# New Synthetic Method for 1,3,4,5-Tetraaryl-2-thioxo-(or -oxo)-2,3-dihydroimidazoles

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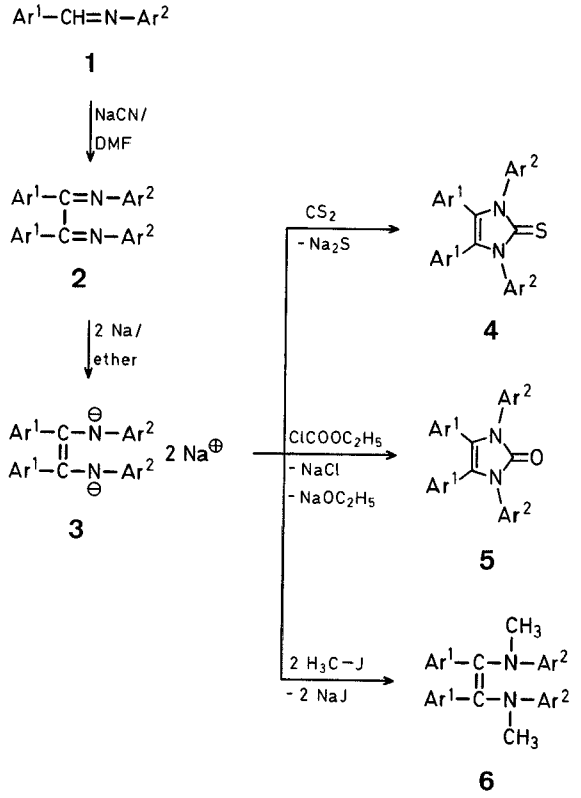
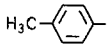
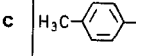
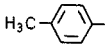
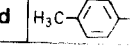
The reductive dimerisation of substituted anils either with active metals like lithium, sodium, or potassium in a non-aqueous solvent[1] or with aluminium in moist ether[2] has been observed. We now report on the reaction of dianils with sodium in dry ether followed by treatment with either carbon disulphide or ethyl carbonochloridate. This procedure provides a new and convenient one-step synthesis of 1,3,4,5-tetraaryl-2-thioxo-(or oxo-)-2,3-dihydroimidazoles (50–70%) and has a distinct superiority over the reported method[3], involving heating of a mixture of a substituted urea or thiourea and a benzoin, as the preparation of these reactants themselves would involve several steps.

The reaction of benzil dianil **(2a)** with sodium in dry ether followed by addition of carbon disulphide gave a solid material identified as 1,3,4,5-tetraphenyl-2-thioxo-2,3-dihydroimidazole **(4a)**. The reaction of **2a** with sodium in dry ether followed by addition of ethyl carbonochloridate gave 2-oxo-1,3,4,5-tetraphenyl-2,3-dihydroimidazole **(5a)**. Similar treatment of the dianils **2b–d** with carbon disulphide and ethyl carbonochloridate gave **4b–d** and **5b–d**, respec-




| 1-6 | Ar¹ | Ar² |
|---|---|---|
| a |  |  |
| b |  |  |
| c |  |  |
| d |  |  |

