Tetrahedron Vol. 35, pp. 1167 to 1171
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0040-4020/79/0501-1167/$02.00/0

# ARYNIC CONDENSATION OF KETONE ENOLATES—XIV†

## CONDENSATION OF AROMATIC α,β-UNSATURATED KETONE ENOLATES ON ARYNES

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(*Received in UK* 16 *October* 1978)

**Abstract**—Benzyne and 1-naphthyne (generated from the corresponding halogeno derivatives and the Complex Base NaNH$_2$–Bu$^t$ONa) condense with α,β-unsaturated ketone enolates β-substituted by an aromatic ring and only enolisable in the α'-position, to lead to α-tetralones and/or indanones. The reaction path depends upon the nature of the ketone enolate and, less strongly, on the solvent. The reaction mechanism is discussed. These reactions constitute new simple and efficient syntheses of numerous α-tetralones and indanones.

It is well known that condensations of saturated ketone enolates with aromatic halides by means of SR$_N$1[2] or arynic[3] reactions, provide a wide variety of aromatic ketones.

On the other hand, unsaturated ketones have been studied less, although these substrates possess some interesting properties. Thus, depending on their structure and the conditions, they may yield enolates 1 or 2 (Scheme 1).

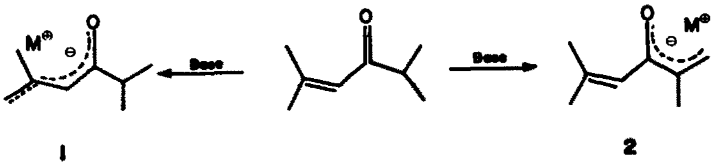
Sammes[4] and ourselves[5] showed that arynic condensations performed on type 1 enolates, lead to aromatic ketones and chiefly to naphthalene derivatives[6].

On the contrary, we reported in a previous short publication[7] that enolates 2 condense with benzyne to give tetralones and/or indanones. In the present paper we wish to report a more complete description of these partially unexpected reactions and a discussion of their mechanism.

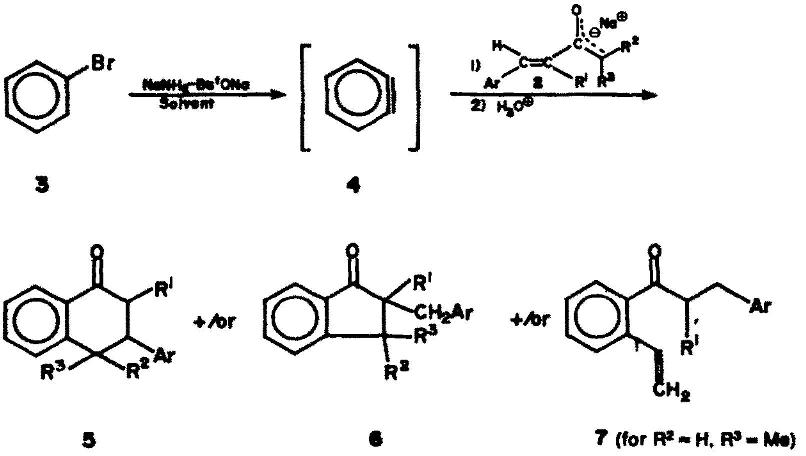
### RESULTS

Enolates 2 generally do not yield with NaNH$_2$, a complex base[3] able to generate the benzyne from halogenoaromatic derivatives. Thus, these condensations need the presence of the complex base NaNH$_2$–Bu$^t$ONa.

General reactions observed are shown in Scheme 2 and quantitative results are summarized in the Table 1.



Scheme 1.



Scheme 2.

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†Part XIII, see Ref. (1).

Table 1. Condensation of 2 with bromobenzene in THF[a]

