

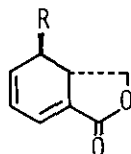
REACTION OF 3a,4-DIHYDROPHthalIDES WITH ACETYLENIC DIENOPHILES¹

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Abstract — The tricyclo[2.2.2]octa-2,5-diene-4,7-carbolactones, the initially-formed Diels-Alder adducts from 3a,4-dihydrophthalides and acetylenic dienophiles, were so strained that they underwent the retro-Diels-Alder reaction to afford the benzene derivatives in good yields.

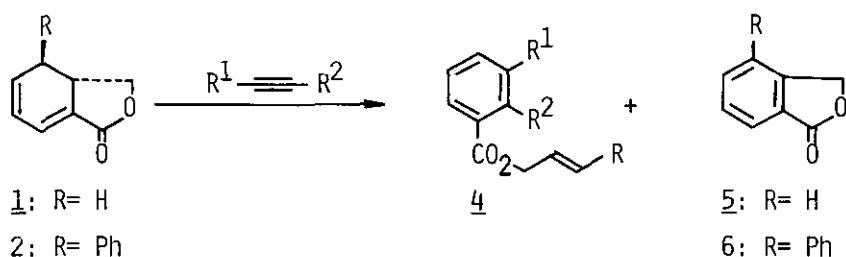
The Diels-Alder reactions utilizing a variety of novel diene systems have provided a significant advance on the methodologies for the ring construction of the stereochemically interesting polycycles.² Previously, we also reported that the 3a,4-dihydrophthalides 1-3, which were prepared by the intramolecular "diene-regenerable" Diels-Alder reaction of 2-pyrones, behaved as a novel type of the fused 1,3-cyclohexadiene system and underwent the intermolecular Diels-Alder reaction with olefinic dienophiles to yield tricyclo[2.2.2]oct-2-ene-4,5-carbolactones stereoselectively.³

1: R= H2: R= Ph3: R= CO₂Me

In the course of our study on the fused 1,3-cyclohexadiene systems, we have investigated the cycloaddition reaction of 1-3 with acetylenic dienophiles expecting the formation of the much highly strained cycloadducts, tricyclo[2.2.2]octa-2,5-diene-4,7-carbolactones. We wish to communicate here that the reaction of 1-3 with acetylenes gives the benzene derivatives via the cycloreversion of the primarily-formed tricyclo[2.2.2]octa-2,5-diene system.

When 1 was allowed to react with dimethyl acetylenedicarboxylate (DMAD) (1.2 equiv.) in refluxing xylene under nitrogen atmosphere for 40 h, a 1:1 adduct 4a and phthalide (5) were obtained in 45 and 3% yields, respectively, together with polymeric products. The structure of 4a was deduced to be an unsymmetrical allyl dimethyl benzene-1,2,3-tricarboxylate from the spectroscopic

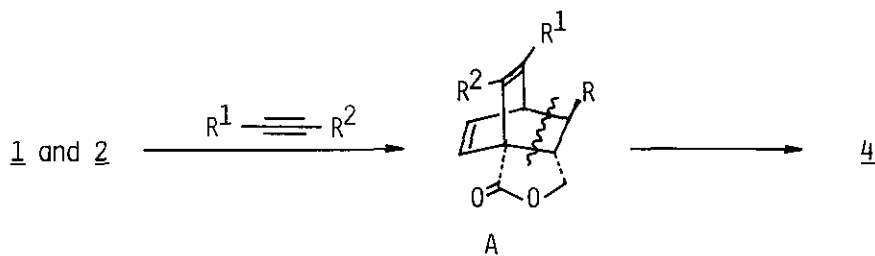
Table 1. Reaction of 3a,4-Dihydrophthalides 1 and 2 with Acetylenic Dienophiles



Compds	R	R ¹	R ²	Yield/%	Phthalides (Yield/%)
<u>4a</u>	H	CO ₂ Me	CO ₂ Me	45	<u>5</u> (3)
<u>4b</u>	H	COPh	COPh	46	<u>5</u> (trace)
<u>4c</u>	Ph	CO ₂ Me	CO ₂ Me	62	<u>6</u> (23)
<u>4d</u> { <u>1</u> <u>2</u>	H	CO ₂ Me H	H CO ₂ Me	10	<u>5</u> (trace)

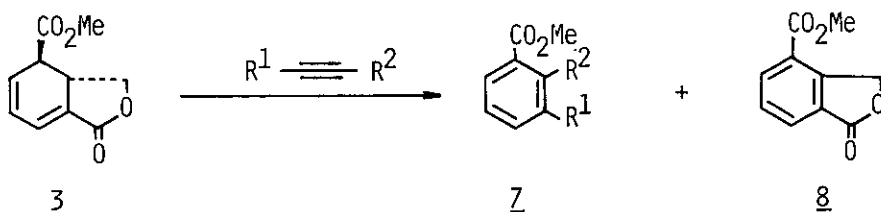
properties and elemental analysis.⁴ The reaction of 1 with dibenzoylacetylene (DBZA) gave similarly 3-allyloxycarbonyl-2-benzoylbenzophenone (4b) and 5. An unsymmetrical trans-cinnamyl dimethyl benzene-1,2,3-tricarboxylate (4c) and 4-phenylphthalide (6) were obtained from 2 and DMAD.

These findings indicated that the tricyclo[2.2.2]octa-2,5-diene-4,7-carbolactones A, which are expected to form initially in the reaction, are too strained to isolate under the conditions and undergo the retro-Diels-Alder reaction to give the benzene derivatives 4.



In order to investigate the regioselectivity of the addition, the reaction with methyl propiolate (MP) was carried out. The reaction of 1 with an excess of MP under reflux in xylene and the usual working-up gave ca. 1:1 mixture of allyl methyl isophthalate (4d-1) and phthalate (4d-2) in total yield of 10%.

