Efficient and direct synthesis of poly-substituted indeno[1,2-*b*]quinolines assisted by *p*-toluene sulfonic acid using high-temperature water and microwave heating *via* one-pot, three-component reaction†

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Reactions of aldehydes, 1,3-indanedione and enaminones were successfully carried out using *p*-toluene sulfonic acid (*p*-TsOH) as a catalyst and high-temperature water as a solvent under microwave irradiation. This method provided several advantages such as rapid reaction times, high yields, and a simple workup procedure. In addition, a possible mechanism to account for the reaction was proposed.

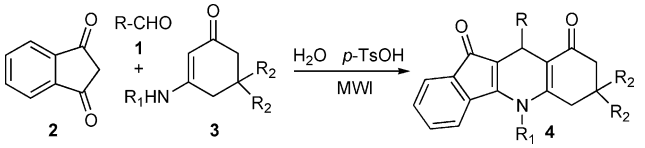
Introduction

The similar polarity of classic organic solvents and high-temperature water has aroused much interest in the investigation of organic transformations in aqueous media.[1] In addition to being a safe, readily available and environmentally friendly solvent,[2] water has also been recognized as an effective reaction medium with unique properties and possibilities for many organic reactions.[3] Simultaneously, high density microwave irradiation has matured into a reliable and useful methodology for accelerating small-scale reactions.[4] Thus, it has become clear that the combined approach of microwave superheating, homogeneous catalysis, and an aqueous medium offers a nearly synergistic strategy in the sense that the combination in itself offers greater potential than the three parts in isolation.[5]

In modern drug discovery a number of solutions to increase the output of unique chemical entities have been presented, *e.g.*, combinatorial synthesis, parallel synthesis, and automated library production.[6] Even though many of these small-scale techniques are productive, they generate significant quantities of chemical waste.[7] Overall, the development of new methods with reduced environmental impact is of increasing importance. The use of water as a nontoxic reaction medium, together with the employment of energy-efficient microwave heating[8] and catalytic methods, must be considered to be both promising and enabling green alternatives.

Indenoquinoline derivatives are important heterocyclic compounds, which exhibit a diverse range of biological properties such as 5-HT-receptor binding activity[9] and anti-inflammatory activity.[10] They also act as antitumor agents,[11] steroid reductase inhibitors,[12] acetylcholinesterase inhibitors,[13] antimalarials[14] and new potential topo I/II inhibitors.[15] Therefore, the synthesis of this type of compounds has attracted considerable attention.[16] In our previous communication,[17] we accomplished the construction of the indeno[1,2-*b*]quinoline scaffold in HOAc with aryl groups being introduced to the nitrogen atom in indeno[1,2-*b*]quinoline. To our delight, we found that this reaction can be successfully carried out in aqueous media, and a series of enaminones derived from various amines such as cyclopropanamine, methylamine, aminoacetic acid, and aromatic amines can take part in this reaction.

p-Toluene sulfonic acid (*p*-TsOH), an easily available and cheap reagent has been used as an acidic catalyst in the synthesis of a variety of heterocyclic compounds.[18] However, the use *p*-TsOH as a catalyst in aqueous media for the synthesis of poly-substituted indeno[1,2-*b*]quinolines and their derivatives has not been reported. In this paper, we wish to report a general and highly efficient synthesis of poly-substituted indeno[1,2-*b*]quinolines, using *p*-TsOH as a catalyst, from various enaminones under microwave irradiation. This is an efficient synthesis in aqueous media, which not only preserves the simplicity of the reaction but also consistently gives the corresponding products in good to excellent yields (Scheme 1).



Scheme 1 Synthetic route to indeno[1,2-*b*]quinoline derivatives.

Result and discussion

3-(Cyclopropylamino)-5,5-dimethylcyclohex-2-enone **3a** has been used as the starting material to synthesize poly-substituted indeno[1,2-*b*]quinolines. We therefore first chose **3a** and searched for the optimized conditions for its reaction with *p*-chlorobenzaldehyde **1a** and 1,3-indanedione **2** affording poly-substituted indeno[1,2-*b*]quinolines under microwave conditions (microwave oven Emrys™ Creator from Personal Chemistry, Uppsala, Sweden) (Scheme 2).