| Run | Ar | $R^1$ | $R^2$ | $R^3$ | Yield (b) | 5 (c) | 6 (c) | 7 (c) |
|---|---|---|---|---|---|---|---|---|
| 1 | $C_6H_5$ | H | H | H | 70 | 86 | 14 | - |
| 2 | $4\text{-MeO-}C_6H_4$ | H | H | H | 45 | 100 | - | - |
| 3 | $3,4\text{-}(MeO)_2C_6H_3$ | H | H | H | 50 | 100 | - | - |
| 4 | $2,4,6\text{-}(MeO)_3C_6H_2$ | H | H | H | 60 | 100 | - | - |
| 5 | 2-furyl | H | H | H | 45 | 100 | - | - |
| 6 | $C_6H_5$ | H | $CH_3$ | H | 60 | - | 100 | - |
| 7 | $4\text{-MeO-}C_6H_4$ | H | $CH_3$ | H | 70 | 29(d) | 58 | 13 |
| 8 | $3,4\text{-}(MeO)_2C_6H_3$ | H | $CH_3$ | H | 50 | - | 100 | - |
| 9 | $4\text{-F-}C_6H_4$ | H | $CH_3$ | H | 50 | - | 100 | - |
| 10 | $C_6H_5$ | $CH_3$ | H | H | 70 | 100(e) | - | - |
| 11 | $C_6H_5$ | $CH_3$ | $CH_3$ | H | 45 | - | - | 100 |
| 12 | $C_6H_5$ | $-(CH_2)_3-$ | | H | 85 | - | 100 | - |
| 13 | $C_6H_5$ | $-(CH_2)_3-$ | | $CH_3$ | 65 | - | 100 | - |
| 14 | $C_6H_5$ | $-(CH_2)_4-$ | | H | 70 | - | 100 | - |
| 15 | $4\text{-MeO-}C_6H_4$ | $-(CH_2)_4-$ | | H | 50 | - | 100 | - |
| 16 | $C_6H_5$ | $-(CH_2)_5-$ | | H | 45 | - | 100 | - |

(a) 4 hours at 30°C for $R^2$ and/or $R^3 \neq$ H and 45°C for $R^2 = R^3 =$ H.
Ratio enolate/bromobenzene = 2

(b) Relative to bromobenzene

(c) Relative percentage

(d) Isomeric mixture

(e) Cis:trans = 66:34

The yields of these reactions were generally fair to excellent and these condensations provided a wide range of tetralones and indanones. Ketones 7 were rather unexpected, and their formation will be discussed later.

From the synthetic view point, these reactions are applied to 1-naphthyne. As previously shown, saturated ketone enolates essentially condense on the position 2 of 1-naphthyne.[8] The same regioselectivity occurs with unsaturated ketone enolates. Thus condensation of 1-bromonaphthalene with cyclic unsaturated ketone enolates 8 lead to polycyclic ketones 10 (Scheme 3 and Table 2).

Table 2. Condensation of 8 on 1-bromonaphthalene in THF (4 h at 30°)

| Run | n | Ar | $R^1$ | 10 (a) |
|---|---|---|---|---|
| 17 | 2 | $C_6H_5$ | H | 60 |
| 18 | 2 | $C_6H_5$ | $CH_3$ | 60 |
| 19 | 3 | $C_6H_5$ | H | 50 |
| 20 | 3 | $4\text{-MeO-}C_6H_4$ | H | 50 |

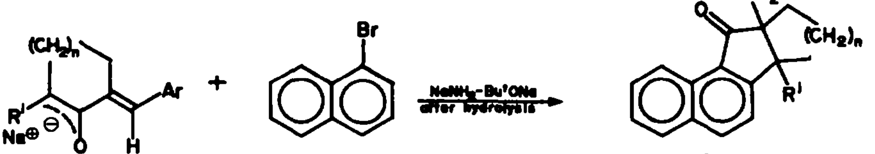
(a) Relative to 1-bromonaphthalene

## DISCUSSION

From the numerous examples previously studied,[3] we can say that the first steps of the reactions are those given in Scheme 4 using benzyne as an example.

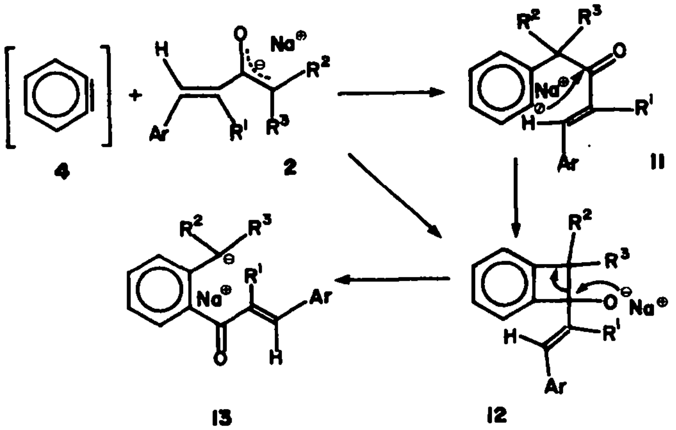
Normally a Michael type reaction, leading to tetralones is expected from 13. However, this was not always the case (*vide supra*). The explanation of the evolution of 13, when 2 is an acyclic ketone enolate, requires the examination of the following points:

