Synthesis of New 3-(Furan-2-yl)-Substituted Dibenzo-Diazepin-1-one Derivatives

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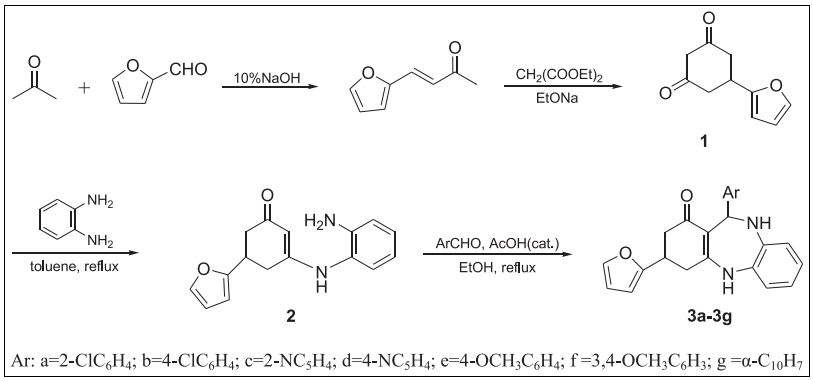

A new series of 3-(furan-2-yl) dibenzo-diazepin-1-one derivatives were synthesized by condensation of 5-(furan-2-yl)-1,3-cyclohexanedione, *o*-phenylenediamine, and aromatic aldehydes, in which in some of them existed two very close isomer compounds. All the compounds were characterized by IR, MS, ^{1}H NMR, and elemental analysis. Also presented were the crystal structures of **3a**, **3b** and **3e**, which were obtained and determined by X-ray single-crystal diffraction.

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INTRODUCTION

Benzodiazepines are well-known nitrogen heterocyclic compounds, owing to their wide range of therapeutic and pharmacological properties, and used as anticonvulsant, anti-anxiety, analgesic, sedative, antidepressive, hypnotic, and anti-inflammatory agents [1–3].

Nowadays, researches on synthesis of benzodiazepines are mainly focused on two directions. Some researchers are interested in the preparation methods of benzodiazepine derivatives, including the catalyst method [4–7], solid state reaction method [8], and microwave radiation method [9,10]. Others focused on fusing benzodiazepines with other heterocyclic systems, such as pyrrolo-, triazole-, isoxazolo-, pyrazolo-, or oxazino-benzodiazepines [11–13]. They looked for strengthening or inducing new pharmacological activities for those benzodiazepines [14–16].

As to the furyl group, it is another potential biologically active heterocyclic functional group that has been detected in almost all organisms, including humans [17]. Recent researches showed that furan moieties are formed upon degradation of natural DNA and can further react by the addition of nucleic acid bases [18,19]. During hydroxyl radical oxidation, the C59 of deoxyribose in DNA has been suggested to be a putative precursor of kinetin [20–22].

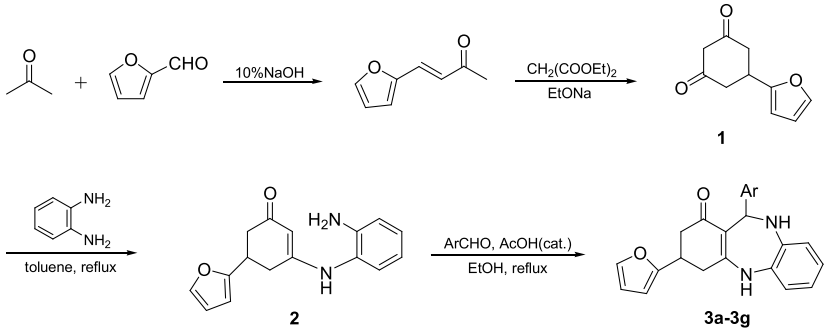
In order to add the furan group to the benzodiazepine system, herein, we reported a new series of 3-(furan-2-yl)-dibenzo-diazepin-1-one derivatives, which were synthesized by condensation of 5-(furan-2-yl)-1,3-cyclohexanedione, *o*-phenylenediamine, and aromatic aldehydes (Scheme 1). Furthermore, three single crystals were obtained and determined by X-ray diffraction analysis.

