CHAPTER 2

Transamidation of Secondary Carboxamides and Amidation of Esters are Facilitated by Magnetic Co@NC Nanoparticles, as a Highly Efficient and Recyclable Catalyst Under Neat Conditions

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2.1 Introduction

Amides are of paramount importance in the realms of biology, chemistry, and industry, owing to their wide-ranging applications and significant contributions to the advancement of novel materials, pharmaceuticals, and chemical processes [1]. Their distinct structural and chemical properties render them indispensable within various research and development domains [2]. These prominent structures hold significant associations with a wide array of biologically active compounds including proteins, agrochemicals, and functionalized polymers. Additionally, amides serve as crucial intermediates and precursors in the realm of organic synthesis [3–5]. The presence of carboxamide functional groups within diverse compounds facilitates the prevention and treatment of numerous health disorders [6–8] (**Figure 2.1**). Because of the significance of amides, various approaches have been devised for their synthesis, with a focus on enhancing prevalence and stability [9]. Among these, transamidation is an effective, practical, and straightforward technique for the diversification of amides [10], involving the reaction between an amide and an amine to form a new amide linkage [11]. Initially, transamidation was primarily carried out with primary and tertiary amides due to their higher reactivity [12].

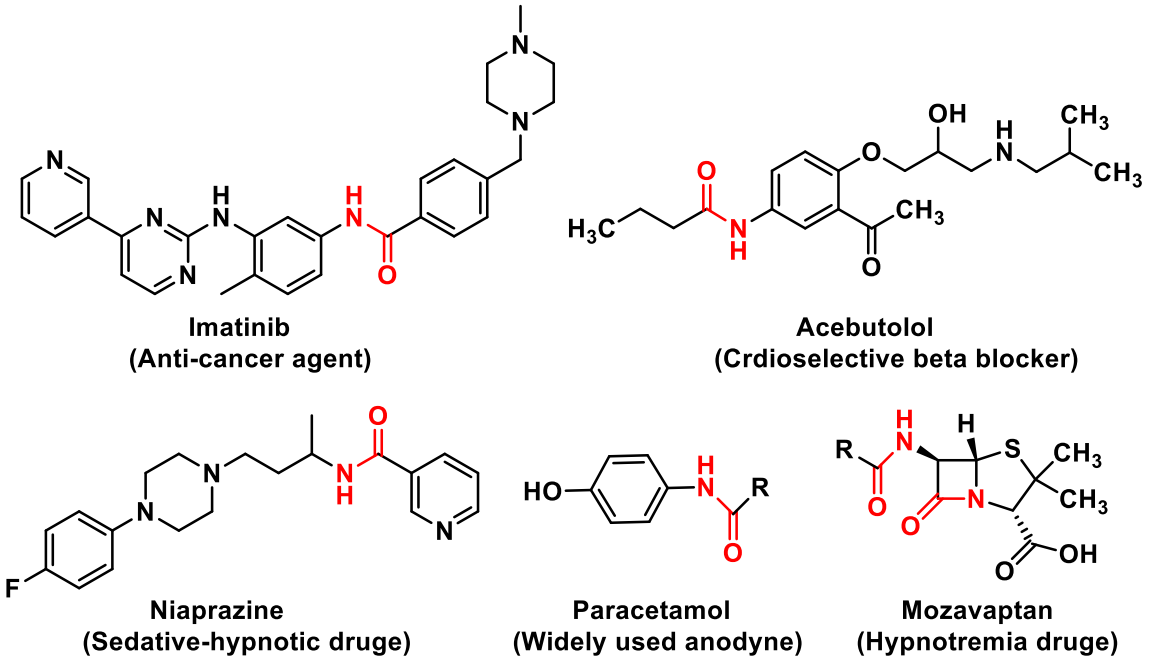


Figure 2.1 Some important drugs bearing amide bonds.

Two-step procedure that allows for the effective transamidation of secondary amides under gentle reaction conditions [13–16]. Initially, planner amides are transformed into twisted amides (such as *N*-Boc, *N*-Cbz, *N*-Ts, *N*-benzoyl cytosine) followed by facilitated by metal catalysts (Co, Zn, Ni, Cu, Pd), additives or bases [17–21]. Recently, a novel approach has been reported for the direct amidation of esters using non-nucleophilic amines to synthesize amides employing various catalysts [22, 23].

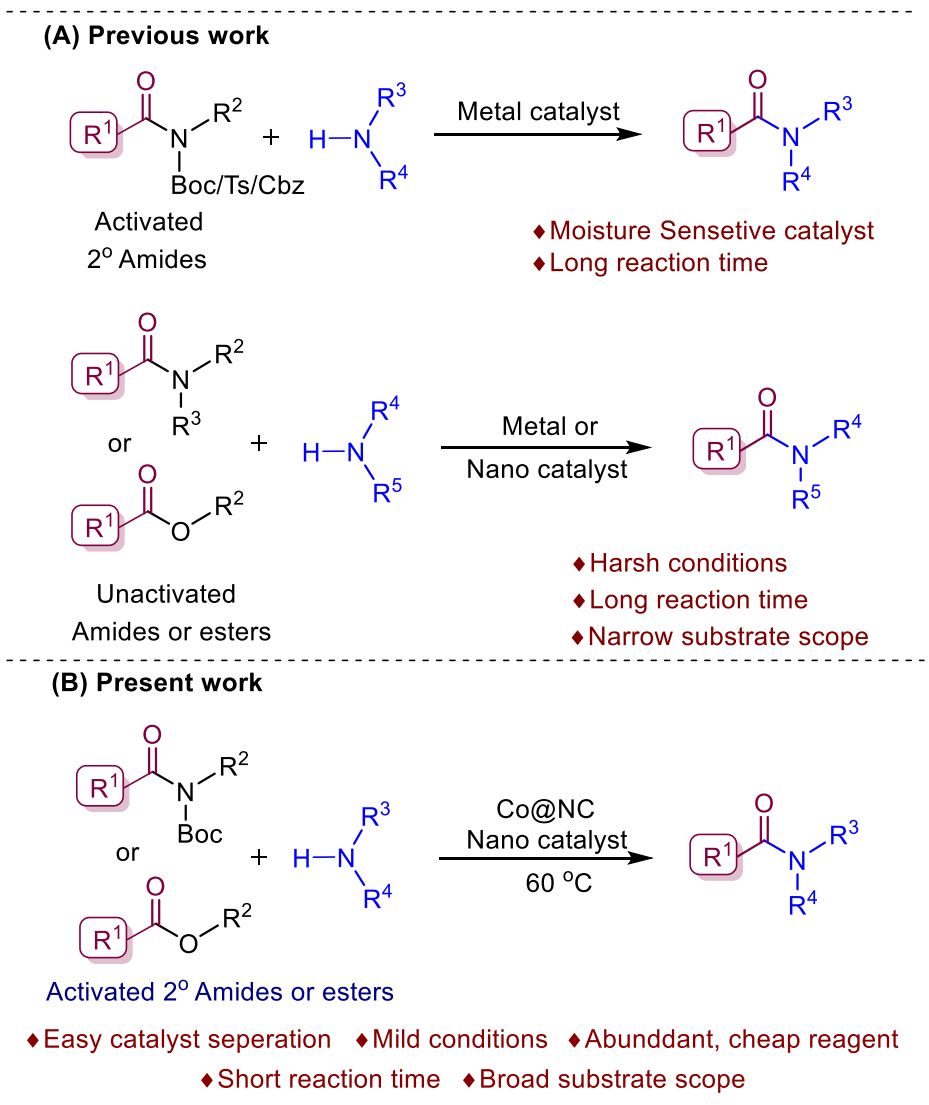
Consequently, numerous effective catalysts have been employed for transamidation across various amides. Furthermore, there is a growing fascination with creating more environmentally friendly processes, particularly by employing heterogeneous catalysts due to ease of separation, without causing a problem of waste disposal, and the option of reuse of heterogeneous catalysts [24, 25] instead of homogeneous ones. In the last few decades,

nanoparticles as catalysts has garnered considerable interest because of their enhanced selectivity and strong catalytic activity in organic reactions [26].

Recently a variety of new nano-catalysts, designed specifically for the transamidation of amides have been developed such as $Fe(OH)_3@Fe_3O_4$ nanoparticles [27], Guanidine acetic acid (GAA) nanoparticles [28], magnetically separable Fe_3O_4 nanoparticles [29], mesoporous silica nanoparticles(MSNs) [30], sulfated poly borate nanocatalyst [31], Fe_3O_4–OSO_3H nano catalyst [32], SiO_2–CeO_2 hybrid nanocomposite [33], nanosized zeolite beta (MSNs) [34] are used for primary amides, Citric acid-coated nanoparticles (Fe_3O_4–CA NPs) for transamidation of primary and secondary amides [35]. Despite their numerous advantages, all these nanoparticle-catalyzed transamidation reactions involving unactivated amides required high temperature and longer time.

Newly developed nitrogen-doped carbon (NC) has emerged as a promising support material for heterogeneous catalysts, offering advantageous adjustments in tuning the chemical properties of catalysts [36]. The Co@NC-supported nanomaterials have nano size, providing increased surface area and active sites. This characteristic contributes to their exceptional catalytic properties across various organic transformations such as *N*-alkylation of amines [37], ester formation [38], transfer hydrogenation [39], *N*-alkylation of anilines [40] etc. they also exhibit high activity in electrocatalysis. In continuation of our efforts in advancing environmentally friendly and sustainable methods, we present a swift and efficient, Co@NC nano-catalyzed transamidation of activated secondary carboxamides and direct amidation of esters with amines. This process yields amide functionality with

exceptional selectivity, cleaving N−C and C−O bonds in a solvent-free environment (**Scheme 2.1**).



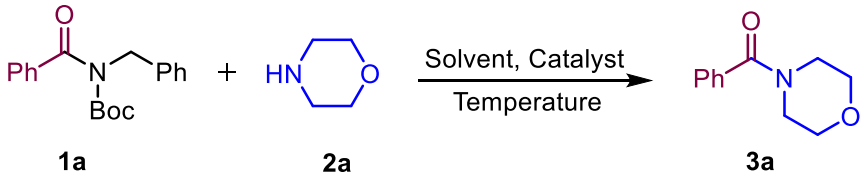
Scheme 2.1 Recent trends in amide bond formation, **(A)** Previous work: Metal catalyzed transamidation of activated secondary amide and transamidation of unactivated amides and esters using metal and nano catalyst, **(B)** Present work: Co@NC nano catalyzed transamidation and amidation reactions by selective N-C/O-C bond cleavage.

2.2 Result and discussion

2.2.1 Optimization of reaction conditions

To ascertain the optimal conditions, *N*-*tert*-butylbenzoyl(benzyl)carbamate **1a** and morpholine **2a** were selected as model substrates and subjected to reaction under different experimental parameters. At the outset, the reaction was conducted in the absence of Co@NC nanocatalyst using water as the solvent, maintaining it at its reflux temperature for 2 hours. Nevertheless, the desired product was not obtained (**Table 2.1, entry 1**). Following that, the reaction was performed in the presence of 1.0 mg of Co@NC nanocatalyst and refluxed in water for 2 h. This resulted in the formation of the corresponding product, *N*-morpholino(phenyl) methanone **3a**, with a yield of 40% (**Table 2.1, entry 2**). To enhance the efficiency of the reaction, different conditions were investigated and the outcomes are summarized in **Table 2.1**. To investigate the influence of different solvents on the yield of product **3a**, the reaction was carried out in various solvents including polar protic ones (ethanol, methanol), polar aprotic ones (1,4-dioxane, DCM, acetonitrile), and non-polar ones (toluene, benzene) (**Table 2.1, entries 3–9**). The yield of product **3a** was found to be low in both polar and non-polar solvents. However, to our satisfaction, the yield of product 3a significantly improved when the reaction was conducted without the use of a solvent at 60 °C**.** The reaction exhibited enhanced efficiency, yielding 65% of the product within only 30 minutes (**Table 2.1, entry 10**). This enhancement could be attributed to the increased concentration of reactants and their close proximity in the absence of solvent [41–44] (**Table 2.1, entry 10**).

Table 2.1 Screening of different parameters for the synthesis of amides **3a**[a]



1a **2a** **3a**

Entry	Solvent	Co@NC (mg)	Temperature (°C)	Time (min.)	Yield (%)[b]
1	Water	-	Reflux	120	N.R.
2	Water	1	Reflux	120	40
3	Ethanol	1	Reflux	120	45
4	Methanol	1	Reflux	120	38
5	1,4 Dioxane	1	Reflux	120	35
6	DCM	1	Reflux	120	38
7	Acetonitrile	1	Reflux	120	42
8	Toluene	1	Reflux	120	30
9	Benzene	1	Reflux	120	20
10	-	1	60	30	65
11	-	1	80	30	65
12	-	1	90	30	67
13	-	1	55	30	60
14	-	2	60	30	75
15	-	3	60	30	82
16	-	4	60	30	88
17	**-**	**5**	**60**	**30**	**92**

18	-	7	60	30	94
19	-	-	60	180	NR

[a]**Reaction conditions:** *tert*-butylbenzoyl(benzyl)carbamate **1a** (1. 0 mmol), morpholine **2a** (1.5 mmol), with Co@NC in 5 ml of the solvents at their refluxed temperature. [b] Isolated yield

Further, all optimizations were performed under neat conditions. Subsequently, the impact of temperature on the progression of the reaction was investigated, revealing that on increasing the temperature up to 90°C did not result in any significant alteration in the product yield. Nevertheless, lowering the temperature led to a decrease in the product yield (**Table 2.1, entries 11&12**). The investigation further explored the effect of different catalyst loadings, ranging from 1 to 7 mg. As the amount of catalyst increased, so did the yield, reaching an optimum at 5 mg (**Table 2.1, entry 17**). In order to assess the significance of the Co@NC nanocatalyst, the reaction was carried out at 60°C without the catalyst under solvent-free conditions. Despite a duration of 180 minutes, no product was obtained (**Table 2.1, entry 16**), highlighting the indispensable function of the Co@NC catalyst in the transamidation process of secondary amides. Hence, the optimized conditions for transamidation involve utilizing 5 mg of catalyst at 60°C for 30 minutes under neat conditions.

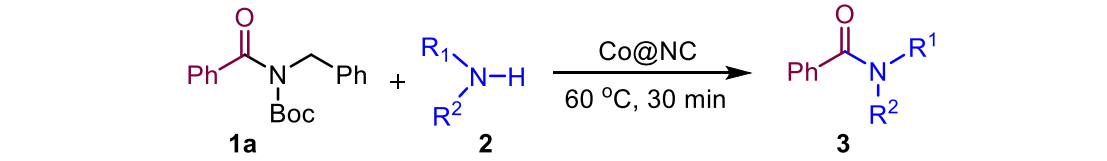
2.2.2 Substrate scope

Having established the optimized conditions, the Co@NC nano-catalyzed transamidation reaction was further investigated for its general applicability, utility, and efficiency. This exploration encompassed a variety of Boc-protected aliphatic and aromatic amides, with

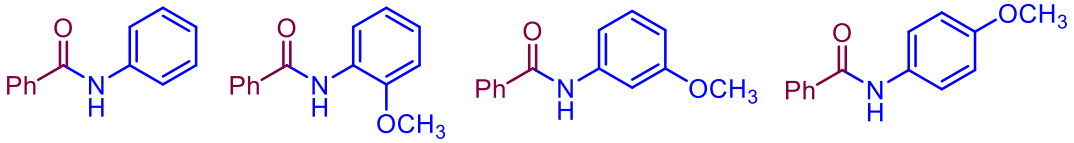
diverse aliphatic, aromatic, cyclic, acyclic, and sterically hindered amines (**Scheme 2.2-2.5**). Under the optimized reaction conditions, all amines underwent smooth reactions. Aromatic amines, specifically aniline derivatives featuring electron-releasing groups at ortho, meta, and para positions, were effectively accommodated with *tert*-butylbenzoyl(benzyl)carbamate **1a**, resulting in high to excellent yields (**3b-3i**).