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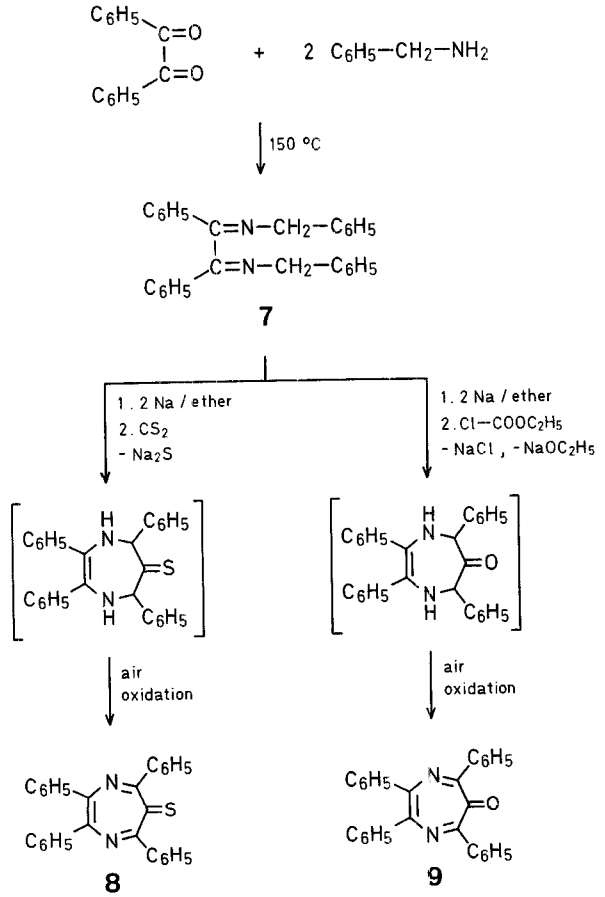
tively. The products **4b**, **5a**, and **5b** were identical (m.p.) with those reported earlier[3,4]. Hydrogenation[5] of 2-oxo-1,3,4,5-tetraphenyl-2,3-dihydroimidazol (**5a**) gave *meso*-2-oxo-1,3,4,5-tetraphenyl-tetrahydroimidazole, identified by comparison (undepressed mixture m.p. and I.R. spectra) with an authentic sample[6].

The disodium salt **3** formed by electron transfer from sodium to dianil attacks carbon disulphide. Intramolecular nucleophilic attack with elimination of sodium sulphide (lead acetate solution gives a black precipitate of lead sulphide) leads to the formation of product **4**. The intermediate **3** reacts with ethyl carbonochloridate with elimination of chloride (detected by the formation of silver chloride on addition of aqueous silver nitrate) and ethoxide ions to give rise to 2-oxo-1,3,4,5-tetraaryl-2,3-dihydroimidazole **5**.

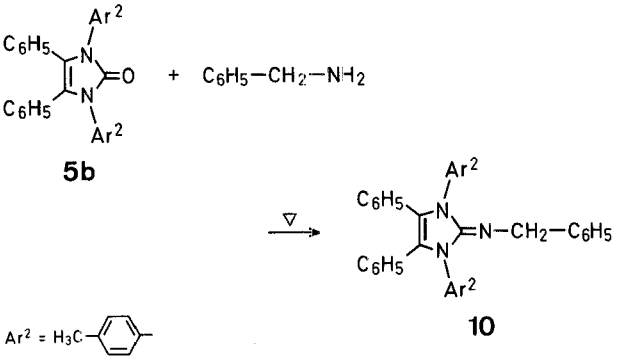
The formation of the intermediate disodium salt **3** was confirmed by the formation of *N,N'*-dimethyl-*p*-toluidinostilbene (**6b**) when methyl iodide was added to the reaction mixture obtained from treatment of the dianil **2b** with sodium and ether for 3 h.

This method is apparently limited to aryl-substituted dianils **2a–d**, as only aromatic aldimines **1** are known to undergo cyanide ion-catalysed dimerisation to form dianils[7]. The dianil was not obtained from the cyanide ion-catalysed reductive dimerisation of benzaldehyde *N*-*t*-butylimine nor from benzil and *t*-butylamine. Reaction of *N,N'*-bis[*p*-tolyl]ethylenediimine with sodium and ether and subsequent addition of either carbon disulphide or ethyl carbonochloridate resulted in the formation of a thick viscous material which could not be further purified and hence unsubstituted diimines cannot be used in this cyclisation.

Application of the reaction to benzil dibenzylimine (**7**) gave 2,3,5,7-tetraphenyl-6-thioxo-6*H*-1,4-diazepine (**8**; treatment of the dianion with carbon disulphide) and 6-oxo-2,3,5,7-tetraphenyl-6*H*-1,4-diazepine (**9**; treatment of the dianion with ethyl carbonochloridate) in fair yields, thus providing convenient syntheses of diazepine derivatives.




The carbonyl group in compound **5b** can be readily converted to its 2-imino derivative **10** on heating with benzylamine.




Thus 2-*N*-arylalkyliminoimidazolines can be conveniently obtained from **5**.