RESULTS AND DISCUSSION

5-(Furan-2-yl)-1,3-cyclohexanedione prepared by condensation of furfural, acetone, and diethyl malonate, according to Ref. [23], reacted with *o*-phenylenediamine in toluene under reflux for 8 h to afford intermediate enamine **2** with high yield. **2** reacted with different aromatic aldehydes under reflux in ethanol with acetic acid as catalyst to yield the title compounds, 3-(furan-2-yl)-dibenzo-diazepin-1-one derivatives.

All data of MS, IR, ^{1}H NMR, and elemental analysis are shown in the Experimental section. In the IR spectrum of the intermediate **2**, the broad absorption bands at 3452 cm^{-1} were the typical absorptions of the amino group. The broad peak at δ: 4.92 in its ^{1}H NMR spectrum can be attributed to the two proton shifts of the same NH_2 group,

Scheme 1. Synthesis of 3-(furan-2-yl)-dibenzo-diazepin-1-one derivatives. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]



Ar: a=2-ClC_6H_4; b=4-ClC_6H_4; c=2-NC_5H_4; d=4-NC_5H_4; e=4-$OCH_3C_6H_4$; f =3,4-$OCH_3C_6H_3$; g =α-$C_{10}H_7$

while the single peak at δ: 8.37 was attributed to the proton shift of the imino group.

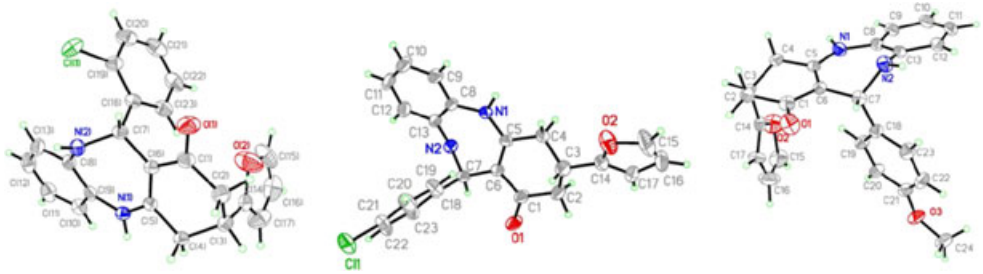
As shown in the IR spectrum of the title 3-(furan-2-yl)-dibenzo-diazepin-1-ones compounds, the broad absorption bands at 3297–3332 cm^{-1} were the typical absorptions of the imino group, and the absorption bands at 1591–1604 cm^{-1} should be attributed to the absorptions of the carbonyl group (C = O). In their ^1H NMR spectrum, the single peaks at δ: 8.84–9.09 were attributed to the proton shifts of the imino group at 5-position. And the peaks at δ: 5.92–6.52 should be attributed to the 10-imino group because of the influence of the methenyl group nearby. In the ESI-MS spectrum, the ion adducts were usually observed as the primary fragment peaks for the title compounds.

When we used the column chromatography to purify the crude products of **3g**, there obtained two very close isomer compounds, **3g-1** and **3g-2**, which were testified by the use of MS and ^1H NMR spectrum, accordingly. Because there existed two chiral carbon atoms, C3 and C11, there maybe existence of some isomers. As to the other compounds, **3a** to **3f**, we obtained only one structure.

Table 1

Crystallographic data for compounds 3a, 3b, and 3e.