On the other hand, the reaction of 4-methoxycarbonyl-3a,4-dihydrophthalide (3) with acetylenes

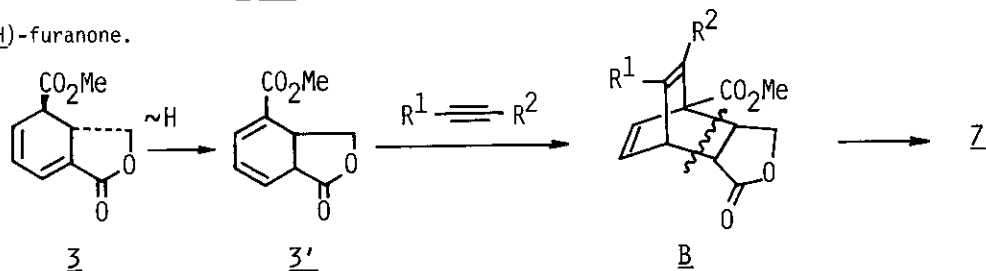
Table 2. Reaction of 4-Methoxycarbonyl-3a,4-dihydrophthalide (3) with Acetylenic Dienophiles

Compds	R ¹	R ²	Yield/%	<u>8</u> Yield/%
<u>7a</u>	CO ₂ Me	CO ₂ Me	61	28
<u>7b</u>	COPh	COPh	60	31
<u>7c</u> { <u>1</u> <u>2</u>	CO ₂ Me	H	41	37
	H	CO ₂ Me	10	

proceeded in a slightly different manner from that of 1 or 2; e.g., firstly the formation of polymeric products was scarcely observed.

The reaction of 3 with DMAD and DBZA gave trimethyl benzene-1,2,3-tricarboxylate (7a) and 3-methoxycarbonyl-2-benzoylbenzophenone (7b), respectively, together with 4-methoxycarbonylphthalide (8). A 1:1 mixture of dimethyl isophthalate (7c-1) and phthalate (7c-2) was also obtained from 3 and MP.

Therein, the 3a,4-dihydrophthalide 3 was converted into the 3a,7a-dihydrophthalide (3') by the thermally-allowed 1,5-hydrogen shift, which underwent Diels-Alder reaction with acetylenes to afford tricyclo[2.2.2]octa-2,5-diene-7,8-carbolactones B. The tetracyclic adducts B yielded the benzene derivatives 7 via the retro-Diels-Alder reaction accompanied with the extrusion of 2(5H)-furanone.



ACKNOWLEDGEMENT

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4. All new compounds in this communication gave satisfactory analytical values and their structures were determined on the basis of the spectral data shown below.

4a: Colorless needles; mp 55-56 °C; ir 1740, 1720 cm^{-1} (CO); nmr δ 3.92, 4.00(2s, 3H each, $-\text{CH}_3$), 4.82(m, 2H, $-\text{CH}_2-$), 5.4(m, 2H, $=\text{CH}_2$), 6.0(m, 1H, $-\text{CH}=\text{}$), 7.52(t, 1H, H-5, $J=7$ Hz), 8.2(m, 2H, H-4 and H-6); mass m/z 278(M^+).

4b: Yellow oil; ir 1750, 1690 cm^{-1} (CO); nmr δ 4.48(dd, 2H, $-\text{CH}_2-$, $J=6$ and 1.5 Hz), 5.18(m, 2H, $=\text{CH}_2$), 5.6(m, 1H, $-\text{CH}=\text{}$), 7.3-7.8(m, 11H, H-3 and phenyl protons), 8.2(m, 2H, H-4 and H-6); mass m/z 370(M^+).

4c: Colorless needles; mp 96-97 °C; ir 1730 cm^{-1} (CO); nmr δ 3.92, 3.96(2s, 3H each, $-\text{CH}_3$), 4.98(d, 2H, $-\text{CH}_2-$, $J=7$ Hz), 6.4(m, 1H, H-5, $J=7$ Hz), 6.7(d, 1H, $=\text{CH}-\text{Ph}$, $J=15$ Hz), 7.3-7.5(m, 5H, phenyl protons), 7.56(t, 1H, H-5, $J=7$ Hz), 8.2(m, 2H, H-4 and H-5); mass m/z 354(M^+).

4d-1: nmr δ 3.95(s, 3H, $-\text{CH}_3$), 4.8($-\text{CH}_2-$), 5.3($=\text{CH}_2$), 5.8-6.1($-\text{CH}=\text{}$), 7.72(m, 1H, H-5), 8.2(m, 2H, H-4 and H-5), 8.68(br t, 1H, H-2, $J=1.5$ Hz).

4d-2: nmr δ 3.89(s, 3H, $-\text{CH}_3$), 4.8($-\text{CH}_2-$), 5.3($=\text{CH}_2$), 5.8-6.2($-\text{CH}=\text{}$), 7.4-7.6(m, 4H, H-3, H-4, H-5, and H-6).

7b: Colorless prisms; mp 122-124 °C; ir 1720, 1655 cm^{-1} (CO); nmr δ 3.60(s, 3H, $-\text{CH}_3$), 7.2(m, 2H, H-4 and H-5), 7.3-7.8(m, 11H, H-6 and phenyl protons); mass m/z 344(M^+).

The structural confirmations of phthalides 5, 6, and 8 and 7a and 7c were accomplished by comparing the physical or spectral data with those of the authentic samples or the reported ones.

5, 6, and 8 and 7c: Identified with the authentic samples.

7a: Colorless needles; mp 103-104 °C(lit.⁵ mp 102 °C).
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