Conversely, aliphatic amines such as piperidine, phenyl piperazine, methanamine, and n-butyl amine exhibited higher efficiency in reacting with *tert*-butylbenzoyl(benzyl) carbamate **1a** compared to aromatic amines, resulting in yields of 90-95% (**Scheme 2.2, 3j-3m**). Subsequently, the study examined the steric effect, revealing that several sterically hindered amines such as dioctyl amine, *tert*-butyl amine, adamantyl amine, 2,6-dichloroaniline, and 2-ethyl-6-methyl aniline yielded moderately due to steric hindrance [45–47] (**Scheme 2.2, 3n-3r**). Heteroaromatic amines such as 2 amino-3- hydroxy pyridine and 4-methylpyridin-2-amine were also employed, this process went well and the transamidation products were produced with high yields (**Scheme 2.2, 3s, 3t**). The protocol's scope was broadened to investigate the substrate range of *N*-Boc amides, extending to include a variety of functionalized *N*-Boc *N*-benzyl benzamides. These substrates underwent transamidation with aniline under the optimized reaction conditions (**Scheme 2.3**). We were pleased to find that *N*-Boc *N*-benzyl benzamide with electron-releasing groups at ortho, meta, and para positions (CH_3, OCH_3) underwent

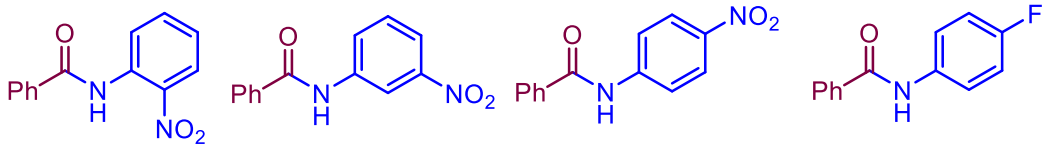
Scheme 2.2 Co@NC nanoparticles catalyzed, transamidation of *N*-Boc activated amides with aryl/aliphatic amines[a]



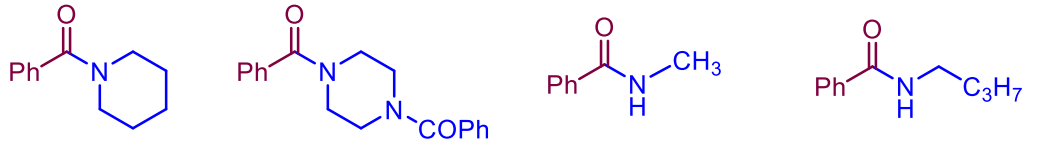
1a **2** **3**



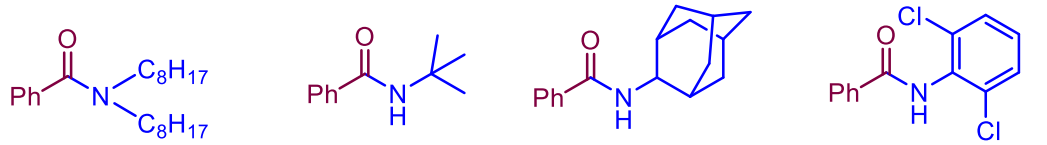
3b: 94% **3c**: 88% **3d**: 94% **3e**: 94%



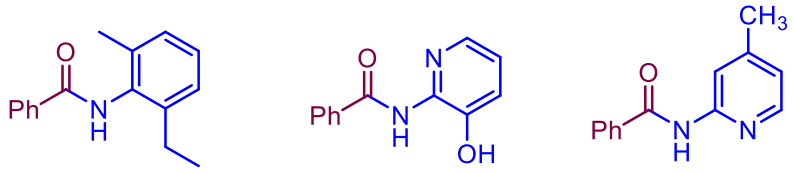
3f: 84% **3g**: 86% **3h**: 86% **3i**: 84%



3j: 94% **3k**: 93% **3l**: 94% **3m**: 94%



3n: 85% **3o**: 82% **3p**: 81% **3q**: 85%

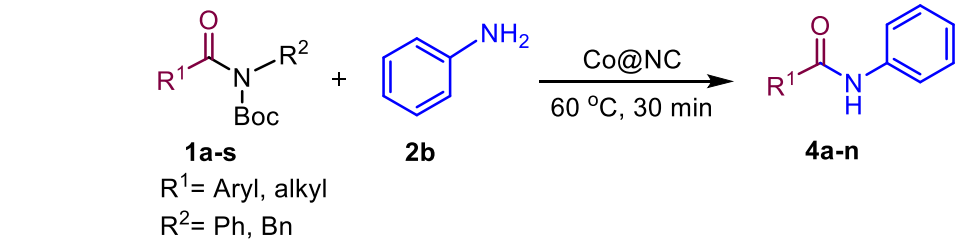


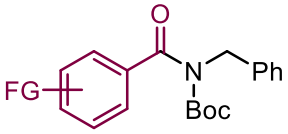
3r: 86% **3s**: 86% **3t**: 90%

[a]**Reaction conditions:** *N*-Boc activated amides (1.0 mmol), aliphatic amines/aromatic amines (1.5 mmol) with Co@NC (5 mg) at 60°C under neat conditions.

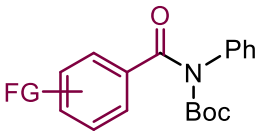
smooth transformation, yielding the desired products in high to excellent yields (**Scheme 2.3, 4a-4d**). Conversely, electron-withdrawing groups (e.g., halogens, trifluoromethyl, nitro) at ortho, meta, and para positions smoothly providing the transamidation products in 88–94% yields (**Scheme 2.3, 4f-4k**).

Scheme 2.3 Co@NC nanoparticles catalyzed, solvent-free transamidation of *N*-Boc secondary amides with aniline[a]

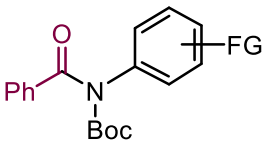




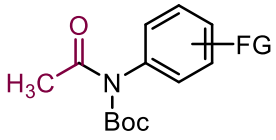
1a: FG = H, **3b**: 94%
1b: FG = *o*-CH_3, **4a**: 87%
1c: FG = *m*-CH_3, **4b**: 91%
1d: FG = *p*-CH_3, **4c**: 90%
1e: FG = *o*-Cl, **4d**: 90%
1f: FG = *p*-Cl, **4e**: 94%
1g: FG = *o*-NO_2, **4f**: 90%
1h: FG = *m*-NO_2, **4g**: 92%
1i: FG = *p*-NO_2, **4h**: 94%
1j: FG = *p*-CF_3, **4i**: 94%



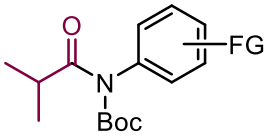
1k: FG = *p*-OCH_3, **4j**: 88%
1l: FG = *p*-F, **4k**: 93%



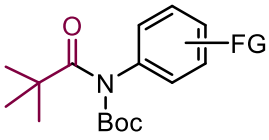
1m: FG = *o*-CH_3, **3b**: 87%
1n: FG = *o*-Cl, **3b**: 90%



1o: FG = H, **4l**: 90%
1p: FG = *p*-Br, **4l**: 90%
1q: FG = *p*-F, **4l**: 90%



1r: FG = H, **4m**: 88%



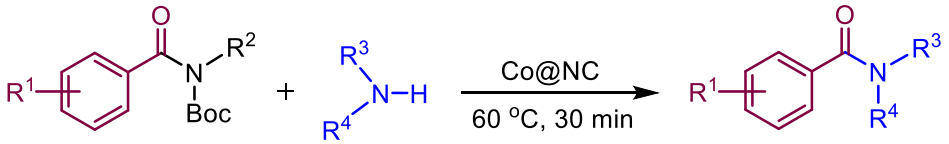
1s: FG = H, **4n**: 86%

[a]**Reaction conditions:** *N*-Boc activated amides (1.0 mmol), aniline (1.5 mmol) with Co@NC (5 mg) at 60°C.

Subsequently, a range of *N*-Boc, *N*-alkyl activated amides were subjected to react with Various amine nucleophiles, ranging from electron-releasing to electron-withdrawing, were employed, resulting in the synthesis of the corresponding new amides in high to excellent yields (**Scheme 2.4, 5a-5l**). To explore the extent of the transamidation process, we conducted reactions of *N*-Boc aliphatic amides with various aryl/aliphatic amines. The reaction proceeded smoothly under the optimized conditions, resulting in moderate to excellent yields (**Scheme 2.5, 6a-6j**).

This process provides the first example of nanoparticles catalyzed efficient approach to amide bond construction from alkyl /aryl esters using amine nucleophiles in solvent-free conditions. In order to optimize the effectiveness of the established amidation technique, we investigated the direct amidation of alkyl/aryl esters (**Scheme 2.6**). Recent years have witnessed substantial research into the effectiveness of activated aryl esters as electrophiles, particularly in selectively cleaving acyl C-O bonds via transition metal mediation [48]. Despite these advancements, achieving direct amidation of typical unactivated alkyl esters has proven to be a significant challenge, largely due to higher tendency for $n_O \rightarrow \pi^*_{C=O}$ isomerization compared to their aryl counterparts [49]. The utilization of plentiful alkyl esters enables the highly appealing direct formation of amide bonds from commonly found ester groups [50]. Both activated and non-activated esters underwent amidation smoothly under the optimized reaction conditions gave good to excellent yields (**Scheme 2.6**).

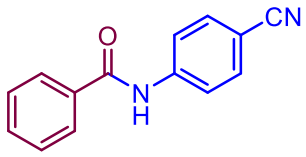
Scheme 2.4 Co@NC nanoparticles catalyzed, solvent-free transamidation of *N*-Boc, *N*-alkyl amides with amines[a]



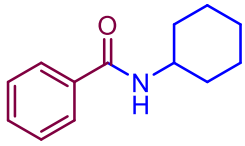
1a
$R^2 = CH_3$, Bn

2

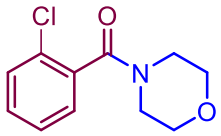
5



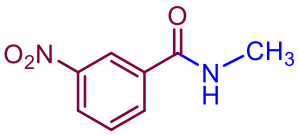
5a: 93%



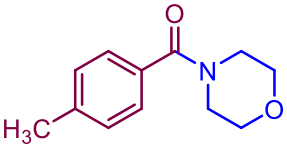
5b: 92%



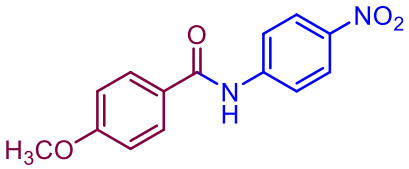
5c: 94%



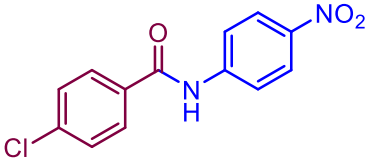
5d: 94%



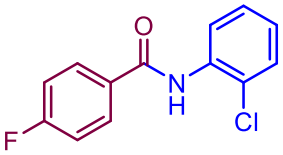
5e: 88%



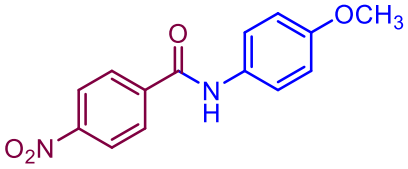
5f: 86%



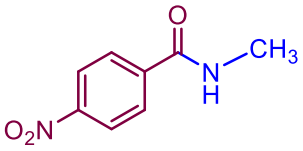
5g: 89%



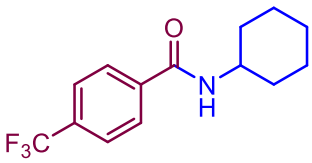
5h: 87%



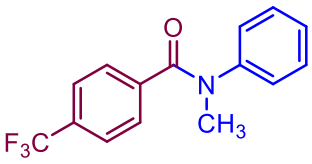
5i: 95%



5j: 94%



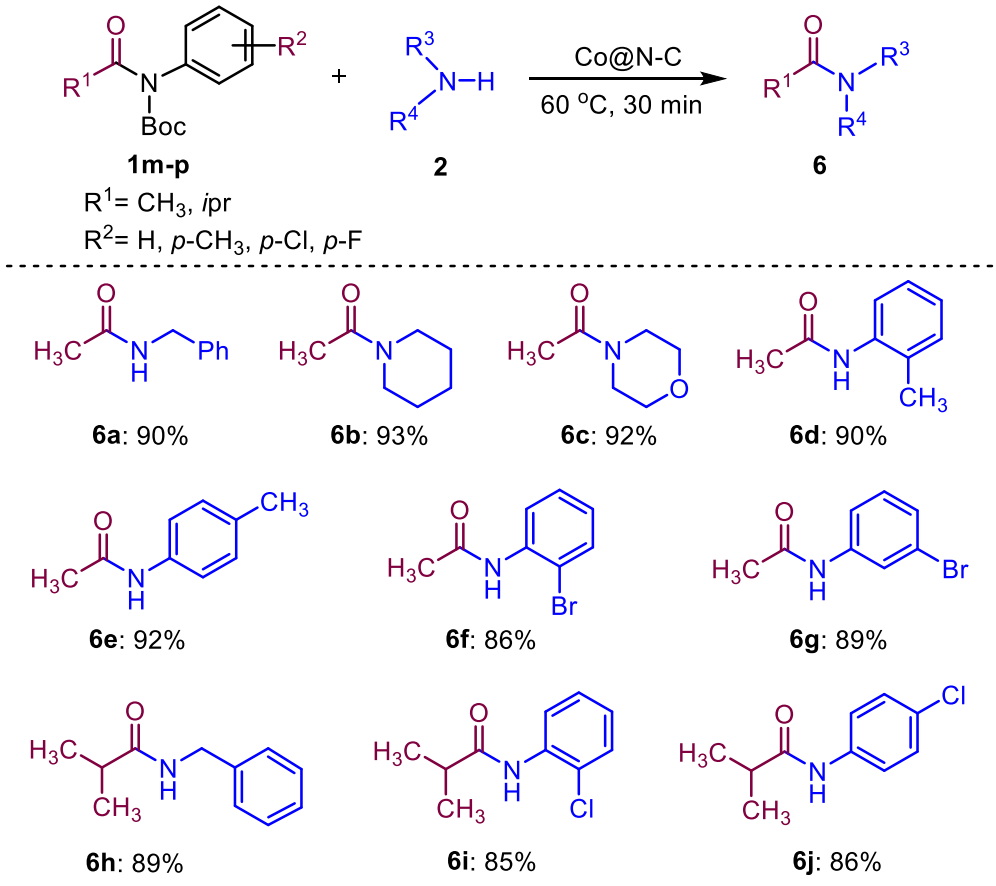
5k: 94%



5l: 90%

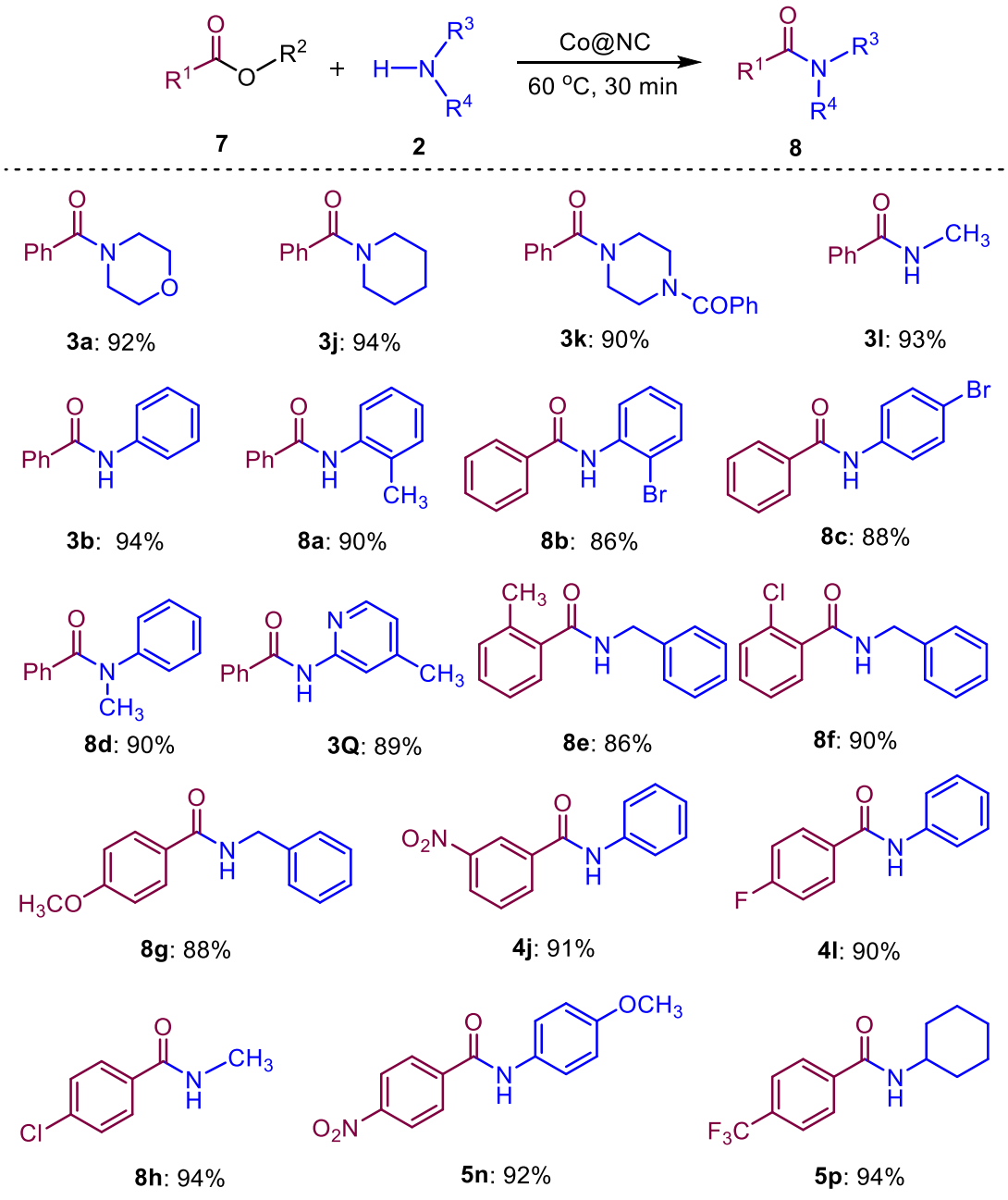
[a]**Reaction conditions:** *N*-Boc activated amides (1.0 mmol), aliphatic amines/aromatic amines (1.5 mmol) with Co@NC (5 mg) at 60 °C.