	3a	3b	3e
Empirical formula	$C_{23}H_{19}N_2O_2Cl$	$C_{23}H_{21}N_2O_3Cl$	$C_{24}H_{22}N_2O_3$
CCDC No.	1009588	1009589	1009590
Formula weight	390.85	408.87	386.44
Temperature	291(2) K	291(2) K	291(2) K
Wavelength	0.71073 Å	0.71073 Å	0.71073 Å
Crystal system and space group	Orthorhombic and *Pbca*	Monoclinic and $P2_1/c$	Monoclinic and $P2_1/c$
Unit cell dimensions	a = 12.399(3) Å b = 13.886(3) Å c = 21.879(5) Å α = β = γ = 90°	a = 14.2967(11) Å b = 8.0027(6) Å c = 18.5928(15) Å α = γ = 90° β = 105.6100(10)°	a = 11.3413(13) Å b = 19.154(2) Å c = 9.2622(11) Å α = γ = 90° β = 106.585(2)°
Volume	3767.1(16) $Å^3$	2048.8(3) $Å^3$	1928.4(4) $Å^3$
Z	8	4	4
Calculated density	1.378 g · cm^{-3}	1.326 g · cm^{-3}	1.331 g · cm^{-3}
Absorption coefficient	0.225 mm^{-1}	0.213 mm^{-1}	0.088 mm^{-1}
F(000)	1632	856	816
Crystal size	0.25 × 0.20 × 0.18 mm	0.25 × 0.18 × 0.15 mm	0.25 × 0.15 × 0.10 mm
Theta range for data collection	1.86–26.00°	1.48–25.00°	2.13–25.00°
Limiting indices	$-15 \le h \le 15$, $-16 \le k \le 17$, $-26 \le l \le 26$	$-17 \le h \le 15$, $-9 \le k \le 9$, $-22 \leqslant l \leqslant 18$	$-13 \leqslant h \leqslant 7$, $-15 \leqslant k \leqslant 22$, $-7 \leqslant l \leqslant 11$
Reflections collected/unique	27353/3694 ($R_{int} = 0.0252$)	11001/3589 ($R_{int} = 0.0257$)	7215/3316 ($R_{int} = 0.0476$)
Completeness to theta = 25.00	99.9%	99.4%	97.5%
Max. and min. transmission	0.960 and 0.948	0.9687 and 0.9586	0.990 and 0.984
Refinement method	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2
Data/restraints/parameters	3694/0/253	3589/0/262	3316/4/262
Goodness-of-fit on F^2	1.020	1.045	1.019
Final *R* indices [$I > 2$sigma(I)]	$R_1 = 0.0593$ and $wR_2 = 0.1634$	$R_1 = 0.0620$ and $wR_2 = 0.1869$	$R_1 = 0.0615$ and $wR_2 = 0.1501$
R indices (all data)	$R_1 = 0.0741$ and $wR_2 = 0.1777$	$R_1 = 0.0847$ and $wR_2 = 0.2038$	$R_1 = 0.0945$ and $wR_2 = 0.1617$
Largest diff. peak and hole	0.483 and −0.499 e. $Å^{-3}$	0.741 and −0.391 e. $Å^{-3}$	0.370 and −0.359 e. $Å^{-3}$



(i) (ii) (iii)

Figure 1. ORTEP of compounds **3a**(**i**), **3b**(**ii**), and **3e**(**iii**) showing 30% probability ellipsoids. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Table 2

Selected Bond lengths (Å) and Bond Angles (°).

Compound **3a**					
Bond	Distance	Bond	Distance	Bond	Distance
C(5)–N(1)	1.353(3)	C(7)–N(2)	1.479(3)	C(8)–N(2)	1.395(4)
C(5)–C(6)	1.377(3)	C(8)–C(9)	1.394(4)	C(9)–N(1)	1.415(3)
C(6)–C(7)	1.505(4)				
Angle	(°)	Angle	(°)	Angle	(°)
N(1)-C(5)-C(6)	126.9(2)	C(5)-C(6)-C(7)	125.2(2)	C(9)-C(8)-N(2)	121.4(2)
N(2)-C(7)-C(6)	112.5(2)	C(8)-C(9)-N(1)	123.6(2)	C(5)-N(1)-C(9)	133.5(2)
C(8)-N(2)-C(7)	118.9(2)				
Compound 3b					
Bond	Distance	Bond	Distance	Bond	Distance
C(5)–N(1)	1.349(3)	C(7)–N(2)	1.494(3)	C(8)–N(1)	1.421(4)
C(5)–C(6)	1.374(4)	C(8)–C(13)	1.396(4)	C(13)–N(2)	1.404(3)
C(6)–C(7)	1.496(4)				
Angle	(°)	Angle	(°)	Angle	(°)
N(1)-C(5)-C(6)	127.0(3)	C(13)-C(8)-N(1)	124.4(2)	C(8)-C(13)-N(2)	121.2(2)
C(5)-C(6)-C(7)	124.8(2)	C(5)-N(1)-C(8)	133.4(2)	C(13)-N(2)-C(7)	118.3(2)
N(2)-C(7)-C(6)	111.7(2)				
Compound 3e					
Bond	Distance	Bond	Distance	Bond	Distance
C(5)–C(6)	1.360(4)	C(7)–N(2)	1.478(3)	C(8)–C(13)	1.414(4)
C(5)–N(1)	1.370(3)	C(8)–N(1)	1.402(3)	C(13)–N(2)	1.376(4)
C(6)–C(7)	1.503(4)				
Angle	(°)	Angle	(°)	Angle	(°)
C(6)-C(5)-N(1)	126.2(3)	N(1)-C(8)-C(13)	124.2(3)	C(5)-N(1)-C(8)	134.6(2)
C(5)-C(6)-C(7)	124.3(2)	N(2)-C(13)-C(8)	122.2(3)	C(13)-N(2)-C(7)	119.9(2)
N(2)-C(7)-C(6)	112.3(2)				