(1) The negative charge on the benzylic carbon of 13 may be more or less delocalized towards the CO function through the aromatic ring. This delocalization is favoured by electrodonating groups $R^2$, $R^3$, by a counter cation of low complexing ability and by a dissociating cationic solvating solvent. For a large delocalization, the structure of 13 looks like 14. In other words, the enone system is disrupted and the Michael cyclisation is hardly possible. Thus, if Ar is sufficiently electroattracting, the

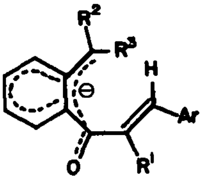


8 9 10

Scheme 3.



Scheme 4.



14

addition on the activated double bond is possible as in styrene compounds.

(2) For $R^2$, $R^3$ given, Z electrodonating groups on the aromatic ring (Scheme 5) do not favour 14 as it may be seen from the resonance formula.

This electrodonating effect must favour the attack of the negative charge on the benzylic position relative to the ring bearing the Z group, thus producing tetralone.

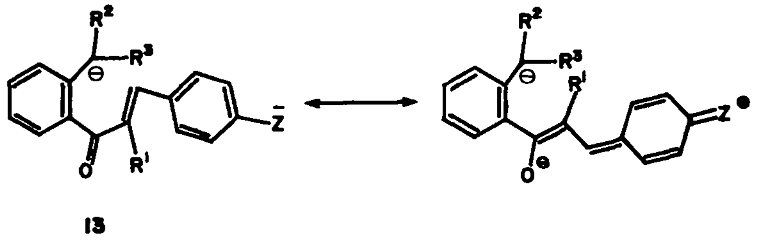
A comparison of runs 1 and 6, 2 and 7, 3 and 8 shows that the replacement of $R^2 = R^3 = H$ by $R^2 = Me$, $R^3 = H$ (which destabilizes the negative charge on the benzylic position) increases the formation of indanones 6.

The effect of donating group Z on the aromatic ring is shown by a comparison of runs 1 and 2, 6 and 7.

The solvent effects on the complexation of the negative charge by the cation $Na^+$ were shown by the reactions summarized in the Table 3.

Comparison of runs 1 and 21 show that HMPA (a strong cation complexing solvent), favours the delocalization of the negative charge resulting in the formation of the indanone.

Comparison of runs 22, 7 and 23 is still more revealing. Passing from THF to a less polar solvent THF-benzene (1:1), promotes the localization of the negative charge on the benzylic position and gives an increased yield of tetralone. On the contrary, the more polar solvent THF–HMPA (1:1) favours indanone formation.



Scheme 5.

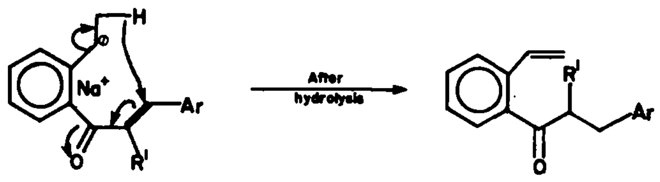
Table 3. Solvent effect on arynic condensations of 2

| Run | Ar | $R^1$ | $R^2$ | $R^3$ | Solvent | t(hrs) | T°C | Yield(a) | 5(b) | 6(b) | 7(b) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | $C_6H_5$ | H | H | H | THF | 4 | 45 | 70 | 86 | 14 | - |
| 21 | $C_6H_5$ | H | H | H | THF+HMPA (1:1) | 4 | 0 | 40 | - | 100 | - |
| 22 | 4-MeO-$C_6H_4$ | H | $CH_3$ | H | THF+$C_6H_6$ (1:1) | 6 | 45 | 50 | 64(c) | 26 | 10 |
| 7 | 4-MeO-$C_6H_4$ | H | $CH_3$ | H | THF | 4 | 30 | 70 | 29(c) | 58 | 13 |
| 23 | 4-MeO-$C_6H_4$ | H | $CH_3$ | H | THF+HMPA (1:1) | 5 | 0 | 40 | - | 100 | - |

(a) Relative to bromobenzene

(b) Relative percentage

(c) Isomeric mixture



13 $(R^2=H, R^3=CH_3)$ 7

Scheme 6.