Different acidic catalysts were examined first. The results of these comparative experiments are summarized in Table 1. From the results it is obvious that *p*-TsOH (entry 1) demonstrates superior catalytic activity and is the best catalyst among those examined. In order to further evaluate the influence of *p*-TsOH

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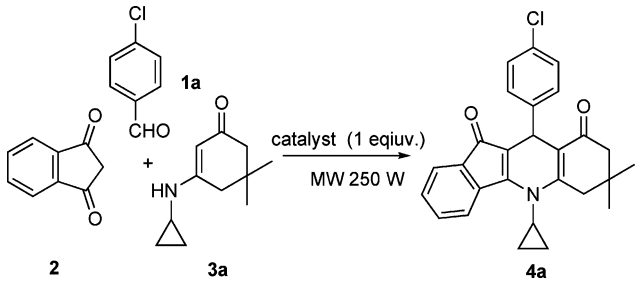


Scheme 2 Optimization of the catalyst in the synthesis of compound **4a**.

Table 1 Optimization of the catalyst in the synthesis of compound **4a** in water at 150 °C under microwave irradiation

Entry	Catalyst	Time/min	Yield (%)
1	*p*-TsOH	3	93
2	L-Proline	3	76
3	Silica sulfuric acid	3	68
4	KH_2PO_4	3	79
5	$KHSO_4$	3	81
6	HCl	3	56
7	H_2SO_4	3	49
8	H_3PO_4	3	72

concentration, this reaction was carried out using different amounts of *p*-TsOH under microwave irradiation. The results are listed in Table 2.

From Table 2 it can be seen that the reaction proceeded in the presence of 0.1 equivalents of *p*-TsOH to give the product **4a** in 79% yield under microwave irradiation at 150 °C after 3 minutes of reaction (entry 1). Increasing the amount of catalyst to 0.3, 0.6, 0.8 and 0.9 equivalents successively resulted in the increasing of the yield to 84%, 89%, 90% and 91%, respectively. Use of just 1.0 equivalent under microwave irradiation was sufficient to reach the highest yield (entry 6). Further increases in the amount of catalyst did not improve the yield (entries 7–8).

Table 2 Optimization of the amount of *p*-TsOH in the synthesis of compound **4a** at 150 °C under microwave irradiation

Entry	*p*-TsOH/eq.	Time/min	Yield (%)
1	0.1	3	79
2	0.3	3	84
3	0.6	3	89
4	0.8	3	90
5	0.9	3	91
6	1.0	3	93
7	1.2	3	91
8	1.4	3	92

We therefore selected 1.0 equivalent of *p*-TsOH as the catalyst for further study. At the beginning of the search for the aldehyde substrate scope, enaminone **3a** and 1,3-indanedione were used as model substrates (Table 3, entries 1–4), and the results indicated that aromatic aldehydes bearing either electron donating or electron withdrawing functional groups such as nitro, chloro, hydroxy, or methoxy were able to effect the synthesis of compounds **4**. We also observed delicate electronic effects: that is, aryl aldehydes with electron-withdrawing groups (Table 3, entries 1–2) reacted rapidly, while substitution of electron-rich groups (Table 3, entry 3) on the benzene ring decreased the reactivity, requiring longer reaction times.

To expand the scope of enaminone substrates, we used different aldehydes and 1,3-indanedione as model substrates and examined various enaminones including **3b**, **3c**, **3d**, **3e** and **3f**. In all these cases, the reactions proceeded smoothly to give the corresponding indeno[1,2-*b*]quinoline-9,11(6*H*,10*H*)-diones in good yields of 86–94%. Moreover, the heterocyclic aldehydes such as thiophene-2-carbaldehyde (Table 3, entries 8, 19 and 23), and aliphatic aldehydes such as 2-phenylacetaldehyde (Table 3, entry 20) still

Table 3 The synthesis of compounds **4** using *p*-TsOH as catalyst in aqueous media under microwave irradiation

