



Full paper/Mémoire

L-Proline-catalysed one-pot synthesis of tetrahydrobenzo[c]acridin-8(7H)-ones at room temperature

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ABSTRACT

Only 10 mol% of L-Proline in ethanol proved to be a very efficient catalyst for the one-pot synthesis of a wide variety of highly substituted tetrahydrobenzo[c]acridin-8(7H)-ones at room temperature. The key advantages of this process are high yields, cost effectiveness of the catalyst, easy work-up and the products can be directly recrystallized from hot ethanol.

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1. Introduction

Recently, multicomponent reactions (MCRs) have been considered as a superior synthetic strategy [1]. The MCRs are very flexible, atom economic in nature, and proceed through a sequence of reaction equilibria, yielding the target product [2]. Moreover, these transformations combine classical concerns such as efficiency, selectivity, molecular complexity and diversity [3,4]. The acridine derivatives have been known first to be used as pigments and dyes since the 19th century [5]. A range of acridines continue to be used today for the treatment of actuelekaemia (amsacrine) [6], as anticancer agents (ledakrin) [7]. To date, ranges of acridine have been reported with a range of chemical and physical properties. Their utility in the pharmaceutical industry has also been reported [8]. A number of methods have been developed for the synthesis of acridine compounds containing 1,4-dihydropyridines, from dimedone, aldehyde and different anilines or ammonium acetate via traditional

heating in organic solvents [9], in water catalyzed by TEBAC [10], under microwave irradiation [11], and using ionic liquids are emerging as effective solvents for green processes. In recent years L-Proline has drawn much interest in different organic reactions due to its experimental simplicity in water and organic solvents, L-Proline has shown considerable catalytic efficiency in different transformations such as enamine based direct catalytic asymmetric aldol condensation [12], α -amination reaction [13], Mannich reaction [14], Diels-Alder reaction [15], Knoevenagel reaction [16], Micheal condensation [17], and as excellent promoter for the copper-catalyzed coupling reaction [18], as well as in solvent-free Biginelli reaction [19], in unsymmetric Hantzsch reaction [20], for the selective synthesis of 2-aryl-1-arylmethyl-1H-benzimidazoles from wide range of substituted *o*-phenylenediamines and aldehydes [21], proline catalysis has emerged recently as an efficient means of generating functionalized cyclohexanes and spirane products via Barbas three-component cycloaddition [22]; proline has also been used as catalyst for two-carbon homologation and in various MCRs in one-pot [23]. The developing of new MCRs and improving known MCRs are an area of considerable current interest. Herein, we report a simple and facile multicomponent one-pot

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synthesis of substituted tetrahydrobenzo[*c*]acridin-8(7H)-ones in high yields, using *L*-Proline (15 mol%) as an organocatalyst. Most of the above reported synthetic methods for the synthesis of substituted tetrahydrobenzo[*c*]acridin-8(7H)-ones suffer from one or more drawbacks, such as a hazardous reaction condition, complex work-up and purification, strong acidic condition [24], high temperature [25,26], use of toxic metal catalyst [27], poor yields, occurrence of side reactions and expensive reagents. Therefore, the development of a mild generalized method to overcome these shortcomings still remains an ongoing challenge for the synthesis of highly substituted tetrahydrobenzo[*c*]acridin-8(7H)-ones for organic chemists.

2. Results and discussion

We report herein, for the first time, a simple, mild, and expeditious synthesis of highly substituted tetrahydrobenzo[*c*]acridin-8(7H)-ones in excellent yields employing *L*-Proline (15 mol%) as an organocatalyst at room temperature (Scheme 1).

