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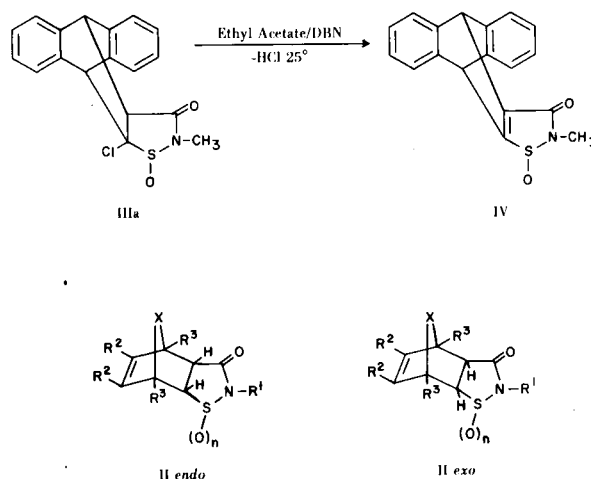
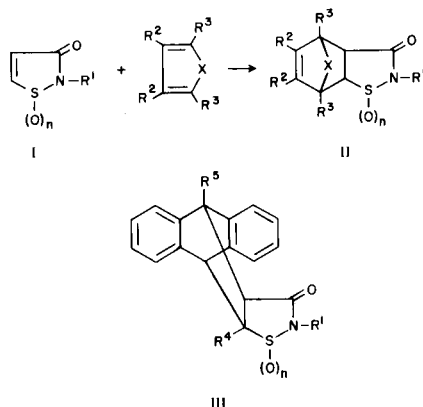
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4-Isothiazolin-3-one 1-oxides and 1,1-dioxides react with a variety of cyclic and acyclic dienes to afford cycloaddition products.

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In the course of studies on the chemistry of 4-isothiazolin-3-one 1-oxides (I, $n = 1$) and 1,1-dioxides (I, $n = 2$), we found these derivatives to exhibit spectroscopic properties characteristic of conjugated imide derivatives and not typical of the heterocyclic 4-isothiazolin-3-one ring system. Consistent with this observation we reported (1) that 4-isothiazolin-3-one 1-oxides (I, $n = 1$) undergo facile halogen addition to provide 4,5-dihaloisothiazolidin-3-one 1-oxides. We now report on the Diels-Alder cycloaddition reaction of compounds I with various dienes to form the adducts II or III. By contrast, 4-isothiazolin-3-ones, the unoxidized version of I, are poor dienophiles and were found not to react with several of the more reactive dienes under similar reaction conditions.



Elemental analyses, ir and nmr spectral data are consistent with the assigned structures. Table II summarizes the analytical data. No effort was made to optimize the reported yields.

EXPERIMENTAL

Melting points were determined on a Thomas-Hoover melting point apparatus and have not been corrected. Ir spectra were taken as nujol mulls or neat on a Perkin-Elmer Infracord, Model 137. Nmr spectra were obtained on a Varian T-60 or XL-100. The multiplicities of absorption are shown in brackets: s, single; d, doublet; and m, multiplet. Elemental analyses were performed by the analytical department of the Research Division of the Rohm and Haas Company. The following experiments illustrate the general reaction procedures employed.

3a,4,7,7a-Tetrahydro-5,6-dimethyl-1,2-benzisothiazolin-3(2H)one 1-Oxide.

To a solution of 2.2 g. (0.019 mole) of 4-isothiazolin-3-one 1-oxide in 50 ml. of ethylene dichloride was added 2.0 g. (0.024 mole) of 2,3-dimethyl-1,3-butadiene. The mixture was heated to 60° and stirred at this temperature overnight. Concentration of the mixture yielded a thick oil, which gave a white solid on trituration with hexane. The solid was filtered and air dried to yield 3.4 g. (90%) of product, m.p. 135-137° (ethyl acetate-hexane); ir: 5.7 (C=O), 9.55 (S-O).

3a,4,7,7a-Tetrahydro-5,6-dimethyl-2-n-octyl-1,2-benzisothiazolin-3(2H)one 1-Oxide.

