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SYNTHESIS AND REACTIVITY OF (E)-4,6,7-OCTATRIENOIC ACID SODIUM SALT IN THE AQUEOUS DIELS-ALDER REACTION

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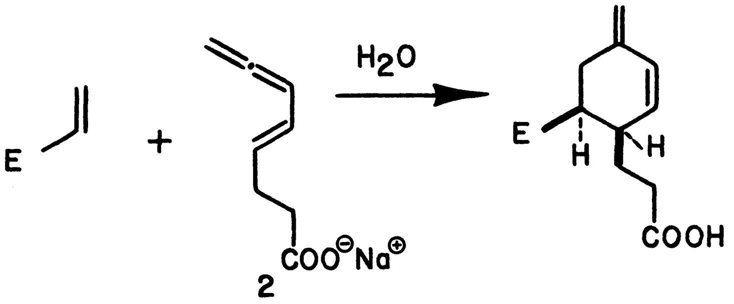
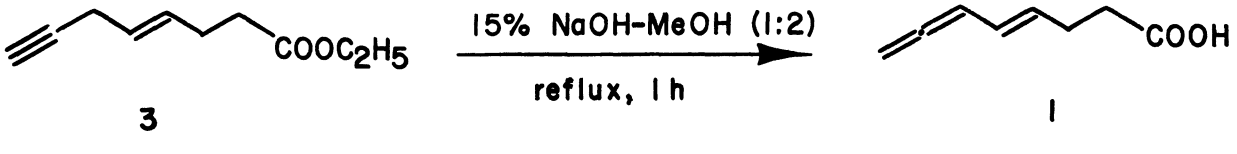
The aqueous Diels-Alder reaction between sodium (E)-4,6,7-octatrienoate and several standard dienophiles has been examined.

Our interest in defining the scope and limitations of the aqueous Diels-Alder reaction[1] has led us to prepare (E)-4,6,7-octatrienoic acid (**1**) and examine the reactivity of its corresponding sodium carboxylate (**2**) with a variety of dienophiles (Eq. 1).



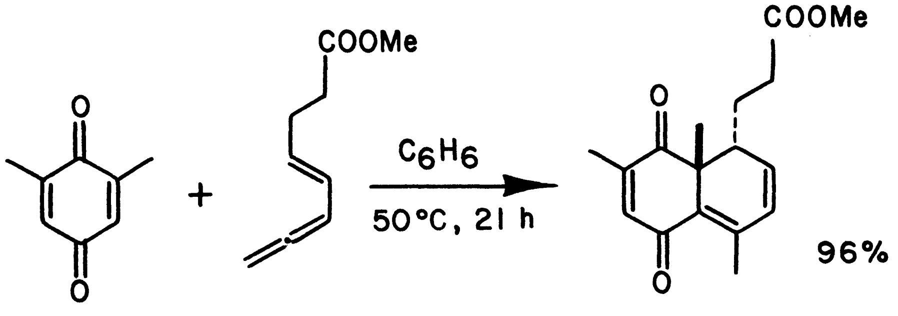
(1)

The new allenyl olefinic acid **1**, which proved to be extremely reactive, was prepared via a three-step sequence. The adduct obtained from condensation of acrolein with propargyl magnesium bromide was subjected to an ortho ester Claisen rearrangement [$CH_3C(OC_2H_5)_3$, C_2H_5COOH (cat.), benzene, reflux] which gave rise to



enyne ester **3** in 54% overall yield from acrolein. Exposure of **3** to aqueous sodium hydroxide in methanol[2] provided after workup a 94% yield of (E)-4,6,7-octatrienoic acid (**1**).

As illustrated in Table 1, the reactions of sodium (E)-4,6,7-octatrienoate (**2**) with a number of dienophiles with the exception of methyl acrylate and acrylonitrile, proceed in water, at room temperature in 0.5-2.0 h in yields ranging from 72-95%. All reactions employed a five-fold excess of triene **2**. The concentration of the triene in water was 2.0 M. For convenience, all compounds were characterized as their methyl esters. In all cases examined, the endo adducts predominated. The 7:1, endo:exo, ratio observed in the case of acrolein stems from slow equilibration of the aldehyde group during the course of the reaction. In the case of the condensation of **2** with 2,6-dimethylbenzoquinone, which proceeds in excellent yield at ambient temperature in 30 min, the initially formed Diels-Alder adduct completely isomerizes under the conditions of the reaction to the fully conjugated system depicted in Table 1. For comparison purposes we examined the Diels-Alder reaction between methyl (E)-4,6,7-octatrienoate and 2,6-dimethylbenzoquinone in benzene (Eq. 2). In order to realize a 96% yield of adduct **4**, heating in benzene at 50 °C for 21 h was required. Once again isomerization of the exocyclic olefin was observed.



