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A convenient approach to δ-amino-β-ketoesters by vinylogous Mannich reaction of masked acetoacetates

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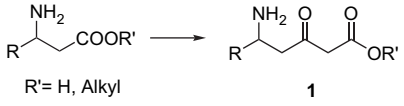
Abstract—$SiCl_4$ is an efficient and selective catalyst for the vinylogous Mannich reaction of linear and cyclic synthetic equivalents of acetoacetate dianion, leading to δ-amino-β-ketoesters in moderate to high yields and complete γ-selectivity; *anti*-diastereoselectivity was observed by using a γ-methyl-substituted cyclic silyloxydiene.

1. Introduction

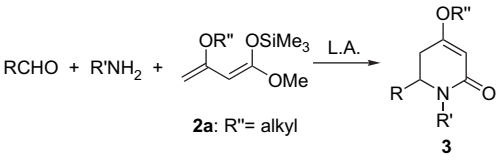
δ-Amino-β-ketoesters **1** represent a valuable class of compounds, widely used, as starting materials, in many procedures for the synthesis of monocyclic and bicyclic alkaloids, containing substituted piperidine moieties,[1] such as the dendrobate alkaloid (+)-241D,[2] (−)-lasubine I and II,[3,4] pseudodistomin B triacetate,[5] (−)-epimyrtine[6] and 4-hydroxypipecolio acids.[7]

The typical approach to racemic and enantioenriched compounds **1** is based on chain-extension processes of β-amino-acids[8] and β-aminoesters[2–7,9] (Scheme 1).



Scheme 1. Chain-extension processes.

In our opinion the vinylogous Mannich reaction[10] of a synthetic equivalent of acetoacetate dianion represents a more convenient approach for the synthesis of **1**. However, previous reports on the imino-aldol reaction of the Brassard diene **2a**, under Lewis acid catalysis (Scheme 2), pointed out the occurrence of the competing cyclization of the resulting open-chain vinylogous intermediates, leading to the dihydropyridone derivatives **3**.[11,12]

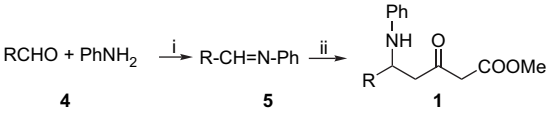


Scheme 2. Imino-aldol reaction of Brassard diene **2a**.

A recent investigation on the vinylogous Mukaiyama aldol reaction of masked forms of 1,3-dicarbonyl compounds[13] has confirmed the notable nucleophilic properties of the Chan diene **2b** (R″=–$SiMe_3$), structurally very similar to Brassard diene **2a**, so that, in the presence of a very weak Lewis acid as $SiCl_4$, the formation of the corresponding aldols took place in high yields and complete γ-selectivity. This finding suggested exploitation of the same protocol for the achievement of a direct approach to δ-amino-β-ketoesters by a vinylogous Mannich reaction.

2. Results and discussion

Preliminary experiments were carried out both on crude isolated and in situ generated imine **5a**, chosen as the representative substrate, under the conditions depicted in Scheme 3 and Table 1 (respectively, entries 1 and 2). Although no reaction was observed at −78 °C, reactive Chan diene afforded at −20 °C and in the absence of catalyst the targeted product **1a** in moderate yield. More interestingly, the employment of



Scheme 3. Synthesis of imino-aldols **1**. Reagents and conditions: (i) CH_2Cl_2, 3 Å MS, SiO_2, 1 h/rt; (ii) CH_2Cl_2, DIPEA, $SiCl_4$, **2b**, 0.5 h/−78 °C.

Keywords: Mannich reaction; Imines; Aldehydes; Silicon tetrachloride; Nucleophilic addition; Diastereoselectivity.
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Table 1. $SiCl_4$-catalyzed vinylogous Mannich reaction of Chan diene **2b**[a]

Entry	R	Aldehyde	$SiCl_4$ (equiv)	DIPEA (equiv)	**1** Yield[b] (%)
1	Ph	**4a**	—	—	36[c,d]
2	Ph	**4a**	—	—	37[d]
3	Ph	**4a**	0.20	0.20	75[c]
4	Ph	**4a**	0.20	0.20	87
5	*p*MeOC$_6$H$_4$	**4b**	0.20	0.20	88
6	*p*MeC$_6$H$_4$	**4c**	0.20	0.20	86
7	PhCH=CH	**4d**	0.20	0.20	77
8	2-Furyl	**4e**	0.20	0.20	72
9	*p*NO$_2$C$_6$H$_4$	**4f**	0.20	0.20	39
10	*p*CNC$_6$H$_4$	**4g**	0.20	0.20	53
11	2-Thiazolyl	**4h**	0.20	0.20	62

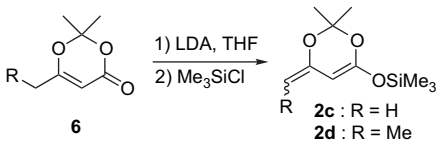
[a] With the exception of entries 1 and 3 **2b** was reacted with in situ generated imines **5** through a one-pot procedure by using 1/1/0.2/0.2/1.3 RCHO/PhNH$_2$/$SiCl_4$/DIPEA/**2** ratios.
[b] All the yields refer to isolated chromatographically pure compounds whose structures were confirmed by analytical and spectroscopic data (MS, IR, ^{1}H NMR and ^{13}C NMR).
[c] In these entries **2b** was reacted with crude isolated imine **5a**.
[d] In these entries the reaction was performed at −20 °C. No reaction was observed at −78 °C.

catalytic $SiCl_4$ (0.20 equiv) at −78 °C proved to be successful since **1a** was obtained in high yields and reduced reaction times (entries 3 and 4). From a preparative point of view, it is to be noted that the one-pot procedure proved to be even more efficient than the stepwise one.

Consequently, the protocol of entry 4 was used for a set of aldehydes in order to assess the scope of the reaction.

Although aliphatic aldehydes such as 3-phenyl propionaldehyde proved to be completely unreactive under the standard conditions, the procedure was successful in the case of aromatic (entries 5, 6, 9 and 10), heteroaromatic (entries 8 and 11) and α,β-unsaturated aldehydes (entry 7) affording in all the cases the corresponding vinylogous imino-aldols **1** as the only products. The type of substituent on the aromatic nucleus exerted a notable influence on the efficiency of the process as confirmed by the lower yields for substrates bearing electron-withdrawing groups, such as NO_2- and CN-substituents (entries 9 and 10).

