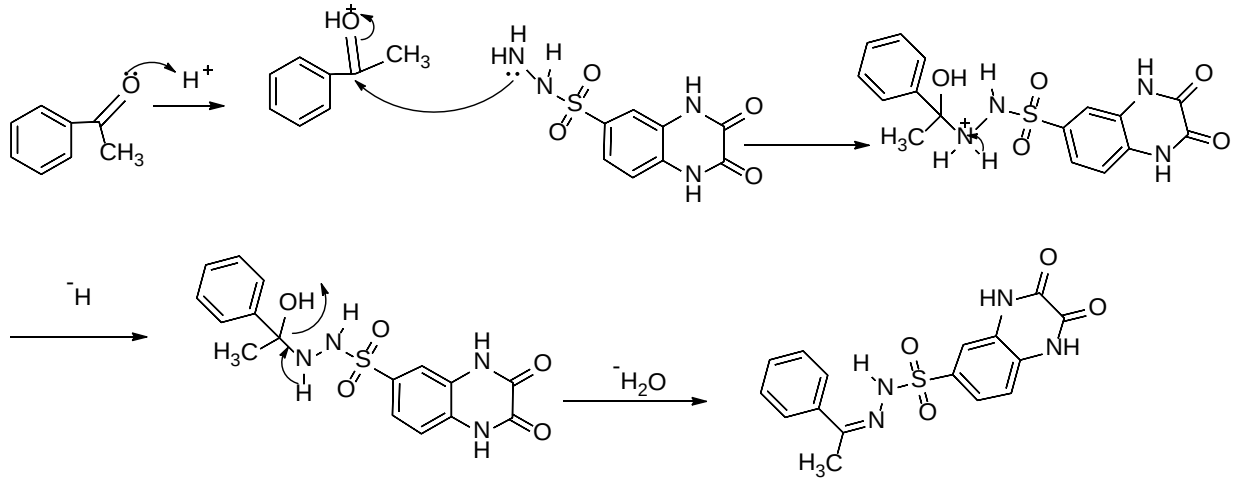


Scheme 6. General mechanism for the reactions of 2, 3-dioxo-1, 2, 3, 4- tetrahydroquinoxaline-6-sulfonyl hydrazide, 1 with different substituted benzaldehydes

occurred from the condensation reaction between (NH_2) of the hydrazide and carbonyl (C=O) group of the 4-hdroxylbenzaldehyde. There are two bands at 1344 and 1155 cm^{-1} which were assigned to (S=O) asymmetric and symmetric stretching vibrations. The bands for Azomethine group (C-H) occurred at 3100 cm^{-1}, while the



Scheme 7. General mechanism for the reactions of 2, 3-dioxo-1, 2, 3, 4- tetrahydroquinoxaline-6-sulfonyl hydrazide, 1 with Isatin.



Scheme 8. General mechanism for the reactions of 2,3-dioxo-1, 2, 3, 4- tetrahydroquinoxaline-6-sulfonyl hydrazide, 1 with acetophenone.

bands for N-N of the hydrazide occurred at 1036.12 cm-1. The amide carbonyl *v* (NHC=O) bands occurred at 1684 cm^{-1} (Table 2).

The evidences from ^{1}H-NMR and ^{13}C-NMR spectra of compound 3 showed that the hydrazine NH proton was observed at a downfield region in the NMR spectrum. This characteristic broad singlet was observed at 11.61 δ ppm. This downfield position of the NH peak suggests that the proton is involved in strong intra-molecular hydrogen bonds. The quinoxaline (-NH-C=O) protons were observed in the NMR spectrum at a further downfield region as broad singlet between 12.18 and 12.12 δ ppm (integrating for 2 protons). This two singlet signals look like a doublet but a closer look at the expanded spectral shows they are two singlet that are very close to one another that makes them look like a doublet. The down field shift of this signal is characteristic for the formation of an intra-molecular hydrogen bond of the NH proton. On observing the expanded spectra a strong singlet at 8.72 δppm was observed which was

Table 2. The Infrared Spectral Data of the 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazones 1-13.