**Dianils 2; General Procedure:**

The starting dianils **2** are obtained by stirring an equimolar mixture of Schiff base **1** and sodium cyanide in dry dimethylformamide for 72 h at room temperature (20 °C) following the method reported[4,7], and characterised on the basis of I.R., U.V. and N.M.R. spectral data.

N,N'-*Bis*[p-*tolyl*]*ethylenediimine* is prepared by adding dropwise 40% aqueous solution of glyoxal to an ice-cooled solution of *p*-toluidine (1:2 mol ratio) in 2-propanol by the reported method[8].

**Attempted Preparations of a Dianil from Benzaldehyde *N*-*t*-Butylimine:**

An equimolar mixture of benzaldehyde *N*-*t*-butylimine (6.44 g) and sodium cyanide (1.96 g) is stirred in dry dimethylformamide (60 ml) at room temperature (20 °C) for 72 h according to the above procedure. The recovered liquid (6.10 g) is identified as benzaldehyde *N*-*t*-butylimine on the basis of comparison (identical I.R., U.V. and N.M.R. spectral data) with the starting material.

A mixture of benzil (2.1 g, 0.01 mol) and *t*-butylamine (6.7 g, 0.1 mol) is heated in a 100 ml flask for 3 h on a water bath. Excess of amine is removed by distillation and the residual matter is crystallised from methanol to give 2.0 g of a crystalline solid which is identified as benzil; m.p. and mixture m.p. 95 °C.

**1,3,4,5-Tetraaryl-2-thioxo-2,3-dihydroimidazoles 4a–d; General Procedure:**

Sodium pieces (1 g, 0.044 mol) are slowly added to dry ether (60 ml) with stirring under a nitrogen atmosphere and a solution of dianil **2** (2 g) in dry ether (10 ml) is added dropwise. Stirring at reflux temperature is continued for 4 h and the contents are allowed to cool. Unreacted sodium pieces are removed by filtration. Dry carbon disulphide (2 ml) is slowly added and the mixture is heated under reflux for 1 h. The ethereal suspension is washed 2–3 times with water and dried with sodium sulphate. The solvent is removed on a rotary evaporator and the residual material is crystallised from benzene/ethanol. Addition of lead acetate solution to the aqueous layer gives a black precipitate of lead sulphide.

**2-Oxo-1,3,4,5-tetraaryl-2,3-dihydroimidazoles 5a–d; General Procedure:**

In place of carbon disulphide in the above method dry ethyl carbonochloridate (2 ml) is slowly added and the product is crystallised from benzene/petroleum ether. Addition of dilute nitric acid and silver nitrate solution to the aqueous layer gives a white precipitate.

A solution of *N,N'*-bis[*p*-tolyl]ethylenediimine (0.5 g) in dry ether (10 ml) on treatment according to the above procedure gives a thick viscous material which could not be purified by either T.L.C. or column chromatography.

**Methylation of the Intermediate Dianion[9] 3:**
Dry methyl iodide (1 ml) is slowly added in place of ethyl carbonochloridate in the above reaction with dianil **2b** (2.0 g) after an interval of 1 h and the product is crystallised from benzene/ethanol to give the starting material **2b**; yield: 1.9 g (95%); m.p. and mixture m.p. 159 °C.

Addition of methyl iodide after 3 h gives a solid which on crystallisation from *n*-hexane gives a product identified as N,N'-*dimethyl*-p-*toluidinostilbene* **(6b)**; yield: 0.68 g (34%); m.p. 149 °C.

| | | | | |
|---|---|---|---|---|
| $C_{30}H_{30}N_2$ | calc. | C 86.08 | H 7.22 | N 6.69 |
| (418.6) | found | 85.94 | 7.31 | 6.59 |

I.R. (Nujol): $\nu = 1600\ cm^{-1}$ (C=C).

U.V. ($C_2H_5OH$): $\lambda_{max} = 260$ nm.

$^1$H-N.M.R. ($CCl_4$): $\delta = 2.25$ (s, 6H, *p*-$H_3C$); 2.55 (s, 6H, N—$CH_3$)[10]; 6.90 ppm (m, 18$H_{arom}$).

