PHOTOCHEMICAL RING CLOSURE OF MUCONIC ACID ANHYDRIDE

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Summary: 2,5-Dimethyl muconic acid anhydride has been synthesized in three steps from catechoI and transformed via a high yielding photochemical ring closure into cis-1,5-dimethyl-3-azabicyclo[3.2.0]heptane-2,4-dione.

Functionalized derivatives of cycloheptadienes or heterocyclic derivatives thereof have been known for a long time to ring close photochemically [1]. In most cases the yield of these reactions is not very good. Belluš and coworkers have recently reported a synthesis of cis-N-(3,5-dichlorophenyl)-1,5-dimethyl-3-azabicyclo [3.2.0] heptane-2,4-dione 4, which is highly active against Botrytis cinerea, a gray mould fungus on grapes [2]. This synthesis relied on the photochemical [2 + 2] cycloaddition between ethylene and dimethylmaleic acid anhydride which proceeded unfortunately only below -50°C [3].

The synthesis of 2,5-dimethylmuconic acid anhydride 1 could easily be achieved in 80 % yield by treating 2,5-dimethylcatechol [4] with a slight excess of MCPA at room temperature [6] (scheme I). The product could be separated from the meta-chlorobenzoic acid by low temperature filtration at -78°C.

\[
\begin{array}{ccc}
\text{OH} & \rightarrow & \text{OH} \\
\text{OH} & \rightarrow & \text{MCPA} \\
\text{CH}_2\text{Cl}_2, 0-25°C & \rightarrow & \text{1}
\end{array}
\]

Scheme I

A 0.12 molar solution of muconic acid anhydride in acetonitrile was smoothly transformed in high yield by irradiation at room temperature with a pyrex filter into cis-2,5-dimethyl-3-oxabicyclo [3.2.0] heptane-2,4-dione (scheme II). This product was directly reduced and the isolated yield over the two steps was 86 %. The anhydride could be treated with 3,5-dichloroaniline to yield the desired product [2]. The imide is now available in three high yielding steps starting from 2,5-dimethyl muconic acid anhydride in 58 % overall yield. The sequence of photochemical ring closure, reduction, imide formation is not restricted to the dimethyl derivative, but has also been achieved starting from 3-t-butylmuconic acid anhydride [7,8]. There are several advantages of this sequence to be mentioned:
1. The use of muconic acid anhydride as starting material allows to alter easily substituents using different starting materials.

2. The photochemical ring closure avoids the problems of crossed addition [2].

3. The chromophores of the starting material ($\lambda_{\text{max}} = 286 \text{ nm}$) and the product ($\lambda_{\text{max}} < 200 \text{ nm}$) make it possible to irradiate the starting material selectively, thereby ensuring a high yield of the photochemical transformation.

**Acknowledgements:** This work was supported by the Swiss National Science Foundation. We are indebted to the following persons for their help: Miss E. Trieschmann and Dr. T. Jenny (NMR) and Mr. G. Holze (MS).

**References and Notes:**


[5] All new compounds gave satisfactory spectroscopic data.

[6] 2,5-dimethylmuconic acid anhydride: $^1$H-NMR (90 MHz in CD$_2$Cl$_2$): 6.47 (s, 2H); 2.15 (s, 6H). $^{13}$C-NMR (90.5 MHz in CHCl$_3$): 161.0 (s); 133.6 (s); 131.7 (d); 21.2 (q). IR (in CHCl$_3$): 3030w, 1770sh, 1725s. MS: $M^+$ exp. = 152.0472, $M^+$ theor. = 152.0473.


[8] 6-t-buty1-3-oxabicyclo[3.2.0]hept-6-ene-2,4-dione: $^1$H-NMR (90 MHz in CDCl$_3$): 6.00 (s, 1H); 3.95 (d, $J = 3$ Hz, 1H); 3.77 (d, $J = 3$ Hz, 1H); 1.12 (s, 4H). 6-t-buty1-3-oxabicyclo[3.2.0]heptane-2,4-dione: $^1$H-NMR (360 MHz in CDCl$_3$): 3.53 (t d x d, br, $J_{5,6} = 10.1$ Hz, $J_{1,5} = 6.8$ Hz, 1H); 3.43 (d x d x d, $J_{1,5} = 6.8$ Hz, $J_{1,7} = 6.1$ Hz, $J_{1,7} = 10.0$ Hz, 1H); 2.88 (d x d x d, $J_{5,6} = 10$ Hz, $J_{5,2} = 10$ Hz, $J_{5,7} = 10$ Hz, 1H); 2.65 (d x d x d x d, $J_{1,7} = 10$ Hz, $J_{5,7} = 1.5$ Hz, $J_{6,7} = 10$ Hz, $J_{7,7} = 12.9$ Hz, 1H); 2.28 (d x d x d x d, $J_{1,7} = 6.1$ Hz, $J_{5,7} = 0.5$ Hz, $J_{6,7} = 10$ Hz, $J_{7,7} = 12.9$ Hz, 1H).