The single crystal structures of **3a**, **3b,** and **3e** were determined by X-ray diffraction analysis. All of their crystallographic data were shown in Table 1. Their ORTEP and packing diagrams were shown in Figure 1 and Figure S1. The selected bond lengths and bond angles for compounds **3a**, **3b,** and **3e** are listed in Table 2. Viewed in Figure 1, the diazepine 7-member rings of **3a**, **3b,** and **3e** had nearly half-boat conformations. Meanwhile, the configurations of the two chiral C3 and C11 atoms in **3a**, **3b,** and **3e** were very different. In **3a**, they existed in an ***R***,***S***-configuration but showed an ***S***,***R***-configuration in **3b** and an ***R***,***R***-configuration in **3e**, accordingly. It meant that their predomination conformations were different.

CONCLUSIONS

In summary, there was a successful synthesis of a new series of 3-(furan-2-yl)-substituted 2,3,4,5,10,11-hexahydro-1*H*-dibenzo[*b*,*e*][1,4]diazepin-1-one derivatives by the condensation reaction of 5-(furan-2-yl)-1,3-cyclohexanedione, *o*-phenylenediamine, and aromatic aldehydes. All the compounds were characterized and testified. Moreover, we also obtained three crystal structures of **3a**, **3b,** and **3e** through X-ray single-crystal diffraction. It disclosed that their diazepine 7-member rings had nearly half-boat conformations, while the configurations of two chiral C3 and C11 atoms in **3a**, **3b,** and **3e** were very

different. We believe that it would be very useful to study the relationship between their biological activities and structures eventually.

EXPERIMENTAL

5-(Furan-2-yl)-l,3-cyclohexanedione **1** was synthesized as the Ref. [23]. Other chemicals were of analytical reagent grade and purchased from commercial sources, which were used directly without further purification. Melting points were determined on a capillary tube method and the temperature was not calibrated. IR spectra were recorded as thin films on KBr using a Digilab FTS 2000 spectrophotometer (Marlborough, MA, USA). ^{1}H NMR spectra were recorded on a Bruker AVANCE III 500 (Billerica, MA, USA) spectrometer. Element analysis was determined by Elementar Vario EL III analyzers (Hanau, Germany). The ESI-MS was determined on an Aglient-6100 (Santa Clara, CA, USA) equipment. Crystallographic data of **3a**, **3b,** and **3e** were collected using a Bruker SMART APEX II CCD-based diffractometer (Billerica, MA, USA) with graphite-monochromatic Mo$K\alpha$ radiation ($\lambda = 0.71073$ Å) at 291(2)K. Data reductions and absorption corrections were performed with SAINT and SADABS software packages [24], respectively. Structures were solved by direct methods using the SHELXL-97 software package [25]. Non-hydrogen atoms were refined anisotropically using the full-matrix least-squares method on F^2. All hydrogen atoms were placed at calculated positions and refined, riding on the parent atoms.

Synthesis of intermediate5-((2-amino-(furan-2-yl))amino)-1,6-dihydro-[1,1′-biphenyl]- 3(2*H*)-one (2). A mixture of 5-(furan-2-yl)-1,-cyclohexanedione **1** (5 mmol) and *o*-phenylenediamine (5 mmol) was dissolved in toluene and refluxed for 8 h. When the reaction was completed, it was cooled to room temperature. The yellowish solid product **2** was collected by filtration and purified by recrystallization from 95% ethanol. Yield 85%; m.p. 206–208°C. ^{1}H NMR (DMSO-d_6, 500 MHz) δ: 2.36 (m, 2H, 4-H), 2.42 (dd, 1H, $J_1 = 5.0$ Hz, $J_2 = 16.0$ Hz, 6a-H), 2.73 (dd, 1H, $J_1 = 5.0$Hz, $J_2 = 16.0$ Hz, 6b-H), 2.84 (m, 1H, 5-H), 4.67 (s, 1H, 2-H), 4.92 (br, 2H, 14-NH), 6.18–6.75 (m, 4H, Ph-H), 6.90 (m, 1H, 3′-H), 7.00 (m, 1H, 4′-H), 7.58 (m, 1H, 5′-H), 8.37 (s, 1H, 7-NH). IR (KBr) υ: 3452 br, 3259 m, 1535 s, 1457 m, 1253 m, 1147 m, 742 s. *Anal*. Calcd. for $C_{16}H_{16}N_2O_2$: C, 71.62; H, 6.01; N, 10.44. Found: C, 71.35; H, 5.75; N, 10.26. MS (ESI) m/z: 269.1 (M + 1).

