Metal catalyst-free amination of 2-chloro-5-nitrobenzoic acid in superheated water

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A series of N-arylanthranilic acid derivatives were synthesised by amination of 2-chloro-5-nitrobenzoic acid with various arylamine in superheated water with potassium carbonate as base. Good yields were achieved within 2–3 h at 150–190 °C. The results indicated that this metal catalyst-free method is a simple, environmentally-friendly and efficient synthesis of N-phenylanthranilic acid derivatives. Furthermore, it will work with an alkylamine and phenol.

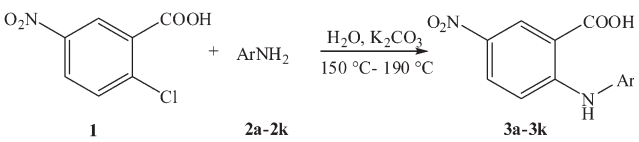
Keywords: N-arylanthranilic acids derivatives, 2-chloro-5-nitrobenzoic acid, superheated water, synthesis

N-Arylanthranilic acid derivatives are versatile compounds with various pharmacological activities, such as antibacterial, anti-inflammatory, antimalarial and anticancer activities.[1–3] For example, flufenamic and mefenamic acids are widely used as powerful analgesic and nonsteroidal anti-inflammatory drugs for the treatment of osteoarthritis, rheumatoid arthritis and other painful musculo-skeletal illnesses. Furthermore, they are possible candidates for the treatment of neurodegenerative and amyloid diseases.[4–6] Therefore, the synthesis of compounds containing an anthranilic acid moiety has recently received attention.

Traditionally, the most widely used strategy for the synthesis of N-arylanthranilic acids derivatives is the coupling of anilines and *o*-halobenzoic acid derivatives with a palladium or copper catalyst.[7–9] However, the requirement for organic solvents, long reaction times, high temperatures, catalysts and tedious procedures for purifying the products, hampered the application of these methods. Ultrasonic and microwave irradiation have been successfully utilised in the synthesis of N-arylanthranilic acids derivatives.[10,11] For example, Rolando and his co-workers[12] have studied the reaction of 2-chlorobenzoic acids and aminothiazoles or aminobenzothiazoles under ultrasonic irradiation using copper catalysis, and the results show that the yields were enhanced and the reaction time was reduced. Younis and his co-workers [13] used microwave irradiation to synthesise N-substituted 5-nitroanthranilic acid derivatives without a catalyst nor solvent and obtained yields up to 99% within 5–30 min at 80–120 °C.

In the past decade, the superheated water has emerged as an efficient, clean, economic and environmentally friendly medium for organic synthesis.[14–17] Superheated water possesses some unique properties including the fact that it is cheap, naturally abundant and nontoxic, and it can simultaneously play the role of solvent, reactant and catalyst.[17,18] It has been applied in various reactions such as hydration,[19] reduction,[20] catalytic oxidation,[21] alkylation,[22] the Heck coupling,[23] the Suzuki reaction[24] and the Claisen rearrangement.[25]

In the present work, we have synthesised the N-phenylanthranilic acid derivatives without a catalyst by the amination of 2-chloro-5-nitrobenzoic acid in superheated water with potassium carbonate as base (Scheme 1).



1 **2a-2k** **3a-3k**

Scheme 1

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Results and discussion

The reaction conditions of 2-chloro-5-nitrobenzoic acid with aniline were optimised in superheated water for 2 hours and the results are given in Table 1. Firstly we examined the effect of temperature. The results showed that the best yield was obtained at 150 °C (Table 1, entry 3). Secondly the proportion of reactants was investigated. The optimum yield was obtained when the ratio of 2-chloro-5-nitrobenzoic acid to aniline was 1:2, Finally, the effect of different amounts of potassium carbonate was examined. The best result was obtained using 0.5 equiv. of potassium carbonate per mole of 2-chloro-5-nitrobenzoic acid (Table 1, entry 3). However, if the reaction time was reduced to 1 h using the previously optimum conditions, the yield decreased to 58% (Table 1, entry 9).