The cyclic silyloxydiene **2c** (R=H), easily available starting from the corresponding 2,2-dimethyl-[1,3]-dioxin-4-one derivative of type **6** (Scheme 4) represents a further equivalent of acetoacetate dianion and its role, as alternative nucleophile to Brassard and Chan dienes, has been widely supported by its employment in a variety of very efficient procedures for the vinylogous Mukaiyama aldol condensation.[14]



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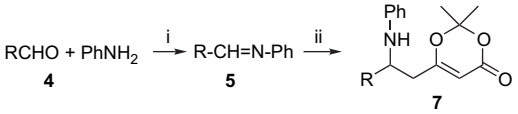
Scheme 4. Synthesis of cyclic silyloxydienes **2c**,**d**.

Therefore, an investigation was devoted to verify the possibility to extend the above one-pot protocol for the imino-aldol reaction to **2c** (Scheme 5 and Table 2).



4 **5** **7**

Scheme 5. Synthesis of imino-aldols **7**. Reagents and conditions: (i) CH_2Cl_2, 3 Å MS, 1 h/rt; (ii) CH_2Cl_2, DIPEA, $SiCl_4$, **2c**, −78 °C.

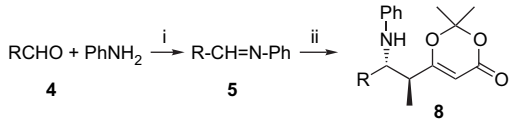
Table 2. $SiCl_4$-catalyzed vinylogous Mannich reaction of silyloxydiene **2c**[a]

Entry	R	Aldehyde	Reaction time (h)	Product **7**	Yield[b] (%)
1[c]	Ph	**4a**	16	**7a**	Traces
2	Ph	**4a**	0.5	**7a**	87
3	*p*MeOC$_6$H$_4$	**4b**	0.5	**7b**	56
4	*p*MeC$_6$H$_4$	**4c**	0.5	**7c**	87
5	PhCH=CH	**4d**	1.0	**7d**	74
6	2-Furyl	**4e**	1.0	**7e**	80
7	*p*NO$_2$C$_6$H$_4$	**4f**	1.3	**7f**	77
8	*p*CNC$_6$H$_4$	**4g**	1.0	**7g**	77
9	2-Thiazolyl	**4h**	1.0	**7h**	53

[a] In all entries 1–9 **2c** was reacted with in situ generated imines **5** though a one-pot procedure by using 1/1/0.2/0.2/1.3 RCHO/PhNH$_2$/$SiCl_4$/DIPEA/**2c** ratios.
[b] All the yields refer to isolated chromatographically pure compounds whose structures were confirmed by analytical and spectroscopic data (MS, IR, ^{1}H NMR and ^{13}C NMR).
[c] In this entry the reaction was carried out in the absence of $SiCl_4$ for 2 h at −78 °C and, then, 14 h at room temperature to give essentially PhCHO.

A control experiment carried out in the absence of $SiCl_4$ (Table 2, entry 1) confirmed the lower nucleophilicity of **2c** with respect to the Chan diene,[13] so that the corresponding imino-aldol could be isolated only in traces (<1% yield). Conversely, in spite of its mildness as Lewis acid, $SiCl_4$ again proved to be a very efficient and selective catalyst promoting the fast formation of the expected **7a** in high yield. Almost comparable efficiency was usually observed with several aromatic, heteroaromatic and α,β-unsaturated aldehydes, while moderate yields were obtained only in entries 3 and 9. Aliphatic substrates **5** (R=alkyl) again showed a complete unreactivity under the typical conditions.

The stereochemical aspects of the vinylogous Mannich reaction were examined by submitting the Me-substituted cyclic silyloxydiene **2d** (easily available as an inseparable ~5/3 *Z*/*E* mixture)[15] to the usual treatment. In spite of the presence of the methyl group on the reaction site, **2d** exhibited a comparable reactivity to **2c**, affording the imino-aldols **8** (Scheme 6) in moderate to high yields (Table 3).



4 **5** **8**

Scheme 6. Synthesis of imino-aldols **8**. Reagents and conditions: (i) CH_2Cl_2, 3 Å MS, 1 h/rt; (ii) CH_2Cl_2, DIPEA, $SiCl_4$, **2d**, −78 °C.

Furthermore, an *anti*-diastereoselectivity was always observed in agreement with related $SiCl_4$-catalyzed Mukaiyama reactions of masked acetoacetates.[13,16]

The employment, as starting materials, of aldehydes bearing electron-donor or electron-withdrawing substituents in *para*-position of the aromatic nucleus did not seem to exert

Table 3. $SiCl_4$-catalyzed vinylogous Mannich reaction of silyloxydiene **2d**[a]

Entry	R	Aldehyde	Reaction time (h)	Product **8**	Yield[b] (%)	d.r.[c]
1	Ph	**4a**	1.0	**8a**	88	72/28
2	*p*$MeOC_6H_4$	**4b**	1.5	**8b**	79	69/31
3	*p*$NO_2C_6H_4$	**4f**	2.0	**8f**	85	72/28
4	2-Thiazolyl	**4h**	2.0	**8h**	50	63/37
5	*o*$MeOC_6H_4$	**4i**	1.0	**8i**	92	59/41
6	*o*$NO_2C_6H_4$	**4j**	1.5	**8j**	77	86/14
7	*o*CNC_6H_4	**4k**	2.0	**8k**	81	79/21
8	*o*$CF_3C_6H_4$	**4l**	2.0	**8l**	41	64/36
9	1-NO_2naphthyl	**4m**	2.0	**8m**	47	79/21

[a] In all entries 1–9 **2d** was reacted with in situ generated imines **5** through a one-pot procedure by using 1/1/0.2/0.2/1.3 RCHO/$PhNH_2$/$SiCl_4$/DIPEA/**2d** ratios.
[b] All the yields refer to isolated chromatographically pure compounds whose structures were confirmed by analytical and spectroscopic data (MS, IR, ^1H NMR and ^{13}C NMR).
[c] The reported values refer to *anti*/*syn* diastereoisomeric ratios, determined by ^1H NMR analysis (400 MHz) on the crude mixtures.

a particular influence both on the level of efficiency and diastereoselectivity. It is noteworthy that *ortho*-substituted aromatic aldehydes, characterized by an enhanced steric crowding in proximity of the formyl group, usually afforded the corresponding products **8i**–**m** in good yields, although in some cases a lower *anti*-diastereoselectivity was observed (entries 5 and 8).

