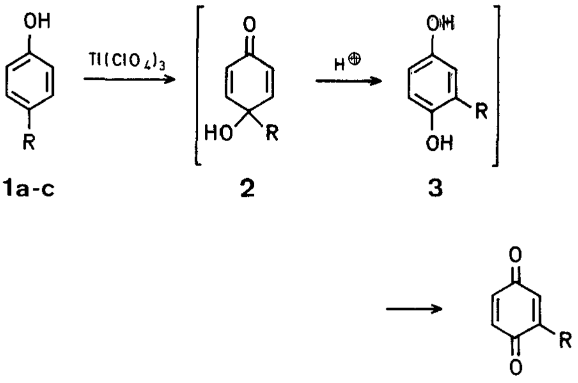
# A Convenient Synthesis of Alkyl-Substituted *p*-Benzoquinones from *p*-Alkylphenols

Yasuji YAMADA*, Kunio HOSAKA

Tokyo College of Pharmacy, Horinouchi, Hachioji, Tokyo 192-03, Japan

It is well known that phenols are converted to benzoquinones by a variety of oxidizing agents[1]. Although *p*-benzoquinone derivatives were also obtained from *p*-alkylphenols by air oxidation[2] and reaction with thallium(III) trifluoroacetate[3], oxidative C—C-bond cleavage of the *para*-substituted alkyl group was encountered in these reactions.

We have found that the reaction of *p*-alkylphenols **1** with thallium(III) triperchlorate in the presence of 60% perchloric acid afforded a good yield of alkyl-substituted *p*-benzoquinones **4**. In this reaction, the alkyl substituents were retained as they underwent rearrangement to the adjacent position. This reaction provides a simple and effective general method for the synthesis of the alkyl-substituted *p*-benzoquinones from readily available *p*-alkylphenols.



**4a-c**

| | R |
|---|---|
| a | $CH_3$ |
| b | $CH_2-CH_2-OAc$ |
| c | $CH_2-CH_2-O-CO-CH_2Cl$ |

**Table.** Preparation of *p*-Benzoquinones **4a–4c**

| Product | R | m.p. | Yield[a] [%] | Molecular formula | M.S. (*m/e*) | I.R. ($CHCl_3$) $\nu$ [$cm^{-1}$] | $^1H$-N.M.R. (60 MHz, $CDCl_3$) $\delta$ [ppm] |
|---|---|---|---|---|---|---|---|
| **4a** | $CH_3$ | 71° | 70 | $C_7H_6O_2$ (122.1) | 122 ($M^{\oplus}$) | 1650, 1595 | 2.08 (d, 3H, $J=2$ Hz), 6.65–6.80 (3H) |
| **4b** | $CH_2CH_2OCOCH_3$ | – | 66 | $C_{10}H_{10}O_4$[b] (194.2) | 194 ($M^{\oplus}$) | 1730, 1655<br>1600 | 2.08 (s, 3H), 2.80 (t, 2H, $J=7$ Hz), 4.30 (t, 2H, $J=7$ Hz), 6.70–6.83 (3H) |
| **4c** | $CH_2CH_2OCOCH_2Cl$ | – | 65 | $C_{10}H_9ClO_4$[b] (228.6) | 228 ($M^{\oplus}$) | 1740, 1650<br>1595 | 2.83 (t, 2H, $J=6$ Hz), 4.08 (s, 2H), 4.41 (t, 2H, $J=6$ Hz), 6.60–6.90 (3H) |

[a] Yield of isolated product.

[b] *The elemental composions of these new compounds given with* the chemical formulae were confirmed by high resolution mass spectrometry (±3 mmass unit).

Treatment of **1a–1c** with thallium(III) triperchlorate in 60% perchloric acid[4] (4 equivalents[5]) at room temperature afforded exclusively the corresponding *p*-benzoquinones **4a–4c** in 65–70% yield. The initial step of this reaction must be the formation of the p-quinol **2**[4], which can be converted to the hydroquinone intermediate **3** by an acid-catalyzed dienone-phenol rearrangement[6], and the subsequent oxidation with the thallium salt leads to the *p*-benzoquinones. This reaction pathway was confirmed by the following experiments: the *p*-quinol **2b**, obtained from **1b** by the reaction with thallium(III) triperchlorate in perchloric acid under the mild conditions (0° and the reduced acid concentration) which could prevent the dienone-phenol rearrangement, was converted to the hydroquinone **3b** in quantitative yield by exposure to 60% perchloric acid, and further oxidation of **3b** with thallium(III) triperchlorate in 60% perchloric acid yielded **4b**.

This simple method will be widely applicable to the synthesis of *p*-benzoquinones from the corresponding *p*-alkylphenols. Furthermore this reaction is of interest in connection with the enzymic formation of homogentisic acid from *p*-hydroxyphenylpyruvic acid (via NIH shift)[7]. A typical procedure is detailed below.

### Preparation of Toluquinone (4a):

A solution of thallium(III) triperchlorate in perchloric acid was prepared by dissolving thallic oxide (6 g) in 60% perchloric acid (100 ml) at 130° for 2 h. To a solution of *p*-cresol (**1a**: 100 mg, 0.93 mmol) in dichloromethane (5 ml), thallium(III) triperchlorate in 60% perchloric acid (15 ml, 3.7 mmol) was added, and the heterogeneous reaction mixture was vigorously stirred at room temperature for 5 min. Excess ice/water was added to the reaction mixture which was then extracted three times with dichloromethane (30 ml). The combined dichloromethane extracts were washed successively with saturated sodium hydrogen carbonate solution, water, and brine. Evaporation of the solvent afforded toluquinone (**4a**) exclusively as yellow crystals; yield: 80 mg (70%); m.p. 71°.

Similar reactions of **1b** and **1c** also afforded exclusively the *p*-benzoquinones **4b** and **4c** in 66 and 65% yield, respectively.

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[5] Stoichiometrically 2 equivalents of the reagent is sufficient for the oxidation, but the reaction time was efficiently reduced by using 4 equivalents of the reagent.

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