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3-HYDROXY-2-PYRONE AS A VINYLKETENE EQUIVALENT FOR THE SYNTHESIS OF DIHYDROPHENOLS AND CYCLOHEXENONES

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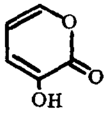
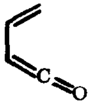
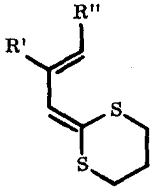
This note describes the use of 3-hydroxy-2-pyrone (I) as a vinylketene (II) equivalent which behaves as a diene in the Diels-Alder process and allows the expeditious synthesis of a variety of dihydrophenolic structures. The use of vinylketenes themselves as diene components is complicated by their relative inaccessibility, their tendency to form 2 + 2 cycloadducts,[1] and their intrinsic instability. Although dithiane derivatives of the type indicated by III have been utilized as dienic vinylketene equivalents in the Diels-Alder reaction,[2] their utility is sharply limited because of unreactivity toward all but the most reactive dienophiles (e.g., tetracyanoethylene and maleic anhydride).[3]



I



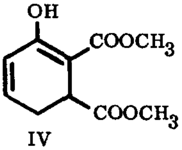
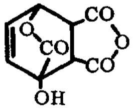
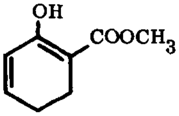
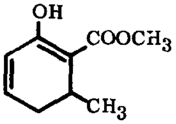
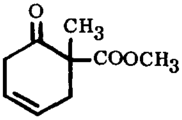
II



III

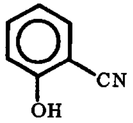
The crystalline hydroxypyrone I is easily prepared by dehydration ($KHSO_4$ as catalyst) of the readily available mucic acid.[4,5] It reacts with a variety of olefinic dienophiles to afford products of Diels-Alder addition and subsequent decarboxylation,[6] dihydrophenols or cyclohexenones, in good yield. Several examples, along with apposite reaction conditions, are given in the accompanying Table.[7] It will be noted that the adducts IV-VIII are relatively inaccessible by other synthetic approaches and that in the case of compounds IV, VI, and VII the stable form is enolic rather than ketonic. The initial adduct from I and maleic anhydride (V) (no decarboxylation) could be obtained in good yield. Also of interest is the isolation of the β,γ-unsaturated ketone VIII from methyl methacrylate as dienophile, rather than the α,β-enone which actually is the more stable isomer. The position specificity of the reactions forming

Table

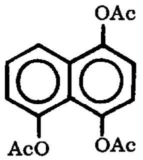
Cycloadduct	Dienophile	Reaction Conditions (temp., solvent, time	% Yield
 IV	dimethyl maleate	115°/C_6H_6/40 hr	73
 V	maleic anhydride	80°/C_6H_6/36 hr	83
 VI	methyl acrylate	170°/C_7H_8/22 hr	56
 VII	methyl crotonate	200°/C_7H_8/22 hr	50
 VIII	methyl methacrylate	205°/C_7H_8/22 hr	85

VI, VII, and VIII is both gratifying and in accord with the expectation that the powerfully electron-donating 3-hydroxyl group in I should play a dominant role in determining the favored transition-state.

Reaction of 2-chloroacrylonitrile and *p*-benzoquinone gave rise to the aromatic products IX and X (after acetylation). Aromatic compounds were also obtained from I and acetylenic dienophiles, for example, dimethyl 3-hydroxyphthalate (95% yield) from I and dimethyl acetylenedicarboxylate (80° in C_6H_6 for 30 hr).



IX



X

Neither I, its benzoate ester or methyl ether were sufficiently reactive toward simple olefins (*e.g.*, cyclohexene) to afford Diels-Alder products, a fact which precludes realization of what would have been a useful ring annelation process.[8,9]

References

1. 2-Propenylketene reacts with ethyl vinyl ether to yield a cyclobutanone rather than a cyclohexenone; see G. B. Payne, *J. Org. Chem.*, **31**, 718 (1966).
2. F. A. Carey and A. S. Court, *J. Org. Chem.*, **37**, 4474 (1972).
3. A recent paper [E. Sonveaux and L. Ghosez, *J. Amer. Chem. Soc.*, **95**, 5417 (1973)] describes the formation of Diels-Alder adducts from a vinylketenimine derivative and a reactive dienophile such as tetracyanoethylene or benzylidene malonitrile. The scope and practicality of this approach leave much to be desired.
4. R. H. Wiley and C. H. Jarboe, *J. Amer. Chem. Soc.*, **78**, 2398 (1956).
5. Separation of the pyrone I from the major by-products of the preparation (furoic acid and furan-2,5-dicarboxylic acid) is easily accomplished on the basis of differing acidities. Adjustment of an aqueous mixture of the reaction to pH 7 (at which the acids are in their salt form) followed by ethereal extraction yields the crystalline pyrone I after concentration. Further purification of the pyrone can be effected by recrystallization or sublimation.
6. For early examples of Diels-Alder addition *cum* carbon dioxide elimination, see K. Alder and H. Rickert, *Chem. Ber.*, **70**, 1354 (1937).

7. Structural assignment to these adducts is supported by infrared, proton magnetic resonance, and mass spectral data obtained on purified samples.
8. For the demonstration of such a process with a different 2-pyrone derivative, see E. J. Corey and D. S. Watt, J. Amer. Chem. Soc., **95**, 2303 (1973).
9. This study was supported in part by the National Institutes of Health.