In order to standardize the reaction, salicylaldehyde (1 mmol), α -naphthylamine (1 mmol), 5,5-dimethylcyclohexane-1,3-dione(dimedone) (1 mmol) were dissolved in ethanol and stirred at room temperature for 30 min. in the absence of the catalyst which led to very poor yields (only 5–6%, as obtained in crude ^1H NMR) of the substituted tetrahydrobenzo[*c*]acridin-8(7H)-ones. We also tried different solvents under similar reaction conditions but no appreciable increment in product yield was observed. Then it was thought worthwhile to study the reaction I in the presence of an organocatalyst like *L*-Proline. Use of 15 mol% of the catalyst produced maximum yield (95%). A further increase of the catalyst concentration does not increase the yield. On the contrary, the reaction slows down on adding more than 15 mol% of catalyst. The standard reaction was also studied in the presence of glycine (15 mol%), when the desired product was obtained after 72 h in only 10% isolated yield. This lower yield could be attributed firstly to the comparatively poor solubility of glycine in ethanol and

Table 1

Multicomponent reaction of salicylaldehyde, α -naphthylamine and 5,5-dimethylcyclohexane-1,3-dione(dimedone) in the presence of different solvents and different catalyst percentages^a.

Entry	Catalyst (mol %)	Solvent	Time (h)	Yield ^b (%)
1	–	EtOH	72	5–6
2	–	MeOH	72	5–6
3	–	CHCl ₃	72	Trace
4	–	CH ₃ CN	72	Trace
5	–	CH ₂ Cl ₂	72	Trace
6	–	1,4-Dioxane	72	Trace
7	–	H ₂ O	72	N.R. ^c
8	5	EtOH	8	55
9	10	EtOH	4	75
10	15	EtOH	1	95
11	20	EtOH	1	85
12	15	MeOH	12	75
13	15	CHCl ₃	12	35
14	15	CH ₃ CN	12	25
15	15	CH ₂ Cl ₂	12	20
16	15	1,4-Dioxane	12	30
17	15	H ₂ O	48	N.R. ^c

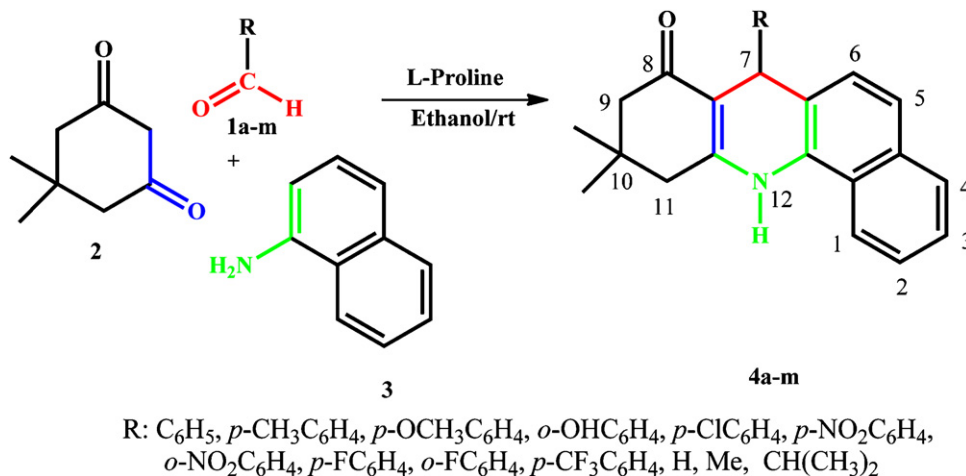
^a 5,5-dimethylcyclohexane-1,3-dione(dimedone)/aldehyde/ α -naphthylamine(1:1:1).

^b Isolated yield.

^c No reaction.

secondly to the reaction passing via imine with lower reactivity rather than iminium ion with *L*-Proline with much higher reactivity (via mechanism). The detailed results of changing catalyst (*L*-Proline) concentration and solvents are given in Table 1.