(2)

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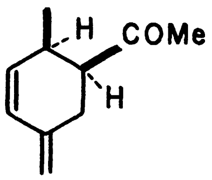
The literature[3)] reveals that the Diels-Alder reaction between allenyl olefins and methyl vinyl ketone requires high temperatures and gives poor endo:exo ratios. For example, Bertrand[3)] has previously shown that condensation (neat) of (E)-1,2,4-hexatriene with methyl vinyl ketone affords after 2 h at 100 °C in a sealed tube a 50% yield of adducts **5** and **6** in a ratio of 3:1.



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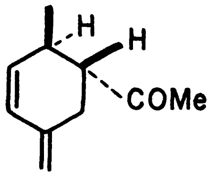

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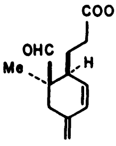
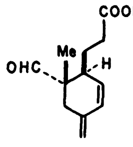
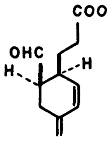
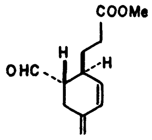
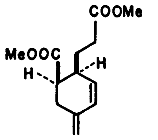
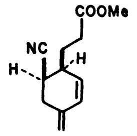
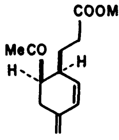
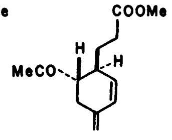
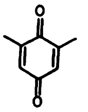
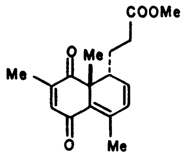
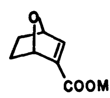
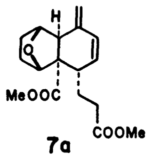
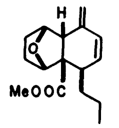
Table I. Reaction of Sodium (*E*)-4,6,7-Octatrienoate in Water with Some Standard Dienophiles a)

Dienophile	Temperature/°C	Time/h	Product(s) b)	Yield/% c)	*endo*/*exo* ratio d)
Methacrolein	r.t.	1	 	73	17:1
Acrolein	r. t.	1	 	75	7:1
Methyl acrylate	50	48		88	e)
Acrylonitrile	50	48		29	e)
Methyl vinyl ketone	r. t.	2	 	86	17:1
	r.t.	0.5		95	e)
	r.t.	2	 7a  7b	72	f)

a) All reactions were carried out with 2.0 M triene. A five-fold excess of triene was employed.

b) Products were characterized as their methyl esters. c) Yields reported are for chromatographically pure materials. d) Ratios (*endo*/*exo*) were determined by ^{1}H NMR (360 MHz). e) The *exo* adduct could not be detected by NMR. f) The ratio of the two adducts was 1:1.

Somewhat surprising are the results from reaction of methyl 7-oxabicyclo-[2.2.1]hept-2-ene-2-carboxylate[4)] with sodium (E)-4,6,7-octatrienoate which gives rise to a 1:1 mixture of two adducts arising from alpha and beta attack on the dienophile. The presence of the unanticipated adduct arising from alpha attack undoubtedly stems from the fact that in the normal mode of addition to the beta face (exo addition) of the [2.2.1]bicyclic system, two serious interactions are encountered. In the beta transition state leading to adduct **7** a severe interaction arises between the terminal allene moiety and the C(4) hydrogen. In addition, serious orbital-orbital interactions exist between the C(7) oxa substituent and the π orbital of the terminal allene.

The results with methyl acrylate and acrylonitrile, while disappointing, were somewhat predictable.

The following procedure employing methacrolein clearly indicates the simplicity of the methodology. To a suspension of 138 mg (1.00 mmol) of (E)-4,6,7-octatrienoic acid in 500 μL of water was added portionwise 80 mg (0.95 mmol) of solid sodium bicarbonate. After 10 min, 16.5 μL (0.20 mmol) of freshly distilled methacrolein was added at ambient temperature. The reaction mixture was vigorously stirred for 1 h. The reaction was quenched at 0 ^{o}C by the addition of 2.0 mL of 10% hydrochloric acid. The crude acid, isolated by extraction with ether, was esterified with ethereal diazomethane and was purified on silica gel, affording 32 mg (73%) of product as a 17:1 mixture of endo and exo adducts, respectively.

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2) Cf. J. Grimaldi and M. Bertrand, Bull. Soc. Chim. Fr., 1971, 947.

3) M. Bertrand, J. Grimaldi, and B. Waegell, Bull. Soc. Chim. Fr., 1971, 962.

4) P.A. Grieco, R.E. Zelle, R. Lis, and J. Finn, J. Am. Chem. Soc., 105, 1403 (1983).

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