66. The reaction of Nopadiene with 4-Substituted 1,2,4-Triazoline-3,5-diones

by **Pnina Ashkenazi**[a]), **Reinhard Benn**[b]), and **David Ginsburg**[a])*

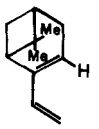
[a]) Department of Chemistry, Israel Institute of Technology, Haifa
[b]) Max-Planck-Institut für Kohlenforschung, D-4330 Mülheim/Ruhr

(30.IX.83)

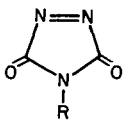
Summary

The title dienophiles attack nopadiene from the less hindered side.

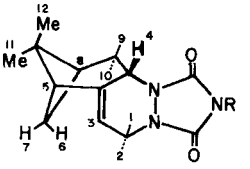
It was of interest to determine the regiospecificity of *Diels-Alder* reactions of 10-methylidene-α-pinene ('nopadiene', **1**) with 4-methyl- (**2a**) (MTAD) and 4-phenyl-1,2,4-triazoline-3,5-dione (PTAD) (**2b**). We expected in view of work conducted on



1



2a R = CH_3
b R = Ph



3b R = Ph

Diels-Alder reactions of dienes involved in a σ-framework that high regiospecifity might be attained in reactions of **1** and **2** and, if so, that the reason might again be secondary orbital interaction between the two components as discussed heretofore [1].

Indeed reaction of **1** with either MTAD or PTAD gives only *Diels-Alder* adduct **3** with apparently complete regiospecificity with respect to attack from a single face of the molecule, but this is accompanied by a by-product which has an additional double bond (two mass units less than **3**).

We could not determine the structures of **3** by X-ray crystallography because the crystals were unsuitable. Nevertheless, it is possible to deduce the structure and configuration of **3b** (R=Ph) unambiguously by means of ^{1}H-NMR spectroscopy. Assignments of each of the twelve resolved multiplets (not counting the *N*-phenyl protons) were made on basis of the chemical shifts and the spin-spin coupling constants. These assignments were confirmed by a two-dimensional COSY spectrum [2]. The *Table* shows the parameters concerned, obtained for the 400-MHz ^{1}H-NMR spectrum of a solution of **3b** in chloroform.

The NOE spectra were recorded in the differential mode [3]. *This technique is extremely sensitive, permitting detection of very small (< 0.5%) intensity changes (cf.*

Table. *^{1}H-NMR Chemical Shifts, Coupling Constants (J(H,H)) and NOE Effects in* **3b**. Assignment of 3–12 unambiguous, 1 and 2 tentatively.

Proton	δ [ppm] (± 0.01)	J [Hz] (± 1)	J [Hz] (± 1)	NOE
1	4.04	$J(1,2) = 16.6$		1→2, 3 (4)
2	4.41	$J(1,3) = 3.0$	$J(2,3) = 3.0$	2→2, 3
3	5.49	$J(1,4) = 3.0$	$J(2,4) = 3.0$	3→1, 2, 5
4	4.75		$J(3,4) = 3.0$	4→12, 9, (1)
5	2.73	$J(4,9) = 9.7$		
6	1.10	$J(4,10) = 7.1$		6→5, 7
7	2.71	$J(5,7) = 5.9$		
8	2.21	$J(5,8) = 5.9$		8→9, 10, 11, 12
9	2.81	$J(6,7) = 9.5$		
10	2.62	$J(7,8) = 5.8$		10→8, 9
11	1.33	$J(7,9) = 2.2$		11→8, 5, 12
12	1.03	$J(8,9) = 4.2$		12→4!, 11, 8, 5
-Ph	7.51	$J(8,10) = 1.9$		
-Ph	7.46	$J(8,10) = 1.9$		
-Ph	7.36	$J(9,10) = 14.3$		

Figure). Irradiation of the multiplet 3 (trace B in the *Figure*) shows its vicinal protons 1 and 2 as well as the proton 5 enhanced. Spectrum C confirms the close vicinity of 4 with 12 and in addition the protons 9 are enhanced. In trace D besides the vicinal neighbors of 8 also both methyl groups 11 and 12 show NOE enhancement. In context with the spatial distances, the effects on 11 are larger than 12. The NOE effects on the methyl groups clearly illustrate the sensitivity achieved in these experiments since methyl groups besides external dipole-dipole interaction have the possibility of spin

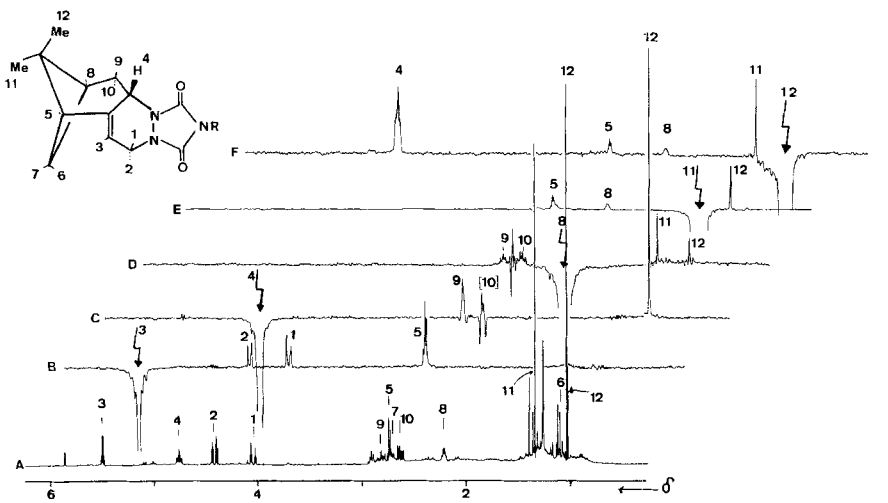


Figure. *400-MHz ^{1}H-NMR spectra of* **3b** *dissolved in $CDCl_3$ (ca. 1% v/v) at 300K.* A: normal spectrum, B–F: NOE difference spectra. The irradiated multiplets are marked with arrows and those protons which show dipole-dipole interaction through space appear as positive signals. Absorption and emission lines within one multiplet ([10] in trace C) result from spin tickling effects. For the assignment in full *cf. Text* and *Table*.

rotation and internal dipole-dipole relaxation. The spectra E and F are control experiments which confirm our stereochemical assignment for **3b**.