3. Conclusion

In conclusion, a convenient synthesis of δ-amino-β-ketoesters has been achieved through a one-pot multicomponent reaction involving a $SiCl_4$-catalyzed Mannich reaction of masked acetoacetates with in situ generated imines. Due to the mild conditions, the competing cyclization of the resulting open-chain imino-aldols is inhibited allowing their attainment in moderate to high yields. In spite of an increased steric crowding on the reaction site, a synthetic equivalent of propionoacetate dianion showed a comparable reactivity under the standard conditions, affording the corresponding γ-methyl-δ-amino-β-ketoesters in a very satisfactory way and *anti*-diastereoselectivity.

4. Experimental section

4.1. General

All reactions were carried out under Ar or N_2 atmosphere by using dried glassware. CH_2Cl_2 was freshly distilled from CaH_2 under Ar; solvents for extraction and purification and commercially available reagents were used without any purification and were purchased from Sigma–Aldrich and Fluka. TLC was performed on silica gel 60 F_{254} 0.25 mm on glass plates (Merck) and non-flash chromatography was performed on silica gel 60 (0.063–0.200 mm) (Merck). All ^1H NMR and ^{13}C NMR spectra were recorded with a DRX 400 MHz Bruker instrument, by using $CDCl_3$ (δ=7.26 ppm in ^1H NMR spectra and δ=77.0 ppm in ^{13}C NMR spectra) as solvent. IR spectra were recorded on a Perkin–Elmer FT-IR spectrometer. ESMS spectra were performed on a Quattro MicroTM Waters mass spectrometer.

4.2. General procedure for the preparation of compounds 1

In a dry round bottom flask silica gel (240 mg), activated 3 Å molecular sieves (220 mg), CH_2Cl_2 (0.6 mL), aldehyde (1 equiv, 0.5 mmol) and aniline (1 equiv, 0.5 mmol) were added. The resulting mixture was stirred for 1 h at room temperature, then it was cooled at −78 °C and after 10 min DIPEA (0.20 equiv, 0.10 mmol), $SiCl_4$ (0.20 equiv, 0.10 mmol) and a solution of Chan's diene **2** (1.3 equiv, 0.65 mmol) in CH_2Cl_2 (1.8 mL) were added dropwise.

The resulting mixture was stirred for 30 min at −78 °C, then it was neutralized by the addition of saturated aq $NaHCO_3$. The reaction mixture was extracted with CH_2Cl_2 and the combined organic phase was dried ($MgSO_4$) and concentrated. The residue was purified by non-flash chromatography (petroleum ether/AcOEt 9/1) to give the products **1**. All new compounds were fully characterized on the basis of IR, ^1H NMR, ^{13}C NMR and mass spectroscopic data.

4.3. General procedure for the preparation of compounds 7 and 8

In a dry round bottom flask activated 3 Å molecular sieves (220 mg), CH_2Cl_2 (0.6 mL), aldehyde (1 equiv, 0.5 mmol) and aniline (1 equiv, 0.5 mmol) were added. The resulting mixture was stirred for 1 h at room temperature, then it was cooled at −78 °C and after 10 min DIPEA (0.20 equiv, 0.10 mmol), $SiCl_4$ (0.20 equiv, 0.10 mmol) and a solution of diene **2c** or **2d** (1.3 equiv, 0.65 mmol) in CH_2Cl_2 (1.8 mL) were added dropwise.

The resulting mixture was stirred for the reported time at −78 °C, then it was neutralized by the addition of saturated aq $NaHCO_3$. The reaction mixture was extracted with CH_2Cl_2 and the combined organic phase was dried ($MgSO_4$) and concentrated. The residue was purified by non-flash chromatography (petroleum ether/AcOEt 9/1) to give the products **7** or **8**. All new compounds were fully characterized on the basis of IR, ^1H NMR, ^{13}C NMR, elemental analysis and mass spectroscopic data.

4.4. Spectral data of new compounds

4.4.1. Methyl 3-oxo-5-phenyl-5-(phenylamino)pentanoate (1a). Slightly yellowish oil, *m*/*z*: 298 $[M+H]^+$, 320 $[M+Na]^+$; IR (KBr, neat) 3400, 3026, 2953, 1745, 1714, 1602, 1503, 1319–1079, 753, 698; ^1H NMR ($CDCl_3$, 400 MHz): δ 7.39–7.09 (7H, m), 6.68 (1H, m), 6.54 (2H, br d, *J*=8.1 Hz), 4.90 (1H, dd, *J*=7.7, 5.4 Hz), 3.70 (3H, s), 3.42 (1H, d, *J*=15.6 Hz), 3.37 (1H, d, *J*=15.6 Hz), 3.11 (1H, dd, *J*=16.3, 7.7 Hz), 3.02 (1H, dd, *J*=16.3, 5.4 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 200.9, 167.4, 146.4, 142.0, 129.1, 128.8, 127.4, 126.2, 118.0, 113.8, 54.2, 52.4, 50.3, 49.4. Anal. Calcd for $C_{18}H_{19}NO_3$: C, 72.71; H, 6.44; N, 4.71%. Found: C, 72.58; H, 6.39; N, 4.79%.

4.4.2. Methyl 5-(4-methoxyphenyl)-3-oxo-5-(phenylamino)pentanoate (1b). Yellow oil, *m*/*z*: 350 $[M+Na]^+$; IR (KBr, neat) 3398, 3004, 2953, 1743, 1715, 1603, 1509, 1318–1106, 753, 695; ^1H NMR ($CDCl_3$, 400 MHz): δ 7.29 (2H, d, *J*=8.4 Hz), 7.11 (2H, m), 6.86 (2H, d, *J*=8.4 Hz),

6.69 (1H, br t, J=7.8 Hz), 6.57 (2H, br d, J=7.8 Hz), 4.86 (1H, t-like, J=6.5 Hz), 3.77 (3H, s), 3.70 (3H, s), 3.42 (1H, d, J=15.6 Hz), 3.37 (1H, d, J=15.6 Hz), 3.08 (1H, dd, J=16.2, 7.6 Hz), 2.99 (1H, dd, J=16.2, 5.5 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 201.1, 167.4, 158.8, 146.6, 134.0, 129.1, 127.3, 117.8, 114.1, 113.7, 55.2, 53.5, 52.4, 50.4, 49.4. Anal. Calcd for $C_{19}H_{21}NO_4$: C, 69.71; H, 6.47; N, 4.28%. Found: C, 69.80; H, 6.42; N, 4.32%.