The optimum reaction conditions for the synthesis of N-substituted 5-nitroanthranilic acid derivatives in superheated water involved the use 0.5 equiv. of potassium carbonate, 2 equiv. of amine to 1 equiv. of 2-chloro-5-nitrobenzoic acid and heating the mixture at 150 °C for 2 h. This procedure was used for the coupling of 2-chloro-5-nitrobenzoic acid with different arylamines. The results are listed in Table 2. According to the differences in the reactivity of the arylamine, the temperature was raised to 170 °C or 190 °C in order to reduce the reaction time for some reactions. Good yields were obtained in the examples when the aromatic ring of the arylamines possessed an electron-donating group (Table 2, **3b–d**, **3h**), except for 2,3-dimethyl substituted arylamine which afforded a yield of 55% (Table 2, **3i**). This is probably due to steric hindrance. Electron-withdrawing substituents on the aromatic ring decreased the yields (Table 2, **3e–g**). This is due to the low reactivity of the starting materials. When, the amination procedure was applied to hindered substrates, they coupled poorly and gave only low yields of the product, even at elevated temperature. For example, 2,6-dimethylaniline and 2,4,6-trimethylaniline gave the corresponding products in yields of 34% and 46% within 3 h at 190 °C, respectively (Table 2, **3j**, **3k**).

Table 1 The reaction of 2-chloro-5-nitrobenzoic acid with aniline under different reaction conditions[a]

Entry	Ratio of **1**/**2a**	Temp/°C	T/h	K_2CO_3/mmol	Yield/%[b]
1	1:2	110	2	1.5	52
2	1:2	130	2	1.5	67
3	1:2	150	2	1.5	88
4	1:2	170	2	1.5	83
5	1:1	150	2	1.5	69
6	1:3	150	2	1.5	90
7	1:2	150	2	0	78
8	1:2	150	2	3	74
9	1:2	150	1	1.5	58

[a] Reaction conditions: 2-chloro-5-nitrobenzoic acid (3 mmol), water (2 mL).
[b] Isolated yield.

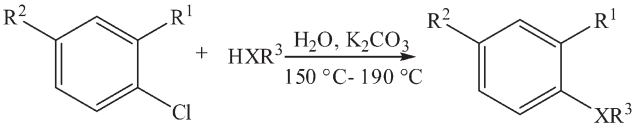
Table 2 Synthesis of N-arylanthranilic acid derivatives in superheated water without catalyst[a]

Entry	Ar	Temp./°C	Time/h	Products	Yield/%[b]
1	C_6H_5	150	2	**3a**	88
2	2-$CH_3C_6H_4$	170	3	**3b**	75
3	3-$CH_3C_6H_4$	150	2	**3c**	78
4	4-$CH_3C_6H_4$	150	2	**3d**	76
5	2-ClC_6H_4	170	3	**3e**	44
6	3-ClC_6H_4	150	2	**3f**	56
7	4-ClC_6H_4	150	2	**3g**	60
8	4-$C_2H_5OC_6H_4$	150	2	**3h**	76
9	2,3-di$CH_3C_6H_3$	170	3	**3i**	55
10	2,6-di$CH_3C_6H_3$	190	3	**3j**	34
11	2,4,6-tri$CH_3C_6H_2$	190	3	**3k**	46

[a]Reaction conditions: 2-chloro-5-nitrobenzoic acid (3 mmol), arylamine (6 mmol), potassium carbonate (1.5 mmol), water (2 mL).
[b]Isolated yield.