Compounds	Infrared spectral Data (cm^{-1})
1	3347(N-H), 3139(N-H), 3050(N-H), 3039(N-H), 1669(C=O), 1595(C=N), 1391 (S=O, assym. Str.), 1159(S=O, sym. Str.).
2	3324(OH), 3239(N-H), 3100(C-H aromatic), 1684 (C=O), 1599(C=N), 1344 (S=O), assym. Str, 1155 (S=O sym. Str.), 1036 (N-N).
3	3239 (N-H), 3216(N-H), 3042(CH aromatic), 1692(C=O), 1603(C=N), 1371 (S=O, assym. Str), 1163 (S=O sym. Str.).
4	3247(N-H), 3239(N-H), 3077(CH aromatic), 1680(C=O), 1599(C=N), 1341 (S=O, assym. Str), 1151 (S=O sym. Str.).
5	3239(N-H), 3131(N-H), 3066(CH aromatic), 1680(C=O), 1607(C=N), 1322 (S=O, assym. Str), 1140(S=O sym. Str.).
6	3668(N-H), 3459(N-H), 3050(CH aromatic), 1684(C=O), 1599(C=N), 1395(C-O), 1322 (S=O, assym. Str), 1151(S=O sym. Str.).
7	3486(N-H), 3212(N-H), 3062(CH aromatic), 1684(C=O), 1586(C=N), 1387(C-O), 1310 (S=O, assym. Str), 1155(S=O sym. Str.).
8	3482(OH), 3208(N-H), 3050(CH aromatic), 1684(C=O), 1615(C=C), 1576 (C=N), 1322 (S=O, assym. Str), 1150(S=O sym. Str.).
9	3355(OH), 3143(N-H), 3042(CH aromatic), 1676(C=O), 1603(C=N), 1318 (S=O, assym. Str), 1155(S=O sym. Str.).
10	3193(N-H), 3135(N-H), 3035(CH aromatic), 1676(C=O), 1584(C=N), 1318 (S=O, assym. Str), 1155(S=O sym. Str.).
11	3363(OH), 3239(N-H), 3054(CH aromatic), 1680(C=O), 1588(C=N), 1391(C-O), 1333 (S=O, assym. Str), 1151(S=O sym. Str.).
12	3324(N-H), 3104(N-H), 1680(C=O), 1595(C=N), 1383(C-O), 1322(S=O, assym. Str), 1163(S=O sym. Str.).
13	3347(N-H), 3139(N-H), 3039(CH aromatic), 2927(CH aliphatic) 1676(C=O), 1595(C=N), 1314 (S=O, assym. Str), 1167(S=O sym. Str.).

assigned to the hydrazono proton (N=C-H). This hydrazono proton (N=C-H) is a single proton not surrounded by any other proton in its vicinity hence a singlet was observed for it, moreover as its carbon is directly attached to electronegative nitrogen moiety or more particularly the C-N-N system and aromatic ring hence it is extremely deshielded and thus found in the downfield region. On further studying the expanded NMR spectrum in the aromatic region, it was observed that there was a mutiplet signal accounting for 1 proton between 7.45 and 7.47 δppm (J=1.7 Hz). This multiplet was assigned to proton at C-5. A doublet of doublet signal accounting for 1 proton between 7.89 and 7.91 δppm (J=8.5 Hz, J=2.4 Hz) was observed, this signal was assigned to proton at C-7. The doublet signal accounting for 1 proton between 7.24 δ ppm and 7.25 δppm (J=8.5 Hz) was assigned to proton at C-8. This splitting was observed because of one adjacent proton at C-7. A multiplet between 7.66 and 7.65 δppm (J=1.9 Hz) which accounts for 2 protons was observed in the NMR spectrum, this multiplet was assigned to proton at C-2′ and C-6′. On further investigation of the NMR specrum, a doublet of doublet was observed, accounting for 2 protons. The characteristic doublet of doublet between 7.56 and 7.6 1 ppm (J=1.86 Hz, J=9 Hz) can be assigned to proton at C-2′ and C-5′.

The ^{13}C NMR spectrum of compound 3 shows signals at 160.58 and 155.18 δppm which are due to amide carbon (C=O) of the quinoxaline ring. The azomethine carbon (C=N) has appeared at 154.78 δppm. The spectrum shows the aromatic carbons in the region between 114.19 and 134.54 δppm. The NMR spectral data are listed in Tables 3 and 4.

The mass spectrum of the compound 3 showed molecular ion peak at m/z 378 (M^+). Other peaks at m/z 254, 123.04, 130.16 which was the base peak, support the structure of compound 3 (Scheme 9). The mass spectrum of the compound 4 showed peak at m/z 342.43 ($[M - NO_2]^+$. Other peaks at m/z 324.43, 287.22, 185.04, 116.98, and 107.04 which was the base peak, support the structure of compound 4 (Scheme 10).