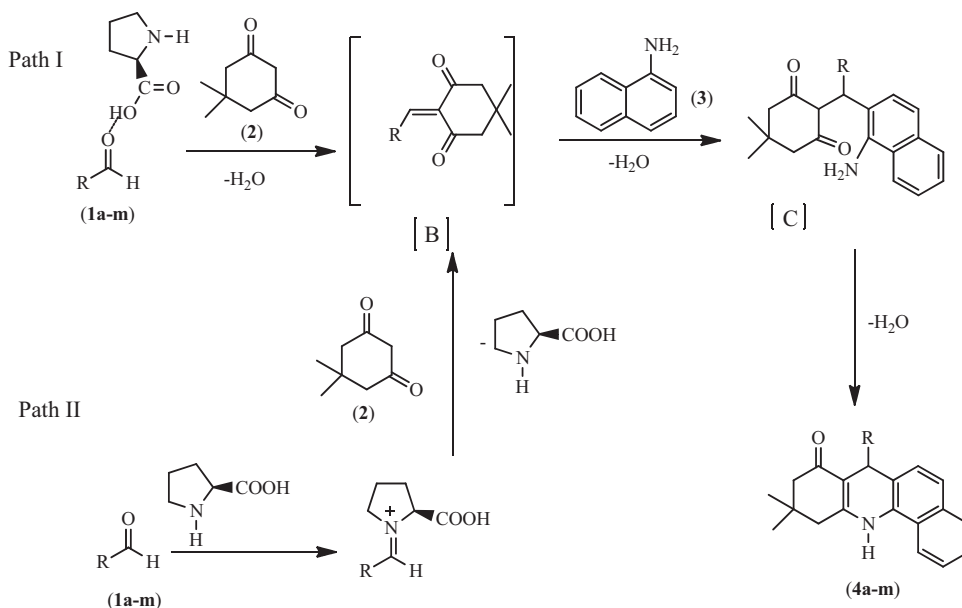
We next examined a wide variety of aldehydes (both aromatic and aliphatic) with various substituents to establish the catalytic importance of *L*-Proline for this reaction. A wide range of *ortho*-, *meta*- and *para*-substituted aromatic aldehydes undergo this one-pot multicomponent synthesis with dimedone and α -naphthylamine to afford substituted tetrahydrobenzo[*c*]acridin-8(7H)-ones in good yields. In all cases, we observed the almost same performance towards this cyclocondensation to give the desired product (**4a–m**) (Table 2). Aliphatic aldehydes gave the corresponding



Scheme 1. *L*-Proline catalyzed synthesis of substituted tetrahydrobenzo[*c*]acridin-8(7H)-ones.

Table 2Synthesis of highly tetrahydrobenzo[*c*]acridin-8(7H)-ones (**4a–m**) at room temperature using *L*-Proline (15 mol %) as an organocatalyst^a.

Entry	R	Time (h)	Product	Yield ^b (%)	Mp (°C)	
					Found	Reported
1	C ₆ H ₅	1	4a	95	257–258	258–259 [28,29]
2	4-CH ₃ C ₆ H ₄	2	4b	91	212–214	–
3	4-CH ₃ OC ₆ H ₄	2	4c	92	206–207	–
4	2-OHC ₆ H ₄	2	4d	92	221–223	220–222 [30]
5	4-ClC ₆ H ₄	1	4e	97	289–290	290–292 [28,29]
6	4-NO ₂ C ₆ H ₄	0.5	4f	95	281–283	281–283 [31]
7	2-NO ₂ C ₆ H ₄	0.5	4g	93	228–229	–
8	4-FC ₆ H ₄	0.5	4h	95	218–219	–
9	2-FC ₆ H ₄	0.5	4i	96	231–233	–
10	4-CF ₃ C ₆ H ₄	0.5	4j	97	276–277	–
11	H	4	4k	88	187–189	–
12	Me	4	4l	87	191–192	–
13	CH(CH ₃) ₂	5	4m	89	195–197	–

^a5,5-dimethylcyclohexane-1,3-dione(dimedone)/aldehyde/ α -naphthylamine (1:1:1).^b Isolated yield.**Scheme 2.** A plausible mechanism for the formation of tetrahydrobenzo[*c*]acridin-8(7H)-ones, *Pathway I*-acid catalysis through intermolecular hydrogen bonding. *Pathway II*-iminium catalysis.

tetrahydrobenzo[*c*]acridin-8(7H)-ones in lower yield (25–35%) than aromatic aldehydes (90–98%). The reaction profile is very clean and no side products are formed. All the synthesized tetrahydrobenzo[*c*]acridin-8(7H)-ones have been characterized on the basis of elemental and spectral studies.