Entry	R	**3**	R_1	R_2	**4**	Time/min	Yield (%)[a]	Mp/°C
1	4-ClC_6H_4 (**1a**)	**3a**	Cyclopropyl	CH_3	**4a**	3	93	295–297
2	4-$NO_2C_6H_4$ (**1b**)	**3a**	Cyclopropyl	CH_3	**4b**	2	94	268–270
3	4-$CH_3OC_6H_4$ (**1c**)	**3a**	Cyclopropyl	CH_3	**4c**	5	89	220–222
4	4-OH-3-$NO_2C_6H_3$ (**1d**)	**3a**	Cyclopropyl	CH_3	**4d**	3	93	245–247
5	C_6H_5 (**1e**)	**3b**	CH_2COOH	CH_3	**4e**	6	89	257–259
6	4-FC_6H_4 (**1f**)	**3b**	CH_2COOH	CH_3	**4f**	4	92	239–240
7	4-OH-3-NO_2-C_6H_3 (**1d**)	**3b**	CH_2COOH	CH_3	**4g**	3	93	248–250
8	2-Thienyl (**1g**)	**3c**	CH_3	CH_3	**4h**	5	87	232–234
9	4-$CH_3OC_6H_4$ (**1c**)	**3c**	CH_3	CH_3	**4i**	5	90	230–233
10	4-BrC_6H_4 (**1h**)	**3c**	CH_3	CH_3	**4j**	3	92	228–230
11	3,4-$OCH_2OC_6H_3$ (**1i**)	**3d**	H	CH_3	**4k**	5	89	282–284
12	4-BrC_6H_4 (**1h**)	**3d**	H	CH_3	**4l**	4	94	>300
13	3,4,5-$(CH_3O)_3C_6H_2$ (**1j**)	**3d**	H	CH_3	**4m**	6	89	276–278
14	4-(Benzo[*d*]oxazol-2yl)C_6H_4 (**1k**)	**3d**	H	CH_3	**4n**	4	90	295–297
15	4-OH-3-$CH_3OC_6H_3$ (**1l**)	**3d**	H	CH_3	**4o**	7	87	274–276
16	4-$CH_3C_6H_4$ (**1m**)	$\mathbf{3e_1}$	4-$CH_3C_6H_4$	CH_3	**4p**	5	88	283–285[17]
17	4-BrC_6H_4 (**1h**)	$\mathbf{3e_1}$	4-$CH_3C_6H_4$	CH_3	**4q**	3	92	255–256[17]
18	3,4-$(CH_3O)_2C_6H_3$ (**1n**)	$\mathbf{3e_2}$	4-$CH_3C_6H_4$	H	**4r**	5	89	257–259[17]
19	2-Thienyl (**1g**)	$\mathbf{3e_2}$	4-$CH_3C_6H_4$	H	**4s**	6	86	267–269
20	$C_6H_5CH_2$ (**1o**)	$\mathbf{3f_1}$	C_6H_5	CH_3	**4t**	7	89	207–209
21	4-$CH_3OC_6H_4$ (**1c**)	$\mathbf{3f_1}$	C_6H_5	CH_3	**4x**	6	91	250–251[17]
22	4-ClC_6H_4 (**1a**)	$\mathbf{3f_2}$	C_6H_5	H	**4y**	3	94	236–237[17]
23	2-Thienyl (**1g**)	$\mathbf{3f_1}$	C_6H_5	CH_3	**4z**	6	87	230–232[17]

[a] Isolated yields.

Table 4 The synthesis of some of compounds **4** in water at 150 °C using conventional heating

Entry	Product	Time/h	Yield (%)
1	**4a**	2	84
2	**4b**	2	87
3	**4c**	2	81
4	**4e**	2	79
5	**4f**	2	85
6	**4j**	2	86
7	**4k**	2	75
8	**4q**	2	82
9	**4y**	2	78

displayed high reactivity and a clean reaction under these standard conditions. It is important to note that this protocol could be applied not only to alicyclic amines (Table 3, entries 1–4), but also to aminoacetic acid (Table 3, entries 5–7), aliphatic amines (Table 3, entries 8–15) and aromatic amines (Table 3, entries 16–23).

Additionally, we performed the reactions for synthesizing some of compounds **4** under classical heating conditions using *p*-TsOH as a catalyst in high-temperature water. A comparison of the results for the nine compounds listed in Table 3 and Table 4 indicated that the reaction was efficiently promoted by microwave irradiation, and the reaction times were strikingly shortened to 2–6 min from the 2 h required under traditional heating conditions, and the yields were increased obviously too.

The structures of all the synthesized compounds were based on their spectroscopic data. The structures of **4b** and **4z** were established by X-ray crystallographic analysis (Figs. 1 and 2, respectively).[19] The IR spectrum of compound **4b** showed strong absorptions at 1684 cm^{-1} and 1645 cm^{-1} due to the C=O group. The ^1H NMR spectrum of **4b** showed a triplet at δ 3.58 due to the NCH proton and a singlet at δ 4.76 due to the CH proton. It is particularly noteworthy that when R_1 was an aryl group, a doublet appeared in the 4.91–5.27 ppm region (see ^1H NMR data), which belonged to the aromatic protons in compounds **4p–z**. This unusually upfield absorption could be explained according to the X-ray diffraction analysis result of **4z**. In the crystal structure of