^1H-NMR and ^{13}C-NMR spectra of compound 12 showed that the hydrazine NH proton was observed at a down field region in the NMR spectrum. This characteristic broad singlet was seen at 10.73 δppm. This downfield position of the NH peak suggests that the proton is involved in strong intra-molecular hydrogen bonds. The quinoxaline (-NH-C=O) protons are observed in the NMR spectrum at a further downfield region as a broad singlet between 12.21 and 12. 17 δppm (integrating for 2 protons). This two singlet signals look like a doublet but a closer look at the expanded spectral shows they are two singlet that are very close to one another that makes them look like a doublet. The downfield shift of this signal is characteristic for the formation of an intra-molecular hydrogen bond of the NH proton. On studying the expanded NMR spectrum in the aromatic region it was observed that there is a

Table 3. ^{1}H NMR Spectral Data of the 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazones 1-13.

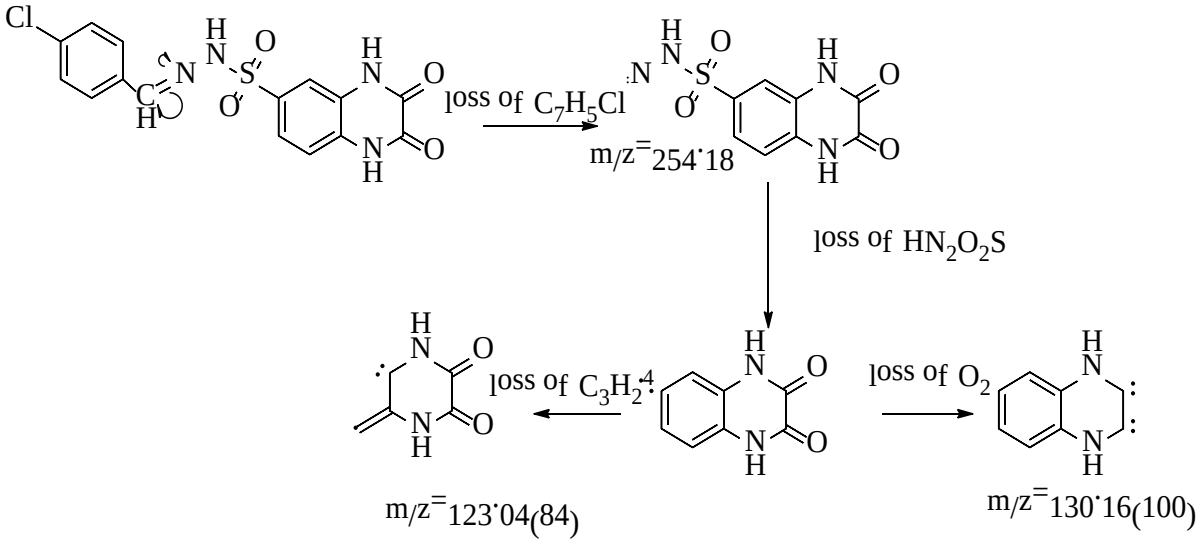
Compounds Code	^{1}H NMR spectral data (DMSO-d_6)
1	3.37(br s, 1H, NH, D_2O exchangeable), 4.12 (br s, 1H, NH, D_2O exchangeable), 12.10(br s, 1H, NH, D_2O exchangeable), 8.37 (br s, 1H, NH, D_2O exchangeable), 7.60 (d, 1H, ArH), 7.49-7.50 (dd, 1H, ArH), 7.27-7.28 (d, 1H, ArH)
2	12.14(br s, 1H, NH, D_2O exchangeable), 12.17 (br s, 1H, NH, D_2O exchangeable), 11.19 (br s, 1H, NH, D_2O exchangeable), 7.66 (d, 1H, ArH), 7.55-7.57 (dd, 1H, ArH), 7.24-7.25 (d, 1H, ArH), 7.40-7.42 (dd, 2H, ArH), 6.76-6.78 (d, 2H, ArH), 7.79 (s, 1H, N=CH).
3	12.12- 12.18(br s, 2H, NH, D_2O exchangeable), 11.61 (br s, 1H, NH, D_2O exchangeable), 7.89- 7.91 (s, 1H, ArH), 7.66-7.67 (d, 1H, ArH), 7.24-7.25 (d, 1H, ArH), 7.44-7.47 (m, 2H, ArH), 7.56-7.61 (m, 2H, ArH), 8.72 (s, 1H, N=CH).
4	12.20(br s, 1H, NH, D_2O exchangeable), 12.13 (br s, 1H, NH, D_2O exchangeable), 12.00(br s, 1H, NH, D_2O exchangeable), 8.27 (d, 1H, ArH), 8.15-8.17(dd, 2H, ArH), 7.58-7.59 (dd, 1H, ArH), 7.26-7.28 (d, 1H, ArH), 7.66-7.68 (m, 1H, ArH), 6.76-6.78(m, 1H, ArH) , 8.97 (s, 1H, N=CH).