Finally, the formation of ketones 7 should be explained (Scheme 6) by an hydride transfer as encountered with saturated ketones.[9]

Concerning the results observed with cyclic ketone enolates, it is clear that they may only allow indanone formation. Indeed, evolution of the corresponding anion 13 toward bicyclic tetralone should pass by an energetic unfavorable anti Bredt like intermediate.

## CONCLUSION

Condensations of unsaturated ketone enolates with arynes provide various tetralones or indanones. The reactions are easily performed and the path taken by the condensation may be partially monitored by adequate choice of solvent.

## EXPERIMENTAL

M.ps (Kofler) are uncorrected. The NMR spectra were recorded with a Perkin–Elmer R 12 B spectrometer or CAMECA (250 MHz) using TMS as internal standard. The IR spectra were obtained on a Perkin–Elmer 457 instrument. The UV spectra were recorded with a Beckmann DK 2A spectrometer, using EtOH as solvent. The starting unsaturated ketones were prepared by condensation of ArCHO on $R^2R^3CH–CO–CH_2R^1$ in basic or acid medium, and had physical properties in accord with those described in the literature.

*General procedure.* A soln of $Bu^tOH$ (25 mM) in THF (10 ml) was added to sodamide (100 mM) in THF (20 ml), and stirred for 1.5 hr at 40–45° under dry $N_2$; then the ketone (25 mM) in THF (20 ml) was added dropwise during 15 min at 25–30°. The mixture was stirred at this temp. for 5–10 min, and bromobenzene (12.5 mM) in THF (10 ml) was added. The reaction was continued during 4 hr at 30° for $R^2$ and/or $R^3 \neq H$ and at 40–45° for $R^2 = R^3 = H$, whatever nature of Ar and $R^1$.

After cooling to room temp., the mixture was poured onto ice, acidified with 20% HCl, extracted with ether (3 × 100 ml) and dried over $MgSO_4$. The solvent was removed under reduced pressure and the residual oil was chromatographied on a silica gel column using 2–5% ether–petroleum ether as eluent, except for runs 3, 4 and 8 (10–30%).

*Run* 1, 5[10] and 6[11,12] have physical properties in accord with those described in literature.

*Run* 2, 5: m.p. 94–95°; $\nu$ (KBr) 1680 cm$^{-1}$ (C=O); $\lambda_{max}$ (log $\epsilon$) 293 sh (3.39), 285 (3.52), 279 (3.51), 248 (4.13); $\delta$ ($CCl_4$) 2.45–3.50 (5 H, m, aliph), 3.71 (3 H, s, OMe), 6.66–7.60 (7 H, m, arom), 7.85–8.12 (1 H, m, arom). (Found: C, 81.22; H, 6.55. $C_{17}H_{16}O_2$ requires: C, 80.92; H, 6.39%).

*Run* 3, 5: m.p. 124°; $\nu$ (KBr) 1680 cm$^{-1}$ (C=O); $\lambda_{max}$ (log $\epsilon$) 294 sh (3.51), 283 (3.71), 245 (4.11); $\delta$ ($CDCl_3$) 2.60–3.62 (5 H, m, aliph), 3.86 (6 H, s, OMe), 6.82 (3 H, br.s, arom), 7.13–7.65 (3 H, m, arom), 7.97–8.21 (1 H, m, arom). (Found: C, 76.46; H, 6.59. $C_{18}H_{18}O_3$ requires: C, 76.57; H, 6.43%).

*Run* 4, 5: m.p. 139°; $\nu$ ($CCl_4$) 1680 cm$^{-1}$ (C=O); $\lambda_{max}$ (log $\epsilon$) 293 (3.48), 250 (4.15), 241 (4.23); $\delta$ ($CDCl_3$)2.40–4.40 (14 H, m with two s at 3.74 and 3.78, OMe), 6.15 (2 H, s, arom), 7.05–7.60 (3 H, m, arom), 8.00–8.22 (1 H, m, arom). (Found: C, 73.03; H, 6.26. $C_{19}H_{20}O_4$ requires: C, 73.06; H, 6.45%).