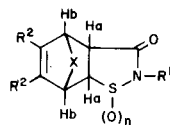
To a solution of 2.2 g. (0.01 mole) of 2-n-octyl-4-isothiazolin-3-one 1-oxide in 15 ml. of ethylene dichloride was added 1.1 g. (0.012 mole) of 2,3-dimethyl-1,3-butadiene. The solution was stirred and maintained at 60° overnight. The mixture was concentrated to give a dark, thick oil. This oil was further purified

Cyclopentadiene, 2,3-dimethyl-1,3-butadiene, 1,3-cyclohexadiene and compounds I underwent cycloaddition reactions at ambient or moderately elevated temperatures (less than 60°) in inert solvents such as ethylene dichloride and dioxane. Anthracene and hexachlorocyclopentadiene, two less reactive and sterically hindered dienes, required higher reaction temperatures (greater than 100°). Aluminum chloride was found to serve as an effective catalyst.

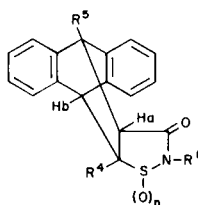
One anthracene adduct, 9a-chloro-3a,4,9a-tetrahydro-2-methyl-4,9-o-benzenonaphth[2,3-d]isothiazolin-3-one 1-oxide (IIIa), was dehydrochlorinated to give 4,9-dihydro-2-methyl-4,6-benzenonaphth[2,3-d]isothiazolin-3-one 1-oxide (IV).

The available spectroscopic data, summarized in Table I, do not allow positive confirmation of the stereochemical nature of the adducts II and III. However, we expect that on the basis of mechanistic considerations (2) the kinetically controlled *endo* products are formed.

Table I
Nuclear Magnetic Resonance Data



X	R ¹	R ²	n	X	R ¹	R ²	H _a	H _b	Solvent (b)
----	H	CH ₃	1	----	10.85	1.60 (s)	2.2-2.8 (m)	3.2-3.8 (m)	A
----	H	CH ₃	2	----	8.45	1.72 (s)	2.3-2.7 (m)	3.4-4.2 (m)	B
----	<i>n</i> -C ₈ H ₁₇	CH ₃	1	----	0.90 (m) 1.30 (m)	1.30 (s)	2.2-2.8 (m)	3.2-3.8 (m)	B
CH ₂	H	H	1	1.52 (m)	10.55	6.12 (m)	3.30 (m)	3.62 (m)	A
C ₂ H ₄	H	H	1	1.0-2.0 (m)	10.80	6.18 (m)	2.8-3.4 (m)	2.8-3.4 (m)	A
C ₂ H ₄	H	H	2	1.0-1.9 (m)	9.65	6.25 (m)	2.8-3.4 (m)	3.4-4.2 (m)	A
C ₂ H ₄	CH ₃	H	1	1.57 (m)	3.02 (s)	6.18 (m)	3.23 (m)	3.23 (m)	B
C ₂ H ₄	<i>n</i> -C ₄ H ₉	H	1	1.63 (m)	0.90 (m) 1.50 (m)	6.24 (m)	3.0-3.9 (m)	3.0-3.9 (m)	B
C ₂ H ₄	<i>n</i> -C ₄ H ₉	H	2	1.58 (m)	0.90 (m) 1.27 (m)	6.27 (m)	3.1-3.9 (m)	3.1-3.9 (m)	B
C ₂ H ₄	<i>n</i> -C ₈ H ₁₇	H	1	1.52 (m)	0.87 (m) 1.27 (m)	6.16 (m)	3.0-3.8 (m)	3.0-3.8 (m)	B
C ₂ H ₄	<i>n</i> -C ₈ H ₁₇	H	2	1.50	0.90 (m)	6.25 (m)	3.0-3.9 (m)	3.0-3.9 (m)	B



R ¹	R ⁴	R ⁵	n	R ¹	R ⁴	R ⁵	H _a	H _b	Solvent (b)
H	H	H	1	10.55	3.67 (d, d; 9.0, 2.0)	4.77 (d; 2.5)	3.39 (d, d; 9.0, 2.0)	5.23 (d; 2.0)	A
H	H	H	2	0	4.05 (m)	4.89 (d; 2.0)	4.05 (m)	5.07 (d; 2.0)	A
H	H	CH ₃	1	10.45	3.49 (d, d; 9.0, 2.0)	2.20 (s)	3.24 (d; 9.0)	5.20 (d; 1.5)	B
CH ₃	Cl	H	1	2.66 (s)	----	4.80 (m)	3.45 (d; 2.5)	4.8 (m)	B
CH ₃	Cl	H	1	2.47 (s)	----	4.80 (d; 2.0)	3.50 (d; 2.0)	5.23 (s)	B
CH ₃	----	----	1	3.13 (s)	----	5.90 (s)	----	5.63 (s)	B

(a) Coupling constants shown in brackets, Hz. (b) Solvents: A = DMSO-*d*₆; B = deuteriochloroform.

by column chromatography (90% benzene/10% acetone, silica gel) to yield 1.58 g. (51%) of pure product (yellow oil); ir: 5.9 (C=O), 9.3 (S-O).