Scheme 2.5 Co@NC nanoparticles catalyzed, solvent-free transamidation of *N*-Boc aliphatic amides with aryl/aliphatic amines[a]



[a]**Reaction conditions:** *N*-Boc activated amides (1. 0 mmol), aliphatic amines/aromatic amines (1.5 mmol) with Co@NC (5 mg) at 60°C.

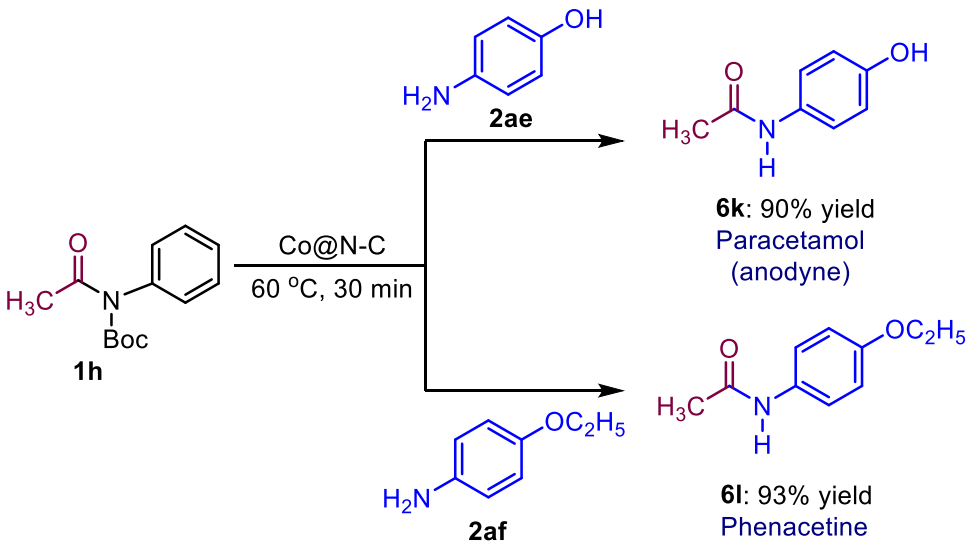
Scheme 2.6 Co@NC nanoparticles catalyzed, solvent-free amidation of esters with various aryl/aliphatic amines[a]



[a]**Reaction conditions:** Alkyl/ aryl esters **7** (1. 0 mmol), amine **2a** (1.5 mmol), with Co@NC (5 mg) at 60 ^{o}C.

This transamidation approach makes it possible to synthesise bioactive compounds and valuable therapeutic medicines. Both phenacetine and paracetamol are commonly used analgesics for pain relief [51, 52]. This popular medicine can be directly synthesized through the transamidation of *N*-Boc acetanilide (**1m**, 1.0 equiv) with *p*-hydroxy aniline (1.5 equiv) /*p*-ethoxy aniline (1.5 equiv), yielding the desired product **6k** in 90% and **6l** in 93% using the present methodology (**Scheme 2.7)**.

Scheme 2.7 Utility of the developed protocol for the synthesis of a drug molecule[a]



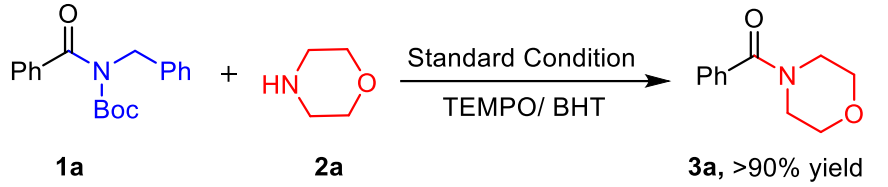
[a]**Reaction conditions:** *N*-Boc activated acetanilide **1h** (1. 0 mmol), aromatic amines (1.5 mmol) with Co@NC (5 mg) at 60°C.

2.3 Mechanistic Studies

2.3.1 Controlled Experiments

In order to elucidate the mechanistic pathway for the Co@NC-catalyzed transamidation of secondary amides, several control experiments were conducted on the model reaction (**Scheme 2.8**) using 2 equivalents of radical quenchers, namely TEMPO (2,2,6,6-tetramethylpiperidin-1-yl) oxidant, and BHT (butylated hydroxytoluene), separately under the optimized reaction conditions, the reaction was not quenched by both TEMPO/BHT. Thus, the possibility that the reaction takes place via a nucleophilic path rather than a radical intermediate pathway.

Scheme 2.8 Control experiments with radical scavengers



2.3.2 Plausible Reaction Mechanism

A probable mechanism for the transamidation process is depicted in (**Figure 2.2**) based on our findings and the literature reports [53–55]. The initial step of the reaction involves the activation of the carbonyl group of the *N*-Boc activated secondary amide by the Co@NC nanocatalyst. Subsequently, an amine attacks the activated amide, forming the tetrahedral intermediate (**A**). This unstable intermediate undergoes C-N bond cleavage, leading to the formation of the desired transamidation product (**3**).

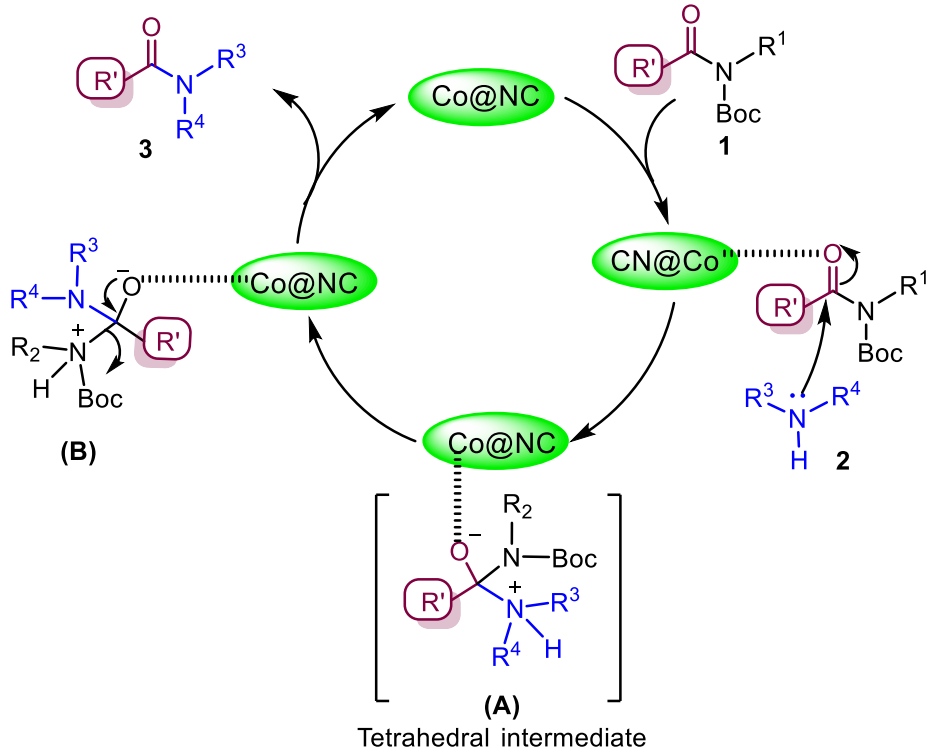
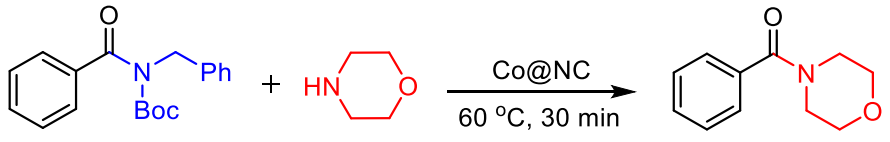


Figure 2.2 Possible reaction mechanism.

2.4 Gram-scale transamidation procedure

The practical feasibility of this procedure was evaluated through a multigram scale synthesis (**Scheme 2.9**). The reaction involving *N*-Boc, *N*-phenyl benzamide **1a** (1.56 g, 5.0 mmol), morpholine **2a** (0.64 g, 7.5 mmol), and catalyzed by 25 mg of Co@NC nanocatalyst, yielded the desired product **3a** in 89% yield (2.02 g).



1a 1.56 g (5.0 mmol) **2a** 0.64 g (7.5 mmol) **3a** (2.02 g) 92% Yield

Scheme 2.9 Gram-scale procedure for transamidation of *N*-Boc amide with amine

2.5 Characterization of catalyst

The Co@NC nanocatalyst was synthesized following a previously reported method [56], and characterized using various analytical and spectroscopic techniques. The XRD pattern of Co@NC nanocatalyst is shown in (**Figure 2.3**). According to a statement using JCPDS database card number 15-0806 the diffraction peaks observed at 2θ values of 44.2°, 51.5° and 75.9° correspond to the indexed planes (100), (200), and (220) reflections of metallic Co, respectively. The peak remaining at approximately 25° is associated with the (002) peak of graphitic carbon [53]. This indicates the formation of pure Co in the cubic crystal structure.

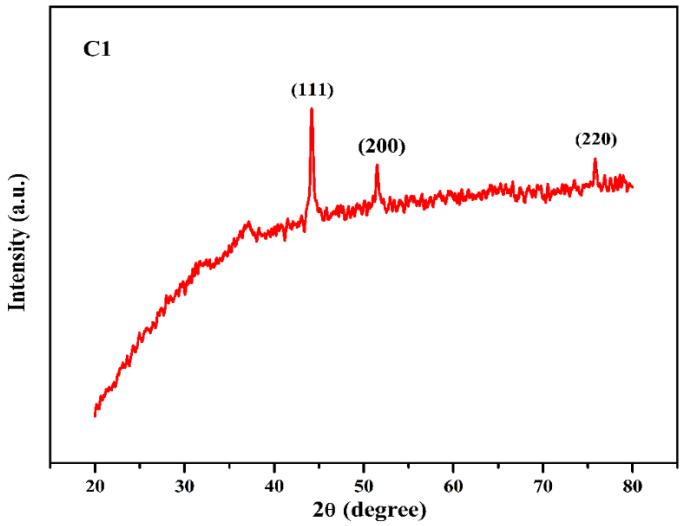


Figure 2.3 XRD pattern of Co@NC

The field emission scanning electron microscopy (FE-SEM) (**Figure 2.4**) reveals their spherical morphology and demonstrates a distinct propensity to form large aggregates, attributed to their magnetic characteristics. The presence of C and N, along with Co the

Energy Dispersive X-Ray Analysis (EDAX) (**Figure 2.5**), confirms the creation of Co@NC nanoparticles. High-resolution transmission electron microscopy (HR TEM) image (**Figure 2.6**) of the catalyst shows dark Co@NC core, spherical surface shape, and an average particle size of 6–12 nm. The atomic force microscopy (AFM) analysis (**Figure 2.7**) confirmed the formation of C@NC nanoparticles and clearly shows the surface morphology of the well-dispersed C@NC NPs. shows the 3D profile of the AFM photograph for the C@NC NPs with an average particle size in the range of 6–12 nm. The sharp absorption peak at 1395 and 1413 cm^{-1} are is attributed to the functional groups of N-C bond and N-Co bond respectively [54, 55] (**Figure 2.8**).

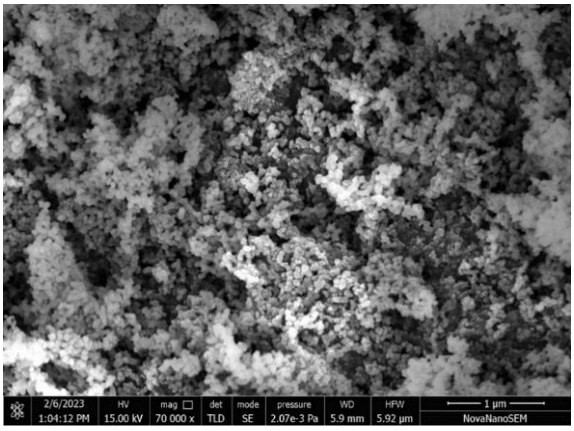


Figure 2.4 SEM pattern of Co@NC

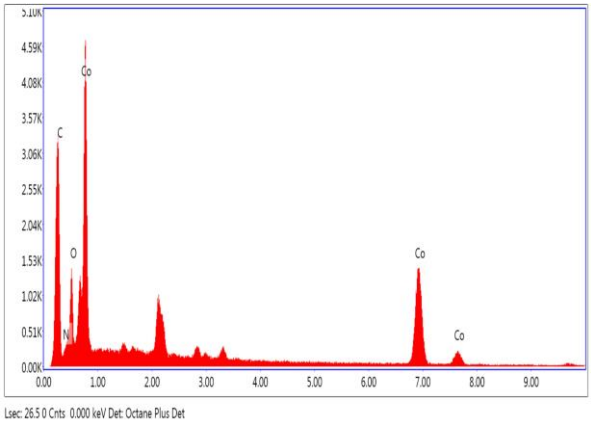


Figure 2.5 EDAX pattern of Co@NC

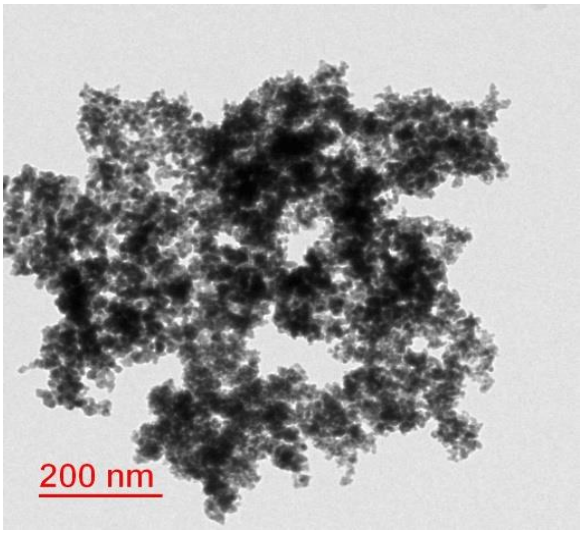


Figure 2.6 TEM pattern of Co@NC

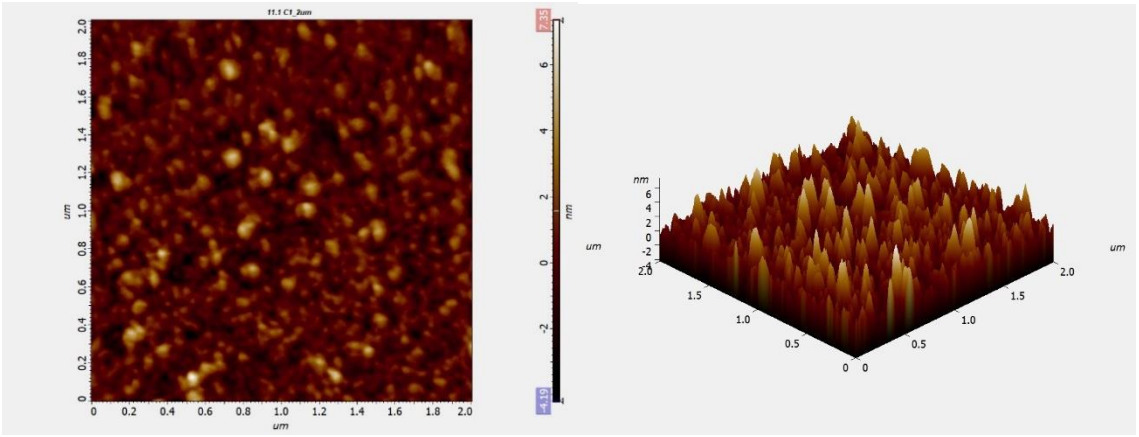


Figure 2.7 AFM 2D and 3D pattern of Co@NC

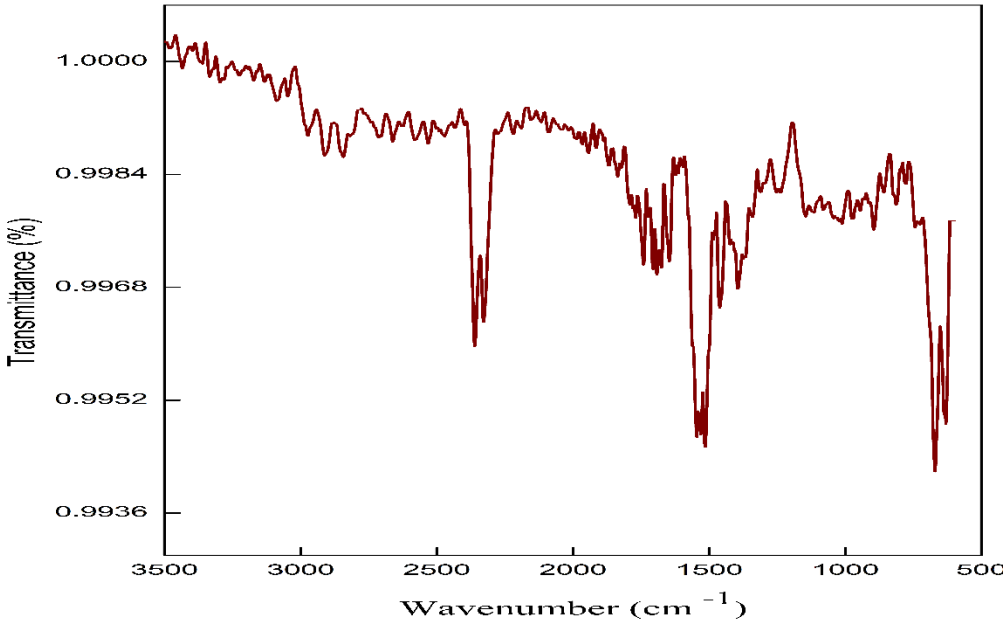


Figure 2.8 FT IR pattern of Co@NC

2.6 Reusability of catalyst

The reusability of the Co@NC nanocatalyst was examined under the optimized reaction conditions of up to five runs (**Figure 2.9**). Due to the magnetic behaviour of the Co@NC nanocatalyst, it was separated after completion of the reaction with the help of external magnet. The catalyst was washed with water followed by methanol (3 × 10mL), and dried at 100 °C and reused in successive reactions up to five times without seeing a noticeable decrease in catalytic activity. The XRD, FT-IR, SEM, EDAX and TEM images of the reused catalyst Co@NC have shown that the reaction conditions do not alter the structure and chemical nature of the catalyst **(Figure 2.10-2.14).**