In further experiments, to investigate the scope of this synthetic method, the procedure was applied to coupling reactions with different reactants (Scheme 2) and the results were listed in Table 3. Firstly the reaction of benzylamine and naphthylamine with 2-chloro-5-nitrobenzoic acid was investigated and the expected compounds were obtained with the yields of 90% and 70%, respectively (Table 3, **3l**, **3m**). It was then utilised in the reaction of *n*-butylamine and 2-chloro-5-nitrobenzoic acid. The reaction proceeded smoothly and the expected product was obtained in 91% isolated yield (Table 3, **3n**). Moreover, the reactions of oxygen and sulfur-based nucleophiles with 2-chloro-5-nitrobenzoic acid were also investigated. Thiophenol gave the desired product in 87% yield (Table 3, **3o**), but phenol gave the relevant product in 38% yield for 3 h at 190 °C (Table 3, **3p**).

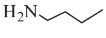
Finally, the importance of the electron-withdrawing nitro group was also studied. When the nitro group was in the *ortho*-position and the carboxyl group was in the *para*-position of the chlorobenzene and it coupled with aniline, the reaction gave a



1' **2l-2r** **3l-3r**

Scheme 2

Table 3 Synthesis of different substituted benzoic acid derivatives[a]

Entry	R^1	R_2	HXR^3	Temp. /°C	Time /h	Products	Yield /%[b]
1	COOH	NO_2		150	2	**3l**	90
2	COOH	NO_2		170	2	**3m**	70
3	COOH	NO_2		150	2	**3n**	91
4	COOH	NO_2	C_6H_5SH	150	2	**3o**	87
5	COOH	NO_2	C_6H_5OH	190	3	**3p**	38
6	NO_2	COOH	$C_6H_5NH_2$	150	2	**3q**	94
7	COOH	H	$C_6H_5NH_2$	190	3	**3r**	30

[a]Reaction conditions: benzoic acid derivatives (3 mmol), amine or phenol (6 mmol), potassium carbonate (1.5 mmol), water (2 mL).
[b]Isolated yield.

94% yield (Table 3, **3q**). When *o*-chlorobenzoic acid was the reactant, the yield was only 30% for 3 h under 190 °C (Table 3, **3r**) due to the absence of the activating nitro group in the *para*-position. This showed that a nitro group on the aromatic ring of the benzoic acid was necessary for high yields of the desired products.

In summary, a simple, metal catalyst-free, environmentally-friendly and efficient amination procedure for synthesis of N-substituted 5-nitroanthranilic acid derivatives in superheated water has been developed in the present study. Several target products were obtained in excellent isolated yields by the coupling of 2-chloro-5-nitrobenzoic acid with arylamines. Additionally, the present method has many advantages, such as the absence of organic solvents or metal catalysts and it can be applied to an alkyl amine and to phenol.

Experimental

All starting materials were purchased from commercial sources and used without further purification. All reactions were carried out in the Teflon lined heated reactor. Melting points were measured using an uncorrected micro-melting point X-4 apparatus. IR spectra were recorded as KBr discs on a Shimadzu IRAffinity-1 spectrometer. All ^{1}H NMR spectra were recorded on Bruker 500 MHz spectrometer in DMSO-*d6* using TMS as an internal standard. High resolution mass spectrometric (HRMS) data of some compounds were obtained using AB (Applied Biosystems) Qtar elite.

Amination of 2-chloro-5-nitrobenzoic acid in superheated water; general procedure

A mixture of 2-chloro-5-nitrobenzoic acid (3 mmol), arylamine (6 mmol), anhydrous potassium carbonate (1.5 mmol) and distilled water (2 mL) were placed in a teflon inner call having a volume of 10 mL an oven. The mixture was heated in a drying oven for the time and temperatures listed in Table 2 and Table 3. After the reactor was cooled to room temperature, the reaction mixture was basified to pH 12 with aqueous NaOH. Then it was filtered and the filter residue was washed with distilled water (3×20 mL). The aqueous layer was acidified with aqueous HCl to pH ≤ 3. The product was precipitated in the acidic medium. The precipitated solid was filtered off, washed with distilled water (3×20 mL) and re-crystallised from ethanol/water to give the desired product with the yields listed in Tables 2 and 3.