General synthesis route of 3-(furan-2-yl)-2,3,4,5,10,11-hexahydro-1*H*-dibenzo[*b*,*e*][1,4] diazepin-1-one (3). The intermediate 2 (5 mmol) reacted with aromatic aldehydes (5 mmol) using acetic acid (2.5 mL) as a catalyst under reflux for 3–4 h. After cooling, the solvent was removed under reduced pressure to get a pale-yellowish solid. The crude products were purified by column chromatography (ethyl acetate/cyclohexane = 2:1) to afford the title compounds. In purifying the crude product **3 g**, there obtained two very close isomer compounds, **3g-1** and **3g-2**, accordingly.

3-(Furan-2-yl)-11-(2-chlorophenyl)-2,3,4,5,10,11-hexahydro-1*H*-dibenzo[*b*,*e*][1,4]diazepin-1-one (3a). Yield 69%; m.p. 144–146°C. ^{1}H NMR (DMSO-d_6, 500 MHz) δ: 2.47 (m, 1H, 2a-H), 2.63 (m, 1H, 2b-H), 3.07 (dd, 1H, $J_1 = 8.0$ Hz, $J_2 = 16.0$ Hz, 4a-H), 3.13 (dd, 1H, $J_1 = 4.5$ Hz, $J_2 = 16.0$ Hz 4b-H), 3.55 (m, 1H, 3-H) , 5.61 (d, 1H, $J = 6.0$ Hz, 11-H), 5.94–6.48 (m, 4H, Ph-H), 6.52 (m, 1H, 10-NH), 6.61(m, 2H, 4″-H, 6″-H), 6.82(m, 1H, 5″-H), 6.98 (m, 1H, 3′-H), 7.03(m, 1H, 4′-H), 7.31(m, 1H, 5′-H), 7.61(s, 1H, 3″-H), 9.09(s, 1H, 5-NH). IR (KBr) υ: 3297 br, 1596 m, 1542 s, 1388 s, 1332 m, 1168 m, 1035 w, 768 m. *Anal*. Calcd. for $C_{23}H_{19}ClN_2O_2$: C, 70.68; H, 4.90; N, 7.17. Found: C, 70.42; H, 4.57; N, 7.03. MS (ESI) m/z: 391.1 (M + 1).

3-(Furan-2-yl)-11-(4-chlorophenyl)-2,3,4,5,10,11-hexahydro-1*H*-dibenzo[*b*,*e*][1,4]diazepin-1-one (3b). Yield 58%; m.p. 226–228°C. ^{1}H NMR (DMSO-d_6, 500 MHz) δ: 2.56 (m, 2H, 2-H), 2.88 (dd, 1H, $J_1 = 11.0$ Hz, $J_2 = 16.0$ Hz, 4a-H), 3.07 (dd, 1H, $J_1 = 11.0$ Hz, $J_2 = 16.0$ Hz, 4b-H), 3.49 (m, 1H, 3-H), 5.73 (d, 1H, $J = 6.0$ Hz, 11-H), 6.22 (m, 1H, 10-NH), 6.30–6.58 (m, 5H, Ph-H, 4′-H), 6.92 (d, 2H, $J = 7.5$ Hz, 2″-H, 6″-H), 7.17 (m, 3H, 3′-H, 3″-H, 5″-H), 7.62 (s, 1H, 5-H), 8.94 (s, 1H, 5-NH). IR (KBr) υ: 3309 br, 1602 m, 1529 s, 1382 s, 1276 w, 1149 w, 738 m. *Anal*. Calcd. for $C_{23}H_{19}ClN_2O_2$: C, 70.68; H, 4.90; N, 7.17. Found: C, 70.35; H, 4.63; N, 6.99. MS (ESI) m/z: 391.1 (M + 1).