A plausible mechanism for the *L*-Proline catalyzed synthesis of highly substituted tetrahydrobenzo[*c*]acridin-8(7H)-ones has been proposed (Scheme 2) in which the reaction proceeds through two different pathways (Path-I and Path-II). Path-I involves the activation of aldehydic carbonyl oxygen by the acidic part of *L*-Proline through intermolecular H-bonding and subsequent condensation with 5,5-dimethylcyclohexane-1,3-dione(dimedone) to form the enone intermediate B. Path-II gives the same

intermediate B via iminium catalysis which condenses with the condensation product of amine and 5,5-dimethylcyclohexane-1,3-dione(dimedone) to form the intermediate C which, on dehydration, gives the tetrahydrobenzo[*c*]acridin-8(7H)-ones (**4a–m**).

3. Conclusion

In conclusion, we have developed a simple and efficient one-pot multicomponent methodology for the synthesis of substituted tetrahydrobenzo[*c*]acridin-8(7H)-ones (**4a–m**) catalyzed by 15 mol% *L*-Proline at room temperature. Simplicity of operation, high yields, easy work-up, purification of compounds by non-chromatography method (crystallization only) and wide

range of substrate applicability are the key advantages of this methodology.

4. Experimental

4.1. General

All reagents were purchased from Merck. Aldehydes were distilled before use. Melting points were determined using a Linkman HF591 heating stage, used in conjunction with a TC92 controller, and re-uncorrected. NMR spectra were recorded using either a Bruker DRX500 machine at room temperature. ^1H , ^{13}C NMR and ^{19}F NMR spectra were measured using DMSO- d_6 as solvent. CHN analyses were performed on Exeter Analytical Inc. 'Model C-400 CHN Analyzer'. Mass spectra were obtained using a Micro Mass LCT machine in ES or EI mode. Infrared spectra were measured on a Perkin Elmer Paragon 100 FT-IR spectrometer. All the reactions were monitored by TLC using 0.25 mm silica gel plates (Merck 60F $_{254}$) UV indicator.

4.2. General procedure for the synthesis of substituted tetrahydrobenzo[*c*]acridin-8(7*H*)-ones (4*a*–*m*)

In a 50 mL round bottom flask 5,5-dimethylcyclohexane-1,3-dione (1 mmol), aldehyde (1 mmol) and α -naphthylamine (1 mmol) were stirred in the presence of 15 mol% of *L*-Proline in ethanol (2 mL) at room temperature for the stipulated time (Table 2). The progress of the reaction was monitored by TLC. After completion of the reaction, the reaction mixture was diluted with water (5 mL) and extracted with ethyl acetate (3 \times 10 mL). The organic layer was dried over anhydrous Na_2SO_4 , concentrated, and recrystallized from hot ethanol to afford the pure product.

4.3. Characterization data of some representative compounds

4.3.1. 10,10-Dimethyl-7-(*p*-tolyl)-9,10,11,12-tetrahydrobenzo[*c*]acridin-8(7*H*)-one (4*b*)

0.334 g (91%); pale yellow solid; mp 212–214 °C. IR (KBr): 3323, 3077, 2985, 1655, 1589 (C=O), 1523, 1446, 804 cm^{-1} . ^1H NMR (DMSO- d_6 , 500 MHz): 1.11 (s, 3H, CH $_3$), 1.26 (s, 3H, CH $_3$), 2.07–2.27 (dd, 2H, C $_9$ -H), 2.51–2.71 (dd, 2H, C $_{11}$ -H), 2.89 (s, 3H, CH $_3$), 5.42 (s, 1H, C $_7$ -H), 7.11–8.10 (m, 9H, Ar-H), 8.52 (d, 1H, *J* = 7.3, C $_6$ -H), 9.40 (s, 1H, NH). ^{13}C NMR (DMSO- d_6 , 125 MHz): δ 27.23, 29.67, 32.64, 36.87, 41.00, 50.56, 67.76, 87.98, 106.84, 119.85, 121.86, 122.72, 123.59, 124.05, 126.53, 128.19, 128.75, 128.92, 131.33, 133.05, 146.14, 152.87, 156.07, 194.01. MS (EI), *m/z* (%) = 367 (M $^+$, 70), 276 (95). HRMS (EI) Found: M $^+$, 367.1904. C $_{26}\text{H}_{25}\text{NO}$ requires M $^+$, 367.1908. Anal Calcd for C $_{26}\text{H}_{25}\text{NO}$: C, 84.98; H, 6.86; N, 3.81. Found: C, 90.05; H, 6.91; N, 3.65.