5-Nitro-2-(phenylamino) benzoic acid (**3a**): M.p. 253–254 °C (lit.[13] 251–253 °C). FT-IR (KBr) ν_{max}: 3449, 3327, 3065, 2922, 1678, 1614, 1597, 1578, 1500, 1342, 1254 cm^{-1}; ^{1}H NMR (DMSO-d_6, 500 MHz): 7.13 (d, *J* = 9.50 Hz, 1H, ArH), 7.27 (t, *J* = 7.00 Hz, 1H, ArH), 7.37 (d, *J* = 7.50 Hz, 2H, ArH), 7.48 (t, *J* = 8.00 Hz, 2H, ArH), 8.18 (dd, *J* = 9.00 Hz, 3.00 Hz, 1H, ArH), 8.72 (d, *J* = 2.50 Hz, 1H, ArH), 10.38 (s, 1H, NH), 13.89 (s, 1H, COOH).

5-Nitro-2-(2-tolylamino)benzoic acid (**3b**): M.p. 258–260 °C. FT-IR (KBr) ν_{max}: 3447, 3310, 3063, 2859, 1663, 1609, 1584, 1501, 1441, 1338, 1248 cm^{-1}; ^{1}H NMR (DMSO-d_6, 500 MHz): 2.20 (s, 3H, CH_3), 6.72 (d, *J* = 9.50 Hz, 1H, ArH), 7.25–7.28 (m, 1H, ArH), 7.30–7.35 (m, 2H, ArH), 7.39 (s, *J* = 7.00 Hz, 1H, ArH), 8.15 (dd, *J* = 9.50 Hz, 3 Hz, 1H, ArH), 8.72 (d, *J* = 2.5 Hz, 1H, ArH), 10.24 (s, 1H, NH), 13.85 (s, 1H, COOH). ^{13}C NMR (DMSO-d_6, 500 MHz) δ = 17.38, 110.29, 112.87, 125.67, 126.72, 127.13, 128.44, 129.37, 131.25, 133.58, 136.17, 136.55, 152.99, 168.73. HRMS calcd. for $C_{14}H_{13}N_2O_4$[M + H$^+$]: 273.0870; found: 273.0869.

5-Nitro-2-(3-tolylamino)benzoic acid (**3c**): M.p. 268–269 °C. FT-IR (KBr) ν_{max}: 3449, 3318, 3103, 2920, 1665, 1603, 1576, 1531, 1491, 1333, 1242 cm^{-1}; ^{1}H NMR (DMSO-d_6, 500 MHz): 2.34 (s, 3H, CH_3), 7.09–7.17 (m, 4H, ArH), 7.35 (t, *J* = 7.50 Hz, 1H, ArH), 8.17 (d, *J* = 9.00 Hz, 1H, ArH), 8.71 (s, 1H, ArH), 10.35 (s, 1H, NH), 13.89 (s, 1H, COOH). ^{13}C NMR (DMSO-d_6, 500 MHz) δ = 20.86, 110.74, 113.22, 120.90, 124.42, 126.47, 128.41, 129.27, 129.52, 136.42, 137.99, 139.36, 152.36, 168.66. HRMS calcd. for $C_{14}H_{13}N_2O_4$[M + H$^+$]: 273.0870; found: 273.0859.

5-Nitro-2-(4-tolylamino)benzoic acid (**3d**): M.p. 263–264 °C (lit.[26] 262°C). FT-IR (KBr) ν_{max}: 3509, 3317, 1924, 2857, 1676, 1585, 1516, 1423, 1317, 1246 cm^{-1}; ^{1}H NMR (DMSO-d_6, 500 MHz): 2.34 (s, 3H, CH_3), 7.04 (d, *J* = 9.50 Hz, 1H, ArH), 7.26 (q, *J* = 9.00 Hz, 4H, ArH), 8.15 (dd, *J* = 9.50 Hz, 3.00 Hz, 1H, ArH), 8.71 (d, *J* = 2.50Hz, 1H, ArH), 10.29(s, 1H, NH), 13.84 (s, 1H, COOH).