4.4.3. Methyl 3-oxo-5-(phenylamino)-5-*p*-tolylpentanoate (1c). Yellow oil, m/z: 312 $[M+H]^+$, 334 $[M+Na]^+$; IR (KBr, neat) 3399, 3022, 2951, 1744, 1716, 1602, 1505, 1318–1166, 752, 696; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.27 (2H, d, J=7.7 Hz), 7.12 (4H, m), 6.70 (1H, br t, J=7.3 Hz), 6.57 (2H, br d, J=8.0 Hz), 4.88 (1H, m), 3.70 (3H, s), 3.43 (1H, d, J=15.6 Hz), 3.38 (1H, d, J=15.6 Hz), 3.09 (1H, dd, J=16.1, 7.8 Hz), 3.00 (1H, dd, J=16.1, 5.4 Hz), 2.33 (3H, s); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 201.1, 167.4, 146.6, 139.0, 137.0, 129.5, 129.1, 126.1, 117.9, 113.7, 53.9, 52.4, 50.4, 49.4, 21.0. Anal. Calcd for $C_{19}H_{21}NO_3$: C, 73.29; H, 6.80; N, 4.50%. Found: C, 73.43; H, 6.75; N, 4.54%.

4.4.4. (*E*)-Methyl 3-oxo-7-phenyl-5-(phenylamino)hept-6-enoate (1d). Yellow oil, m/z: 324 $[M+H]^+$, 346 $[M+Na]^+$; IR (KBr, neat) 3397, 3025, 2952, 1745, 1715, 1600, 1507, 1318–1074, 750, 696; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.36–7.17 (7H, m), 6.76–6.68 (3H, m), 6.62 (1H, d, J=15.8 Hz), 6.23 (1H, dd, J=15.8, 6.0 Hz), 4.56 (1H, m), 3.71 (3H, s), 3.52 (1H, d, J=15.7 Hz), 3.48 (1H, d, J=15.7 Hz), 3.01 (1H, dd, J=16.9, 6.6 Hz), 2.95 (1H, dd, J=16.9, 5.9 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 201.1, 167.3, 146.5, 136.4, 131.0, 129.6, 129.2, 128.5, 127.6, 126.4, 118.1, 113.9, 52.4, 51.8, 49.5, 48.0. Anal. Calcd for $C_{20}H_{21}NO_3$: C, 74.28; H, 6.55; N, 4.33%. Found: C, 74.46; H, 6.49; N, 4.40%.

4.4.5. Methyl 5-(furan-2-yl)-3-oxo-5-(phenylamino)pentanoate (1e). Yellow oil, m/z: 310 $[M+Na]^+$; IR (KBr, neat) 3392, 3032, 2950, 1744, 1716, 1602, 1503, 1317–1072, 750, 694; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.33 (1H, br s), 7.16 (2H, t-like, J=7.9 Hz), 6.74 (1H, br t, J=7.2 Hz), 6.65 (2H, br d, J=7.9 Hz), 6.28 (1H, br s), 6.20 (1H, d, J=2.9 Hz), 5.05 (1H, t, J=6.3 Hz), 3.70 (3H, s), 3.44 (2H, s), 3.18 (1H, dd, J=16.7, 6.3 Hz), 3.10 (1H, dd, J=16.7, 6.3 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 200.6, 167.3, 154.1, 146.2, 141.7, 129.2, 118.5, 113.9, 110.4, 106.5, 52.4, 49.4, 48.1, 46.4. Anal. Calcd for $C_{16}H_{17}NO_4$: C, 66.89; H, 5.96; N, 4.88%. Found: C, 66.98; H, 5.90; N, 4.95%.

4.4.6. Methyl 5-(4-nitrophenyl)-3-oxo-5-(phenylamino)-pentanoate (1f). Yellow oil, m/z: 343 $[M+H]^+$, 365 $[M+Na]^+$; IR (KBr, neat) 3401, 3030, 2953, 1744, 1716, 1605, 1507, 1319–1107, 856, 753, 697; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.16 (2H, d, J=8.6 Hz), 7.58 (2H, d, J=8.6 Hz), 7.09 (2H, br t, J=7.8 Hz), 6.70 (1H, t-like, J=7.4 Hz), 6.50 (2H, br d, J=8.0 Hz), 5.00 (1H, dd, J=7.8, 4.8 Hz), 3.71 (3H, s), 3.49 (1H, d, J=15.9 Hz), 3.43 (1H, d, J=15.9 Hz), 3.17 (1H, dd, J=17.0, 7.8 Hz), 3.04 (1H, dd, J=17.0, 4.8 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 200.1, 167.5, 150.0, 147.1, 145.9, 129.2, 127.3, 124.0, 118.5, 113.8, 55.5, 53.6, 49.8, 49.1. Anal. Calcd for $C_{18}H_{18}N_2O_5$: C, 63.15; H, 5.30; N, 8.18%. Found: C, 63.28; H, 5.26; N, 8.24%.

4.4.7. Methyl 5-(4-cyanophenyl)-3-oxo-5-(phenylamino)-pentanoate (1g). Yellow oil, m/z: 323 $[M+H]^+$, 345 $[M+Na]^+$; IR (KBr, neat) 3394, 3024, 2954, 2228, 1745, 1715, 1601, 1502, 1319–1078, 753, 699; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.59 (2H, d, J=8.1 Hz), 7.51 (2H, d, J=8.1 Hz), 7.09 (2H, br t, J=7.9 Hz), 6.69 (1H, br t, J=7.3 Hz), 6.49 (2H, br d, J=7.9 Hz), 4.94 (1H, dd, J=8.0, 4.9 Hz), 3.70 (3H, s), 3.48 (1H, d, J=15.7 Hz), 3.42 (1H, d, J=15.7 Hz), 3.12 (1H, dd, J=16.9, 8.0 Hz), 3.00 (1H, dd, J=16.9, 4.9 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 200.1, 167.4, 148.0, 146.0, 132.6, 129.2, 127.2, 118.4, 113.7, 113.5, 111.1, 55.6, 53.7, 49.8, 49.1. Anal. Calcd for $C_{19}H_{18}N_2O_3$: C, 70.79; H, 5.63; N, 8.69%. Found: C, 70.66; H, 5.70; N, 8.73%.

4.4.8. Methyl 3-oxo-5-(phenylamino)-5-(thiazol-2-yl)pentanoate (1h). Yellow oil, m/z: 327 $[M+Na]^+$; IR (KBr, neat) 3393, 2953, 2923, 1745, 1717, 1603, 1503, 1317–1079, 753, 696; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.17–7.13 (3H, m), 6.97–6.92 (1H, m), 6.74 (1H, br t, J=7.0 Hz), 6.65 (2H, br d, J=7.8 Hz), 5.22 (1H, t-like, J=6.2 Hz), 3.71 (3H, s), 3.46 (1H, d, J=15.8 Hz), 3.41 (1H, d, J=15.8 Hz), 3.23 (1H, dd, J=16.7, 6.9 Hz), 3.11 (1H, dd, J=16.7, 5.6 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 200.5, 167.3, 146.8, 146.2, 129.2, 126.9, 124.2, 118.5, 113.9, 52.4, 50.1, 50.0, 49.5. Anal. Calcd for $C_{15}H_{16}N_2O_3S$: C, 59.19; H, 5.30; N, 9.20%. Found: C, 59.31; H, 5.36; N, 9.14%.