3-(Furan-2-yl)-11-(2-pyridyl)-2,3,4,5,10,11-hexahydro-1*H*-dibenzo[*b*,*e*][1,4]diazepin-1-one (3c). Yield 43%; m.p. 224–226°C. ^{1}H NMR (DMSO-d_6, 500 MHz) δ: 2.63 (m, 1H, 2a-H), 2.91 (m, 1H, 2b-H), 3.09 (dd, 2H, $J_1 = 3.5$ Hz, $J_2 = 14.5$ Hz, 4-H), 3.90 (m, 1H, 3-H), 5.79 (d, 1H, $J = 6.0$ Hz, 11-H), 6.15 (m, 1H, 10-NH), 6.22–6.56 (m, 7H, Ph-H, 3′-H, 4′-H, 6″-H), 6.92 (m, 2H, 5′-H, 4″-H), 7.50 (m, 1H, 5″-H), 8.37 (m, 1H, 3″-H), 8.95 (s, 1H, 5-NH). IR (KBr) υ: 3307 br, 1594 m, 1531 s, 1388 s, 1348 m, 1145 w, 1010 w, 746 m. *Anal*. Calcd. for $C_{22}H_{19}N_3O_2$: C, 73.93; H, 5.36; N, 11.76. Found: C, 73.68; H, 5.25; N, 11.63. MS (ESI) m/z: 358.1 (M + 1).

3-(Furan-2-yl)-11-(4-pyridyl)-2,3,4,5,10,11-hexahydro-1*H*-dibenzo[*b*,*e*][1,4]diazepin-1-one (3d). Yield 51%; m.p. 188–190°C. ^{1}H NMR (DMSO-d_6, 500 MHz) δ: 2.67 (m, 1H, 2a-H), 2.56 (m, 1H, 2b-H), 3.07 (dd, 2H, $J_1 = 4.5$ Hz, $J_2 = 16.0$ Hz, 4-H), 3.56 (m, 1H, 3-H), 5.66 (d, 1H, $J = 6.0$ Hz, 11-H), 6.17 (m, 1H, 10-NH), 6.41–6.59 (m, 4H, Ph-H), 6.65 (m, 1H, 3′-H), 6.88 (d, 2H, $J = 5.5$ Hz, 2″-H, 6″-H), 6.91 (m, 1H, 4′-H), 7.62 (m, 1H, 5′-H), 8.22 (d, 2H, $J = 5.5$ Hz, 3″-H, 5″-H), 8.97 (s, 1H, 5-NH). IR (KBr) υ: 3305 br, 1598 m, 1527 s, 1392 s, 1334 m, 1263 w, 1164 w, 755 m. *Anal*. Calcd. for $C_{22}H_{19}N_3O_2$: C, 73.93; H, 5.36; N, 11.76. Found: C, 73.71; H, 5.11; N, 11.52. MS (ESI) m/z: 358.1 (M + 1).

3-(Furan-2-yl)-11-(4-methoxyphenyl)-2,3,4,5,10,11-hexahydro-1*H*-dibenzo[*b*,*e*][1,4]diazepin-1-one (3e). Yield 58%; m.p. 217–220°C. ^{1}H NMR (DMSO-d_6, 500 MHz) δ: 2.54 (m, 1H, 2a-H), 2.65 (m, 1H, 2b-H), 3.01 (dd, 1H, $J_1 = 7.5$ Hz, $J_2 = 16.0$ Hz, 4a-H), 3.02 (dd, 1H, $J_1 = 4.5$Hz, $J_2 = 16.0$ Hz, 4b-H), 3.53 (m, 1H, 3-H), 3.60 (s, 3H, 4″-OCH_3), 5.63 (d, 1H, $J = 6.0$ Hz, 11-H), 6.23 (m, 1H, 10-NH), 6.24–6.84 (m, 9H, Ph-H, 2′-H, 3″-H, 5′-H, 6″-H, 3′-H), 6.88 (m, 1H, 4′-H), 7.61 (m, 1H, 5′-H), 8.85 (s, 1H, 5-NH). IR (KBr) υ: 3324 br, 1591 m, 1542 s, 1386 m, 1240 w, 1170 w, 748 m. *Anal*. Calcd. for $C_{24}H_{22}N_2O_3$: C, 74.59; H, 5.74; N, 7.25. Found: C, 74.32; H, 5.45; N, 7.13. MS (ESI) m/z: 387.0 (M + 1).