4.3.2. 7-(4-Methoxyphenyl)-10,10-dimethyl-9,10,11,12-tetrahydrobenzo[*c*]acridin-8(7*H*)-one (4*c*)

0.352 g (92%); white solid; mp 206–207 °C. IR (KBr): 3318, 3098, 2921, 1651, 1532 (C=O), 1505, 1434, 1154, 832 cm^{-1} . ^1H NMR (DMSO- d_6 , 500 MHz): 1.13 (s, 3H, CH $_3$), 1.31 (s, 3H, CH $_3$), 2.03–2.25 (dd, 2H, C $_9$ -H),

2.45–2.74 (dd, 2H, C $_{11}$ -H), 4.32 (s, 3H, OCH $_3$), 6.06 (s, 1H, C $_7$ -H), 7.14–8.06 (m, 9H, Ar-H), 8.62 (d, 1H, *J* = 7.5, C $_6$ -H), 9.54 (s, 1H, NH). ^{13}C NMR (DMSO- d_6 , 125 MHz): δ 26.31, 28.56, 30.54, 35.53, 40.09, 51.43, 64.87, 76.98, 81.21, 89.76, 104.65, 118.76, 120.65, 123.65, 123.97, 125.03, 127.43, 128.20, 129.43, 129.54, 130.43, 132.43, 144.32, 150.43, 155.43, 195.54. MS (EI), *m/z* (%) = 383 (M $^+$, 70), 276 (92). HRMS (EI) Found: M $^+$, 383.2109. C $_{26}\text{H}_{25}\text{NO}_2$ requires M $^+$, 383.1921. Anal Calcd for C $_{26}\text{H}_{25}\text{NO}_2$: C, 81.43; H, 6.57; N, 3.65. Found: C, 81.21; H, 6.65; N, 3.86.

4.3.3. 10,10-Dimethyl-7-(4-nitrophenyl)-9,10,11,12-tetrahydrobenzo[*c*]acridin-8(7*H*)-one (4*f*)

0.378 g (95%); yellow solid; mp 241–242 °C. IR (KBr): 3306, 3065, 2897, 1643, 1567 (C=O), 1512, 1421, 1142, 839 cm^{-1} . ^1H NMR (DMSO- d_6 , 500 MHz): 1.18 (s, 3H, CH $_3$), 1.41 (s, 3H, CH $_3$), 2.08–2.34 (dd, 2H, C $_9$ -H), 2.56–2.83 (dd, 2H, C $_{11}$ -H), 5.89 (s, 1H, C $_7$ -H), 7.18–7.98 (m, 9H, Ar-H), 8.74 (d, 1H, *J* = 8.0, C $_6$ -H), 9.67 (s, 1H, NH). ^{13}C NMR (DMSO- d_6 , 125 MHz): δ 27.21, 29.33, 31.43, 33.43, 42.49, 52.55, 66.54, 74.88, 88.76, 106.88, 117.43, 121.33, 122.21, 123.30, 124.21, 126.10, 129.11, 129.43, 129.42, 131.34, 133.54, 147.21, 153.65, 157.87, 196.33. MS (EI), *m/z* (%) = 398 (M $^+$, 70), 196 (94). HRMS (EI) Found: M $^+$, 398.2002. C $_{25}\text{H}_{22}\text{N}_2\text{O}_3$ requires M $^+$, 398.1611. Anal Calcd for C $_{25}\text{H}_{22}\text{N}_2\text{O}_3$: C, 75.36; H, 5.57; N, 7.03. Found: C, 75.30; H, 5.87; N, 7.21.