2-(2-Chlorophenylamino)-5-nitrobenzoic acid (**3e**): M.p. 263–265 °C (lit.[27] 273–275 °C). FT-IR (KBr) ν_{max}: 3449, 3279, 2922, 2853, 1684, 1593, 1502, 1437, 1341, 1251 cm^{-1}; ^1H NMR (DMSO-d6, 500 MHz): 6.99 (d, *J* = 9.50 Hz, 1H, ArH), 7.33 (t, *J* = 7.50 Hz, 1H, ArH), 7.46 (t, *J* = 8.00 Hz, 1H, ArH), 7.61 (d, *J* = 8.00 Hz, 1H, ArH), 7.65 (d, *J* = 8.00, 1H, ArH), 8.21 (dd, *J* = 9.50 Hz, 2.50 Hz, 1H, ArH), 8.74 (d, *J* = 2.50 Hz, 1H, ArH), 10.57 (s, 1H, NH), 13.85 (s, 1H, COOH).

2-(3-Chlorophenylamino)-5-nitrobenzoic acid (**3f**): M.p. 272–274 °C (lit.[13] 274–276 °C). FT-IR (KBr) ν_{max}: 3468, 3310, 3098, 3019, 1684, 1612, 1587, 1497, 1342, 1319, 1234 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 7.20 (d, *J* = 9.50 Hz, 1H, ArH), 7.32 (d, *J* = 8.00 Hz, 1H, ArH), 7.35 (d, *J* = 8.00 Hz, 1H, ArH), 7.47 (t, *J* = 8.00 Hz, 2H, ArH), 8.21 (dd, *J* = 9.50 Hz, 2.50 Hz, 1H, ArH), 8.71 (d, *J* = 3.00 Hz, 1H, ArH), 10.35 (s, 1H, NH), 13.94 (s, 1H, COOH).

2-(4-Chlorophenylamino)-5-nitrobenzoic acid (**3g**): M.p. 287–288 °C (lit.[27] 285 °C). FT-IR (KBr) ν_{max}: 3450, 3316, 3072, 2980, 1670, 1597, 1585, 1508, 1337, 1242 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 7.13 (d, *J* = 9.50 Hz, 1H, ArH), 7.40 (d, *J* = 9.00 Hz, 2H, ArH), 7.51 (d, *J* = 8.50 Hz, 2H, ArH), 8.18 (dd, *J* = 9.00 Hz, 3.00 Hz, 1H, ArH), 8.71 (d, *J* = 2.50 Hz, 1H, ArH), 10.32 (s, 1H, NH), 13.92 (s, 1H, COOH).

2-(4-Ethoxyphenylamino)-5-nitrobenzoic acid (**3h**): M.p. 198–200 °C (lit.[13] 199–201 °C). FT-IR (KBr) ν_{max}: 3449, 3306, 3073, 2926, 1676, 1589, 1526, 1502, 1335, 1250, 1130 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 1.34 (t, *J* = 7.00 Hz, 3H, CH_3), 4.05(q, *J* = 7.00 Hz, 2H, CH_2), 6.90 (d, *J* = 9.50 Hz, 1H, ArH), 7.01 (d, *J* = 8.50 Hz, 2H, ArH), 7.26 (d, *J* = 8.50 Hz, 2H, ArH), 8.14 (dd, *J* = 9.50 Hz, 2.50 Hz, 1H, ArH), 8.70 (d, *J* = 3.00 Hz, 1H, ArH), 10.20 (s, 1H, NH), 13.80 (s, 1H, COOH).

2-(2,3-Dimethylphenylamino)-5-nitrobenzoic acid (**3i**): M.p. 266–268 °C (lit.[13] 262–264 °C). FT-IR (KBr) ν_{max}: 3470, 3310, 3071, 2859, 1659, 1607, 1580, 1499, 1443, 1337, 1242 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 2.09 (s, 3H, CH_3), 2.31 (s, 3H, CH_3), 6.59 (d, *J* = 9.50 Hz, 1H, ArH), 7.14–7.22 (m, 3H, ArH), 8.13 (dd, *J* = 9.50 Hz, 2.00 Hz, 1H, ArH), 8.72 (d, *J* = 2.50 Hz, 1H, ArH), 10.21 (s, 1H, NH), 13.80 (s, 1H, COOH).

