Mononitroarenes in the oxidative coupling of methyl aryl ketones: a new synthesis of 1,4-diarylbutane-1,2,4-triones

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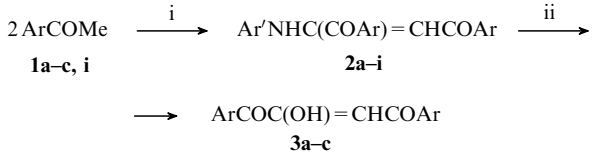
Mononitroarenes are condensed with 2 mol methyl aryl ketone in DMSO–KOH to yield (*Z*)-arylamino-1,2-diaroylethylenes, which undergo acid-promoted hydrolysis to 1,4-diarylbutane-1,2,4-triones.

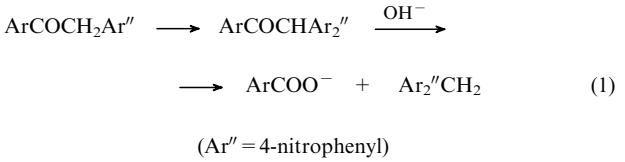
Oxidation of ketones generally results in either C–C bond cleavage[1] or introduction of an oxygen-containing function into the α-position.[2,3] However, ketones can also be oxidized into compounds with double the carbon chain length when they are treated with nitric acid.[4] In addition, oxidative coupling of Li-enolates in the presence of copper(I) chloride appears to be a general method for the preparation of symmetrical 1,4-diketones.[5] Recently, McMurry coupling of acetophenone was reported to give (*Z*)-2,3-diphenylbut-2-ene.[6]

We present here a hitherto unknown method for the oxidative coupling of methyl aryl ketones **1** based on a recently discovered[7] 2:1 condensation of **1** with mononitroarenes in DMSO–KOH to form (*Z*)-arylamino-1,2-diaroylethylenes **2** and subsequent hydrolysis to 1,4-diarylbutane-1,2,4-triones[8,9] **3** † (Scheme 1, Table 1):



Scheme 1 *Reagents and conditions*: i, $Ar'NO_2$, DMSO, KOH, 20–60 °C, 24–72 h; ii, H_2SO_4, H_2O, 1,4-dioxane, 100 °C, 0.5–1 h.

Some spectral data for the compounds synthesized are detailed below. ‡ The effectiveness of the entire method depends mainly on the first step, because hydrolysis of the adducts occurs in high yields. Both aromatic and heterocyclic ketones can be oxidized. Substituents located at the *para*-position of the nitrobenzene ring influence the yields of the adducts. Indeed, the total yield of trione **3a** obtained starting from various 4-substituted nitrobenzenes *via* adducts **2d**–**h** was 17%, 25%, 38%, 69% and 42%, respectively. The more electronegative the substituent, the less the yield of adduct. 4,4-Dinitrodiphenylmethane (8–16%) was found in the reaction mixtures in the synthesis of adducts **2a**, **2d**–**f**. This could be as a result of competitive aromatic nucleophilic substitution of hydrogen, MeO^-, Cl^- and F^- by enolate anion and further alkali cleavage of ketone intermediates, reaction (1):



† A typical reaction procedure is as follows: mononitroarene (30 mmol) and ketone **1** (25 mmol) were added to a suspension of KOH (180 mmol) in 25 ml DMSO. The reaction mixture was kept at 20, 40 or 50 °C for 24 or 72 h. The reaction was monitored using TLC. The reaction mixture was then poured into dilute (10%) HCl (200 ml) and extracted with benzene (3 × 50 ml). After being dried (Na_2CO_3) the combined benzene extracts were passed through Al_2O_3 (100 ml) and product **2** was obtained. Compound **2** (3.5 mmol) was then treated with H_2SO_4 (1 ml) in 20 ml H_2O and 30 ml 1,4-dioxane at 100 °C for 0.5–1 h, after which triones **3** were extracted with benzene (3 × 20 ml) and separated.

On starting from 4-R_2N-substituted nitrobenzenes or 9-methyl-3-nitrocarbazole no by-products were detected, only the adducts. Surprisingly, the bulky 4-acetyltriphenylamine smoothly condenses with 4-nitro-*N*,*N*-diethylaniline (4-NDEA) to give the corresponding adduct **2i**, which failed to hydrolyse under conditions appropriate for compounds **2a**–**h**.