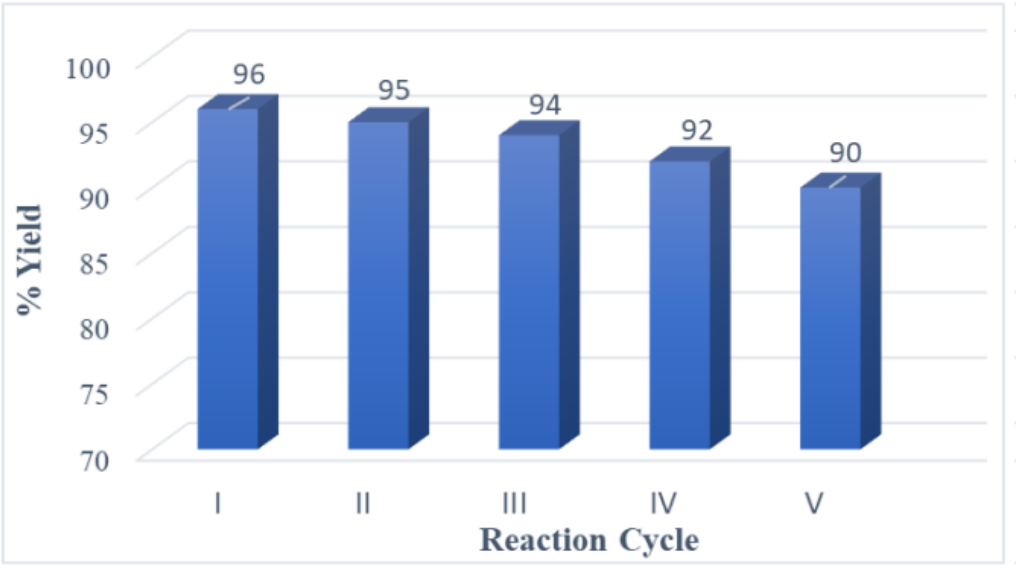


Fig 2.9 Reusability performance of nano Co@NC catalyst.

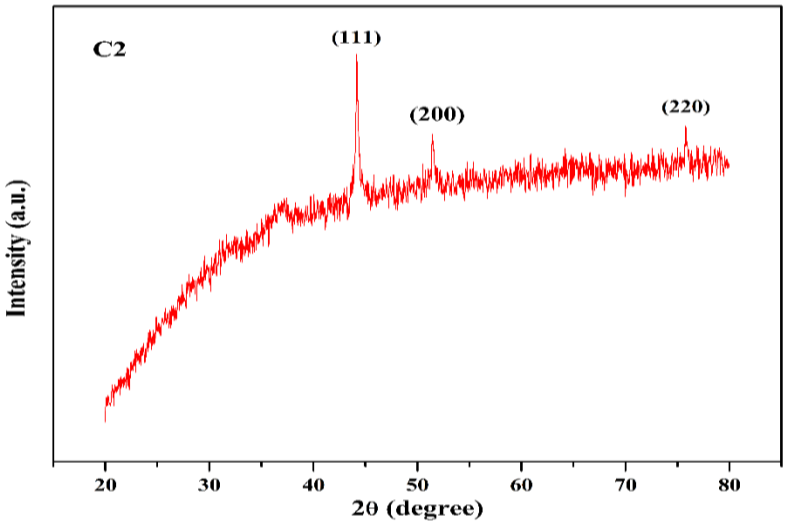


Figure 2.10 XRD pattern of reused Co@NC

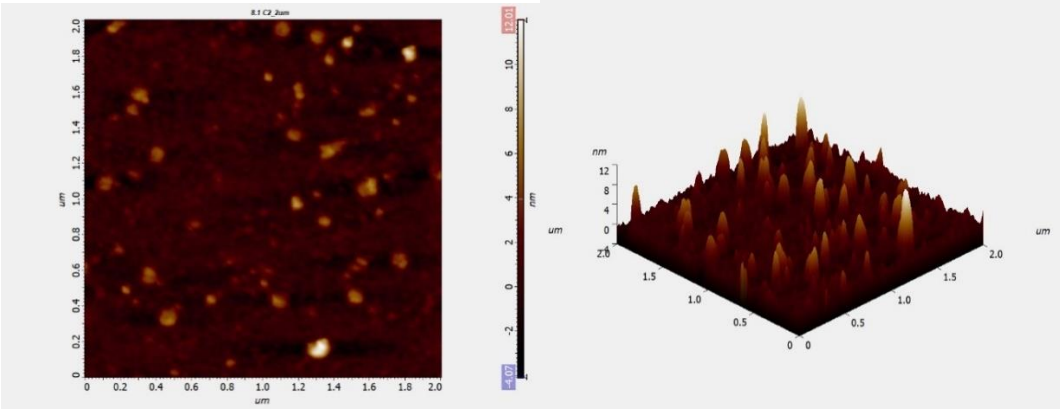


Figure 2.11 AFM pattern of reused Co@NC

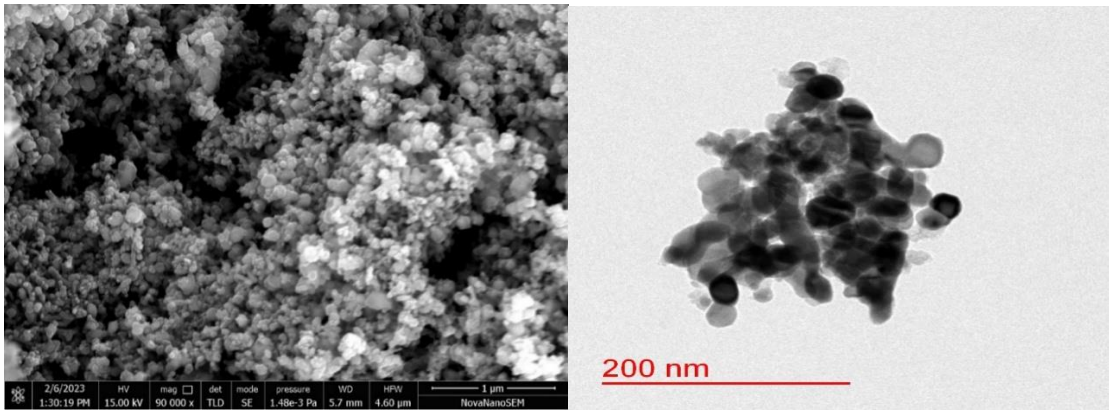


Figure 2.12 SEM pattern of reused Co@NC **Figure 2.13** TEM pattern of reused Co@NC

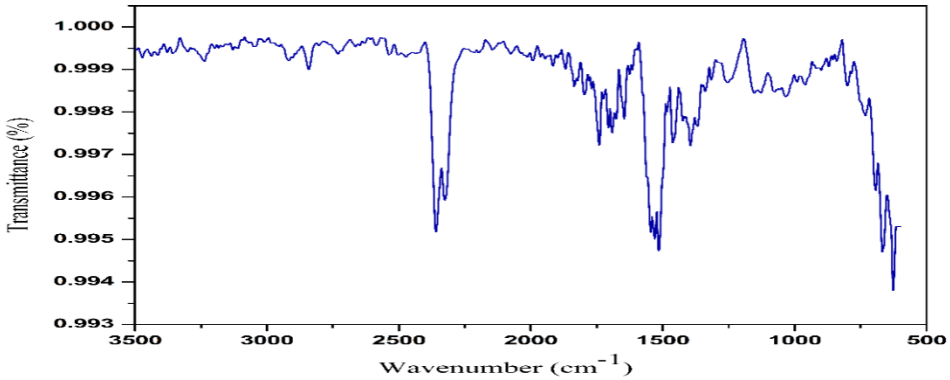


Figure 2.14 FT IR pattern of reused Co@NC

2.7 Experimental Section

2.7.1 General procedure for synthesis of amides. All amides used in the study were synthesized by previously reported methods [56].

2.7.2 General procedure for the Synthesis of *N*-Boc activated secondary amides. *N*-Boc-activated amides were synthesized according to the reported method [17].To an oven-dried round bottom flask, amide (1.0 equiv.), DMAP (0.1 equiv.) and dichloromethane were added, the reaction temperature was maintained at 0 °C to this Boc anhydride (1.5 equiv.) was added dropwise. After the addition of Boc anhydride, the reaction mixture was stirred for 14-24 h at room temperature. The progress of the reaction was monitored with TLC, after the completion of the reaction, mixture was concentrated under reduced pressure and purified by column chromatography and the product was obtained in excellent yield. Following the addition of Boc anhydride, the reaction mixture was stirred for 14-24 hours at room temperature. The reaction progress was tracked using TLC. Upon completion, the mixture was concentrated under reduced pressure and subjected to purification by column chromatography, yielding the product in excellent yield.

2.7.3 General procedure for Co@NC catalyzed transamidation of *N*-Boc activated secondary amides with amines

N-Boc activated amide (1.0 mmol), amine (1.5 mmol) and Co@NC (5 mg) were mixed in a round bottom flask. The mixture was heated at 60°C under solvent-free conditions, and the progress of reaction was monitored by TLC. Upon completion of the reaction, the mixture was diluted with ethyl acetate, and the catalyst was separated using an external magnet.

Subsequently, the solvent was evaporated under vacuum, and the crude product was purified through column chromatography. All the products were confirmed using m.p., ^{1}H, ^{13}C NMR and HRMS spectral data.

2.8 Analytical data

2.8.1 Analytical data of starting materials

***tert*-butyl benzoyl(benzyl)carbamate (1a)** Yield 95%; White solid; m.p. 72 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.51 (d, 2H), 7.47-7.42 (m, 3H), 7.38 (t, 2H), 7.33 (t, 2 H), 7.28- 7.23 (m, 1H), 4.99 (d, 2H), 1.12 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 173.4, 153.1, 138.1, 137.8, 131.2, 128.7, 128.3, 128.2, 127.0, 127.4, 83.2, 48.9 27.46. HRMS (ESI) for $C_{19}H_{21}NO_3$ (m/z) $[M + H]^+$ calcd: 312.1521, found: 312.1511.

***tert*-butyl benzyl(2-methylbenzoyl)carbamate (1b)** Yield 94%; White solid; m.p. 69-71 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.75 (d, 1H), 7.45 (t, 1H), 7.39 (d, 2H), 7.32 (t, 2H), 7.29 (t, 2H), 7.22 (m, 1H), 4.90 (d, 2H), 2.29 (s, 1H), 1.38 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 173.1, 155.4, 138.4, 137.0, 130.7, 130.5, 128.7, 128.5, 128.0, 126.8, 83.4, 41.5 27.9, 20.3; HRMS (ESI) for $C_{20}H_{23}NO_3$ (m/z) $[M + H]^+$ calcd: 326.1678found: 326.1691.

***tert*-butyl benzyl(3-methylbenzoyl)carbamate (1c)** Yield 94%; White solid; m.p. 63 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.95 (s, 1H), 7.60 (d, 1H), 7.37-7.31 (m, 4H), 7 .29 (t, 2H), 7.22 (m, 1H) 1.22 (s, 9H); (t, 1H), 7.29-7.18 (m, 2H), 4.96 (d, 2H), 2.36 (s, 1H,), 1.20 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 173.3, 155.9 139.5, 137.8, 134.9, 131.5, 128.7, 128.6,

128.5, 128.3, 127.0, 80.5, 41.5, 28.5, 21.7; HRMS (ESI) for $C_{20}H_{23}NO_3$ (m/z) $[M + H]^+$ calcd: 326.1678 found: 326.1686.

***tert*-butyl benzyl (4-methylbenzoyl)carbamate (1d)** Yield 88%; White solid; m.p. 58–60 ^oC; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.75 (d, 2H), 7.39 (d, 2H), 7.31 (d, 2H), 7.29-7.21 (m, 3H), 2.41 (s, 3H), 1.28 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 172.8, 155.4, 141.8, 137.2, 133.0, 129.2, 128.7, 128.5, 128.1, 127.4, 81.8, 53.4, 27.5. 21.3; HRMS (ESI) for $C_{20}H_{23}NO_3$ (m/z) $[M + H]^+$ calcd: 326.1678, found: 326.1684

***tert*-butyl benzyl(2-chlorobenzoyl)carbamate (1e)** Yield 88%; White solid; m.p. 65 ^oC **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.56 (dd, 2H), 7.41-7.32 (m, 5H), 7.32-7.23 (m, 2H), 5.01 (s, 2 H), 1.17 (s, 9 H); **^{13}C NMR** (125 MHz, $CDCl_3$); δ 176.3, 154.8, 137.6, 134.9, 131.3, 130.6, 130.2, 130.1, 128.7, 127.8, 127.6, 127.0, 83.08, 47.87, 27.49. HRMS (ESI) for $C_{19}H_{20}ClNO_3$ (m/z) $[M + H]^+$ calcd: 346.1132, found: 346.1151.

***tert*-butyl benzyl(4-chlorobenzoyl)carbamate (1f)** Yield 90%; White solid; m.p. 61 ^oC **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.72 (d, 2H), 7.38 (d, 2H), 7.36–7.26 (m, 5H), 5.01 (s, 2 H), 1.17 (s, 9 H); **^{13}C NMR** (125 MHz, $CDCl_3$); δ 174.3, 153.5, 137.8, 137.7, 132.6, 128.7, 128.3, 127.8, 127.6, 83.08, 47.87, 27.49. HRMS (ESI) for $C_{19}H_{20}ClNO_3$ (m/z) $[M + H]^+$ calcd: 346.1132, found: 346.1144.

***tert*-butyl benzyl(2-nitrobenzoyl)carbamate (1g)** Yield 93%; White solid; m.p. 65–67 ^oC **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.26 (d, 1H), 8.05 (d, 1H), 7.78-7.73 (m, 2H), 7.37 (d, 2H) 7.30 (m, 2H) 7.24 (t, 1H) 5.01 (s, 2 H), 1.17 (s, 9 H); **^{13}C NMR** (125 MHz, $CDCl_3$); δ

174.4, 156.0, 147.6, 137.3, 135.5, 133.2, 131.6, 128.9, 128.5, 127.9, 127.2, 83.08, 47.87, 27.49. HRMS (ESI) for $C_{19}H_{20}N_2O_5$ (m/z) $[M + H]^+$ calcd: 357.1372, found: 357.1356.

***tert*-butyl benzyl(3-nitrobenzoyl)carbamate (1h)** Yield 92%; White solid; m.p. 73 ^oC **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.60 (s, 1H), 8.41 (d, 1H), 8.23 (d, 1H), 7.79-7.71 (m, 1H), 7.39 (d, 2H), 7.28 (t, 2H), 7.37-7.21 (m, 1H), 5.01 (d 2 H), 1.17 (s, 9 H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 173.9, 155.4, 147.7, 138.4, 137.0, 134.3, 129.7, 128.5, 128.0, 125.5, 123.7, 83.08, 47.87, 27.49. HRMS (ESI) for $C_{19}H_{20}N_2O_5$ (m/z) $[M+H]^+$ calcd: 357.1372 found: 357.1366.

***tert*-butyl benzyl(4-nitrobenzoyl)carbamate (1i)** Yield 94%; White solid; m.p. 78-79 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.20 (d, 2H), 7.83 (d, 2H), 7.39-7.27 (m, 5H), 4.93 (s, 2H) 1.18 (s, 9 H); **^{13}C NMR** (125 MHz, $CDCl_3$); δ 172.3, 154.4, 152.5, 142.8, 137.3, 128.8, 128.1, 127.8, 127.7, 126.7, 84.08, 48.93, 27.56. HRMS (ESI) for $C_{19}H_{20}N_2O_5$ (m/z) $[M + H]^+$ calcd: 357.1372 found: 357.1379.

***tert*-butyl benzyl(4-(trifluoromethyl)benzoyl)carbamate (1j)** Yield 95%; White solid; m.p. 79 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.63 (d, 2 H), 7.60 (d, 2 H), 7.39 (d, 2 H), 7.34 (t, 2 H), 7.31-7.26 (m, 1 H), 5.01 (s, 2 H), 1.17 (s, 9 H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 171.86, 153.09, 141.25, 137.62, 128.68, 128.29, 127.75, 127.67, 125.28, 125.22, 84.02, 48.90, 27.52; **^{19}F NMR** (471 MHz, $CDCl_3$); δ 62.89. HRMS (ESI) for $C_{20}H_{20}F_3NO_3$ (m/z) $[M + H]^+$ calcd: 380.1395 found: 380.1383.