4.3.4. 10,10-Dimethyl-7-(2-nitrophenyl)-9,10,11,12-tetrahydrobenzo[*c*]acridin-8(7*H*)-one (4*g*)

0.378 g (93%); yellow solid; mp 228–229 °C. IR (KBr): 3318, 3098, 2921, 1651, 1532 (C=O), 1505, 1434, 1154, 832 cm^{-1} . ^1H NMR (DMSO- d_6 , 500 MHz): 1.16 (s, 3H, CH $_3$), 1.38 (s, 3H, CH $_3$), 2.10–2.41 (dd, 2H, C $_9$ -H), 2.58–2.89 (dd, 2H, C $_{11}$ -H), 5.91 (s, 1H, C $_7$ -H), 7.14–8.03 (m, 9H, Ar-H), 8.82 (d, 1H, *J* = 8.0, C $_6$ -H), 9.83 (s, 1H, NH). ^{13}C NMR (DMSO- d_6 , 125 MHz): δ 25.43, 30.23, 32.54, 36.42, 40.87, 53.33, 67.34, 77.41, 88.76, 119.55, 120.22, 121.66, 122.41, 124.09, 125.31, 125.87, 129.09, 129.65, 130.42, 132.76, 135.31, 148.43, 156.72, 158.34, 197.67. MS (EI), *m/z* (%) = 398 (M $^+$, 70), 196 (95). HRMS (EI) Found: M $^+$, 398.1342. C $_{25}\text{H}_{22}\text{N}_2\text{O}_3$ requires M $^+$, 398.1611. Anal Calcd for C $_{25}\text{H}_{22}\text{N}_2\text{O}_3$: C, 75.36; H, 5.57; N, 7.03. Found: C, 75.16; H, 5.65; N, 7.09.

4.3.5. 7-(4-Fluorophenyl)-10,10-dimethyl-9,10,11,12-tetrahydrobenzo[*c*]acridin-8(7*H*)-one (4*h*)

0.352 g (95%); white solid; mp 218–219 °C. IR (KBr): 3315, 3069, 2973, 1640, 1531 (C=O), 1514, 1439, 1125, 836 cm^{-1} . ^1H NMR (DMSO- d_6 , 500 MHz): 1.10 (s, 3H, CH $_3$), 1.29 (s, 3H, CH $_3$), 2.08–2.34 (dd, 2H, C $_9$ -H), 2.45–2.81 (dd, 2H, C $_{11}$ -H), 5.92 (s, 1H, C $_7$ -H), 7.11–7.89 (m, 9H, Ar-H), 8.62 (d, 1H, *J* = 7.5, C $_6$ -H), 9.61 (s, 1H, NH). ^{13}C NMR (DMSO- d_6 , 125 MHz): δ 27.32, 31.03, 33.04, 37.23, 44.92, 58.41, 69.29, 78.44, 89.70, 119.02, 120.44, 120.89, 123.07, 124.26, 125.04, 125.89, 129.12, 129.54, 131.07, 133.52, 139.54, 149.43, 157.56, 159.42, 198.98. ^{19}F NMR (DMSO- d_6 , 470 MHz): δ -60.09. MS (EI), *m/z* (%) = 371 (M $^+$, 70), 276 (92). HRMS (EI) Found: M $^+$, 371.2101. C $_{25}\text{H}_{22}\text{FNO}$ requires M $^+$, 371.1703. Anal Calcd for C $_{25}\text{H}_{22}\text{FNO}$: C, 80.84; H, 5.97; N, 3.77. Found: C, 80.42; H, 6.05; N, 3.73.