4,5,6,7,8,8-Hexachloro-3a,7a-dihydro-4,7-methano-1,2-benzisothiazol-3(2H)one 1-Oxide.

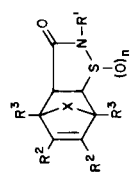
A solution of 4.4 g. (0.038 mole) of 4-isothiazolin-3-one 1-oxide in 40 ml. of nitrobenzene and 10.9 g. (0.04 mole) of hexa-

chlorocyclopentadiene was heated to 120° for 4 hours. The nitrobenzene was removed by distillation to give a tarry residue. Trituration with ether gave 5.2 g. (33%) of product, m.p. 280° (ether); ir: 5.9 (C=O), 9.3 (S-O).

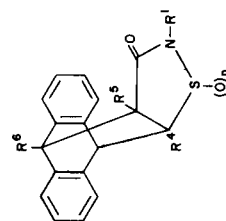
3a,4,7,7a-Tetrahydro-4,7-ethano-1,2-benzisothiazol-3(2H)one 1,1-Dioxide.

A solution of 5.3 g. (0.04 mole) of 4-isothiazolin-3-one 1,1-

Table II



X	R ¹	R ²	R ³	M	Yield %	M.p. °C	Empirical Formula	Elemental Analysis							
								Calcd.	Found						
								C	H	N	S	C	H	N	S
----	H	CH ₃	H	1	90	135-137	C ₉ H ₁₃ NO ₂ S	54.25	6.57	7.02	16.06	54.12	6.73	7.00	16.13
----	H	CH ₃	H	2	89	110-112	C ₉ H ₁₃ NO ₃ S	50.22	6.08	6.50	14.89	50.24	6.11	6.37	14.76
---	<i>n</i> -C ₈ H ₁₇	CH ₃	H	1	51	Oil	C ₁₇ H ₁₉ NO ₂ S	65.55	9.38	4.49	10.29	65.12	9.44	4.20	10.18
CH ₂	H	H	H	1	88	165-167	C ₈ H ₉ NO ₂ S	52.50	4.95	7.66	17.50	52.47	4.80	7.76	17.25
CC ₁₂	H	Cl	Cl	1	33	280	C ₈ H ₃ C ₁₆ NO ₂ S	24.64	0.77	3.59	8.22	24.93	0.98	3.53	8.32
C ₂ H ₄	H	H	H	1	61	183-185	C ₉ H ₁₁ NO ₂ S	54.80	5.62	7.12	16.25	54.31	5.78	6.95	16.16
C ₂ H ₄	H	H	H	2	79	200-202	C ₉ H ₁₁ NO ₃ S	50.67	5.19	6.56	15.04	50.84	5.40	6.52	14.96
C ₂ H ₄	CH ₃	H	H	1	93	119-120	C ₁₀ H ₁₃ NO ₂ S	56.85	6.20	6.62	15.17	56.86	6.28	6.62	15.19
C ₂ H ₄	<i>n</i> -C ₄ H ₉	H	H	1	41	45-47	C ₁₃ H ₁₉ NO ₂ S	61.63	7.55	5.52	12.65	60.94	7.34	5.49	12.54
C ₂ H ₄	<i>n</i> -C ₄ H ₉	H	H	2	91	123-125	C ₁₃ H ₁₉ NO ₃ S	57.97	7.10	5.19	11.90	57.68	7.01	5.11	11.99
C ₂ H ₄	<i>n</i> -C ₈ H ₁₇	H	H	1	97	Oil	C ₁₇ H ₂₇ NO ₂ S	65.98	8.79	4.52	10.36	66.21	8.68	4.59	10.28
C ₂ H ₄	<i>n</i> -C ₈ H ₁₇	H	H	2	49	96-98	C ₁₇ H ₂₇ NO ₃ S	62.74	8.36	4.30	9.85	62.50	8.21	4.08	9.67