***tert*-butyl (4-methoxybenzoyl)(phenyl)carbamate (1k)** Yield 93%; White solid; m.p. 143–145 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.43 (d, 2H), 7.34 (t, 2H), 7.25 (d, 2H), 7.14 (t, 1H), 6.76 (d, 2H), 3.72 (s, 3H), 1.09 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 172.7, 162.1, 153.8, 138.3, 130.0, 129.6, 128.5, 128.3, 127.7, 113.5, 82.8, 55.3, 27.4; HRMS (ESI) for $C_{19}H_{21}NO_4$ (m/z) $[M + H]^+$ calcd: 328.1471 found: 328.1467.

***tert*-butyl (4-fluorobenzoyl) (phenyl)carbamate (1l)** Yield 93%; White solid; m.p. 75 ^{o}C **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.61 (d, 2H), 8.55 (d, 2H), 7.36 (d, 2H), 7.31 (d, 2H), 7.24 (t, 1H), 1.09 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 171.2, 164.75 (d, J = 251.25 Hz), 138.0, 130.52 (d, J = 3.75 Hz), 129.34 (d, J = 8.75 Hz), 128.8, 127.9, 127.7, 115.62 (d, J = 21.25 Hz), 84.3, 27.8; **^{19}F NMR** (471 MHz, $CDCl_3$); δ 63.2; HRMS (ESI) for $C_{18}H_{18}FNO_3$ (m/z) [M + H]+ calcd: 316.1271found: 316.1254.

***tert*-butyl benzoyl(o-tolyl)carbamate (1m)** Yield 94%; White solid; m.p. 70 °C; **^{1}H NMR 500 MHz, $CDCl_3$)**; δ 7.80 (d, 2H), 7.51-7.38 (m, 1H), 7.31 (t, 2H), 7.25 (m, 3H), 7.11 (t, 1H) 2.28 (s, 1H); 1.12 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 169.9, 153.8, 136.9, 134.9, 132.8, 131.3, 129.7, 128.7, 127.4, 126.5, 80.2, 27.8, 18.3; HRMS (ESI) for $C_{19}H_{21}NO_3$ (m/z) $[M + H]^+$ calcd: 312.1521 found: 312.1531.

***tert*-butyl benzoyl(2-chlorophenyl)carbamate (1n)** Yield 94%; White solid; m.p. 68 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.87 (d, 2H), 7.51 (t, 1H), 7.45 (t, 2H), 7.39 (d, 1H), 7.26-7.23 (m, 2H) 7.10 (t, 1H); 1.10 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 170.3, 153.7, 134.9, 133.7, 133.4, 131.6, 131.3 130.4, 128.7 128.1, 127.9, 80.4, 28.9; HRMS (ESI) for $C_{18}H_{18}ClNO_3$ (m/z) $[M + H]^+$ calcd: 332.0975 found: 332.0979.

***tert*-butyl acetyl(phenyl)carbamate (1o)** Yield 90%; White solid; m.p. 58 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.43-7.36 (m, 2H), 7.35 -7.28 (m, 1H), 7.11-7.10 (m, 2H), 2.59 (s, 3H), 1.40 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 172.9, 152.8, 138.9, 128.9, 128.2, 127.8, 83.2, 27.8, 26.3; HRMS (ESI) for $C_{13}H_{17}NO_3$ (m/z) $[M + H]^+$ calcd: 236.1208 found: 236.1211.

***tert*-butyl acetyl(4-bromophenyl)carbamate (1p)** Yield 90%; White solid; m.p. 122 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.54 (d, 2H), 6.99 (d, 2H), 2.61 (s, 3H), 1.41 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 172.8, 152.4, 137.9, 132.2, 129.9, 121.7, 83.6, 27.9, 26.5; HRMS (ESI) for $C_{13}H_{16}BrNO_3$ (m/z) $[M + H]^+$ calcd: 314.0314 found: 314.0308.

***tert*-butyl acetyl(4-fluorophenyl)carbamate (1q)** Yield 91%; White solid; m.p. 116 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.81 (d, 2H), 7.09 (d, 2H), 2.73 (s, 3H), 1.52 (s, 9H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 173.8, 152.7, 138.0, 132.1, 129.7, 121.7, 83.9, 28.2, 26.5; HRMS (ESI) for $C_{13}H_{16}FNO_3$ (m/z) $[M + H]^+$ calcd: 254.1114 found: 254.1118.

***tert*-butyl isobutyryl(phenyl)carbamate (1r)** Yield 88%; Yellow oil; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.33-7.28 (t, 2H), 7.25-7.21 (d, 1H) 7.03-6.98 (m, 2H), 3.57-3.54 (m, 1H), 1.32 (s, 9H), 1.15 (d, 6H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 180.3, 152.7, 139.8, 128.7, 128.4, 128.3, 127.4, 82.8, 34.8, 34.7, 27.9, 19.6; HRMS (ESI) for $C_{15}H_{21}NO_3$ (m/z) $[M + H]^+$ calcd: 264.1521 found: 264.1513.

***tert*-butyl phenyl(pivaloyl)carbamate (1s)** Yield 89%; White solid; (m.p. 88 °C; ^{1}H NMR (500 MHz, $CDCl_3$); δ 7.36 (t, 2H), 7.28 (d, 2H), 7.11 (t, 1H), 1.49 (s, 9H), 1.31 (s, 9H); ^{13}C

NMR (126 MHz, $CDCl_3$); δ 177.8, 152.8, 133.6, 127.9, 127.4, 127.2, 80.2, 40.4, 27.8; HRMS (ESI) for $C_{16}H_{23}NO_3$ (m/z) $[M + H]^+$ calcd: 278.1678 found: 278.1651.

2.8.2 Analytical data of transamidation products

morpholino(phenyl)methanone (3a) Yield 94%; Yellow solid; m.p.73–75 ^oC; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.41-7.42 (m, 5H), 3.78-3.46 (m, 8H), **^{13}C NMR** (126 MHz, $CDCl_3$); δ 170.4, 135.5, 129.7, 128.4, 127.3, 66.7, 48.5, 42.4; HRMS (ESI) for $C_{11}H_{13}NO_2$ (m/z) $[M + H]^+$ calcd: 192.0946 found: 192.0940.

***N*-phenylbenzamide (3b)** Yield 94%; White solid; m.p. 164 ^oC; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.90 (d, 3H), 7.68 (d, 2H), 7.56 (t, 1H), 7.40 (t, 2H), 7.19 (t, 2H), 7.16 (t, 1H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.9, 137.8, 135.0, 131.8, 129.2, 128.8, 127.1, 124.5, 120.4; HRMS (ESI) for $C_{13}H_{11}NO$ (m/z) $[M + H]^+$ calcd: 198.0841 found: 198.0853.

***N*-(2-methoxyphenyl)benzamide (3c)** Yield 88%; White solid; m.p. 60 ^oC; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.51 (d, 2H), 7.95 (m, 2H), 7.51 –7.53 (m, 3H), 7.55 (m, 2H), 6.90 (s, 1H), 3.95 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$); δ 165.1, 148.2, 135.8, 131.1, 129.3, 128.2, 127.5, 124.7, 121.8, 121.6, 120.4, 110.3, 56.5; HRMS (ESI) for $C_{14}H_{13}NO_2$ (m/z) $[M + H]^+$ calcd: 228.0946 found: 228.0935.

***N*-(3-methoxyphenyl)benzamide (3d)** Yield 94%; White solid; m.p. 108 ^oC; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 7.67 (d, 2H), 7.35 (s, 1H), 7.62 (d, 2H), 7.33–7.32 (m, 3H), 7.21 – 7.18 (m, 1H), 7.11 (m, 1H), 6.95 (d, 1H), 6.71–6.70 (m, 1H), 3.82 (s, 3H); **^{13}C NMR** (126

MHz, DMSO-d_6): δ 165.7, 156.9, 138.5, 135.1, 131.4, 129.5, 128.2, 127.6, 112.3, 110.1, 105.3, 55.6; HRMS (ESI) for $C_{14}H_{13}NO_2$ (m/z) $[M + H]^+$ calcd: 228.0946 found: 228.0955.

***N*-(4-methoxyphenyl)benzamide (3e)** Yield 94%; Green solid; m.p. 153–154 ^oC; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.85 (m, 3H), 7.51 (m, 3H), 7.51–7.45 (m, 2H), 6.23 (d, 2H), 3.89 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.2, 135.5, 131.6, 131.1, 128.8, 127.2, 122.3, 114.5, 99.9, 55.6; HRMS (ESI) for $C_{14}H_{13}NO_2$ (m/z) $[M + H]^+$ calcd: 228.0946 found: 228.0934.

***N*-(2-nitrophenyl)benzamide (3f)** Yield 84%; White solid; m.p. 96 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.59 (d, 1H), 8.44 (s, 1H), 7.96 (d, 2H), 7.61–7.57 (t, 1H), 7.56–7.52 (t, 2H), 7.44 (dd, 1H), 7.33–7.21 (m, 1H), 7.07–7.05 (m, 1H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 165.5, 135.1, 134.2, 132.6, 129.2, 129.4, 128.3, 127.4, 125.1, 123.9, 121.7; HRMS (ESI) for $C_{13}H_{10}N_2O_3$ (m/z) $[M + H]^+$ calcd: 243.0691 found: 243.0689.

***N*-(3-nitrophenyl)benzamide (3g)** Yield 86%; Yellow oil; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 11.09 (s, 1H), 8.77 (s, 1H), 8.60–8.59 (m, 1H), 8.45–8.44 (m, 1H), 8.38-8.37 (s, 2H), 8.30-8.27 (m, 1H), 8.17-8.14 (m, 1H), 8.12-8.09 (m, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.5, 148.9, 138.3, 134.8, 132.4, 129.2, 129.1, 128.0, 127.2, 121.7, 116.5. HRMS (ESI) for $C_{13}H_{10}N_2O_3$ (m/z) $[M + H]^+$ calcd: 243.0691 found: 243.0685.

***N*-(4-nitrophenyl)benzamide (3h)** Yield 86%; White solid; m.p. 194 ^oC; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 10.83 (s, 1H), 8.21 (d, 2H), 8.02 (d, 2H), 7.61–7.66 (m, 1H), 8.01 (d, 2H), 7.57–7.55(m, 2H); **^{13}C NMR** (126 MHz, DMSO-d_6); δ 166.1, 145.2, 142.8, 134.5,

132.6, 128.9, 128.2, 125.1, 120.2; HRMS (ESI) for $C_{13}H_{10}N_2O_3$ (m/z) $[M + H]^+$ calcd: 243.0691 found: 243.0688.

***N*-(4-fluorophenyl)benzamide (3i)** Yield 84%; White solid m.p. 184–186 °C; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 10.34 (s, 1H), 8.0107.84 (d, 2H), 7.81 (d, 2H), 7.62 (m, 1H), 7.63 (d, 2H), 7.57–7.21 (m, 2H); **^{13}C NMR** (126 MHz, DMSO-d_6); δ 165.7, 159.8 (d, J = 240.6 Hz), 135.9, 135.3 (d, J = 6.3 Hz), 131.8, 128.6, 127.1, 122.4 (d, J = 7.6 Hz), 115.3 (d, J = 22.7 Hz); **^{19}F NMR** (471 MHz, $CDCl_3$): δ - 117.9; HRMS (ESI) for $C_{13}H_{10}FNO$ (m/z) $[M + H]^+$ calcd: 216.0746 found: 216.0736.

phenyl(piperidin-1-yl)methanone (3j) Yield 94%; White solid; m.p. 49 °C; **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.42–7.30 (m, 5H), 3.77 (s, 2H), 3.38 (s, 2H), 1.73 (s, 2H), 1.74 (s, 2H), 1.57 (s, 2H); **^{13}C NMR** (126 MHz, $CDCl_3$): δ 170.6, 135.8, 129.7, 128.4, 127.1, 48.9, 43.3, 24.8; HRMS (ESI) for $C_{12}H_{15}NO$ (m/z) $[M + H]^+$ calcd: 190.1154 found: 190.1144.

piperazine-1,4-diylbis(phenylmethanone) (3k) Yield 93%; White solid; m.p. 194–95 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.42 (s, 10 H), 3.64 (d, 8 H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 170.81, 135.25, 130.25, 128.79, 127.19, 47.64, 42.51. HRMS (ESI) for $C_{18}H_{18}N_2O_2$ (m/z) $[M + H]^+$ calcd: 295.1368 found: 295.1385.

***N*-methylbenzamide (3l)** Yield 94%; Yellow solid; m.p. 81–82 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.75-7.71 (m, 2H), 7.49-7.33 (m, 1H), 7.35-7.25 (m, 2H), 6.40 (s, 1H), 2.98-2.95 (m, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 168.1, 134.5, 131.6, 128.2, 127.3, 27.2; HRMS (ESI) for C_8H_9NO (m/z) $[M + H]^+$ calcd: 136.0684 found: 136.0675.

***N*-butylbenzamide (3m)** Yield 94%; Yellow oil; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.79-7.73 (m, 2H), 7.51-7.45 (m, 1H), 7.42 (t, 2H), 6.13 (s, 1H), 3.46 (q, 2H), 1.64-1.52 (m, 2H), 1.48-1.36 (m, 2H), 0.96 (t, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.6, 135.01, 131.41, 130.62, 129.03, 128.18, 126.93, 39.94, 31.89, 20.32, 13.93. HRMS (ESI) for $C_{11}H_{15}NO$ (m/z) $[M + H]^+$ calcd: 178.1154 found:178.1165.

***N, N*-dioctylbenzamide (3n)** Yield 85%; Dark brown oil; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.33–7.30 (m, 5H), 3.45 (s, 2H), 3.15 (s, 2H), 1.47-1.10 (m, 22H), 0.89 (bs, 8H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 171.7, 137.5, 129.1, 128.4, 126.5, 49.1, 44.8, 31.9, 29.4, 29.2, 27.6, 27.2, 26.6, 22.7, 19.3, 14.2. HRMS (ESI) for $C_{23}H_{39}NO$ (m/z) $[M + H]^+$ calcd: 346.3032 found: 346.3025.

***N*-(tert-butyl)benzamide (3o)** Yield 82%; White solid; m.p. 134-135 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.71 (dd, 2H), 7.52-7.41 (m, 1H), 7.43 (t, 2 H), 5.98 (s, 1H), 1.44 (s, 9 H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.03, 136.06, 131.22, 128.66, 126.81, 51.75, 29.03. HRMS (ESI) for $C_{11}H_{15}NO$ (m/z) $[M + H]^+$ calcd: 178.1154, found: 178.1165.

***N*-(3s,5s,7s)-adamantan-1-yl)benzamide (3p)** Yield 81%; White solid; m.p. 141–142 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.72-7.70 (m, 2H), 7.51-7.42 (m, 1H), 7.43–7.22 (t, 2H), 5.80 (s, 1H), 2.11 (s, 9H), 1.70 (d, 6H); **^{13}C NMR** (125 MHz, $CDCl_3$); δ 166.8, 162.5, 136.4, 134.9, 131.4, 130.6, 129.2, 129.4, 128.9, 126.6, 52.3, 41.1, 36.7, 29.8; HRMS (ESI) for $C_{17}H_{21}NO$ (m/z) $[M + H]^+$ calcd: 256.1623 found: 256.1634

***N*-(2,6-dichlorophenyl)benzamide (3q)** Yield 85%; White solid; m.p. 115-117 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.90 (d, 2H), 7.49 (t, 1H), 7.46 (t, 2H), 7.27 (d, 2H), 7.20 (s, 1H), 7.02 (t, 1H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.5, 139.9, 134.8, 131.6, 131.0, 129.4, 128.8, 128.5, 128.2 HRMS (ESI) for $C_{13}H_9Cl_2NO$ (m/z) $[M + H]^+$ calcd: 266.0061 found: 266.0043.

***N*-(2-ethyl-6-methylphenyl)benzamide (3r)** Yield 86%; White solid; mp, 167–168 0C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.91 (d, 2H), 7.54 (t, 1H), 7.57 (t, 2H), 7.44 (s, 1H), 7.11–7.04 (m, 3H), 2.30 (s, 3H); 2.73 (q, 2H), 1.29 (t, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.0, 135.7, 134.6, 133.9, 131.97, 128.9, 128.4, 127.6, 127.3, 18.6. HRMS (ESI) for $C_{16}H_{17}NO$ (m/z) $[M + H]^+$ calcd: 240.1310 found: 240.1325.

***N*-(3-hydroxypyridin-2-yl)benzamide (3s)** Yield 86%; White solid; m.p. 93–96 °C; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 7.95 (d, 1H), 7.73 (d, 2H), 7.42-7.31 (m, 1H), 7.28 (m, 2H,), 7.29 (s, 1H), 7.22 (d, 1H), 7.23 (m, 1H,) 4.51 (s, 1H,); **^{13}C NMR** (126 MHz, DMSO-d_6); δ 168.8, 146.5, 143.1, 138.4, 134.6, 131.7, 129.2, 129.5, 124.7, 120.2; HRMS (ESI) for $C_{12}H_{10}N_2O_2$ (m/z) $[M+H]^+$ calcd: 215.0742 found: 215.0748.