*Run* 5, 5: $\nu$ (film) 1690 cm$^{-1}$ (C=O); $\lambda_{max}$ (log $\epsilon$) 293 (3.43), 248 (4.13); $\delta$ ($CCl_4$) 2.15–3.80 (5 H, m, aliph), 5.89–6.27 (2 H, m, furyl), 6.90–7.77 (4 H, m, furyl + arom), 7.82–8.09 (1 H, m, arom). (Found: C, 79.41; H, 5.58. $C_{14}H_{12}O_2$ requires: C, 79.22; H, 5.70%).

*Run* 6, 6: $\nu$ (film) 1710 cm$^{-1}$ (C=O); $\lambda_{max}$ (log $\epsilon$) 295 (3.71), 288 (3.72), 246 (4.07); $\delta$ ($CCl_4$) 1.10 (3H, d, J = 7.3 Hz, Me), 2.20–3.50 (4H, m, aliph), 7.10–7.80 (9 H, m, arom). (Found: C, 86.42; H, 6.76. $C_{17}H_{16}O$ requires: C, 86.40; H, 6.83%). 6 treated by Na–$D_2O$ during 12 hr under reflux gave 6 ($R^1$ = D): $\delta$ ($CCl_4$) 1.06 (3 H, d, J = 7.3 Hz, Me), 2.20–3.55 (3 H, m, aliph), 7.00–7.75 (1 H, m, arom). The catalytic reduction[13] of 3-methyl, 2-benzylidene, indan, 1-one[14] gave quantitatively 3-methyl, 2-benzyl, indan, 1-one which had the physical properties (NMR, IR and tlc) of 6 formed by arynic condensation.

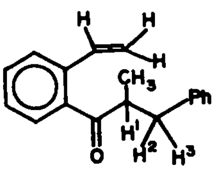
*Run* 7, 5 (isomeric mixture): $\nu$ ($CCl_4$) 1690 cm$^{-1}$ (C=O); $\lambda_{max}$ (log $\epsilon$) 295 sh (3.48), 285 (3.58), 278 (3.56), 248 (4.12); $\delta$ ($CCl_4$) 0.96 (d, J = 6.7 Hz) and 1.19 (d, J = 6 Hz) (3H, two Me of the two isomers), 2.50–3.50 (4 H, m, aliph), 3.64 (3 H, br. s, OMe), 6.55–7.62 (7 H, m, arom), 7.80–8.10 (1 H, m, arom). (Found: C, 81.22; H, 6.75. $C_{18}H_{18}O_2$ requires: C, 81.17; H, 6.81%). 6: $\nu$ (film) 1710 cm$^{-1}$ (C=O); $\lambda_{max}$ (log $\epsilon$) 292 sh (3.50), 286 (3.63), 279 sh (3.62), 246 (4.13), 225 (4.16); $\delta$ ($CCl_4$) 1.10 (3H, d, J = 7.3 Hz, Me), 2.14–3.36 (4 H, m, aliph), 3.64 (3 H, br. s, OMe), 6.57–7.60 (8 H, m, arom), (Found: C, 80.98; H, 6.92. $C_{18}H_{18}O_2$ requires: C, 81.17; H, 6.81%). 6 treated with Na–$D_2O$ during 12 hr under reflux gave 6 ($R^1$ = D): $\delta$ ($CCl_4$) 1.10 (3 H, d, J = 7.3 Hz, Me), 2.5–3.3 (3 H, m, aliph), 3.64 (3 H, br.s, OMe), 6.57–7.75 (8 H, m, arom). 7: $\nu$ (film) 1690 cm$^{-1}$ (C=O); $\delta$ ($CCl_4$) 2.82–3.08 (4 H, m, $(CH_2)_2$), 3.64 (3 H, br. s, OMe), 5.07–5.68 (2 H, m, C=$CH_2$), 6.50–7.58 (9 H, m, arom. + Ar–CH=C). (Found: C, 81.25; H, 6.53. $C_{18}H_{18}O_2$ requires: C, 81.17; H, 6.81%).