5	12.16(br s, 2H, NH, D_2O exchangeable), 12.51 (br s, 2H, NH, D_2O exchangeable), 11.19(br s, 1H, NH, D_2O exchangeable), 8.72 (s, 1H, ArH), 7.58-7.59 (m, 1H, ArH), 7.26 (d, 1H, ArH), 7.89-7.91 (m, 2H, ArH), 6.40 (m, 3H, ArH), 7.68 (s, 1H, N=CH).
6	12.18(br s, 1H, NH, D_2O exchangeable), 12.13 (br s, 1H, NH, D_2O exchangeable), 11.30(br s, 1H, NH, D_2O exchangeable), 7.77 (d, 1H, ArH), 7.67 (d, 1H, ArH), 7.24-7.26 (dd, 1H, ArH), 7.52-7.54 (d, 2H, ArH), 6.94-6.96 (d, 2H, ArH), 8.64 (s, 1H, N=CH), 3.75 (s, 3H, -OCH_3).
7	12.18(br s, 2H, NH, D_2O exchangeable), 11.52(br s, 1H, NH, D_2O exchangeable), 7.88 (d, 1H, ArH), 7.58 (dd, 1H, ArH), 7.17 (d, 1H, ArH), 7.12 (m, 1H, ArH), 7.27 (dd, 1H, ArH), 7.32 (t, 1H. ArH), 6.96-6.98(m, 1H, ArH) 7.68 (s, 1H, N=CH), 3.78 (s, 3H, -OCH_3).
8	12.15(br s, 1H, NH, D_2O exchangeable), 11.51(br s, 1H, NH, D_2O exchangeable), 10.16(br s, 1H, NH, D_2O exchangeable) 9.01 (m, 1H, ArH), 7.50-7.56 (m, 1H, ArH), 7.66-7.71 (m, 1H, ArH), 7.41 (m, 1H, ArH), 6.98-6.99 (q, 2H, ArH), 7.22-7.27 (m, 1H. ArH), 8.17 (s, 1H, N=CH).
9	12.16(br s, 3H, NH, D_2O exchangeable), 9.72 (s, 1H, ArH), 8.59 (d, 1H, ArH), 7.65 (d, 1H, ArH), 8.36 (s, 1H, ArH), 7.81 (s, 2H, ArH), 7.18 (t, 1H. ArH), 7.59 (d, 1H. ArH), 9.59 (s, 1H, N=CH).
10	12.13(br s, 1H, NH, D_2O exchangeable), 11.92(br s, 1H, NH, D_2O exchangeable), 10.04(br s, 1H, NH, D_2O exchangeable), 7.76 (s, 1H, ArH), 7.74 (d, 2H, ArH), 7.55 (ddd, 1H, ArH), 7.38-7.44 (dd, 2H, ArH), 7.23-7.32 (ddd, 1H, ArH), 8.61 (s, 1H, N=CH), 2.50 (s, 6H, CH_3).
11	12.13(br s, 2H, NH, D_2O exchangeable), 11.20(br s, 1H, NH, D_2O exchangeable), 9.50 (s, 1H, ArH), 7.56-7.57 (dd, 1H, ArH), 7.66 (d, 1H, ArH), 6.98 (dd, 1H, ArH), 7.24-7.26 (d, 1H, ArH), 7.10 (d, 1H, ArH), 7.77 (s, 1H, N=CH), 3.78 (s, 6H, OCH_3).
12	12.21(br s, 1H, NH, D_2O exchangeable), 12.17(br s, 1H, NH, D_2O exchangeable), 10.73(br s, 1H, NH, D_2O exchangeable), 7.72 (d, 1H, ArH), 7.87 (d, 1H, ArH), 7.63-7.65 (dd, 1H, ArH), 6.85-6.86 (d, 1H, ArH), 7.27-7.29 (d, 1H, ArH), 7.37 (t, 1H, ArH), 7.06 (t, 1H, ArH).
13	12.17(br s, 2H, NH, D_2O exchangeable), 8.36(br s, 1H, NH, D_2O exchangeable), 8.35 (s, 1H, ArH), 7.91 (m, 1H, ArH), 7.25 (d, 1H, ArH), 7.60 (d, 1H, ArH), 7.46 (m, 3H, ArH), 2.50 (s, 3H, CH_3).