4.3.6. 7-(2-Fluorophenyl)-10,10-dimethyl-9,10,11,12-tetrahydrobenzo[*c*]acridin-8(7H)-one (4i)

0.356 g (96%); pale yellow solid; mp 231–233 °C. IR (KBr): 3373, 3053, 2983, 1674, 1530 (C=O), 1520, 1423, 1145, 823 cm⁻¹. ¹H NMR (DMSO-*d*₆, 500 MHz): 1.12 (s, 3H, CH₃), 1.42 (s, 3H, CH₃), 2.05–2.35 (dd, 2H, C₉-H), 2.42–2.65 (dd, 2H, C₁₁-H), 6.05 (s, 1H, C₇-H), 7.21–8.11 (m, 9H, Ar-H), 8.74 (d, 1H, *J* = 8.0, C₆-H), 9.65 (s, 1H, NH). ¹³C NMR (DMSO-*d*₆, 125 MHz): δ 29.43, 32.43, 32.43, 35.04, 39.54, 44.56, 59.54, 68.65, 75.87, 89.43, 118.54, 121.44, 121.99, 123.65, 124.54, 125.43, 125.65, 129.43, 129.84, 131.37, 133.62, 141.54, 147.43, 154.58, 159.54, 197.87. ¹⁹F NMR (DMSO-*d*₆, 470 MHz): –61.03. MS (EI), *m/z* (%) = 371 (M⁺, 70), 276 (95). HRMS (EI) Found: M⁺, 371.165709. C₂₅H₂₂FNO requires M⁺, 371.1708. Anal Calcd for C₂₅H₂₂FNO: C, 80.84; H, 5.97; N, 3.77. Found: C, 80.61; H, 5.65; N, 3.83.

4.3.7. 10,10-Dimethyl-7-(4-(trifluoromethyl)phenyl)-9,10,11,12-tetrahydrobenzo[*c*]acridin-8(7H)-one (4j)

0.408 g (97%); white solid; mp 276–277 °C. IR (KBr): 3332, 3076, 2971, 1651, 1522 (C=O), 1525, 1474, 1124, 822 cm⁻¹. ¹H NMR (DMSO-*d*₆, 500 MHz): 1.11 (s, 3H, CH₃), 1.23 (s, 3H, CH₃), 2.05–2.32 (dd, 2H, C₉-H), 2.43–2.84 (dd, 2H, C₁₁-H), 5.97 (s, 1H, C₇-H), 7.17–8.12 (m, 9H, Ar-H), 8.73 (d, 1H, *J* = 7.5, C₆-H), 9.45 (s, 1H, NH). ¹³C NMR (DMSO-*d*₆, 125 MHz): δ 26.34, 29.42, 31.54, 33.65, 42.76, 55.65, 68.65, 76.54, 85.43, 88.65, 105.43, 119.54, 121.43, 123.98, 124.54, 126.32, 127.08, 128.21, 129.21, 129.76, 131.32, 133.83, 137.96 (q, ¹*J*_{CF} = 255.76 Hz), 147.34, 156.43, 158.09, 198.56. ¹⁹F NMR (DMSO-*d*₆, 470 MHz): –111.2. MS (EI), *m/z* (%) = 421 (M⁺, 70), 276 (98). HRMS (EI) Found: M⁺, 421.2106. C₂₆H₂₂F₃NO requires M⁺, 421.1709. Anal Calcd for C₂₆H₂₂F₃NO: C, 74.10; H, 13.52; N, 3.32. Found: C, 74.54, 13.21; H, 3.45.

4.3.8. 10,10-Dimethyl-9,10,11,12-tetrahydrobenzo[*c*]acridin-8(7H)-one (4k)