***N*-(4-methylpyridin-2-yl)benzamide(3t)** Yield 90%; White solid; m.p. 114–115 ^{o}C; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 8.11 (d, 1H), 7.73 (d, 2H), 7.67 (s, 1H), 7.64–7.52 (m, 1H), 7.30–7.25 (m, 2H), 7.27 (s, 1H), 7.01 (s, 1H), 2.35 (s, 3H); **^{13}C NMR** (126 MHz, DMSO-d_6): δ 165.4, 152.1, 152.3, 148.5, 133.1, 131.7, 129.4, 128.7, 127.2, 120.4, 19.3; HRMS (ESI) for $C_{13}H_{12}N_2O$ (m/z) $[M + H]^+$ calcd: 213.0945 found: 213.0938.

2-methyl-*N*-phenylbenzamide (4a) Yield 87%; Yellow solid; m.p. 126 - 127 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.53 (d,, 2H), 7.42 (s, 1H), 7.39 (d, 1H), 7.30 – 7.27 (m, 3H), 7.19 – 7.15 (m, 2H), 7.08 (t, 1H), 2.42 (s, 3H); **^{13}C NMR** (126 MHz, CDCl3); δ 168.1, 138.0, 136.4, 131.3, 130.3, 129.1, 126.6, 125.9, 124.6, 119.9, 19.8; HRMS (ESI) for $C_{14}H_{13}NO$ (m/z) $[M+H]^+$ calcd: 212.0997 found: 212.0975.

3-methyl-*N*-phenylbenzamide (4b) Yield 91%; White solid; m.p. 128–129 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.85 (s, 1H), 7.63 (s, 1H), 7.57 – 7.56 (m, 3H), 7.30 – 7.27 (m, 4H), 7.07 (t, 1H), 2.34 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.2, 138.4, 138.1, 135.3, 132.6, 129.1, 128.4, 127.8, 124.2, 124.3, 120.7, 21.4; HRMS (ESI) for $C_{14}H_{13}NO$ (m/z) $[M+H]^+$ calcd: 212.0997 found: 212.0984.

4-methyl-*N*-phenylbenzamide (4c) Yield 90%; White solid. M.p. 145 - 146 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.70 (d, 2H), 7.57 (d, 2H), 7.43 (s, 1H), 7.30 (t, 2H), 7.23 (d, 2H), 7.08 (t, 1H), 2.34 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.4, 142.4, 138.2, 132.5, 129.3, 128.9, 127.0, 124.6, 120.1, 21.5; HRMS (ESI) for $C_{14}H_{13}NO$ (m/z) $[M+H]^+$ calcd:212.0997 found: 212.0974.

2-chloro-*N*-phenylbenzamide (4d) Yield 90%; Yellow solid; m.p. 72–74^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.87 (d, 1H), 7.56 (s, 1H), 7.46 (d, 1H), 7.42 (t, 1H), 7.36-7.32 (m, 3H), 7.16 (t, 1H), **^{13}C NMR** (126 MHz, $CDCl_3$); δ 169.9, 136.7, 134.1, 134.0, 132.0, 130.6, 129.3, 127.3, 127.0, 124.5, 121.3 HRMS (ESI) for $C_{13}H_{10}ClNO$ (m/z) $[M+H]^+$ calcd:232.0451 found: 232.0455.

4-chloro-*N*-phenylbenzamide (4e) Yield 94%; Yellow solid; m.p. 165 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.82 (d, 2H), 7.57-7.51 (m, 5H), 7.36 (t, 2H), 7.15 (t, 1H), **^{13}C NMR** (126 MHz, $CDCl_3$); δ 170.6, 137.1, 136.8, 135.3, 129.0, 128.8, 128.2, 124.9, 122.4; HRMS (ESI) for $C_{13}H_{10}ClNO$ (m/z) $[M+H]^+$ calcd: 232.0451 found: 232.0467.

2-nitro-*N*-phenylbenzamide (4f) Yield 90%; Yellow solid; m.p. 137 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.93 (d, 1H), 7.73 (s, 1H), 7.62 (d, 1H), 7.49 (t, 1H), 7.41-7.37 (m, 3H), 7.21(t, 1H), **^{13}C NMR** (126 MHz, $CDCl_3$); δ 172.2, 139.4, 135.1, 134.7, 133.1, 130.3, 129.6, 127.8, 127.1, 124.6, 122.1; HRMS (ESI) for $C_{13}H_{10}N_2O_3$ (m/z) $[M+H]^+$ calcd: 243.0691, found: 243.0675.

3-nitro-*N*-phenylbenzamide (4g) Yield 92%; Yellow solid; m.p. 72–74 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.86 (s, 1H), 8.32 (d, 1H), 8.20 (d, 1H), 7.72 (t, 1H), 7.49 (s, 1H), 7.45 (d, 2H), 7.32 (d, 2H), 7.12 (t, 1H), **^{13}C NMR** (126 MHz, $CDCl_3$); δ 169.6, 147.1, 138.8, 137.7, 136.2, 129.9, 129.3, 127.0, 124.9, 124.1, 122.4; HRMS (ESI) for $C_{13}H_{10}N_2O_3$ (m/z) $[M+H]^+$ calcd: 243.0691, found: 243.0695.

4-nitro-*N*-phenylbenzamide (4h) Yield 94%; Yellow solid; m.p. 144-146 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.42 (d, 2H), 8.16 (d, 2H), 7.46 (s, 1H), 7.42 (d, 2H), 7.33 (t, 2H), 7.14 (t, 1H), **^{13}C NMR** (126 MHz, $CDCl_3$); δ 173.3, 139.2, 138.8, 136.3, 130.0, 128.9, 128.2, 125.6, 122.7; HRMS (ESI) for $C_{13}H_{10}N_2O_3$ (m/z) $[M+H]^+$ calcd:243.0691, found: 243.0685.

***N*-phenyl-4-(trifluoromethyl)benzamide (4i)** Yield 94%; White solid. M.p. 207 - 208 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 10.42 (s, 1H), 8.16 (d, 2H), 7.91 (d, , 2H), 7.78 – 7.75 (m, 2H), 7.38 – 7.35 (m, 2H), 7.14 (t, 1H); **^{13}C NMR** (126 MHz, DMSO-d_6); δ 164.7, 139.6, 139.1, 131.8 (d, *J* C-F = 32.8 Hz), 129.3, 129.1, 125.8 (q, *J* C-F = 3.8 Hz), 125.5 (q, *J* C-F = 273.4 Hz), 124.5, 120.6 HRMS (ESI) for $C_{14}H_{10}F_3NO$ (m/z) $[M+H]^+$ calcd: 266.0714, found: 266.0725.

4-methoxy-*N*-phenylbenzamide (4j) Yield 88%; White solid. M.p. 168 - 170 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.83 (d, 2H), 7.67 (s, 1H), 7.43 (d, 2H), 7.37 (t, 2H), 7.13 (t, 1H), 7.03 (d, 2H), 3.73 (s, 3H), **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.2, 162.7, 138.1, 129.1, 128.9, 127.1, 124.2, 120.5, 114.2, 55.3; HRMS (ESI) for $C_{14}H_{13}NO_2$ (m/z) $[M+H]^+$ calcd: 228.0946, found: 228.0965.

4-fluoro-*N*-phenylbenzamide (4k) Yield 93%; White solid. M.p. 187 - 188 ^{o}C.; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.82 (d, 2H), 7.72 (s, 1H), 7.55 (d, 2H), 7.31 (d, 2H), 7.10 (t, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.1 (d, *J* C-F = 253.3 Hz), 164.9, 137.9, 131.3 (d, *J*C-F = 3.8 Hz), 129.6 (d, *J*C-F = 8.8 Hz), 129.3, 125.2, 120.5, 116.3 (d, *J*C-F = 22.7 Hz); HRMS (ESI) for $C_{13}H_{10}FNO$ (m/z) $[M+H]^+$ calcd: 216.0746, found: 216.0755.

***N*-phenylacetamide (4l)** Yield 90%; White solid; (m.p. 58 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.44 (d, 2H), 7.35 (t, 2H), 7.13 (t, 1H), 6.47 (s, 1H), 2.23 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 170.8, 138.1, 129.5, 122.9, 120.8, 83.7, 23.6; HRMS (ESI) for C8H9NO (m/z) $[M + H]^+$ calcd: 136.0684, found: 136.0661.

***N*-phenylisobutyramide (4m)** Yield 88%; Yellow solid; m.p. 74 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.49 (d, 2H), 7.37 (t, 2H), 7.17 (t, 1H), 6.42 (s, 1H), 2.93 (q, 1H), 1.30 (d, 6H), **^{13}C NMR** (126 MHz, $CDCl_3$); δ 174.3, 137.1, 129.8, 124.3, 121.9, 34.1, 19.3; HRMS (ESI) for $C_{10}H_{13}NO$ (m/z) $[M+H]^+$ calcd: 164.0997, found: 164.0985.

***N*-phenylpivalamide (4n)** Yield 93%; Yellow solid; m.p. 169–171 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.01 (s, 1H), 7.86 (d, 1H), 7.77 (d, 1H), 7.66–7.69 (m, 3H), 7.62–7.55 (m, 2H), 7.42–7.31 (m, 2H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 173.1, 142.3, 133.7, 133.9, 129.5, 129.1, 128.4, 127.3, 120.2; HRMS (ESI) for $C_{14}H_{10}N_2O$ (m/z) $[M+H]^+$ calcd: 223.0793, found: 223.0796.

***N*-(4-cynophenyl)benzamide (5a)** Yield 93%; Yellow solid; m.p. 169–171 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.01 (s, 1H), 7.86 (d, 1H), 7.77 (d, 1H), 7.66–7.69 (m, 3H), 7.62–7.55 (m, 2H), 7.42–7.31 (m, 2H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 173.1, 142.3, 133.7, 133.9, 129.5, 129.1, 128.4, 127.3, 120.2; HRMS (ESI) for $C_{14}H_{10}N_2O$ (m/z) $[M+H]^+$ calcd: 223.0793, found: 223.0796.

***N*-cyclohexylbenzamide (5b)** Yield 92%; White Solid; m.p. 153–155 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.76–7.70 (m, 2H), 7.45–7.41 (m, 1H), 7.44–7.23 (d, 2H), 5.80 (s, 1H), 4.02–3.96 (d, 1H), 2.09–2.04 (m, 2H), 1.77–1.71 (m, 2H), 1.66–1.61 (m, 1H), 1.41–1.38 (m, 2H), 1.38–1.25 (m, 2H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.8, 135.3, 131.5, 128.7, 127.2, 49.1, 33.4, 25.9, 25.1. HRMS (ESI) for $C_{13}H_{17}NO$ (m/z) $[M + H]^+$ calcd: 204.1310, found: 204.1307.

(2-chlorophenyl)(morpholino)methanone (5c) Yield 94%; White solid; m.p. 73 ^{o}C; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 7.77 (d, 1H), 7.46 (d, 1H), 7.42 (t, 1H), 7.32 (t, 1H), 3.74 (t, 4H), 3.63 (t, 2H), 3.52 (t, 2H); **^{13}C NMR** (126 MHz, DMSO-d_6); δ 172.1, 135.6, 133.4, 130.5, 128.9, 127.3, 126.8, 66.1, 45.0; HRMS (ESI) for $C_{11}H_{12}ClNO_2$ (m/z) $[M + H]^+$ calcd:226.0557, found: 226.0530.

***N*-methyl-3-nitrobenzamide (5d)** Yield 94%; White solid; m.p. 178-180 ^{o}C; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 8.97 (s, 1H), 8.36 (d, 1H), 8.27 (d, 1H), 7.70 (t, 1H), 6.40 (s, 1H), 2.89 (s, 3H); **^{13}C NMR** (126 MHz, DMSO-d_6); δ 168.3, 147.1, 138.2, 133.6, 129.9, 125.4, 123.4, 26.3; HRMS (ESI) for $C_{14}H_{13}NO$ (m/z) $[M + H]^+$ calcd: 212.0997, found: 212.0998.

morpholino(p-tolyl)methanone (5e) Yield 88%; White solid; m.p. 76 ^{o}C; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 7.76 (d, 2H), 7.33 (d, 2H), 3.71 (t, 4H), 3.65 (t, 2H), 3.53 (t, 1H), 2.35 (s, 3H); **^{13}C NMR** (126 MHz, DMSO-d_6); δ 169.3, 140.2, 134.2, 129.3, 127.3, 66.2, 43.3, 21.6; HRMS (ESI) for $C_{12}H_{15}NO_2$ (m/z) $[M + H]^+$ calcd: 206.1103, found: 206.1117.

4-methoxy-*N*-(4-nitrophenyl)benzamide (5f) Yield 86%; Yellow solid; m.p. 183–184 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.23 (d, 1H), 8.11 (s, 1H), 8.12–8.03 (m, 2H), 7.89–7.80 (m, 2H), 7.01–6.93 (m, 2H), 6.63 (d, 1 H), 3.85 (s, 3 H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 164.8, 163.2, 152.6, 144.2, 132.9, 129.3, 126.5, 125.3, 119.5, 114.3, 114.3, 113.5, 77.4, 77.2, 76.9, 55.7. HRMS (ESI) for $C_{14}H_{12}N_2O_4$ (m/z) $[M + H]^+$ calcd: 273.0797, found: 273.0777.

4-chloro-*N*-(4-nitrophenyl)benzamide (5g) Yield 89%; Yellow solid; m.p 272–274 ºC; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 11.09 (s, 1H), 8.41–8.39 (m, 2H), 8.32–8.23 (m, 2H), 8.26 (d, 2H), 8.08 (d, 2H); **^{13}C NMR** (126 MHz, DMSO-d_6); δ 164.78, 149.45, 144.92, 142.81, 139.85, 129.48, 124.83, 123.68, 120.01 HRMS (ESI) for $C_{13}H_9ClN_2O_3$ (m/z) $[M + H]^+$ calcd:277.0302, found: 277.0312.

***N*-(2-chlorophenyl)-4-fluorobenzamide (5h)** Yield 87%; white solid; m.p. 127 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.18 (s, 1H), 7.85 (d, 2H), 7.53 (d, 1H), 7.36 (d, 1H), 7.25 (t, 1H), 6.17 (d, 2H), 7.04 (t, 1H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.6, 165.3, 134.8, 130.8, 130.4, 130.0, 128.2, 127.8, 127.3, 126.4, 114.8; HRMS (ESI) for $C_{13}H_9ClFNO$ (m/z) $[M + H]^+$ calcd: 250.0357, found: 250.0334.

***N*-(4-methoxyphenyl)-4-nitrobenzamide (5i)** yield 95% Green solid; mp 196–97 0C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.33 (d, 2 H), 8.07 (d, 2 H), 7.75 (s, 1 H), 7.49 (d, 2 H), 6.97 (d, 2 H), 3.91 (s, 3 H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 169.2, 157.33, 150.3, 140.76, 130.35, 128.35, 124.16, 122.45, 114.55, 55.68; HRMS (ESI) for $C_{14}H_{12}N_2O4$ (m/z) $[M + H]^+$ calcd: 273.0798, found: 273.0784.

***N*-methyl-4-nitrobenzamide (5j)** Yield 94%; White solid; m.p. 217–219 °C; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 8.37 (d, 2H), 8.01 (d, 2H), 6.23 (s, 1H), 2.84 (s, 3H,); **^{13}C NMR** (126 MHz, DMSO-d_6); δ 168.9, 147.5, 139.9, 128.2, 124.1, 26.4; HRMS (ESI) for $C_8H_8N_2O_3$ (m/z) $[M + H]^+$ calcd: 181.0535, found: 181.0558.

***N*-cyclohexyl-4-(trifluoromethyl)benzamide (5k)** yield 94%; White solid; m.p. 182-183 °C; **^{1}H NMR** (500 MHz,$CDCl_3$); δ 7.87 (d, 2 H), 7.68 (d, 2 H), 6.06 (s, 1 H), 4.28 – 3.87 (m, 1 H), 2.06 (d, 2 H), 1.73 (dd, 2 H), 1.42 (dd, 2 H), 1.32 – 1.15 (m, 3 H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.5, 138.4, 127.7, 125.7 (q, *J C-F* = 3.6 Hz), 49.1, 33.0, 25.5, 25.2; 19F NMR (471 MHz, CDCl3) δ -65.7. HRMS (ESI) for $C_{14}H_{16}F_3NO$ (m/z) $[M + H]^+$ calcd: 272.1184, found: 272.1164.

***N*-methyl-N-phenyl-4-(trifluoromethyl)benzamide (5l)** Yield 90%; Yellow solid; m.p. 72-73 °C; **^{1}H NMR** (500 MHz, $CDCl_{3;}$) δ 7.35 (q, 4H), 7.25–7.06 (m, 3H), 6.97 (d, 2H), 3.46 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 169.38, 144.35, 139.45, 129.59, 129.11, 127.19, 127.04, 124.88 (q, JCF = 3.6 Hz), 38.47; HRMS (ESI) for $C_{15}H_{12}F_3NO$ (m/z) $[M + H]^+$ calcd: 280.0871, found: 280.0854.