Table 4. ^{13}C NMR Spectral Data of the 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonyl hydrazones 1-1..3

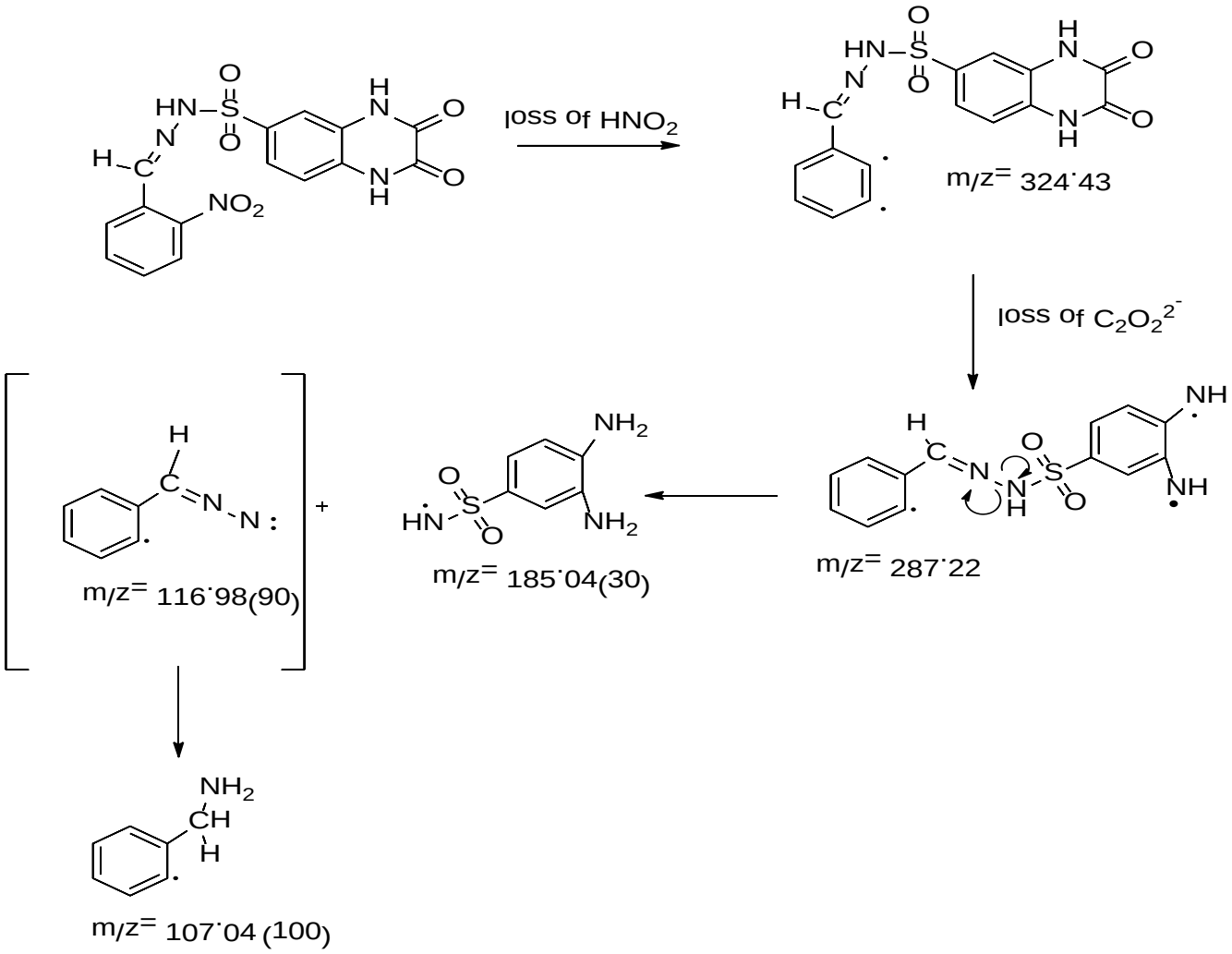
Compounds	^{13}C NMR spectral data(DMSO-d_6)
1	154.86(C=O), 131.98(Aromatic), 128.95(Aromatic), 125.50(Aromatic), 122.33(Aromatic), 115.27(Aromatic), 114.96(Aromatic)
2	159.35(C-O), 155(C=O), 154(C=N), 147.65(Aromatic), 132.86(Aromatic), 130.16(Aromatic), 129.36(Aromatic), 128.60(Aromatic), 125.76(Aromatic), 124.64(Aromatic), 122(Aromatic), 115.74(Aromatic), 115.56(Aromatic), 115.35(Aromatic), 114.35(Aromatic).
3	160.58(C=O), 155.18(C=O), 154.92(C=N), 145.79, 134.54(Aromatic), 132.53-132.66(Aromatic), 130.00(Aromatic), 129.52(Aromatic), 129.07(Aromatic), 128.84(Aromatic), 128.45(Aromatic), 125.85(Aromatic), 121.97(Aromatic), 115.42(Aromatic), 114.20(Aromatic).
4	158.65(C=O), 155.19(C=O), 154.91(C=N), 148.85(Aromatic), 147.85(Aromatic), 133.91(Aromatic), 133.75(Aromatic), 132.14(Aromatic), 129.63(Aromatic), 129.41(Aromatic), 127.94(Aromatic), 127.79(Aromatic), 125.93(Aromatic), 124.76(Aromatic), 124.65(Aromatic), 115.55(Aromatic), 114.20(Aromatic).