Thus, nitrobenzene and 4-NDEA are the most convenient

Table 1 Preparation of arylamino-1,2-diaroylethylenes **2** and triones **3**.[a]

Compounds	Ar	Ar′	Conditions Time/h	Conditions *T*/°C	Mp/°C	Yield (%)
2a	Ph	Ph	24	20	124–125	55
2b	4-BrC_6H_4	Ph	24	20	164–165	40
2c	thien-2-yl	Ph	24	40	137–138	58
2d	Ph	4-FC_6H_4	24	20	161–162	18
2e	Ph	4-ClC_6H_4	24	20	148–149	26
2f	Ph	4-$MeOC_6H_4$	24	20	115–116	42
2g	Ph	4-$Et_2NC_6H_4$	72	50	112–113	81
2h	Ph	9-methyl-carbazol-3-yl	48	50	191–192	48
2i	4-$Ph_2NC_6H_4$	4-$Et_2NC_6H_4$	72	50	99–100	76
3a	Ph	–	0.5	100	62–63	52.5
3b	4-BrC_6H_4	–	1	100	136–138	37
3c	thien-2-yl	–	1	100	158–159	56

[a] Total yields after two steps are given.

‡ *Spectroscopic data* for preparatively-isolated reaction products:

2a: ^{1}H NMR (100 MHz, $CDCl_3$) δ 13.11 (s, 1H, NH), 5.95 (s, 1H, =CH), MS (electron impact) *m*/*z* 327 (M^+), IR, ν/cm^{-1} (KBr pellets): 1657 (C=O), 3400 (NH, wide).

2b: ^{1}H NMR (100 MHz, $CDCl_3$) δ 12.25 (s, 1H, NH), 6.00 (s, 1H, =CH), MS (electron impact) *m*/*z* 483, 485, 487 (M^+), IR, ν/cm^{-1} (KBr pellets): 1700 (C=O), 3400 (NH, wide).

2c: ^{1}H NMR (100 MHz, $CDCl_3$) δ 12.10 (s, 1H, NH), 5.98 (s, 1H, =CH), MS (electron impact) *m*/*z* 390 (M^+), IR, ν/cm^{-1} (KBr pellets): 1660 (C=O), 3400 (NH, wide).

2d: ^{1}H NMR (100 MHz, $CDCl_3$) δ 12.40 (s, 1H, NH), 6.09 (s, 1H, =CH), MS (electron impact) *m*/*z* 345 (M^+), IR, ν/cm^{-1} (KBr pellets): 1680 (C=O), 3400 (NH, wide).

2e: ^{1}H NMR (100 MHz, $CDCl_3$) δ 12.70 (s, 1H, NH), 6.08 (s, 1H, =CH), MS (electron impact) *m*/*z* 361, 363 (M^+), IR, ν/cm^{-1} (KBr pellets): 1680 (C=O), 3450 (NH, wide).

2f: ^{1}H NMR (100 MHz, $CDCl_3$) δ 12.45 (s, 1H, NH), 6.03 (s, 1H, =CH), MS (electron impact) *m*/*z* 357 (M^+), IR, ν/cm^{-1} (KBr pellets): 1670 (C=O), 3420 (NH, wide).

2g: ^{1}H NMR (100 MHz, $CDCl_3$) δ 12.75 (s, 1H, NH), 5.85 (s, 1H, =CH), MS (electron impact) *m*/*z* 398 (M^+), IR, ν/cm^{-1} (KBr pellets): 1700 (C=O), 3440 (NH, wide).

2h: ^{1}H NMR (100 MHz, $CDCl_3$) δ 12.75 (s, 1H, NH), 6.10 (s, 1H, =CH), MS (electron impact) *m*/*z* 430 (M^+), IR, ν/cm^{-1} (KBr pellets): 1700 (C=O), 3440 (NH, wide).

2i: ^{1}H NMR (100 MHz, $CDCl_3$) δ 12.76 (s, 1H, NH), 5.85 (s, 1H, =CH), MS (electron impact) *m*/*z* 732 (M^+), IR, ν/cm^{-1} (KBr pellets): 1670 (C=O), 3440 (NH, wide).

3a: ^{1}H NMR (100 MHz, $CDCl_3$) δ 6.84 (s, 1H, =CH), MS (electron impact) *m*/*z* 252 (M^+), IR, ν/cm^{-1} (KBr pellets): 1675 (C=O).

3b: ^{1}H NMR (100 MHz, $CDCl_3$) δ 6.80 (s, 1H, =CH), MS (electron impact) *m*/*z* 408, 410, 412 (M^+), IR, ν/cm^{-1} (KBr pellets): 1670 (C=O).

3c: ^{1}H NMR (100 MHz, $CDCl_3$) δ 6.88 (s, 1H, =CH), MS (electron impact) *m*/*z* 264 (M^+), IR, ν/cm^{-1} (KBr pellets): 1645 (C=O).

reagents with which to convert methyl aryl ketones into butanetriones. We propose to apply the method to aliphatic ketones as well.

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