4.4.9. 6-(2-Phenylamino-2-phenylethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (7a). Yellow oil, m/z: 346 $[M+Na]^+$; IR (KBr, neat) 3366, 2360, 2340, 1720, 1602, 1499, 1274, 1205, 1013, 772, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.37–7.26 (5H, m), 7.11 (2H, m), 6.69 (1H, t-like, J=7.3 Hz), 6.54 (2H, br d, J=7.8 Hz), 5.27 (1H, s), 4.68 (1H, dd, J=8.6, 5.8 Hz), 2.76 (1H, dd, J=14.6, 5.8 Hz), 2.69 (1H, dd, J=14.6, 8.6 Hz), 1.63 (3H, s), 1.57 (3H, s); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 168.2, 161.1, 146.4, 141.8, 129.5, 129.2, 128.1, 126.4, 118.4, 113.8, 107.1, 95.7, 55.6, 42.4, 25.8, 24.7. Anal. Calcd for $C_{20}H_{21}NO_3$: C, 74.28; H, 6.55; N, 4.33%. Found: C, 74.39; H, 6.59; N, 4.28%.

4.4.10. 6-(2-(4-Methoxyphenyl)-2-phenylaminoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (7b). Yellow oil, m/z: 376 $[M+Na]^+$; IR (KBr, neat) 3364, 2359, 2339, 1717, 1603, 1273, 1249, 1205, 1014, 772, 693; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.26 (2H, d, J=8.6 Hz), 7.11 (2H, m), 6.86 (2H, d, J=8.6 Hz), 6.71 (1H, m), 6.54 (2H, br d, J=7.5 Hz), 5.23 (1H, s), 4.63 (1H, t-like, J=7.2 Hz), 3.78 (3H, s), 2.71 (2H, m), 1.61 (3H, s), 1.58 (3H, s); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 168.4, 161.1, 159.3, 146.5, 133.7, 129.5, 127.6, 118.4, 114.5, 113.8, 107.1, 95.7, 55.5, 42.4, 25.7, 24.8. Anal. Calcd for $C_{21}H_{23}NO_4$: C, 71.37; H, 6.56; N, 3.96%. Found: C, 71.47; H, 6.63; N, 3.88%.

4.4.11. 6-(2-Phenylamino-2-*p*-tolylethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (7c). Yellow oil, m/z: 360 $[M+Na]^+$; IR (KBr, neat) 3365, 2999, 2360, 2339, 1718, 1603, 1500, 1274, 1204, 1014, 751, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.23 (2H, d, J=8.0 Hz), 7.14–7.09 (4H, m), 6.71 (1H, m), 6.54 (2H, br d, J=7.3 Hz), 5.23 (1H, s), 4.64 (1H,

t-like, J=7.2 Hz), 2.74 (2H, m), 2.31 (3H, s), 1.61 (3H, s), 1.57 (3H, s); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 168.4, 161.1, 146.8, 139.0, 137.6, 129.8, 129.5, 126.3, 118.2, 113.6, 107.1, 95.7, 55.2, 42.5, 25.8, 24.8, 21.3. Anal. Calcd for $C_{21}H_{23}NO_3$: C, 74.75; H, 6.87; N, 4.15%. Found: C, 74.61; H, 6.79; N, 4.20%.

4.4.12. 6-((*E*)-2-Phenylamino-4-phenylbut-3-enyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (7d). Yellow oil, *m/z*: 372 $[M+Na]^+$; IR (KBr, neat) 3366, 3028, 2359, 2339, 1726, 1662, 1601, 1274, 1203, 1014, 750, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.40–7.08 (7H, m), 6.76–6.60 (4H, m), 6.15 (1H, dd, J=15.7, 5.9 Hz), 5.35 (1H, s), 4.37 (1H, m), 2.64 (2H, m), 1.67 (3H, s), 1.60 (3H, s); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 168.4, 161.1, 146.5, 136.4, 131.8, 129.6, 129.4, 128.9, 128.1, 126.7, 118.7, 114.0, 107.2, 95.7, 53.3, 40.2, 25.7, 24.9. Anal. Calcd for $C_{22}H_{23}NO_3$: C, 75.62; H, 6.63; N, 4.01%. Found: C, 75.50; H, 6.70; N, 4.06%.

4.4.13. 6-(2-(Furan-2-yl)-2-phenylaminoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (7e). Yellow oil, *m/z*: 336 $[M+Na]^+$; IR (KBr, neat) 3366, 2361, 1722, 1635, 1602, 1392, 1376, 1275, 1203, 1013, 750, 693; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.35 (1H, br s), 7.17 (2H, br t, J=7.6 Hz), 6.76 (1H, br t, J=7.3 Hz), 6.65 (2H, br d, J=7.9 Hz), 6.28 (1H, br s), 6.20 (1H, br s), 5.35 (1H, s), 4.85 (1H, t-like, J=7.1 Hz), 2.85 (2H, m), 1.61 (3H, s), 1.58 (3H, s); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 168.0, 161.1, 153.9, 146.2, 142.3, 129.6, 119.0, 114.0, 110.5, 107.1, 95.7, 49.6, 39.0, 25.5, 25.0. Anal. Calcd for $C_{18}H_{19}NO_4$: C, 68.99; H, 6.11; N, 4.47%. Found: C, 69.13; H, 6.04; N, 4.52%.

4.4.14. 6-(2-(4-Nitrophenyl)-2-phenylaminoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (7f). Yellow oil, *m/z*: 391 $[M+Na]^+$; IR (KBr, neat) 3366, 2361, 2341, 1720, 1635, 1602, 1521, 1346, 1275, 1204, 1014, 752, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.19 (2H, d, J=8.7 Hz), 7.57 (2H, d, J=8.7 Hz), 7.09 (2H, m), 6.70 (1H, m), 6.47 (1H, br d, J=7.8 Hz), 5.35 (1H, s), 4.79 (1H, dd, J=9.5, 4.6 Hz), 2.77 (1H, dd, J=14.7, 4.6 Hz), 2.66 (1H, dd, J=14.7, 9.5 Hz), 1.67 (3H, s), 1.58 (3H, s); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 167.2, 160.8, 149.9, 147.7, 145.9, 129.6, 127.4, 124.5, 118.8, 113.7, 107.4, 96.2, 55.1, 42.3, 26.0, 24.5. Anal. Calcd for $C_{20}H_{20}N_2O_5$: C, 65.21; H, 5.47; N, 7.60%. Found: C, 65.35; H, 5.42; N, 7.70%.