*Run* 8, 6: $\nu$ (film): 1710 cm$^{-1}$ (C=O); $\lambda_{max}$ (log $\epsilon$) 284 (3.72), 244 sh (4.13), 237 (4.16); $\delta$ ($CCl_4$) 1.15 (3 H, d, J = 7.3 Hz, Me), 2.18–3.35 (4 H, m; aliph), 3.71 (6 H, s, OMe), 6.60–6.80 (3 H, m, arom), 7.10–7.79 (4 H, m, arom). (Found: C, 70.06; H, 6.66. $C_{19}H_{20}O_3$ requires: C, 70.00; H, 6.66%). 6 treated by Na–$D_2O$ during 12 hr under reflux gave 6 ($R^1$ = D): $\delta$ ($CCl_4$) 1.15 (3 H, d, J = 7.3 Hz, Me), 2.4–3.4 (3 H, m, aliph), 3.72 (6 H, s, OMe), 6.63–6.80 (3 H, m, arom), 7.10–7.79 (4 H, m, arom).

*Run* 9, 6: m.p. 58°; $\nu$ (KBr) 1715 cm$^{-1}$ (C=O); $\delta$ ($CCl_4$) 1.13 (3 H, d, J = 7.3 Hz, Me), 2.05–3.60 (4 H, m, aliph), 6.70–7.80 (8 H, m, arom). (Found: C, 81.35; H, 4.45; F, 7.15. $C_{17}H_{15}FO$ requires: C, 81.58; H, 4.45; F, 7.59%).

*Run* 10, Arynic condensation gave an isomeric mixture of 5. At the end of the reaction, EtOH (100 ml) was added. After stirring 3 hr epimerisation occurs and after hydrolysis, one isomer only was isolated (55–60%). m.p. 62°. It should be the *trans* isomer and had physical properties in accord with that described in the literature.[15]

*Run* 11, 7: $\nu$ (film) 1695 cm$^{-1}$ (C=O), $\delta$ ($CCl_4$) 1.05 (3 H, d, J = 6.7 Hz, Me), 2.28–3.58 (3H, m, $H^1 + H^2 + H^3$), 5.03–5.70 (2 H, m, C=$CH_2$), 6.62–7.62 (10 H, m, arom + Ar–CH=C). (Found: C, 86.17; H, 7.23. $C_{18}H_{18}O$ requires: C, 86.26; H, 7.25). 7 treated with Na–$D_2O$ during 12 hr under reflux gave 7 ($H^1$=D): $\delta$



($CCl_4$) 1.06 (3 H, s, Me), 2.5 and 3.06 (2 H, AB system, J = 13.5 Hz, $H^2$, $H^3$), 5.05–5.70 (2 H, m, $C{=}CH_2$), 6.62–7.62 (10 H, m, arom + Ar–CH=C).

*Run* 12, 6: ν (film) 1710 cm$^{-1}$ (C=O); $\lambda_{max}$ (log ε) 2.96 (3.43), 288 (3.42), 248 (4.09); δ ($CCl_4$) 0.80–2.26 (6 H, m, cyclic $CH_2$), 2.6–3.8 (3 H, m, benzylic protons), 7.00–7.68 (9 H, m, arom). (Found: C, 86.98; H, 6.91. $C_{19}H_{18}O$ requires: C, 86.49; H, 6.88%).

*Run* 13, 6: ν (film) 1710 cm$^{-1}$ (C=O); $\lambda_{max}$ (log ε) 292 (3.44), 247 (4.13); δ ($CCl_4$) 0.80–2.25 (9 H, m with s at 1.40, cyclic $CH_2$ + Me), 2.7–3.0 (2 H, AB system, J = 13.9 Hz, Ph–$CH_2$), 7.00–7.72 (9 H, m, arom), (Found: C, 86.86; H, 7.12. $C_{20}H_{20}O$ requires: C, 86.92; H, 7.29%).

*Run* 14, After elimination of the starting ketone by liquid chromatography, the crude product contained some impurities. It was purified by reduction with LAH to two alcohols easily isolated by liquid chromatography. Oxidation of these alcohols by Jones reagent gave 6: m.p. 60–61°; ν (KBr) 1710 cm$^{-1}$ (C=O); $\lambda_{max}$ (log ε) 297 (3.57), 290 (3.56), 246 (4.13); δ ($CCl_4$) 0.80–2.13 (8 H, two m, cyclic $CH_2$), 2.67–3.4 (3 H, m, benzylic protons), 6.95–7.82 (9 H, m, arom), (Found: C, 86.70; H, 7.39. $C_{20}H_{20}O$ requires: C, 86.92; H, 7.29%). Alkylation of 1,2,3,4,4a,9a-hexahydrofluoren, 9 - one by Ph–$CH_2$Cl gave 9a - benzyl, 1,2,3,4,4a,9a - hexahydrofluoren, 9 - one (yield: 84%) which had the physical properties (m.p., NMR, IR and tlc) of 6 formed by arynic condensation.