R ¹	R ⁴	R ⁵	R ⁶	<i>n</i>											
H	H	H	H	1	94	259-261	C ₁₇ H ₁₃ NO ₂ S	69.40	4.40	4.75	10.85	68.91	4.59	4.76	10.81
H	H	H	H	2	41	268-270	C ₁₇ H ₁₃ NO ₃ S	65.58	4.20	4.49	10.29	65.79	4.34	4.39	10.48
H	H	H	CH ₃	1	63	258-260	C ₁₈ H ₁₅ NO ₂ S	69.88	4.89	4.53	10.36	69.99	5.00	4.34	10.31
CH ₃	Cl	H	H	1	21	237-239	C ₁₈ H ₁₄ ClNO ₂ S	62.88	4.08	4.08	9.32	63.22	4.23	3.96	9.53
CH ₃	----	----	H	1	34	207-209	C ₁₈ H ₁₃ NO ₂ S	70.36	4.23	4.56	10.42	70.94	4.54	4.20	10.66

dioxide in 40 ml. of ethylene dichloride and 3.2 g. (0.04 mole) of 1,3-cyclohexadiene was heated at reflux for 4 hours. The solution was cooled, the solid filtered and dried to yield 6.7 g. (79%) of product, m.p. 200-202° (ethyl acetate); ir: 5.9 (C=O), 7.55, 8.75 (S-O₂).

2-*n*-Butyl-3a,4,7,7a-tetrahydro-4,7-ethano-1,2-benzisothiazolin-3-one 1,1-Dioxide.

A solution of 4.8 g. (0.025 mole) of 2-*n*-butyl-4-isothiazolin-3-one 1,1-dioxide in 100 ml. of ethylene dichloride and 2.0 g. (0.025 mole) of 1,3-cyclohexadiene was heated at 55° for 12 hours. The solution was concentrated, the solid filtered, washed with cold ethylene dichloride and dried to afford 6.1 g. (91%) of product, m.p. 123-125° (ethyl acetate); ir: 5.85 (C=O), 9.1 (S-O₂).

3a,4,9,9a-Tetrahydro-4,9-*o*-benzenonaphth[2,3-*d*]isothiazolin-3-(2*H*)one 1,1-Dioxide.

A solution of 5.3 g. (0.04 mole) of 4-isothiazolin-3-one 1,1-dioxide in 40 ml. of ethylene dichloride and 7.1 g. (0.04 mole) of anthracene was heated at reflux for 5 hours and stirred at room temperature for an additional 12 hours. The solution was filtered to remove a small amount (≈ 0.5 g.) of unreacted anthracene. The filtrate was concentrated, the solid filtered, washed with cold ethylene dichloride and dried to give 5.1 g. (41%) of product, m.p. 268-270° (ethyl acetate); ir: 5.85 (C=O), 7.5, 8.85 (S-O₂).

9a-Chloro-3a,4,9,9a-tetrahydro-2-methyl-4,9-benzenonaphth[3,2-*d*]isothiazolin-3-one 1-Oxide.

A solution of 4.96 g. (0.03 mole) of 5-chloro-2-methyl-4-isothiazolin-3-one 1-oxide in 75 ml. of nitrobenzene, catalytic quanti-

ties of aluminum chloride, and 5.88 g. (0.033 mole) of anthracene was heated at 130-140° for 4 hours. The mixture was allowed to cool and was filtered to remove small amounts of unreacted anthracene. The filtrate was concentrated and the residue was dissolved in a minimum of ethyl acetate and treated with carbon (Darco G-60). On cooling, additional anthracene separated which was removed by filtration. Concentration of the filtrate gave 2.8 g. of crude product. Recrystallization from ethyl acetate provided 2.2 g. (21%) of pure product, m.p. 237.5-239°; ir: 5.9 (C=O), 8.85 (S-O₂).

4,9-Dihydro-2-methyl-4,9-*o*-benzenonaphth[2,3-*d*]isothiazolin-3-one 1-Oxide.

A solution of 0.86 g. (0.0025 mole) of 9a-chloro-3a,4,9,9a-tetrahydro-2-methyl-4,9-benzenonaphth[2,3-*d*]isothiazolin-3-one 1-oxide in 50 ml. of ethyl acetate was treated with 0.62 g. (0.005 mole) of 1,5-diazobicyclo[4.3.0]non-5-ene (DBN). A slight temperature rise occurred and after a few minutes a white solid precipitated which was removed by filtration. The filtrate was diluted with ether, washed with dilute hydrochloric acid and water successively. The ether was dried (magnesium sulfate) and concentrated. The residue was recrystallized from ethanol to give 0.26 g. (34%) of product, m.p. 207-209°; ir: 5.95 (C=O), 9.25 (S-O₂).

REFERENCES AND NOTES

- (1) E. D. Weiler, G. A. Miller and M. Hausman, *J. Heterocyclic Chem.*, **13**, 1321 (1976).
- (2) T. Sauer, *Angew. Chem., Int. Ed. Engl.*, **6**, 16 (1967).