Table 4. Contd.

5	161.45(C=O), 155.18(C=O), 154.93(C=N), 147.09(Aromatic), 133.75(Aromatic), 133.58(Aromatic), 132.72(Aromatic) 131.34(Aromatic), 130.09(Aromatic), 129.48(Aromatic), 128.88(Aromatic), 128.73(Aromatic), 128.32(Aromatic), 126.80(Aromatic), 125.82(Aromatic), 121.98(Aromatic), 115.39(Aromatic), 114.27(Aromatic).
6	160.77(C-O), 160.46(C=O), 155.19(C=O), 154.94(C=N), 147.17(Aromatic), 132.81(Aromatic), 129.94(Aromatic), 129.40(Aromatic), 128.43(Aromatic), 126.51(Aromatic), 126.19(Aromatic), 125.77(Aromatic), 122.01(Aromatic), 115.35(Aromatic), 114.35(Aromatic), 114.31(Aromatic), 114.19(Aromatic), 55.23(CH_3), 55.34(CH_3).
7	159.39(C=O), 155.20(C=O), 154.95(C=N), 146.97(Aromatic), 134.97(Aromatic), 132.66(Aromatic), 130.30(Aromatic), 129.87(Aromatic), 129.50(Aromatic), 125.81(Aromatic), 125.58(Aromatic), 122.41(Aromatic), 122.02(Aromatic), 119.36(Aromatic), 115.85(Aromatic), 115.42(Aromatic), 114.31(Aromatic), 112.87(Aromatic), 111.61(Aromatic), 55.10(CH_3).
8	162.79(C-O), 158.60(C=O), 156.40(C=O), 155.18(C=N), 154.92(Aromatic), 145.81(Aromatic), 133.21(Aromatic), 132.49(Aromatic), 131.45(Aromatic), 130.82(Aromatic), 129.56(Aromatic), 127.23(Aromatic), 125.89(Aromatic), 121.93(Aromatic), 119.57(Aromatic), 119.38(Aromatic), 119.11(Aromatic), 118.13(Aromatic), 116.49(Aromatic) 116.12(Aromatic), 115.48(Aromatic), 114.19(Aromatic).
9	157.41(C=O), 155.13(C=O), 154.89(C=N), 147.24, 138.61(Aromatic)), 137.54(Aromatic), 134.75(Aromatic), 132.72(Aromatic), 129.76(Aromatic), 125.73(Aromatic), 121.93(Aromatic), 118.22(Aromatic), 117.81(Aromatic), 116.54(Aromatic), 115.38(Aromatic), 114.63(Aromatic), 114.15(Aromatic), 112.59(Aromatic), 111.25(Aromatic).
10	155.18(C=O), 154.92(C=O), 137.27(Aromatic), 132.79(Aromatic), 132.05(Aromatic), 129.72(Aromatic), 129.40(Aromatic), 129.02(Aromatic), 128.40(Aromatic), 128.34(Aromatic), 126.44(Aromatic), 126.01(Aromatic), 125.66(Aromatic), 125.58(Aromatic), 122.40(Aromatic), 14.67(CH_3), 14.27(CH_3).
11	154.89(C=O), 148.79(C=N), 147.73(C-O), 132.72(Aromatic), 129.32(Aromatic), 125.68(Aromatic), 124.96(Aromatic), 121.99(Aromatic), 121.08(Aromatic), 115.35(Aromatic), 115.29(Aromatic), 114.31(Aromatic), 109.50(Aromatic), 55.47(CH_3).
12	171.93(C=O), 163.61(C=O), 155.16(C=O), 154.86(C=N), 143.84(Aromatic), 141.84(Aromatic), 133.07(Aromatic), 131.58(Aromatic), 129.86(Aromatic), 126.58(Aromatic), 125.67(Aromatic), 122.75(Aromatic), 121.60(Aromatic), 115.36(Aromatic), 115.12(Aromatic), 115.02(Aromatic) 110.50(Aromatic).
13	158.56(C=O), 155.12(C=O) 154.88(C=N), 151.13, 148.17(Aromatic), 143.28(Aromatic), 132.89(Aromatic), 129.23(Aromatic), 128.09(Aromatic), 125.65(Aromatic), 124.58(Aromatic), 121.96(Aromatic), 120.51(Aromatic), 115.23(Aromatic), 114.31(Aromatic), 111.93(Aromatic) 111.84(Aromatic), 20.95(CH_3).