4.4.15. 6-(2-(4-Cyanophenyl)-2-phenylaminoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (7g). Yellow oil, *m/z*: 371 $[M+Na]^+$; IR (KBr, neat) 3365, 2360, 2341, 2228, 1719, 1635, 1603, 1376, 1274, 1204, 1014, 753, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.65 (2H, d, J=8.2 Hz), 7.51 (2H, d, J=8.2 Hz), 7.10 (2H, m), 6.72 (1H, t-like, J=7.4 Hz), 6.47 (1H, br d, J=8.0 Hz), 5.32 (1H, s), 4.72 (1H, dd, J=9.5, 4.9 Hz), 2.76 (1H, dd, J=14.7, 4.9 Hz), 2.64 (1H, dd, J=14.7, 9.5 Hz), 1.66 (3H, s), 1.57 (3H, s); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 167.5, 161.0, 148.0, 146.1, 133.0, 129.6, 127.3, 118.8, 118.7, 113.6, 111.7, 107.4, 96.1, 55.1, 42.3, 26.0, 24.5. Anal. Calcd for $C_{21}H_{20}N_2O_3$: C, 72.40; H, 5.79; N, 8.04%. Found: C, 72.29; H, 5.70; N, 8.10%.

4.4.16. 6-(2-Phenylamino-2-(thiazol-2-yl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (7h). Yellow oil, *m/z*: 353 $[M+Na]^+$; IR (KBr, neat) 3358, 2997, 2360, 2339, 1719, 1635, 1603, 1392, 1376, 1274, 1203, 1013, 752–669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.76 (1H, br s), 7.26 (1H, br s), 7.17 (2H, m), 6.77 (1H, m), 6.63 (2H, br d, J=7.9 Hz), 5.31 (1H, s), 5.10 (1H, dd, J=8.6, 4.9 Hz), 3.11 (1H, dd, J=14.6, 4.9 Hz), 2.84 (1H, dd, J=14.6, 8.6 Hz), 1.63 (3H, s), 1.54 (3H, s); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 173.6, 167.4, 160.9, 146.1, 143.3, 129.6, 119.6, 119.4, 113.9, 107.3, 96.1, 54.0, 40.7, 25.7, 24.7. Anal. Calcd for $C_{17}H_{18}N_2O_3S$: C, 61.80; H, 5.49; N, 8.48%. Found: C, 61.67; H, 5.41; N, 8.55%.

4.4.17. 6-(1-Phenylamino-1-phenylpropan-2-yl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (8a). Yellow oil, *m/z*: 338 $[M+H]^+$, 360 $[M+Na]^+$; IR (KBr, neat) 3400, 2360, 1717, 1630, 1603, 1391, 1317, 1274, 1202, 1030, 808–702. *The compound exists as a mixture of two diasteroisomers*. *syn*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.25 (5H, m), 7.10 (2H, m), 6.65 (1H, m), 6.51 (2H, br d, J=8.1 Hz), 5.29 (1H, s), 4.68 (1H, d, J=5.4 Hz), 2.83 (1H, m), 1.62 (3H, s), 1.52 (3H, s), 1.14 (3H, d, J=7.1 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 172.5, 161.4, 147.0, 140.8, 129.3, 128.9, 127.8, 127.0, 118.1, 113.7, 107.0, 94.3, 59.3, 44.8, 26.0, 24.3, 11.7. *anti*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.32 (5H, m), 7.10 (2H, m), 6.65 (1H, m), 6.51 (2H, br d, J=8.1 Hz), 5.34 (1H, s), 4.38 (1H, d, J=9.2 Hz), 2.62 (1H, m), 1.70 (3H, s), 1.57 (3H, s), 1.05 (3H, d, J=7.0 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 173.0, 161.4, 146.8, 141.1, 129.3, 128.9, 127.9, 127.3, 118.0, 113.7, 107.1, 94.5, 60.3, 46.0, 26.0, 24.5, 15.8. Anal. Calcd for $C_{21}H_{23}NO_3$: C, 74.75; H, 6.87; N, 4.15%. Found: C, 74.70; H, 6.98; N, 4.19%.

4.4.18. 6-(1-(4-Methoxyphenyl)-1-phenylaminopropan-2-yl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (8b). Yellow oil, *m/z*: 368 $[M+H]^+$, 390 $[M+Na]^+$; IR (KBr, neat) 3366, 2999, 2361, 1718, 1630, 1603, 1391, 1317, 1274, 1249, 1203, 1032, 838–668. *The compound exists as a mixture of two diasteroisomers*. *syn*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.24 (2H, m), 7.06 (2H, m), 6.85 (2H, m), 6.64 (1H, m), 6.50 (2H, br d, J=8.0 Hz), 5.27 (1H, s), 4.62 (1H, d, J=5.5 Hz), 3.77 (3H, s), 2.80 (1H, m), 1.61 (3H, s), 1.53 (3H, s), 1.14 (3H, d, J=7.0 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 172.6, 161.4, 159.2, 147.1, 132.7, 129.4, 128.1, 117.9, 114.3, 113.7, 107.1, 94.3, 58.8, 55.4, 45.0, 26.0, 24.4, 11.9. *anti*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.24 (2H, m), 7.06 (2H, m), 6.85 (2H, m), 6.64 (1H, m), 6.50 (2H, br d, J=8.0 Hz), 5.33 (1H, s), 4.33 (1H, d, J=9.2 Hz), 3.77 (3H, s), 2.59 (1H, m), 1.70 (3H, s), 1.57 (3H, s), 1.04 (3H, d, J=7.0 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 173.2, 161.4, 159.2, 146.9, 133.1, 129.3, 128.3, 117.9, 114.3, 113.7, 107.1, 94.4, 59.8, 55.4, 46.2, 26.0, 24.5, 15.7. Anal. Calcd for $C_{22}H_{25}NO_4$: C, 71.91; H, 6.86; N, 3.81%. Found: C, 72.00; H, 6.79; N, 3.77%.