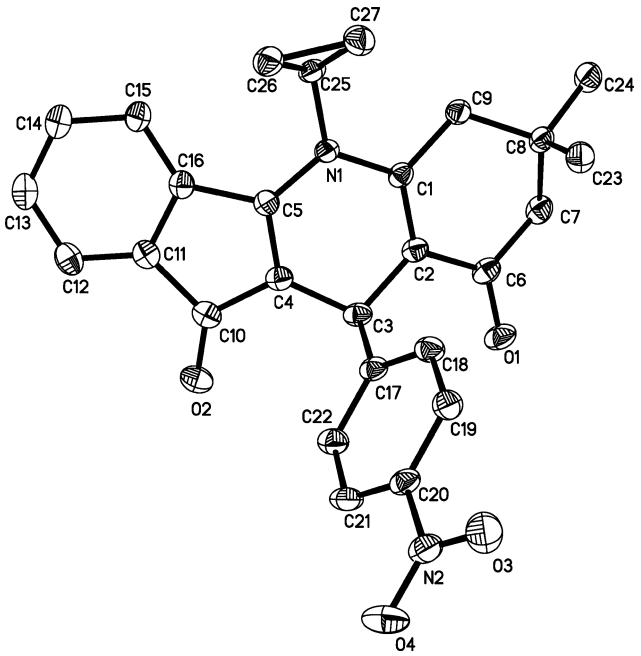


Fig. 1 The molecular structure of **4b**.

4z (Fig. 2), the distance between the proton at C_{14} and the benzene ring (C_{17} to C_{22}) was 2.53 Å, indicating that it was strongly shielded by the benzene ring (C_{17} to C_{22}).[17]

The formation of **4** is likely to proceed *via* initial condensation of aldehydes **1** with 1,3-indanedione **2** to afford 2-arylideneindene-1,3-dione **5**, which further undergoes *in situ* Michael addition reaction with enaminones **3** to yield products **4** (Scheme 3). In order to support the proposed mechanism, the compound **5h** was prepared independently from *p*-bromobenzaldehyde **1h** and 1,3-indanedione **2** and then employed in a two component reaction with enaminone **3d** to afford product **4l** in 92% yield. However, *p*-bromobenzaldehyde **1h** first condensed with **3d** followed by reaction with 1,3-indanedione **2** failed to give the target compound **4**. Instead, compound **6** and intermediate **5h** were obtained respectively (Scheme 4). When *p*-bromobenzaldehyde **1h** was first

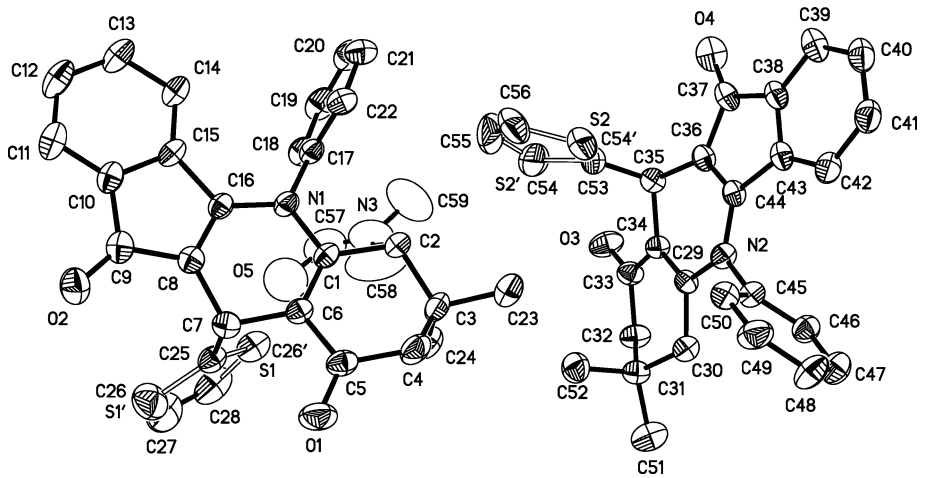
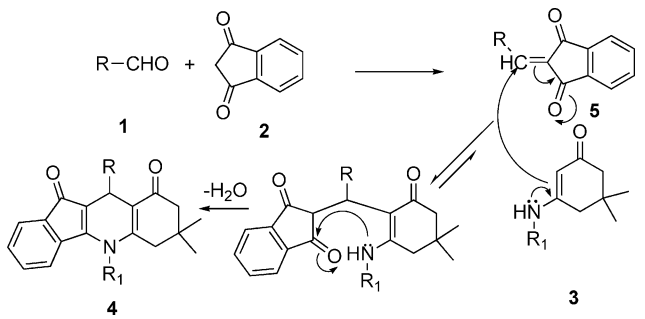


Fig. 2 The molecular structure of **4z**.