Scheme 9. Proposed Fragmentation of Compound 3.



Scheme 10. Proposed fragmentation of compound 4.

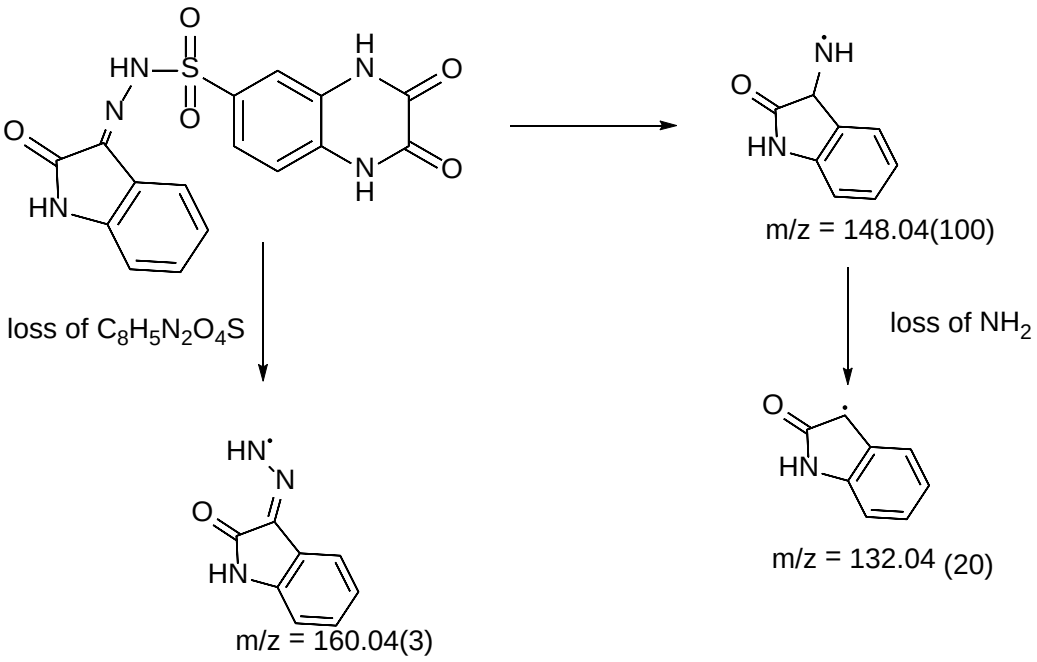
doublet signal accounting for 1 proton at 8.87 δppm. This doublet was assigned to proton at C-5. A doublet of doublet between 7.63-7.65 δppm (J = 8.64 Hz) (integrating for 1 proton) was assigned to proton at C-7. A doublet signal accounting for 1 proton at 7.22 δppm was assigned to proton sat C-8. On studying the aromatic region a doublet of doublet between 6.85 and 6.86 δppm (J = 8 Hz) which accounts for 1 proton was observed. This signal is assigned to proton at C-4′. The triplet signal accounting for 1 proton at 7.37 δppm was assigned to proton at C-5′. A triplet at 7.06 δppm which accounts for 1 proton was assigned to proton at C-6′. The doublet signal accounting for 1 proton between 7. 27 and 7.29 δppm (J = 8 Hz) was assigned to proton at C-7′. The ^{13}C NMR spectrum of compound 12 shows signals between 155.16 and 163.61 δppm which are due to amide carbon (C=O) on the quinoxaline ring. The azomethine carbon (C=N) has appeared at 154.86 δppm. The spectrum shows the aromatic carbons in the region of 110.50 and 143.84 δppm.