*Run* 15, 6: m.p. 87–88°; ν ($CCl_4$) 1710 cm$^{-1}$ (C=O); $\lambda_{max}$ (log ε) 292 (3.61), 286 (3.63), 225 (4.14); δ ($CDCl_3$) 0.85–2.15 (8 H, m, cyclic $CH_2$), 2.55–3.45 (3 H, m, benzylic protons), 3.62 (3 H, s, OMe), 6.55–7.87 (8 H, m, arom). (Found: C, 82.25; H, 7.25. $C_{21}H_{22}O_2$ requires: C, 82.32; H, 7.24%).

*Run* 16, 6: m.p. 89–90°; ν (KBr) 1710 cm$^{-1}$ (C=O); $\lambda_{max}$ (log ε) 295 (3.43), 248 (4.11); δ (250 MHz) ($CDCl_3$) 0.96–2.14 (10 H, four m, cyclic $CH_2$), 2.75 and 2.9 (2 H, AB system, J = 14 Hz, Ph–$CH_2$), 3.52 (1H, m, benzylic proton), 7.0–7.8 (9 H, four m, arom). (Found: C, 86.88; H, 7.70. $C_{21}H_{22}O$ requires: C, 86.85; H, 7.64%).

. *Run* 17, 6; m.p. 90°; ν (KBr) 1685 cm$^{-1}$ (C=O); $\lambda_{max}$ (log ε) 333 sh (3.69), 317 sh (3.86), 309 (3.95), 300 sh (3.85), 233 (4.40); δ ($CDCl_3$) 0.80–2.35 (6 H, m, cyclic $CH_2$), 2.8–3.3 (2 H, AB system, J = 13.3 Hz, Ph–$CH_2$), 3.6 (1 H, m, benzylic H), 6.90–7.95 (10 H, m, arom), 9.10–9.30 (1 H, m, arom). (Found: C, 88.21; H, 6.67. $C_{23}H_{20}O$ requires: C, 88.42; H, 6.45%).

*Run* 18, 6: m.p. 79°; ν (KBr) 1690 cm$^{-1}$ (C=O); $\lambda_{max}$ (log ε) 333 sh (3.69), 316 sh (3.85), 309 (3.94), 296 sh (3.83), 233 (4.36); δ ($CCl_4$) 0.8–2.3 (9 H, m with s at 1.43, cyclic $CH_2$ + Me), 2.7 and 3.1 (2 H, AB system, J = 14 Hz, Ph–$CH_2$), 6.9–8.05 (10 H, m, arom), 9.1–9.3 (1 H, m, arom). (Found: C, 88.28; H, 6.82. $C_{24}H_{22}O$ requires: C, 88.31; H, 6.79%).

*Run* 19, 6: m.p. 132°; ν (KBr) 1685 cm$^{-1}$ (C=O); $\lambda_{max}$ 333 sh (3.73), 310 (3.98), 300 sh (3.87), 233 (4.65); δ ($CDCl_3$) 0.9–2.2 (8 H, m, cyclic $CH_2$), 2.8–3.5 (3 H, m, benzylic protons), 6.95–8.05 (10 H, m, arom), 9.05–9.2 (1 H, m, arom). (Found: C, 88.48; H, 6.90. $C_{24}H_{22}O$ requires: C, 88.31; H, 6.79%).

*Run* 20, 6: ν (film) 1695 cm$^{-1}$ (C=O); $\lambda_{max}$ (log ε) 332 sh (3.67), 310 (3.93), 300 sh (3.84), 287 (3.68); δ ($CDCl_3$) 0.7–2.1 (8 H, m, cyclic $CH_2$), 2.5–3.6 (6 H, m with s at 3.45, benzylic protons + OMe), 6.49–7.97 (9 H, m, arom), 9.1–9.3 (1 H, m, arom). (Found: C, 84.28; H, 6.98. $C_{25}H_{24}O_2$ requires: C, 84.24; H, 6.79%).

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