Scheme 3 The possible reaction mechanism.

condensed with $\mathbf{3e_1}$ followed by reaction with 1,3-indanedione **2**, the desired compound **4q** was not obtained. Instead, compound **7** and unreacted **2** were isolated respectively (Scheme 5).

Conclusion

In conclusion, we have developed a microwave-assisted, three-component condensation of aldehydes, 1,3-indanedione and enaminones using *p*-toluene sulfonic acid (*p*-TsOH) as a catalyst in high-temperature water, and have shown its application to the synthesis of a number of poly-substituted indeno[1,2-*b*]quinolines. This green procedure offers several advantages including operational simplicity, clean reactions, increased safety for small-scale high-speed synthesis, and minimal environmental impact that make it a useful and attractive process for the synthesis of these compounds.

Experimental

General

Microwave irradiation was carried out with a microwave oven (Emrys™ Creator from Personal Chemistry, Uppsala, Sweden). Melting points were determined in open capillaries and were uncorrected. IR spectra were taken on a FT-IR-Tensor 27 spectrometer in KBr pellets and reported in cm^{-1}. ^1H NMR spectra were measured on a Bruker DPX 400 MHz spectrometer in DMSO-d_6 with chemical shift (δ) given in ppm relative to TMS as internal standard. Elemental analyses were determined by using a Perkin-Elmer 240c elemental analysis instrument. X-Ray crystallographic analysis was performed with a Siemens SMART CCD and a Semens P4 diffractometer.

General procedure for the syntheses of compounds 4 with microwave irradiation

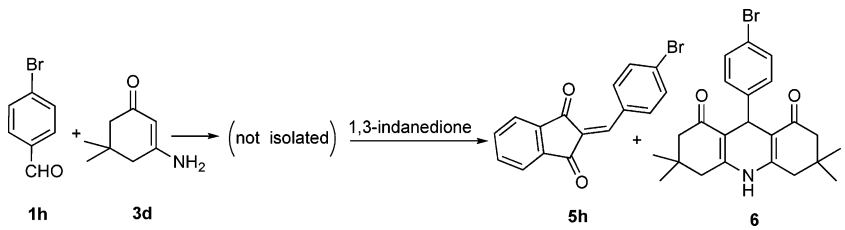
All the reactions were performed in a monomodal Emrys™ Creator from Personal Chemistry, Uppsala, Sweden. In a 10 mL Emrys™ reaction vial, an aldehyde **1** (1 mmol), 1,3-indanedione **2** (1 mmol), an enaminone **3** (1 mmol), *p*-TsOH (1 mmol) and water (1.0 mL) were mixed and then capped. The mixture was irradiated for a given time at power of 250 W at 150 °C. Upon completion as monitored by TLC, the reaction mixture was cooled to room temperature. The resulting suspension was neutralized with 0.4 mL of 10% NaOH. Then the mixture was stirred for 5 min and the solid was collected by Büchner filtration and washed with EtOH (95%), and subsequently dried and recrystallized from EtOH (95%) to give the pure red product.

General procedure for the synthesis of compounds 4 with conventional heating

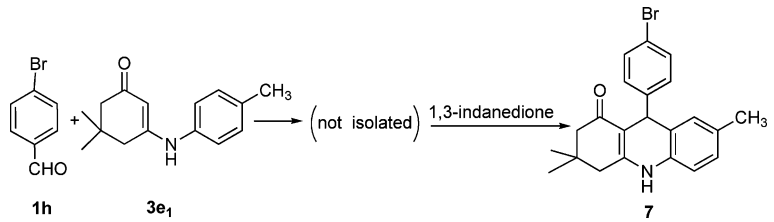
A mixture containing an aldehyde **1** (1 mmol), 1,3-indanedione **2** (1 mmol), an enaminone **3** (1 mmol), *p*-TsOH (1 mmol) and water (1.0 mL) was introduced into a 10 mL Emrys™ reaction vial, capped and then stirred at 150 °C (oil bath temperature) for two hours. The subsequent work-up procedure was the same as in the microwave irradiation reactions.