The mass spectrum of the compound 12 showed peak at m/z 254.01. Other peaks at m/z 160.04, 148.04 (which was the base peak) and 132.04 support the structure of compound 12 (Scheme 11). The mass spectrum of the compound 13 showed peak at m/z 243.03. Other peaks at m/z 243.03, 163.06, 129.13 and 111.12 (which was the base peak) support the structure of compound 13 (Scheme 12).

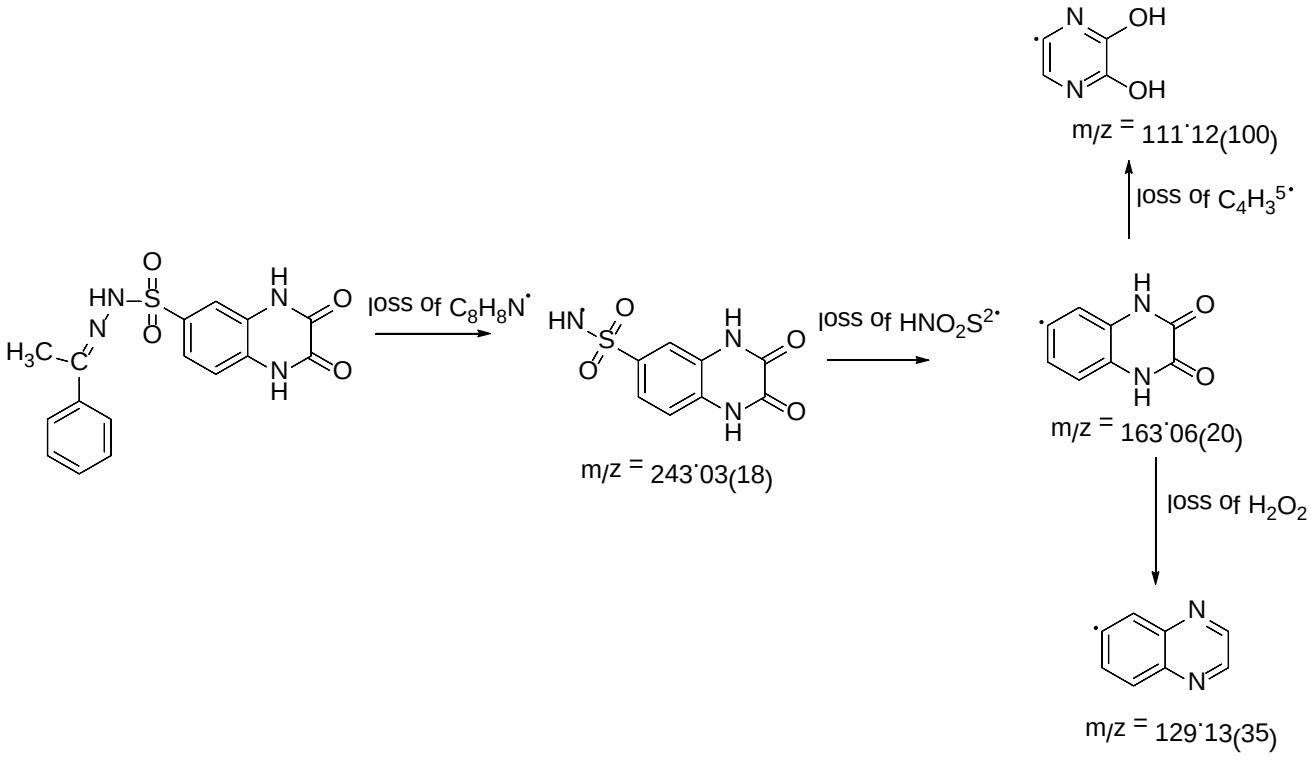
Conclusion

This work is in the areas of research related to heterocyclic chemistry.. It aims at the synthesis and characterization of new heterocyclic systems, using 2,3-dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonohydrazide as starting material.

It can be concluded that the synthesis of some new



Scheme 11. Proposed fragmentation of compound 12.



Scheme 12. Proposed fragmentation of compound 13.

2,3- Dioxo-1,2,3,4-tetrahydroquinoxaline-6-sulfonohydrazide derivatives were successful. The synthetic methodology was efficient and environmentally friendly, this was due to the fact that the work-up stages

were carried out in water.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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