4.4.19. 6-(1-(4-Nitrophenyl)-1-phenylaminopropan-2-yl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (8f). Yellow oil, *m/z*: 405 $[M+Na]^+$; IR (KBr, neat) 3365, 2938, 2361, 2341, 1719, 1633, 1602, 1521, 1346, 1275, 1031, 752–669. *The compound exists as a mixture of two diasteroisomers*. *syn*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.21 (2H, d, J=8.5 Hz), 7.53 (2H, d, J=8.5 Hz), 7.09 (2H, m), 6.70 (1H, m), 6.43 (2H, m), 5.33 (1H, s), 4.10 (1H, br d, J=4.9 Hz), 2.87 (1H,

m), 1.67 (3H, s), 1.52 (3H, s), 1.12 (3H, d, J=7.2 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 171.6, 161.2, 149.0, 147.6, 146.3, 129.5, 128.1, 124.2, 118.6, 113.6, 107.3, 94.7, 58.8, 44.3, 26.2, 24.1, 11.3. *anti*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.21 (2H, d, J=8.5 Hz), 7.53 (2H, d, J=8.5 Hz), 7.09 (2H, m), 6.70 (1H, m), 6.43 (2H, m), 5.34 (1H, s), 4.24 (1H, br d, J=6.2 Hz), 2.63 (1H, m), 1.70 (3H, s), 1.58 (3H, s), 1.10 (3H, d, J=7.0 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 172.2, 161.3, 149.3, 147.7, 146.3, 129.5, 128.5, 124.2, 118.5, 113.6, 107.4, 94.9, 59.8, 45.4, 26.0, 24.4, 15.7. Anal. Calcd for $C_{21}H_{22}N_2O_5$: C, 65.96; H, 5.80; N, 7.33%. Found: C, 65.78; H, 5.73; N, 7.29%.

4.4.20. 6-(1-Phenylamino-1-(thiazol-2-yl)propan-2-yl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (8h). Yellow oil, *m/z*: 345 $[M+H]^+$, 367 $[M+Na]^+$; IR (KBr, neat) 3365, 2361, 2341, 1718, 1634, 1602, 1393, 1275, 1203, 772–653. *The compound exists as a mixture of two diasteroisomers*. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.78 (1H, dd-like, J=4.6, 3.5 Hz, *anti* and *syn*), 7.27 (1H, m, *anti* and *syn*), 7.15 (2H, m, *anti* and *syn*), 6.75 (1H, m, *anti* and *syn*), 6.62 (2H, dd-like, J=8.3, 2.3 Hz, *anti* and *syn*), 5.31 (1H, s, *anti* and *syn*), 5.09 (1H, d, J=5.0 Hz, *syn*), 4.91 (1H, d, J=7.8 Hz, *anti*), 3.29 (1H, m, *syn*), 3.10 (1H, m, *anti*), 1.69 (3H, s, *anti* or *syn*), 1.61 (3H, s, *anti* or *syn*), 1.57 (3H, s, *anti* or *syn*), 1.49 (3H, s, *anti* or *syn*), 1.22 (3H, t-like, J=6.7 Hz, *anti* and *syn*); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 173.3 (*anti*), 172.6 (*syn*), 171.5, 161.1, 146.6 (*anti* or *syn*), 146.3 (*anti* or *syn*), 143.4 (*anti* or *syn*), 143.1 (*anti* or *syn*), 129.6, 119.6 (*anti* or *syn*), 119.5 (*anti* or *syn*), 119.3 (*anti* or *syn*), 119.1 (*anti* or *syn*), 114.0 (*anti*), 113.8 (*syn*), 107.2 (*anti*), 107.0 (*syn*), 95.0 (*anti*), 94.5 (*syn*), 58.4 (*anti*), 58.0 (*syn*), 44.8 (*anti*), 43.5 (*syn*), 25.8 (*anti* or *syn*), 25.7 (*anti* or *syn*), 24.6 (*anti* or *syn*), 24.5 (*anti* or *syn*), 15.0 (*anti*), 11.6 (*syn*). Anal. Calcd for $C_{18}H_{20}N_2O_3S$: C, 62.77; H, 5.85; N, 8.13%. Found: C, 62.89; H, 5.90; N, 8.17%.

4.4.21. 6-(1-(2-Methoxyphenyl)-1-phenylaminopropan-2-yl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (8i). Yellow oil, *m/z*: 368 $[M+H]^+$, 390 $[M+Na]^+$; IR (KBr, neat) 3381, 3003, 2360, 2340, 1718, 1632, 1602, 1391, 1317, 1274, 1240, 1203, 1027, 771–669. *The compound exists as a mixture of two diasteroisomers*. *syn*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.26–7.05 (4H, m), 6.89 (2H, m), 6.66–6.56 (3H, m), 5.29 (1H, s), 4.92 (1H, d, J=6.0 Hz), 3.87 (3H, s), 3.09 (1H, m), 1.55 (3H, s), 1.52 (3H, s), 1.18 (3H, d, J=6.8 Hz). *anti*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.26–7.05 (4H, m), 6.89 (2H, m), 6.66–6.56 (3H, m), 5.37 (1H, s), 4.77 (1H, d, J=9.3 Hz), 3.87 (3H, s), 2.92 (1H, m), 1.69 (3H, s), 1.55 (3H, s), 1.04 (3H, d, J=6.9 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 174.2 (*anti*), 173.7 (*syn*), 161.8, 157.7 (*anti*), 157.1 (*syn*), 147.5, 129.3, 128.8, 128.5, 121.0, 120.8, 117.7 (*syn*), 117.6 (*anti*), 113.7, 111.1 (*anti*), 110.9 (*syn*), 107.0 (*anti*), 106.8 (*syn*), 94.3 (*anti*), 93.7 (*syn*), 56.2 (*syn*), 55.9 (*anti*), 55.6, 44.4 (*anti*), 42.3 (*syn*), 26.1 (*anti* or *syn*), 25.7 (*anti* or *syn*), 24.5 (*syn*), 24.3 (*anti*), 15.8 (*anti*), 12.8 (*syn*). Anal. Calcd for $C_{22}H_{25}NO_4$: C, 71.91; H, 6.86; N, 3.81%. Found: C, 72.06; H, 6.89; N, 3.89%.