**Hydrogenation of 2-Oxo-1,3,4,5-tetraphenyl-2,3-dihydroimidazole (5a):**
In a pressure bottle a suspension of **5a** (250 mg) in glacial acetic acid (10 ml) is hydrogenated[5] (40 °C, 3 atm) in the presence of platinum oxide (25 mg) as catalyst for 4 h. The suspension is filtered, washed with aqueous sodium hydroxide solution and extracted with ether. The solvent is removed under reduced pressure and the residual matter, on crystallisation from ethanol, gives a solid identified as *meso*-2-oxo-1,3,4,5-tetraphenyltetrahydroimidazole on the basis of comparison (undepressed mixed m.p. and identical I.R. spectral data) with an authentic sample[6]; yield: 60%; m.p. and mixture m.p. 134 °C.

**Benzildibenzylimine 7:**
A mixture of benzil (4.2 g) and benzylamine (8 ml) is heated under nitrogen for 30 min at 150 °C. After cooling, the mixture is washed with water to remove benzylamine and the material is taken in hot alcohol. Fractional crystallisation from methanol gives three products: *2,3,5,6-tetraphenylpyrazine*; m.p. 246 °C; *1-benzyl-2,4,5-triphenylimidazole*; m.p. 162–163 °C and *benzildibenzylimine* **(7)**; yield of **7**; 0.7 g (16%); m.p. 97 °C.

| | | | | |
|---|---|---|---|---|
| $C_{28}H_{24}N_2$ | calc. | C 86.56 | H 6.29 | N 7.21 |
| (388.5) | found | 86.24 | 6.02 | 6.88 |

I.R. (Nujol): $\nu = 1620\ cm^{-1}$ (C=N).

U.V. ($C_2H_5OH$): $\lambda_{max} = 250$ nm.

$^1$H-N.M.R. ($CDCl_3$): $\delta = 4.6$ (s, 4H, $CH_2$); 7.65 ppm (m, 20$H_{arom}$).

**2,3,5,7-Tetraphenyl-6-thioxo-6*H*-1,4-diazepine (8):**
Dry carbon disulphide (2 ml) is slowly added in the reaction with benzildibenzylimine (**7**; 2 g) following the above procedure for compounds **4**. The product is recrystallised from benzene/ethanol mixture to give 2,3,5,7-tetraphenyl-1,4-diazepin-6-thione; yield: 1.2 g (54%); m.p. 250 °C.

| | | | | |
|---|---|---|---|---|
| $C_{29}H_{20}N_2S$ | calc. | C 81.29 | H 4.71 | N 6.54 |
| (428.5) | found | 81.28 | 4.25 | 6.62 |

I.R. (Nujol): $\nu = 1395\ cm^{-1}$ (C=S).

U.V. ($C_2H_5OH$): $\lambda_{max} = 290$; 300 nm.

$^1$H-N.M.R. ($CDCl_3$): $\delta = 7.60$ ppm (m, $H_{arom}$).

**6-Oxo-2,3,5,7-tetraphenyl-6*H*-1,4-diazepine (9):**
In place of carbon disulphide, dry ethyl carbonochloridate (2 ml) is slowly added in the above reaction. The product on crystallisation from ethanol gives a solid; yield: 1.3 g (61%); m.p. 235 °C.

| | | | | |
|---|---|---|---|---|
| $C_{29}H_{20}N_2O$ | calc. | C 84.44 | H 4.85 | N 6.79 |
| (412.5) | found | 84.68 | 5.12 | 7.01 |

I.R. (Nujol): $\nu = 1760\ cm^{-1}$ (C=O).

U.V. ($C_2H_5OH$): $\lambda_{max} = 305$; 340 nm.

$^1$H-N.M.R. ($CDCl_3$): $\delta = 7.65$ ppm (m, $H_{arom}$).