***N*-benzylacetamide (6a)** Yield 90%; White solid; m.p. 61-62 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.34–7.17 (m, 5H), 6.26 (s, 1H), 4.30 (d, 2H), 1.80 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 170.21, 138.35, 128.60, 127.88, 127.68, 43.77, 23.11; HRMS (ESI) for $C_9H_{11}NO$ (m/z) $[M + H]^+$ calcd: 150.0841, found: 150.0834.

1-(piperidin-1-yl)ethan-1-one (6b) Yield 93%; Colour less liquid; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 3.73 (t, 2H), 3.28 (t, 2H), 2.06 (s, 3H), 1.78 (q, 4H), 1.78 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$); δ 170.1, 44.6, 26.8, 23.7, 21.3; **HRMS** (ESI) for $C_7H_{13}NO$ (m/z) $[M + H]^+$ calcd: 128.0997, found: 128.0991.

1-morpholinoethan-1-one (6c) Yield 92%; Colour less liquid; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 3.76 (t, 4H,), 3.70 (t, 2H), 3.50 (m, 2H), 2.09 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$); δ 170.1, 67.4, 45.6, 21.4; HRMS (ESI) for $C_6H_{11}NO_2$ (m/z) $[M + H]^+$ calcd:130.0790, found: 130.0781.

***N*-(2-methylphenyl)acetamide (6d)** Yield 90%; White solid; m.p. 136 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.60 (d, 1H), 7.25 – 7.23 (m, 2H), 7.07 (t, 1H), 4.66 (d, 2H), 6.13 (s, 2H); 2.36 (1, 3H), 2.26 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 170.7, 137.7, 132.2, 130.1, 127.8, 124.1, 122.5, 23.7, 17.5; HRMS (ESI) for $C_9H_{11}NO$ (m/z) $[M + H]^+$ calcd6:150.0841, found: 150.0818.

***N*-(4-methylphenyl)acetamide (6e)** Yield 92%; Yellow liquid; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.46 (d, 2H), 7.25 (d, 2H), 6.47 (s, 1H), 2.36 (s, 3H), 2.17 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 170.3, 136.5, 132.4, 129.9, 118.8, 24.2, 21.6; HRMS (ESI) for $C_9H_{11}NO$ (m/z) $[M + H]^+$ calcd: 150.0841, found: 150.0832.

***N*-(2-bromophenyl)acetamide (6f)** Yield 86%; White solid; m.p. 85–87 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.27 (d, 1H), 7.56 (s, 1H, NH), 7.30 (d, 1H), 7.26 (m, 1H), 7.20–6.19 (m, 1H), 2.16 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 168.9, 134.3, 129.7, 127.8, 124.9, 122.5, 121.3, 25.1; HRMS (ESI) for C_8H_8BrNO (m/z) $[M + H]^+$ calcd:213.9789, found: 213.9785

***N*-(3-bromophenyl)acetamide (6g)** Yield 89%; White solid; m.p. 85 ^{o}C; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 7.61 (d, 1H), 7.57 (s, 1H), 7.25 (d, 1H), 7.24 (t, 1H), 6.49 (s, 1H), 2.29

(s, 1H); NMR (126 MHz, DMSO-d_6); δ 170.6, 140.1, 130.8, 137.3, 122.4, 121.3, 119.7, 23.9; HRMS (ESI) for C_8H_8BrNO (m/z) $[M+H]^+$ calcd: 213.9789, found: 213.9785.

***N*-benzylisobutyramide (6h)** Yield 89%; White solid; m.p. 91-92 °C; **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.59 (d, 2H), 7.42–7.29 (m, 3H), 7.17 (t, 1H), 2.61–2.45 (m, 1H), 1.28 (d, 6H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 175.42, 138.11, 137.96, 129.01, 124.37, 121.79, 119.98, 36.83, 19.79. HRMS (ESI) for $C_{11}H_{15}NO$ (m/z) $[M+H]^+$ calcd: 178.1154, found: 178.1146

***N*-(2-chlorophenyl)isobutyramide (6i)** Yield 85%; White solid; m.p. 92-94 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.36 (d, 1H), 7.69 (s, 1H, NH), 7.22 (d, 1H), 7.27 (t, 1H), 6.93 (t, 1H), 2.63–2.40 (m, 1H), 1.20 (d, 6H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 175.30, 134.85, 129.08, 127.81, 124.59, 122.78, 121.67, 37.13, 19.70. HRMS (ESI) for $C_{10}H_{12}ClNO$ (m/z) $[M+H]^+$ calcd:198.0607, found: 198.0626.

***N*-(4-chlorophenyl)isobutyramide (6j)** Yield 86%; White solid; m.p. 92-94 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.36 (d, 1H), 7.69 (s, 1H, NH), 7.22 (d, 1H), 7.27 (t, 1H), 6.93 (t, 1H), 2.63–2.40 (m, 1H), 1.20 (d, 6H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 175.30, 134.85, 129.08, 127.81, 124.59, 122.78, 121.67, 37.13, 19.70. HRMS (ESI) for $C_{10}H_{12}ClNO$ (m/z) $[M+H]^+$ calcd:198.0607, found: 198.0604.

***N*-(4-hydroxyphenyl)acetamide (6k)** Yield 90%; White solid; m.p. 168 ^{o}C; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 9.62 (s, 1H), 9.14 (s, 1H), 7.34 – 7.31 (m, 2H), 6.68 – 6.63 (m, 2H), 1.95 (s, 3H); **^{13}C NMR** (126 MHz, DMSO-d_6); δ 167.4, 153.1, 131.2, 120.7, 114.8, 23.6; HRMS (ESI) for $C_8H_9NO_2$ (m/z) $[M + H]^+$ calcd: 152.0633, found: 152.0641.

***N*-(4-ethoxyphenyl)acetamide (6l)** Yield 93%; White solid; m.p. 135 ^{o}C; **^{1}H NMR** (500 MHz, DMSO-d_6); δ 7.69 (d, 2H), 6.93 (d, 2H), 6.42 (s, 1H), 4.13 (q, 2H), 2.27 (s, 1H), 1.45 (t, 1H); **^{13}C NMR** (126 MHz, DMSO-d_6); δ171.4, 156.2, 131.4, 121.9, 115.4, , 64.9, 23.6, 13.7; HRMS (ESI) for $C_{10}H_{13}NO_2$ (m/z) $[M + H]^+$ calcd:180.0964, found: 180.0956.

***N*-(2-methylphenyl)benzamide (8a)** Yield 90%; Green solid; m.p. 145 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.86 (d, 2H), 7.51 (d, 1H), 7.49 (t, 2H), 7.44 (t, 2H), 7.25-7.22 (m, 3H), 7.03 (t ,1H) 2.34 (s, 1H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.7, 136.2, 134.7, 132.0, 131.5, 129.9, 128.6, 128.2, 127.5, 125.3, 123.3, 17.2; HRMS (ESI) for $C_{14}H_{13}NO$ (m/z) $[M + H]^+$ calcd:212.0997, found: 212.0977.

***N*-(2-bromophenyl)benzamide (8b)** Yield 86%; White solid; m.p. 107 °C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.60 (d, 1H), 8.43 (s, 1H), 7.93 (d, 2H), 7.56 (t, 1H), 7.50 (t, 2H), 7.42 (dd, 1H), 7.34-7.26 (m, 1H), 7.11-7.07 (m, 1H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 166.2, 135.4, 134.7, 132.3, 129.4, 129.3, 128.1, 127.3, 125.1, 123.3, 121.5; HRMS (ESI) for $C_{13}H_{10}BrNO$ (m/z) $[M + H]^+$ calcd:275.9946, found: 275.9934.

***N*-(4-bromophenyl)benzamide (8c)** Yield 88%; Yellow solid; m.p. 205 ^{o}C; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.82 (d, 2H), 7.57 (d, 2H), 7.57 (t, 2H), 7.47 (t, 1H), 7.44 (s, 1H), 7.40 (d, 2H), **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.5, 135.3, 134.9, 131.7, 128.5, 128.1, 123.3, 119.2 HRMS (ESI) for $C_{13}H_{10}BrNO$ (m/z) $[M + H]^+$ calcd:275.9946, found: 275.9955

***N*-methyl-*N*-phenylbenzamide (8d)** Yield 90%; Yellow oil; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.23 (d, 2H), 7.20-7.14 (m, 3H), 7.11-7.07 (m, 3H), 6.99-6.96 (d, 2H), 3.40 (s, 3H); **^{13}C**

NMR (126 MHz, $CDCl_3$); δ 170.7, 145.3, 126.2, 129.5, 129.4, 128.6, 127.7, 127.2, 123.4, 38.3; HRMS(ESI) for $C_{14}H_{13}NO$ (m/z) $[M + H]^+$ calcd:212.0997, found: 212.0973.

***N*-benzyl-2-methylbenzamide (8e)** Yield 86%; White solid; m.p. 104 ^oC; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.25 (d, 1H), 7.42 (t, 1H), 7.32-7.29 (m, 4H), 7.27-7.22 (m, 3H), 6.51 (d, 1H), 4.67 (d, 2H), 2.37 (s, 1H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 172.4, 139.4, 138.7, 136.9, 130.9, 128.5, 127.5, 127.2, 126.9, 126.6, 73.8, 20.6; HRMS (ESI) for $C_{15}H_{15}NO$ (m/z) $[M + H]^+$ calcd:226.1153, found: 226.1168.

***N*-benzyl-2-chlorobenzamide (8f)** Yield 90%; White solid; m.p. 103–105 ^oC; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.66–7.35 (m, 1H), 7.33-7.24 (m, 7H), 6.50 (d, 1H), 4.67 (d, 2H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 165.8, 152.6, 149.1, 144.9, 131.5, 129.2, 120.6, 99.1, 59.7, 53.6, 18.2, 14.7. HRMS (ESI) for $C_{14}H_{12}ClNO$ (m/z) $[M + H]^+$ calcd: 246.0607, found: 246.0603.

***N*-benzyl-4-methoxybenzamide (8g)** Yield 88%; White solid; m.p. 125 ^oC; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 8.01 (d, 1H), 7.66 (d, 2H), 7.30–7.21 (m, 4H), 6.80 (d, 2H), 6.79 (s, 1H), 4.55 (d, 2H), 3.70 (s, 3H); **^{13}C NMR** (126 MHz, $CDCl_3$); δ 167.2, 167.6, 164.7, 162.4, 162.9, 138.7, 133.2, 129.0, 129.3, 128.2, 127.7, 126.4, 121.6, 114.9, 114.3, 55.4, 44.7; HRMS (ESI) for $C_{15}H_{15}NO_2$ (m/z) $[M + H]^+$ calcd:242.1103, found: 242.1107.

4-chloro-*N*-methylbenzamide (8h) Yield 94%; White solid; m.p. 153 ^oC; **^{1}H NMR** (500 MHz, $CDCl_3$); δ 7.71 (d, 2H), 7.45 (d, 2H), 6.15 (s, 1H), 2.75 (s, 1H); **^{13}C NMR** (126 MHz,

DMSO-d_6); δ 168.8, 136.6, 36.0, 128.3, 128.1, 19.0, 26.8; HRMS (ESI) for C_8H_8ClNO (m/z) $[M+H]^+$ calcd:170.0294, found: 170.0284.

2.9 Spectral data of few products

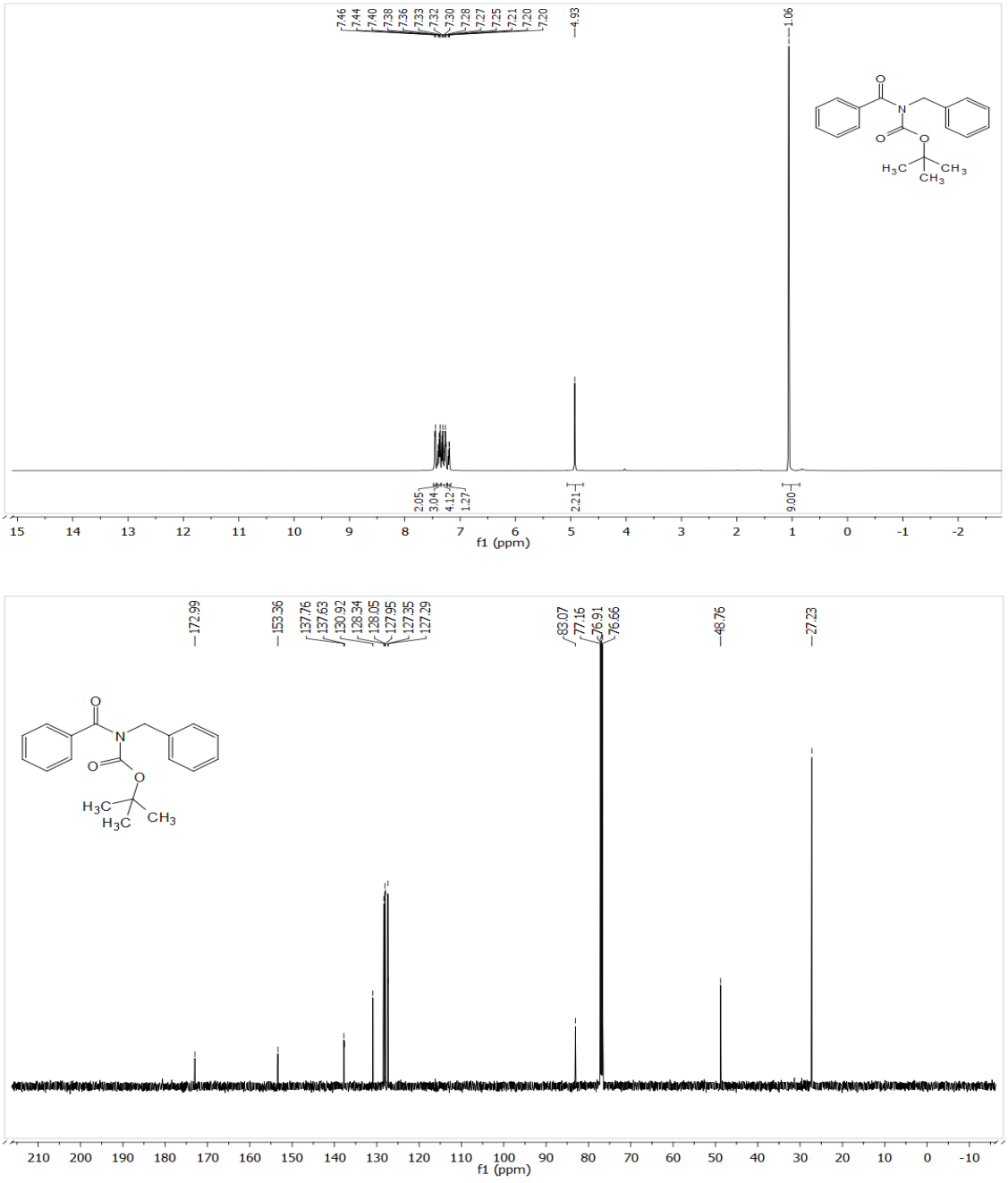


Figure 2.15 ^{1}H ^{13}C NMR Spectra of *tert*-butyl benzoyl(phenyl)carbamate **(1a)**

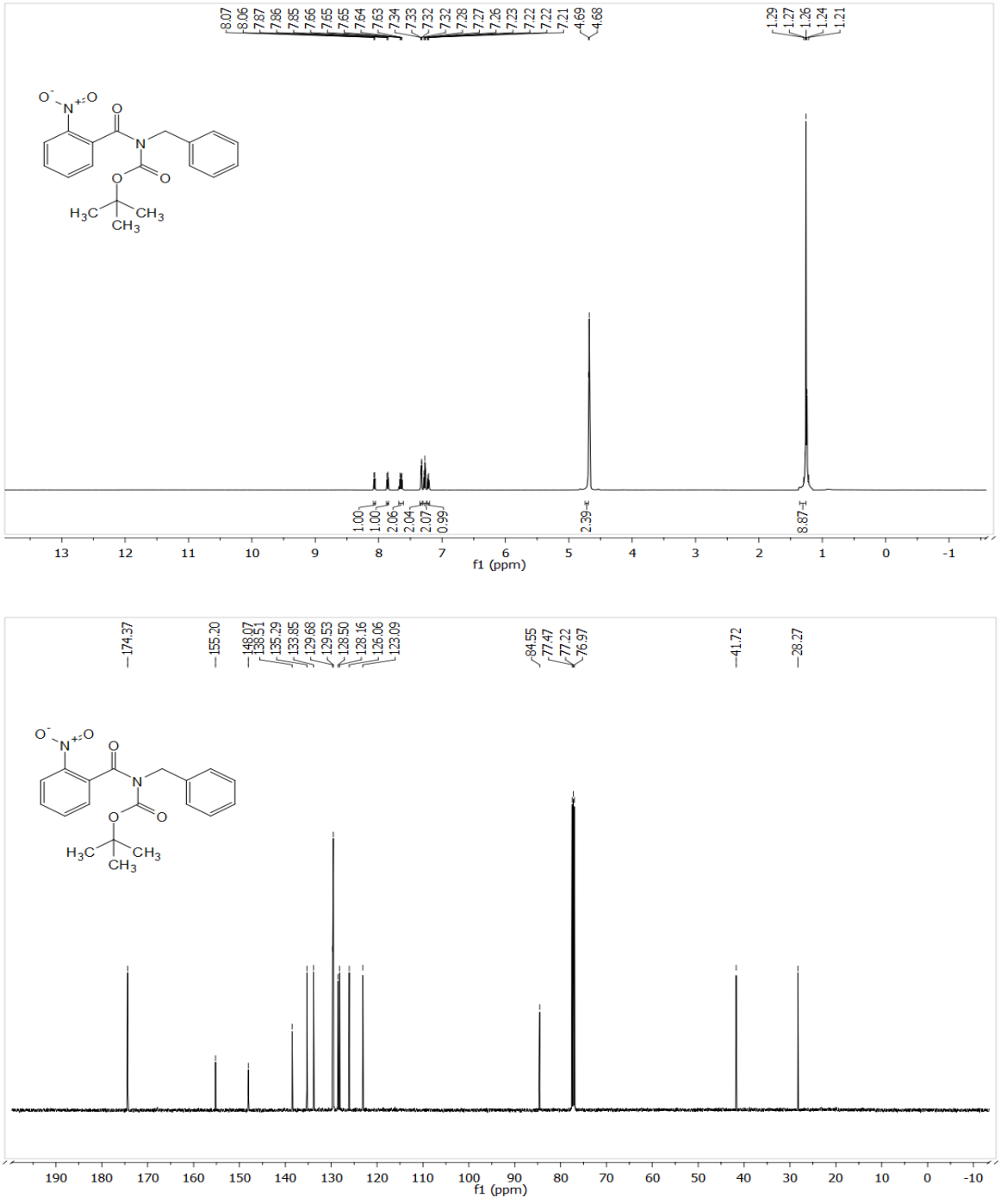


Figure 2.16 ^{1}H & ^{13}C NMR Spectra of *tert*-butyl benzyl(2-nitrobenzoyl)carbamate (**1g**)