2-(2,6-Dimethylphenylamino)-5-nitrobenzoic acid (**3j**): M.p. 236–238 °C. FT-IR (KBr) ν_{max}: 3450, 3325, 3101, 2954, 1668, 1641, 1574, 1495, 1330, 1238 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 2.12 (s, 6H, CH_3), 6.18 (d, *J* = 9.50 Hz, 1H, ArH), 7.04 (s, 2H, ArH), 8.12 (dd, *J* = 9.00 Hz, 2.50 Hz, 1H, ArH), 8.72 (d, *J* = 2.50 Hz, 1H, ArH), 9.97 (s, 1H, NH), 13.72 (s, 1H, COOH). ^{13}C NMR (DMSO-d_6, 500 MHz) δ = 17.65, 109.76, 112.25, 127.54, 128.56, 128.62, 129.57, 135.28, 135.73, 135.94, 153.48, 168.64. HRMS calcd. for $C_{15}H_{15}N_2O_4$[M + H^+]: 287.1026; found:287.1025.

2-(Mesitylamino)-5-nitrobenzoic acid (**3k**): M.p. 233–234 °C. FT-IR (KBr) ν_{max}: 3450, 3345, 2922, 2857, 1672, 1609, 1578, 1499, 1439, 1248, 1128 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 2.07 (s, 6H, CH_3), 2.29 (s, 3H, CH_3), 6.17 (d, *J* = 9.00 Hz, 1H, ArH), 7.23 (s, 3H, ArH), 8.10 (dd, *J* = 9.50 Hz, 2.00 Hz, 1H, ArH), 8.71 (s, 1H, ArH), 9.89 (s, 1H, NH), 13.55 (s, 1H, COOH). ^{13}C NMR (DMSO-d_6, 500 MHz) δ = 18.07, 21.02, 110.54, 112.84, 129.71, 129.74, 130.06, 133.15, 135.90, 137.37, 137.25, 158.61, 168.66. HRMS calcd. for $C_{16}H_{17}N_2O_4$[M + H^+]: 301.1183; found:301.1183.

2-(Benzylamino)-5-nitrobenzoic acid (**3l**): M.p. 239–241 °C (lit.[13] 239–241 °C). FT-IR (KBr) ν_{max}: 3471, 3336, 3096, 2866, 1668, 1583, 1547, 1502, 1443, 1335, 1248 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 4.64 (d, *J* = 6.00 Hz, 2H, CH_2), 6.84 (d, *J* = 9.50 Hz, 1H, ArH), 7.27–7.30 (m, 2H, ArH), 7.35–7.38 (m, 4H, ArH), 8.13 (dd, *J* = 9.00 Hz, 2.50 Hz, 1H, ArH), 8.66 (d, *J* = 2.50 Hz, 1H, ArH), 9.19 (t, *J* = 5.50 Hz, 1H, NH), 13.55 (s, 1H, COOH).

2-(Naphthalen-1-ylamino)-5-nitrobenzoic acid (**3m**): M.p. 251–252 °C (lit.[28] 247–249 °C). FT-IR (KBr) ν_{max}: 3449, 3306, 3094, 3057, 1668, 1607, 1578, 1526, 1499, 1333, 1240 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 6.69 (d, *J* = 9.50 Hz, 1H, ArH), 7.57–7.64 (m, 4H, ArH), 7.89 (d, *J* = 8.00 Hz, 1H, ArH), 7.97 (t, *J* = 7.00 Hz, 1H, ArH), 8.06 (dd, *J* = 7.50 Hz, 1H, ArH), 8.10 (dd, *J* = 9.50 Hz, 3.00 Hz, 1H, ArH), 8.77 (d, *J* = 3.00 Hz, 1H, ArH), 10.69 (s, 1H, NH), 13.97 (s, 1H, COOH).