5-Cyclopropyl-7,8-dihydro-7,7-dimethyl-10-(4-nitrophenyl)-5*H*-indeno[1,2-*b*]quinoline-9,11(6*H*,10*H*)-dione (4b)

IR (KBr, ν, cm^{-1}): 2959, 2869, 1677, 1647, 1556, 1518, 1346, 1219, 1136, 878, 727; ^1H NMR (DMSO-*d6*) (δ, ppm): 8.10 (d, 2H, ArH, J = 8.4 Hz), 7.83 (d, 1H, ArH, J = 7.6 Hz), 7.48–7.46 (m, 2H, ArH), 7.36 (d, 2H, ArH, J = 8.4 Hz), 7.32 (d, 1H, ArH, J = 7.6 Hz), 4.62 (s, 1H, CH), 3.60 (t, 1H, CH, J = 3.2 Hz), 3.12 (d,



Scheme 4 The investigation of a possible reaction mechanism.



Scheme 5 The investigation of a possible reaction mechanism.

1H, CH_2, $J = 17.2$ Hz), 2.75 (d, 1H, CH_2, $J = 17.2$ Hz), 2.27 (d, 1H, CH_2, $J = 16.0$ Hz), 2.20 (d, 1H, CH_2, $J = 16.0$ Hz), 1.32–1.26 (m, 2H, CH_2), 1.05 (s, 6H, CH_3), 1.02–0.86 (m, 2H, CH_2), Anal calcd. for $C_{27}H_{24}N_2O_4$, C, 73.62; H, 5.49; N, 6.36; found C, 73.81; H, 5.43; N, 6.51%.

2-(10-(4-Fluorophenyl)-6,7,8,9-tetrahydro-7,7-dimethyl-9,11-dioxo-10*H*-indeno[1,2-*b*]quinolin-5(11*H*)-yl)acetic acid (4f)

IR (KBr, ν, cm^{-1}): 2965, 1731, 1682, 1627, 1602, 1549, 1403, 1379, 1221, 984, 874, 740; ^1H NMR (DMSO-d_6) (δ, ppm): 13.71 (br s, 1H, COOH), 7.44–7.41 (m, 1H, ArH), 7.36–7.30 (m, 5H, ArH), 7.05–7.00 (m, 2H, ArH), 5.09–4.98 (m, 2H, CH_2), 4.80 (s, 1H, CH), 2.86–2.85 (m, 1H, CH_2), 2.40–2.35 (m, 1H, CH_2), 2.24 (d, 1H, CH_2, $J = 16.0$ Hz), 2.14 (d, 1H, CH_2, $J = 16.0$ Hz), 1.03 (s, 3H, CH_3), 0.95 (s, 3H, CH_3). Anal calcd. for $C_{26}H_{22}FNO_4$, C, 72.38; H, 5.14; N, 3.25; found C, 72.51; H, 5.05; N, 3.32%.

10-(4-Bromophenyl)-7,8-dihydro-5,7,7-trimethyl-5*H*-indeno[1,2-*b*]quinoline-9,11(6*H*,10*H*)-dione (4j)

IR (KBr, ν, cm^{-1}): 2953, 2868, 1677, 1643, 1626, 1549, 1368, 1215, 1008, 871, 692; ^1H NMR (DMSO-d_6) (δ, ppm): 7.67 (d, 1H, ArH, $J = 7.6$ Hz), 7.46–7.43 (m, 1H, ArH), 7.40 (d, 2H, ArH, $J = 8.4$ Hz), 7.37–7.30 (m, 2H, ArH), 7.17 (d, 2H, ArH, $J = 8.4$ Hz), 4.78 (s, 1H, CH), 3.74 (s, 3H, NCH_3), 2.90 (d, 1H, CH_2, $J = 17.2$ Hz), 2.55 (d, 1H, CH_2, $J = 17.2$ Hz), 2.22–2.14 (m, 2H, CH_2), 1.06 (s, 3H, CH_3), 1.00 (s, 3H, CH_3). Anal calcd. for $C_{25}H_{22}BrNO_2$, C, 66.97; H, 4.95; N, 3.12; found C, 67.11; H, 4.87; N, 3.20%.