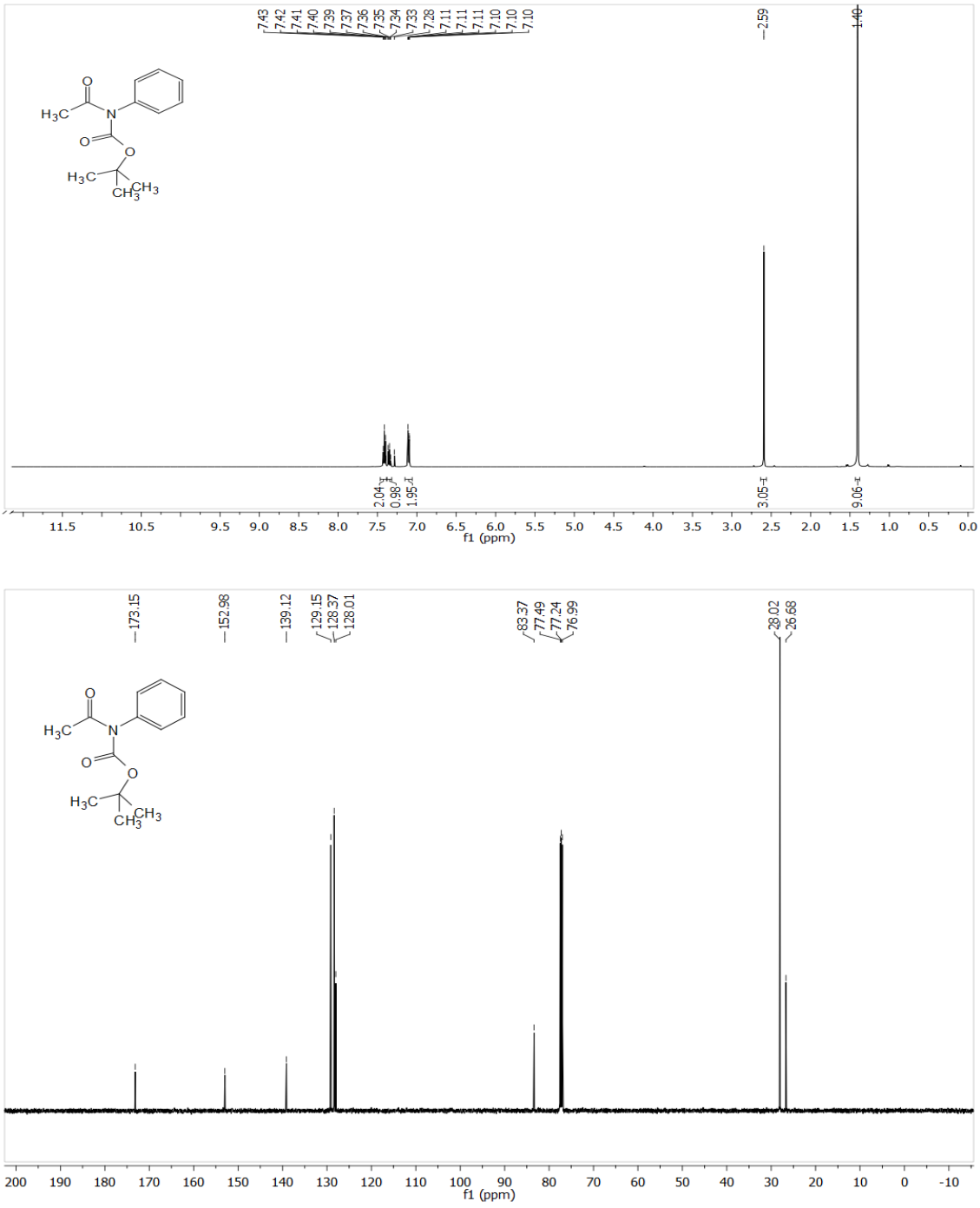


Figure 2.17 ^{1}H & ^{13}C NMR Spectra of *tert*-butyl acetyl(phenyl)carbamate (**1o**)

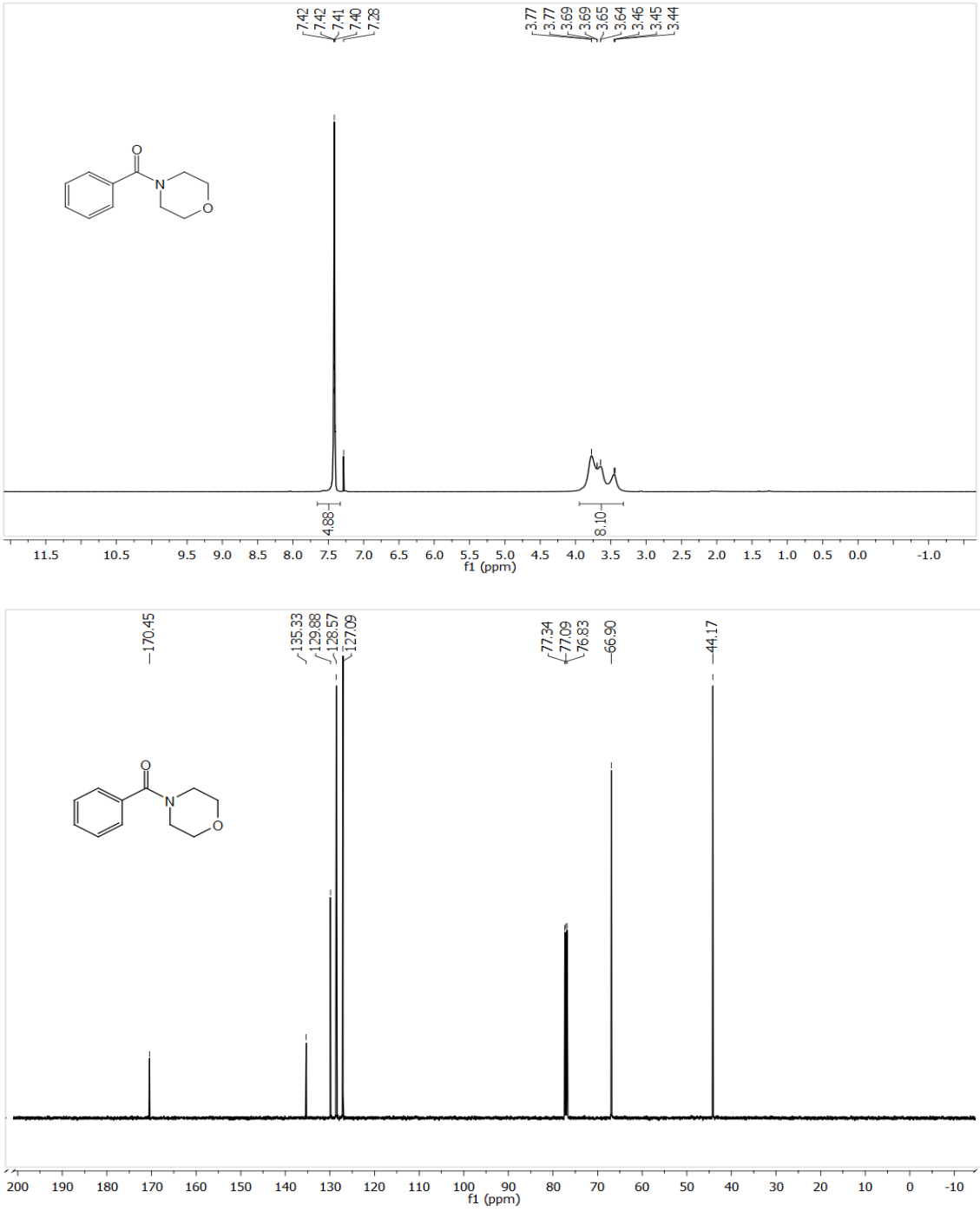


Figure 2.18 ^{1}H & ^{13}C NMR of morpholino(phenyl)methanone (**3a**)

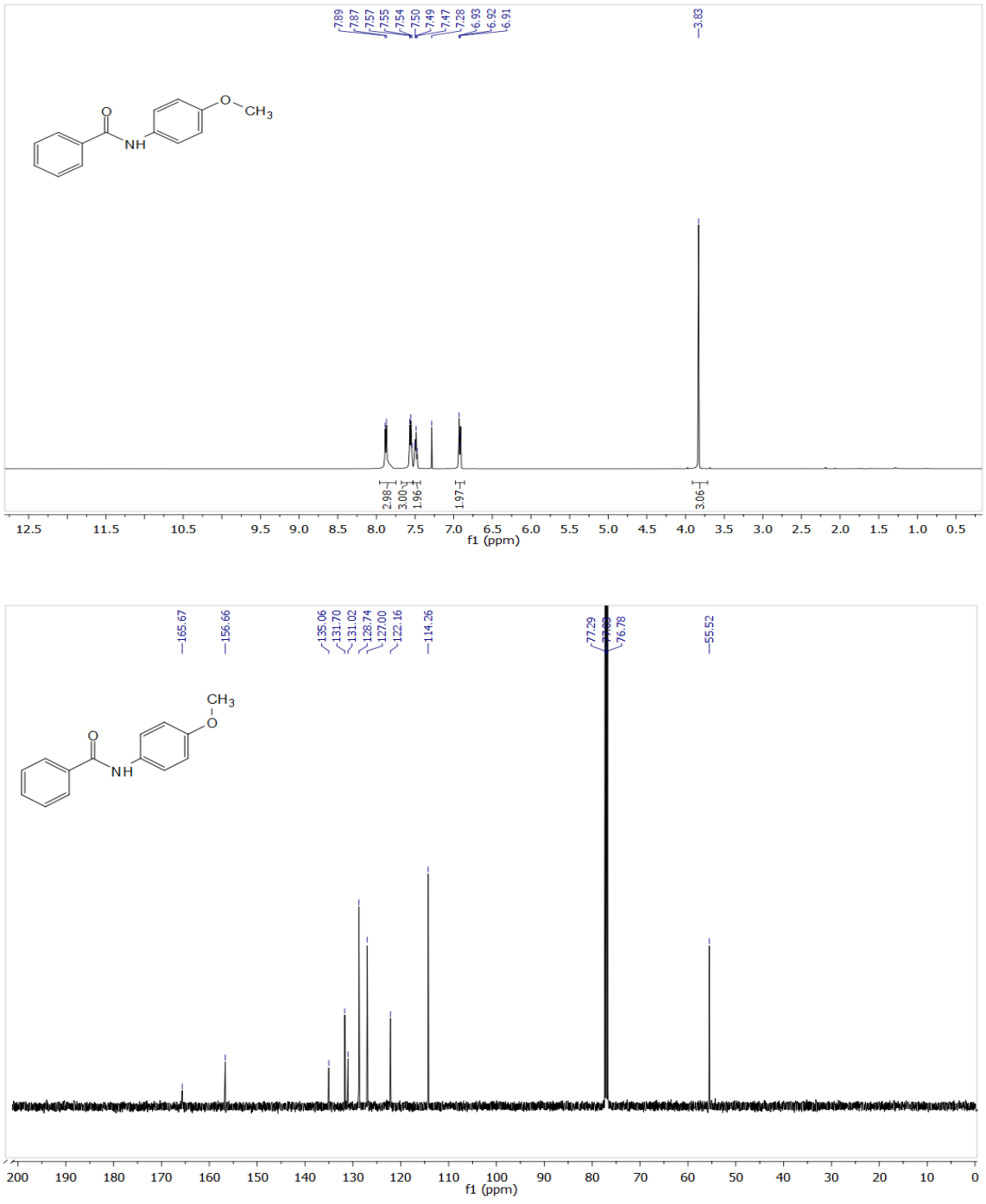


Figure 2.19 ^{1}H & ^{13}C NMR Spectra of *N*-(4-methoxyphenyl)benzamide (**3e**)

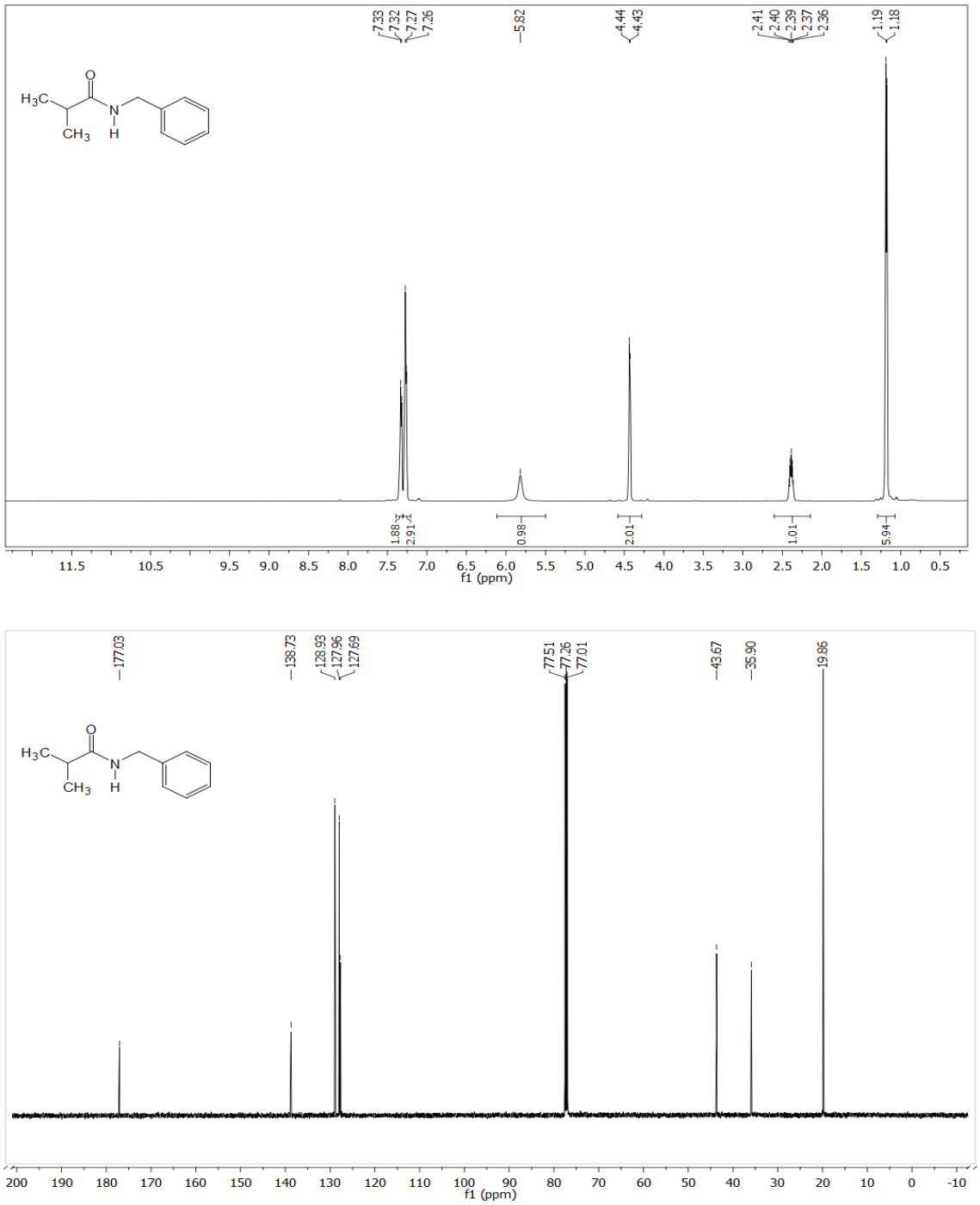


Figure 2.20 ^{1}H & ^{13}C NMR Spectra of *N*-benzylisobutyramid*e* (**6h**)

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