2-(Butylamino)-5-nitrobenzoic acid (**3n**): M.p. 186–188 °C (lit.[29] 180 °C). FT-IR (KBr) ν_{max}: 3492, 3356, 3108, 2930, 2870, 1665, 1610, 1582, 1487, 1331, 1244 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 0.92 (t, *J* = 7.50 Hz, 3H, CH_3), 1.38 (q, *J* = 7.50 Hz, 2H, CH_2), 1.60 (quint, *J* = 7.00 Hz, 2H, CH_2), 3.33 (q, *J* = 6.50 Hz, 2H, CH_2), 6.90 (d, *J* = 9.50 Hz, 1H, ArH), 8.16 (dd, *J* = 9.50 Hz, 3.00 Hz, 1H, ArH), 8.63 (d, *J* = 3.00 Hz, 1H, ArH), 8.77 (s, 1H, NH), 13.47 (s, 1H, COOH).

5-Nitro-2-(phenylthio)benzoic acid (**3o**): M.p. 225–227 °C (lit.[30] 227 °C). FT-IR (KBr) ν_{max}: 3468, 3099, 2868, 1692, 1595, 1564, 1510, 1340, 1252 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 6.87 (d, *J* = 9.00 Hz, 1H, ArH), 7.58–7.60 (m, 3H, ArH), 7.62–7.64 (m, 2H, ArH), 8.20 (dd, *J* = 9.00 Hz, 2.50 Hz, 1H, ArH), 8.65 (d, *J* = 2.50 Hz, 1H, ArH), 13.95 (s, 1H, COOH).

5-Nitro-2-phenoxybenzoic acid (**3p**): M.p. 161–162 °C (lit.[31] 155–156 °C). FT-IR (KBr) ν_{max}: 3428, 3082, 2851, 1690, 1616, 1577, 1514, 1477, 1348, 1260 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 7.02 (d, *J* = 9.00 Hz, 1H, ArH), 7.15 (d, *J* = 7.50 Hz, 2H, ArH), 7.28 (t, *J* = 7.50 Hz, 1H, ArH), 7.49 (t, *J* = 8.00 Hz, 2H, ArH), 8.34 (dd, *J* = 9.00 Hz, 2.50 Hz, 1H, ArH), 8.60 (d, *J* = 3.00 Hz, 1H, ArH), 13.59 (s, 1H, COOH).

3-Nitro-4-(phenylamino)benzoic acid (**3q**): M.p. 260–261°C (lit.[32] 262 °C). FT-IR (KBr) ν_{max}: 3335, 3088, 2816, 1686, 1626, 1568, 1531, 1497, 1288, 1217 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 7.13 (d, *J* = 9.50 Hz, 1H, ArH), 7.30 (t, *J* = 7.50 Hz, 1H, ArH), 7.37 (d, *J* = 7.50 Hz, 2H, ArH), 7.48 (t, *J* = 8.00 Hz, 2H, ArH), 7.93 (dd, *J* = 9.00 Hz, 2.00 Hz, 1H, ArH), 8.64 (d, *J* = 2.00 Hz, 1H, ArH), 9.81 (s, 1H, NH), 13.01 (s, 1H, COOH).

2-(Phenylamino)benzoic acid (**3r**): M.p. 181–182 °C (lit.[33] 181–183 °C). FT-IR (KBr) ν_{max}: 3485, 3337, 3042, 2889, 1663, 1582, 1514, 1435, 1261 cm^{-1}; ^1H NMR (DMSO-d_6, 500 MHz): 6.78 (t, *J* = 9.50 Hz, 1H, ArH), 7.30 (t, *J* = 7.50 Hz, 1H, ArH), 7.37 (d, *J* = 7.50 Hz, 3H, ArH), 7.34–7.40 (m, 3H, ArH), 7.91 (dd, *J* = 9.00 Hz, 1.50 Hz, 1H, ArH), 9.64 (s, 1H, NH), 13.08 (s, 1H, COOH).

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