**1,3-Bis[*p*-tolyl]-4,5-diphenyl-2-benzylimino-2,3-dihydroimidazole (10):**
A mixture of 1,3-bis[*p*-tolyl]4,5-diphenyl-2-oxo-2,3-dihydroimidazole (**5b**; 0.42 g, 0.001 mol) and benzylamine (1.07 g, 0.01 mol) is heated at 250 °C for 3 days. The unreacted benzylamine is removed by distillation. The contents are cooled and purified by passing through a column packed with neutral alumina. The solvents are removed on a rotary evaporator and the residual material, on crystallisation from ethanol, gives solid **10**; yield: 0.3 g (60%); m.p. 267 °C. This compound is insoluble in $CCl_4$, $CDCl_3$, DMSO, $CS_2$, and acetone and hence the N.M.R. spectrum of this compound could not be obtained.

| | | | | |
|---|---|---|---|---|
| $C_{36}H_{31}N_3$ | calc. | C 85.51 | H 6.18 | N 8.31 |
| (505.6) | found | 85.09 | 5.97 | 7.97 |

I.R. (Nujol): $\nu = 1620\ cm^{-1}$ (C=N).

U.V. ($C_2H_5OH$): $\lambda_{max} = 228$; 300 nm.

**Table.** Compounds **4a–d** and **5a–d** prepared

| Product | Yield [%] | m.p. [°C] found | m.p. [°C] reported | Molecular formula[a] | I.R. (nujol) [cm$^{-1}$][b] $\nu_{C=S}$ | I.R. (nujol) [cm$^{-1}$][b] $\nu_{C=O}$ | U.V. ($C_2H_5OH$)[c] $\lambda$ [nm] | $^1$H-N.M.R. (solvent)[d] $\delta$ [ppm] |
|---|---|---|---|---|---|---|---|---|
| **4a** | 65 | 249° | — | $C_{27}H_{20}N_2S$ (404.5) | 1305 | — | 298 | ($CDCl_3$): 7.12 (s, 10$H_{arom}$); 7.42 (s, 10$H_{arom}$) |
| **4b** | 50 | 236–237° | 233°[3] | $C_{29}H_{24}N_2S$ (432.5) | 1240 | — | 295 | ($CDCl_3$): 7.2 (m, 18$H_{arom}$); 2.31 (s, 6H, $CH_3$) |
| **4c** | 70 | 242–243° | — | $C_{31}H_{28}N_2S$ (460.6) | 1220 | — | 295 | ($CDCl_3$): 7.1 (m, 16$H_{arom}$); 2.3 (m, 12H, $CH_3$) |
| **4d** | 70 | 257° | — | $C_{29}H_{24}N_2S$ (432.5) | 1220 | — | 295 | ($CDCl_3$): 7.38 (s, 10$H_{arom}$); 6.9 (s, 8$H_{arom}$); 2.23 (s, 6H, $CH_3$) |
| **5a** | 65 | 207° | 208–209°[4] | $C_{27}H_{20}N_2O$ (388.4) | — | 1700 | 293 | ($CDCl_3$): 7.3 (m, 20$H_{arom}$) |
| **5b** | 60 | 222° | 214°[3] | $C_{29}H_{24}H_2O$ (416.5) | — | 1695 | 295 | ($CDCl_3$): 7.1 (m, 18$H_{arom}$); 2.33 (s, 6H, $CH_3$) |
| **5c** | 70 | 249° | — | $C_{31}H_{28}N_2O$ (444.5) | — | 1695 | 295 | ($CDCl_3$): 6.97 (s, 8$H_{arom}$); 7.15 (s, 8$H_{arom}$); 2.25 (s, 6H, $CH_3$); 2.32 (s, 6H, $CH_3$) |
| **5d** | 65 | 227° | — | $C_{29}H_{24}N_2O$ (416.5) | — | 1700 | 310 | ($CCl_4$): 7.20 (s, 10$H_{arom}$); 7.00 (s, 8$H_{arom}$); 2.20 (s, 6H, $CH_3$) |

[a] The microanalyses were carried out using Coleman carbon-hydrogen analyser and Coleman nitrogen analyser and are in satisfactory agreement with the calculated values (C ±0.34, H ±0.28, N ±0.44).
[b] The I.R. spectra were recorded on a Perkin-Elmer 720 spectrophotometer.
[c] The U.V. spectra were recorded on a Cary-14 spectrophotometer.
[d] The N.M.R. spectra were recorded on a Varian A-60D spectrometer using TMS as internal standard.

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