3-(Furan-2-yl)-11-(3,4-dimethoxyphenyl)-2,3,4,5,10,11-hexahydro-1*H*-dibenzo[*b*,*e*][1,4]diazepin-1-one (3f). Yield 68%; m.p. 126–128°C. ^{1}H NMR (DMSO-d_6, 500 MHz) δ: 2.54 (m, 1H, 2a-H), 2.65 (m, 1H, 2b-H), 3.00 (dd, 1H, $J_1 = 7.5$ Hz, $J_2 = 16.0$ Hz, 4a-H), 3.07 (dd, 1H, $J_1 = 4.5$ Hz, $J_2 = 16.0$ Hz, 4b-H), 3.54 (m, 1H, 3-H), 3.59 (m, 6H, 3″-OCH_3, 4″-OCH_3), 5.62 (d, 1H, $J = 6.0$ Hz, 11-H), 6.16 (m, 1H, 10-NH), 6.17–6.50 (m, 4H, Ph-H), 6.59 (m, 3H, 6″-H, 3′-H, 4′-H), 6.81 (d, 1H,

J = 1.5 Hz, 2″-H), 6.88 (d, 1H, J = 8.0 Hz, 5″-H), 7.61 (m, 1H, 5′-H), 8.84 (s, 1H, 5-NH). IR (KBr) v: 3332 br, 1691 m, 1604 s, 1531 s, 1327 m, 1147 m, 1024 s, 711 s. *Anal*. Calcd. for $C_{25}H_{24}N_2O_4$: C, 72.10; H, 5.81; N, 6.73. Found: C, 72.02; H, 5.55; N, 6.64. MS (ESI) m/z: 417.1 (M + 1).

3-(Furan-2-yl)-11-(naphthalen-1-yl)-2,3,4,5,10,11-hexahydro-1*H*-dibenzo[*b*,*e*][1,4]diazepin-1-one (3g). **3g-1**: Yield 35%; m.p. 156–158°C. ^{1}H NMR (DMSO-d_6, 500 MHz) δ: 2.56 (m, 2H, 2-H), 3.10 (dd, 1H, J_1 = 8.5 Hz, J_2 = 16.5 Hz, 4a-H), 3.17 (dd, 1H, J_1 = 4.5 Hz, J_2 = 16.0 Hz, 4b-H), 3.59 (m, 1H, 3-H), 6.06 (m, 1H, 11-H), 6.07 (m, 1H, 10-NH), 6.16–6.42 (m, 6H, Ph-H, 3′-H, 4′-H), 7.51 (m, 1H, 5′-H), 7.61 (m, 4H, 4″-H, 5″-H, 8″-H, 9″-H), 7.84 (t, 2H, J = 9.5 Hz, 3″-H ,6″-H), 8.50 (d, 1H, J = 8.5 Hz, 7″-H), 9.06 (s, 1H, 5-NH). IR (KBr) v: 3310 br, 1598 m, 1523 s, 1388 s, 1290 m,1151 m, 1010 w, 796 m. *Anal*. Calcd. for $C_{27}H_{22}N_2O_2$: C, 79.78; H, 5.46; N, 6.89. Found: C, 79.52; H, 5.26; N, 6.84. MS (ESI) m/z: 407.2 (M + 1).

3g-2: Yield 30%; m.p. 156–158°C. ^{1}H NMR (DMSO-d_6, 500 MHz) δ: 2.64 (m, 1H, 2a-H), 2.98 (m, 1H, 2b-H), 3.22 (dd, 2H, J_1 = 4.5 Hz, J_2 = 16.5 Hz, 4-H), 3.51 (m, 1H, 3-H), 5.91 (m, 1H, 11-H), 5.92 (m, 1H, 10-NH), 6.24–6.44 (m, 4H, Ph-H), 6.55 (m, 1H, 3′-H), 6.63 (m, 1H, 4′-H), 6.97 (m, 5H, 5′-H, 4″-H, 5″-H, 8″-H, 9″-H), 7.13 (t, 1H, J = 7.5 Hz, 3″-H), 7.55 (m, 1H, 6″-H), 8.53 (m, 1H, 7″-H), 9.08 (s, 1H, 5-NH). IR (KBr) v: 3310 br, 1598 m, 1523 s, 1388 s, 1290 m, 1151 m, 1010 w, 796 m. *Anal*. Calcd. for $C_{27}H_{22}N_2O_2$: C, 79.78; H, 5.46; N, 6.89. Found: C, 79.61; H, 5.13; N, 6.78. MS (ESI) m/z: 407.2 (M + 1).

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