4.4.22. 6-(1-(2-Nitrophenyl)-1-phenylaminopropan-2-yl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (8j). Yellow oil, *m/z*: 405 $[M+Na]^+$; IR (KBr, neat) 3366, 2360, 1716, 1632, 1603, 1526, 1392, 1366, 1254, 1202, 1031, 751–695. *The compound exists as a mixture of two diasteroisomers*. *syn*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.99 (1H, d, J=7.9 Hz), 7.67–7.54 (2H, m), 7.39 (1H, m), 7.06 (2H, m), 6.64 (1H, m), 6.50 (2H, br d, J=7.9 Hz), 5.50 (1H, d, J=4.3 Hz), 5.38 (1H, s), 3.03 (1H, m), 1.64 (3H, s), 1.52 (3H, s), 1.25 (3H, d, J=6.8 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 172.0, 161.2, 149.9, 146.2, 136.4, 133.6, 129.6, 129.1, 128.8, 125.7, 118.7, 113.4, 107.3, 94.4, 55.1, 42.6, 25.9, 24.2, 11.0. *anti*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.89 (1H, d, J=7.9 Hz), 7.67–7.54 (2H, m), 7.39 (1H, m), 7.06 (2H, m), 6.64 (1H, m), 6.50 (2H, br d, J=7.9 Hz), 5.32 (1H, d, J=7.7 Hz), 5.28 (1H, s), 2.82 (1H, m), 1.67 (3H, s), 1.59 (3H, s), 1.16 (3H, d, J=6.8 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 172.0, 161.2, 149.9, 146.2, 136.9, 133.7, 129.6, 129.1, 128.8, 125.1, 118.5, 113.3, 107.3, 95.0, 55.5, 45.5, 25.6, 24.8, 15.5. Anal. Calcd for $C_{21}H_{22}N_2O_5$: C, 65.96; H, 5.80; N, 7.33%. Found: C, 66.14; H, 5.75; N, 7.26%.

4.4.23. 6-(1-(2-Cyanophenyl)-1-phenylaminopropan-2-yl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (8k). Yellow oil, *m/z*: 385 $[M+Na]^+$; IR (KBr, neat) 3366, 2360, 2340, 1716, 1633, 1603, 1526, 1457, 1394, 1275, 1203, 1030, 771–652. *The compound exists as a mixture of two diasteroisomers*. *syn*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.67 (1H, d, J=7.9 Hz), 7.58–7.48 (2H, m), 7.37 (1H, m), 7.09 (2H, m), 6.69 (1H, m), 6.51 (2H, br d, J=7.7 Hz), 5.35 (1H, s), 4.99 (1H, d, J=6.0 Hz), 3.02 (1H, m), 1.64 (3H, s), 1.56 (3H, s), 1.23 (3H, d, J=6.9 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 172.0, 161.4, 146.2, 145.2, 133.8, 133.3, 129.5, 128.5, 128.2, 118.7, 118.0, 113.7, 112.0, 107.3, 94.5, 58.0, 43.8, 25.9, 24.5, 12.2. *anti*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.67 (1H, d, J=7.9 Hz), 7.58–7.48 (2H, m), 7.37 (1H, m), 7.09 (2H, m), 6.69 (1H, m), 6.51 (2H, br d, J=7.7 Hz), 5.30 (1H, s), 4.80 (1H, d, J=8.9 Hz), 2.79 (1H, m), 1.70 (3H, s), 1.58 (3H, s), 1.13 (3H, d, J=6.8 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 172.0, 161.4, 146.0, 145.8, 133.6, 133.5, 129.5, 128.5, 128.2, 118.5, 118.2, 113.5, 112.0, 107.5, 94.9, 58.4, 45.5, 25.9, 24.5, 15.5. Anal. Calcd for $C_{22}H_{22}N_2O_3$: C, 72.91; H, 6.12; N, 7.73%. Found: C, 73.10; H, 6.19; N, 7.66%.

4.4.24. 6-(1-(2-Trifluoromethylphenyl)-1-phenylaminopropan-2-yl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (8l). Yellow oil, *m/z*: 406 $[M+H]^+$, 428 $[M+Na]^+$; IR (KBr, neat) 3399, 2360, 1717, 1651, 1456, 873–669. *The compound exists as a mixture of two diasteroisomers*. *syn*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.74–7.35 (4H, m), 7.07 (2H, m), 6.65 (1H, m), 6.48 (2H, br d, J=8.1 Hz), 5.42 (1H, s), 5.23 (1H, d, J=3.3 Hz), 2.94 (1H, m), 1.63 (3H, s), 1.53 (3H, s), 1.12 (3H, d, J=7.3 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 172.5, 161.5, 146.4, 139.8, 132.3, 129.5, 128.0, 127.8, 126.7, 123.5, 118.4, 113.5, 107.1, 94.1, 54.6, 42.8, 25.8, 25.2, 9.6. *anti*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.74–7.35 (4H, m), 7.07 (2H, m), 6.65 (1H, m), 6.53 (2H, br d, J=8.1 Hz), 5.13 (1H, s), 4.99 (1H, d, J=6.7 Hz), 2.74 (1H, m), 1.70 (3H, s), 1.69 (3H, s), 1.18 (3H, d, J=7.1 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 171.6, 161.0, 146.4, 140.8, 132.6, 129.5, 128.0, 127.8, 126.7, 123.5, 118.4, 113.7, 107.2, 95.4, 56.5, 46.3, 25.5, 25.0, 15.8. Anal. Calcd for $C_{22}H_{22}F_3NO_3$: C, 65.18; H, 5.47; N, 3.45%. Found: C, 65.00; H, 5.41; N, 3.38%.

4.4.25. 6-(1-(2-Nitronaphthalen-3-yl)-1-phenylaminopropan-2-yl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (8m). Yellow oil, *m/z*: 455 $[M+Na]^+$; IR (KBr, neat) 3365, 2361, 2342, 1717, 1635, 1524, 1457, 872, 772. *The compound exists as a mixture of two diasteroisomers*. *syn*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.93–7.54 (6H, m), 7.06 (2H, m), 6.65 (1H, m), 6.54 (2H, br d, J=7.9 Hz), 5.41 (1H, s), 5.01 (1H, d, J=4.6 Hz), 3.05 (1H, m), 1.66 (3H, s), 1.53 (3H, s), 1.20 (3H, d, J=7.0 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 172.0, 161.4, 147.5, 146.1, 133.5, 131.6, 130.8, 129.6, 129.5, 129.1, 128.2, 127.9, 123.7, 118.9, 113.6, 107.3, 94.6, 55.1, 43.4, 26.0, 24.2, 10.9. *anti*: ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.93–7.54 (6H, m), 7.06 (2H, m), 6.65 (1H, m), 6.59 (2H, br d, J=8.1 Hz), 5.39 (1H, s), 4.75 (1H, d, J=9.0 Hz), 2.86 (1H, m), 1.71 (3H, s), 1.61 (3H, s), 1.13 (3H, d, J=7.1 Hz); ^{13}C NMR ($CDCl_3$, 400 MHz): δ 172.0, 161.4, 148.1, 146.0, 133.5, 131.6, 130.8, 129.6, 129.5, 129.1, 128.2, 127.9, 123.7, 118.8, 113.6, 107.5, 95.1, 56.1, 45.7, 25.6, 24.8, 15.6. Anal. Calcd for $C_{25}H_{24}N_2O_5$: C, 69.43; H, 5.59; N, 6.48%. Found: C, 69.62; H, 5.51; N, 6.54%.

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