7,8-Dihydro-10-(thiophen-2-yl)-5-*p*-tolyl-5*H*-indeno[1,2-*b*]quinoline-9,11(6*H*,10*H*)-dione (4s)

IR (KBr, ν, cm^{-1}): 3059, 2943, 2923, 2866, 1678, 1643, 1588, 1510, 1395, 1177, 896, 844, 711; ^1H NMR (DMSO-d_6) (δ, ppm): 7.59–7.58 (m, 1H, thiophenyl-H), 7.47 (d, 2H, ArH, $J = 7.6$ Hz), 7.42–7.40 (m, 1H, thiophenyl-H), 7.32–7.21 (m, 3H, ArH), 7.07–7.03 (m, 1H, thiophenyl-H), 6.91–6.89 (m, 2H, ArH), 5.27 (d, 1H, ArH, $J = 7.6$ Hz), 5.20 (s, 1H, CH), 2.48 (s, 3H, CH_3), 2.33–2.31 (m, 3H, CH_2), 2.16–2.11 (m, 1H, CH_2), 1.92–1.69 (m, 2H, CH_2); Anal calcd. for $C_{27}H_{21}NO_2S$, C, 76.57; H, 5.00; N, 3.31; S, 7.57; found C, 76.40; H, 5.12; N, 3.41; S, 7.43%.

10-Benzyl-7,8-dihydro-7,7-dimethyl-5-phenyl-5*H*-indeno[1,2-*b*]quinoline-9,11(6*H*,10*H*)-dione (4t)

IR (KBr, ν, cm^{-1}): 3026, 2960, 1686, 1637, 1587, 1398, 1101, 882, 718; ^1H NMR (DMSO-d_6) (δ, ppm): 7.61–7.52 (m, 4H, ArH), 7.34 (d, 1H, ArH, $J = 6.8$ Hz), 7.26–7.18 (m, 4H, ArH), 6.94 (t, 1H, ArH, $J = 7.6$ Hz), 6.89 (d, 2H, ArH, $J = 6.8$ Hz), 6.21 (s, 1H, ArH), 4.91 (d, 1H, ArH, $J = 7.6$ Hz), 4.20 (t, 1H, CH, $J = 3.8$ Hz), 2.87–2.78 (m, 2H, CH_2), 2.28 (s, 2H, CH_2), 2.16 (d, 1H, CH_2, $J = 17.6$ Hz), 1.63 (d, 1H, CH_2, $J = 17.6$ Hz), 0.93 (s, 3H, CH_3), 0.91 (s, 3H, CH_3). Anal calcd. for $C_{31}H_{27}NO_2$, C, 83.57; H, 6.11; N, 3.14; found C, 83.76; H, 6.02; N, 3.16%.

Preparation of compound 5h

The reaction was performed in a monomodal Emrys™ Creator from Personal Chemistry, Uppsala, Sweden. In a 10 mL Emrys™ reaction vial, 4-bromobenzaldehyde **1h** (2 mmol), 1,3-indanedione **2** (2 mmol) and water (1.0 mL) were mixed and then capped. The mixture was irradiated for 2 min at 250 W power and 150 °C. Upon completion, the reaction mixture was cooled to room temperature and then filtered, washed with EtOH (95%), and subsequently dried and recrystallized from EtOH (95%) to give the pure product **5h**.

Substep reaction of aldehyde 1h, enaminone 3d or $3e_1$ and 1,3-indanedione 2

The reaction was performed in a monomodal Emrys™ Creator from Personal Chemistry, Uppsala, Sweden. In a 10 mL Emrys™ reaction vial, 4-bromobenzaldehyde **1h** (1 mmol), 3-amino-5,5-dimethylcyclohex-2-enone **3d** (or 5,5-dimethyl-3-(4-methylphenylamino)cyclohex-2-enone **$3e_1$**) (1 mmol), *p*-TsOH (1 mmol) and water (1.0 mL) were mixed and then capped. The mixture was irradiated for 2 min at a power of 250 W and 150 °C, and then 1,3-indanedione **2** (1 mmol) was added. The mixture was irradiated for 3 min at 250 W power and 150 °C again. Upon completion (TLC monitoring), the reaction mixture was cooled to room temperature. The resulting suspension was neutralized with 0.4 mL of 10% NaOH. Then the mixture was stirred for 5 min and the solid was collected by Büchner filtration and washed with EtOH (95%). The solid was purified by column chromatography on silica gel (200–300 mesh) using petroleum ether (bp 60–90 °C)–acetone (1 : 1) as eluent to give compounds **5h**, **6** and **7**.

2-(4-Bromobenzylidene)-2*H*-indene-1,3-dione (5h). Mp: 176–178 °C; IR (KBr, ν, cm^{-1}): 3084, 3009, 2941, 1714, 1676, 1587, 1275, 804, 743; ^1H NMR (DMSO-d_6) (δ, ppm): 8.45 (d, 2H, ArH, $J = 8.4$ Hz), 8.04–8.02 (m, 2H, ArH), 7.99–7.97 (m, 2H, ArH), 7.85 (s, 1H, CH), 7.81 (d, 2H, ArH, $J = 8.4$ Hz); Anal calcd. for $C_{16}H_9BrO_2$, C, 61.37; H, 2.90; found C, 61.52; H, 2.81%.