0.243 g (88%); yellow solid; mp 187–189 °C. IR (KBr): 3323, 3065, 2937, 1665, 1548 (C=O), 1512, 1423, 1129, 823 cm⁻¹. ¹H NMR (DMSO-*d*₆, 500 MHz): 1.09 (s, 3H, CH₃), 1.23 (s, 3H, CH₃), 2.15–2.43 (dd, 2H, C₉-H), 2.48–2.87 (dd, 2H, C₁₁-H), 6.18 (s, 1H, C₇-H), 7.08–7.78 (m, 6H, Ar-H), 8.65 (d, 1H, *J* = 8.0, C₆-H), 9.76 (s, 1H, NH). ¹³C NMR (DMSO-*d*₆, 125 MHz): δ 28.31, 29.50, 33.74, 38.03, 44.87, 76.98, 81.21, 89.76, 125.03, 127.43, 128.20, 129.43, 129.54, 130.43, 132.43, 144.32, 150.43, 155.43, 195.54. MS (EI), *m/z* (%) = 277 (M⁺, 70), 151 (76). HRMS (EI) Found: M⁺, 277.1509. C₁₉H₁₉NO requires M⁺, 277.1501. Anal Calcd for C₁₉H₁₉NO: C, 82.28; H, 6.90; N, 5.05. Found: C, 82.34; H, 6.65; N, 5.36.

4.3.9. 7,10,10-Trimethyl-9,10,11,12-tetrahydrobenzo[*c*]acridin-8(7H)-one (4l)

0.253 g (87%); yellow solid; mp 191–192 °C. IR (KBr): 3336, 3087, 2987, 1643, 1543 (C=O), 1532, 1465, 1132, 818 cm⁻¹. ¹H NMR (DMSO-*d*₆, 500 MHz): 1.12 (s, 3H, CH₃), 1.28 (s, 3H, CH₃), 2.12–2.45 (dd, 2H, C₉-H), 2.55–2.60 (dd, 2H, C₁₁-H), 3.56 (s, 3H, CH₃), 6.32 (s, 1H, C₇-H), 7.09–7.78 (m, 5H, Ar-H), 8.56 (d, 1H, *J* = 8.0, C₆-H), 9.65 (s, 1H, NH). ¹³C NMR (DMSO-*d*₆, 125 MHz): δ 28.08, 29.23, 33.34, 37.76,

46.65, 57.88, 68.98, 79.07, 80.54, 88.76, 110.65, 125.43, 129.28, 129.74, 131.43, 138.43, 149.33, 154.43, 156.76, 196.87. MS (EI), *m/z* (%) = 291 (M⁺, 70), 166 (79). HRMS (EI) Found: M⁺, 291.180309. C₂₀H₂₁NO requires M⁺, 291.1608. Anal Calcd for C₂₀H₂₁NO: C, 82.44; H, 7.26; N, 4.81. Found: C, 82.06; H, 7.32; N, 4.43.

4.3.10. 7-Isopropyl-10,10-dimethyl-9,10,11,12-tetrahydrobenzo[*c*]acridin-8(7H)-one (4m)

0.283 g (89%); pale yellow solid; mp 195–197 °C. IR (KBr): 3318, 3098, 2921, 1651, 1532 (C=O), 1505, 1434, 1154, 832 cm⁻¹. ¹H NMR (DMSO-*d*₆, 500 MHz): 1.13 (s, 3H, CH₃), 1.31 (s, 3H, CH₃), 2.03–2.25 (dd, 2H, C₉-H), 2.45–2.74 (dd, 2H, C₁₁-H), 3.45 (hep., 1H, CH), 4.56 (d, 6H, 2 × CH₃), 6.21 (s, 1H, C₇-H), 7.16–8.02 (m, 5H, Ar-H), 8.72 (d, 1H, *J* = 7.5, C₆-H), 9.65 (s, 1H, NH). ¹³C NMR (DMSO-*d*₆, 125 MHz): δ 26.31, 28.56, 30.54, 32.43, 33.27, 34.65, 35.53, 40.09, 51.43, 64.87, 76.98, 81.21, 89.76, 128.20, 129.43, 129.54, 131.04, 131.23, 143.32, 152.65, 153.43, 194.60. MS (EI), *m/z* (%) = 319 (M⁺, 70), 276 (90), 193 (45). HRMS (EI) Found: M⁺, 319.1908. C₂₂H₂₅NO requires M⁺, 319.1932. Anal Calcd for C₂₂H₂₅NO: C, 82.72; H, 7.89; N, 4.38. Found: C, 82.56; H, 7.65; N, 4.66.

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