9-(4-Bromophenyl)-3,4,6,7-tetrahydro-3,3,6,6-tetramethylacridine-1,8(2*H*,5*H*,9*H*,10*H*)-dione (6). Mp: >300 °C; IR (KBr, ν, cm^{-1}): 3273, 2931, 1644, 1579, 1427, 833, 753; ^1H NMR (DMSO-d_6) (δ, ppm): 9.35 (s, 1H, NH), 7.36 (d, 2H, ArH, $J = 8.4$ Hz), 7.10 (d, 2H, ArH, $J = 8.4$ Hz), 4.77 (s, 1H, CH), 2.46 (d, 2H, CH_2, $J = 17.2$ Hz), 2.32 (d, 2H, CH_2, $J = 17.2$ Hz), 2.18 (d, 2H, CH_2, $J = 16.0$ Hz), 1.99 (d, 2H, CH_2, $J = 16.0$ Hz), 1.01 (s, 6H, $2CH_3$), 0.86 (s, 6H, $2CH_3$); Anal. calcd. for $C_{23}H_{26}BrNO_2$, C, 64.49; H, 6.12; N, 3.27; Found C, 64.43; H, 6.09; N, 3.33%.

9-(4-Bromophenyl)-3,4-dihydro-3,3,7-trimethylacridin-1(2*H*,9*H*,10*H*)-one (7). Mp: 240–241 °C; IR (KBr, ν, cm^{-1}): 3270, 3089, 1696, 1618, 1552, 1486, 1288, 1145; ^1H NMR (400 MHz, DMSO-d_6) (δ, ppm): 9.42 (1H, s, NH), 7.37 (2H, d, ArH $J = 8.4$ Hz), 7.11 (2H, d, ArH, $J = 8.4$ Hz), 6.92–6.83 (3H, m, ArH), 5.02 (1H, s, CH), 2.48 (s, 3H, CH_3), 2.44 (d, 1H, CH_2, $J = 17.2$ Hz), 2.29 (d, 1H, CH_2, $J = 17.2$ Hz), 2.16 (d, 1H, CH_2, $J = 16.0$ Hz), 1.94 (d, 1H, CH_2, $J = 16.0$ Hz), 1.03 (s, 3H, CH_3), 0.93 (s, 3H, CH_3); Anal. calcd. for $C_{21}H_{20}BrNO$, C, 65.98; H, 5.27; N, 3.66; found C, 66.06; H, 5.21; N, 3.77%.

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19 The single-crystal growth was carried out in DMF at room temperature. Crystal data for **4b**: $C_{27}H_{24}N_2O_4$, red, crystal dimensions 0.64 × 0.26 × 0.15 mm, monoclinic, space group $C2/c$, $a = 28.768(5)$ Å, $b = 8.9966(12)$ Å, $c = 17.703(5)$ Å, $\alpha = \gamma = 90°$, $\beta = 108.727(4)°$, $V = 4339.2(12)$ Å^3, $Mr = 440.48$, $Z = 8$, $Dc = 1.349$ Mg m^{-3}, $\lambda(Mok\ \alpha) = 0.71070$ Å, $\mu = 0.091$ mm^{-1}, $F(000) = 1856$, $3.14° < \theta < 25.35°$, $R = 0.0617$, $wR_2 = 0.1182$. $S = 1.195$, largest diff. peak and hole: 0.158 and −0.173 e Å^{-3}. **4z**: $C_{59}H_{53}N_3O_5S_2$, red, crystal dimensions 0.43 × 0.32 × 0.28 mm, monoclinic, space group $P2_1/c$, $a = 15.081(2)$ Å, $b = 9.4381(14)$ Å, $c = 35.102(6)$ Å, $\alpha = \gamma = 90°$, $\beta = 92.041(3)°$, $V = 4992.9(13)$ Å^3, $Mr = 948.16$, $Z = 4$, $Dc = 1.261$ Mg m^{-3}, $\lambda(Mok\ \alpha) = 0.71073$ Å, $\mu = 0.160$ mm^{-1}, $F(000) = 2000$, $1.75° < \theta < 25.01°$, $R = 0.0629$, $wR_2 = 0.1486$. $S = 1.017$, largest diff. peak and hole: 0.408 and −0.374 e Å^{-3}. CCDC reference numbers 617295 and 617296. For crystallographic data in CIF or other electronic format see DOI: 10.1039/b611462h.