The unambiguous deduction may therefore be made that **3** is formed by attack with PTAD of the *less* hindered side of **1**, in *contradistinction* to attack of other bicyclic systems, *i.e.* [2.2.1], [2.2.2] systems fused to a dienic system, in which attack occurs from the *more* hindered side. The latter mode of attack has been explained by involving secondary orbital interactions of the σ-framework and the π-reaction site [4]. Clearly the modulation found for the [3.1.1] bicyclic system requires further explication within the argument which involves secondary orbital interaction control of the regiospecificity of attack by the dienophile.

We thank Prof. Dr. *G. Wilke* for a sample of nopadiene and for his encouragement and interest.

Experimental Part

General. All melting points are uncorrected. IR spectra were measured on a *Perkin Elmer* model *257* grating spectrophotometer. NMR spectra were measured on a *Varian T-60* spectrometer. The ^{1}H-NMR spectra of **3b** were measured on a *Bruker WH 400* spectrometer, equipped with a fast pulse programmer. The NOE experiments were carried out under temperature control. (For details of the experimental procedure *cf.* [3]). A dilute sample of **3b** was dissolved in purified $CDCl_3$ (concentration *ca.* 1% *v/v*), prepared under Ar and sealed in 5 mm tubes. Mass spectra were measured on a *Varian 711* spectrometer using the heated inlet system at 200°. The electron energy was maintained at 100 eV. Only the major fragments are listed.

Diels-Alder adducts. a) Treatment of nopadiene (158 mg) in CH_2Cl_2 (10 ml) with MTAD (146 mg) in CH_2Cl_2 (5 ml) gave immediate reaction. Removal of solvent gave the adduct (280 mg), m.p. 118–120° (pentane). IR ($CHCl_3$): 1760, 1700, 1470. ^{1}H-NMR ($CDCl_3$): 5.4 (*q*, 1 vinylic H); 4.7 (*m*, 1CHN); 4.2, 4.0 (*AB*, $2CH_2N$); 3.15 (*s*, $3NCH_3$); 2.9–2.5 (*m*, 4CH, CH_2); 2.35–2.0 (*m*, 2 cyclobutyl-H); 1.45 (*s*, $3CH_3$); 1.1 (*s*, $3CH_3$). MS: 261(32), 192(100), 163(84), 146(15). M.W.: Calc. 261.1476, Found 261.1455.

A by-product (6 mg) deposited in hexane, m.p. 100°. MS: 259(37), 216(21), 191(11), 159(16), 142(76), 115(100). M.W.: Calc. 259.1321, Found, 259.1340.

b) Nopadiene (70 mg) in CH_2Cl_2 (10 ml) treated with PTAD (86 mg) in CH_2Cl_2 (5 ml) gave immediate reaction. Purification on prep. SiO_2 plate using hexane/$CHCl_3$ (6:4) as eluent gave the adduct, m.p. 126–128°. IR ($CHCl_3$): 1770, 1710, 1410. ^{1}H-NMR ($CDCl_3$): 7.45 (*m*, 5 arom. H); 5.5 (*q*, 1 vinylic H); 4.8 (*m*, 1 CHN); 4.3, 4.15 (*AB*, 2 CH_2N); 2.85–2.6 (*m*, 4CH, CH_2); 2.5–2.1 (*m*, 2 cyclobutyl-H); 1.4 (*s*, $3CH_3$); 1.1 (*s*, $3CH_3$). MS: 323(16), 321(4), 255(9), 178(9), 149(16), 135(42), 84(100). M.W.: Calc. 323.1634, Found 323.1614 (accompanied by unisolated 321.1476).

c) Nopadiene (165 mg), *N*-methylmaleimide (156 mg) and benzene (50 ml) were heated under reflux for 5 h. Removal of solvent followed by TLC on prep. SiO_2 plate using hexane/$CHCl_3$ (6:4) gave the pure product, oil (172 mg). IR ($CHCl_3$): 1690, 1390. ^{1}H-NMR ($CDCl_3$): 5.4 (*m*, 1 vinylic H); 2.95 (*s*, $3NCH_3$); 3.1–2.0 (*m*, 11 CH, CH_2); 1.3 (*s*, $3CH_3$); 0.8 (*s*, $3CH_3$). MS: 259(7), 244(2), 216(31), 147(12), 131(13), 112(100). M.W.: Calc. 259.1572, Found 259.1583. Anal. calc. for $C_{16}H_{21}NO_2$: N 5.40; found: 4.90.

d) Nopadiene (173 mg), *N*-phenylmaleimide (160 mg) and benzene (50 ml) were heated under reflux for 5 h. After workup as in *c* the oily product (279 mg) was obtained. IR ($CHCl_3$): 1700, 1390. ^{1}H-NMR ($CDCl_3$): 7.6–7.1 (*m*, 5 arom. H); 5.5 (*m*, 1 vinylic H); 3.3 (*m*, 2 CHCO); 3.3–2.0 (*m*, 9CH, CH_2); 1.35 (*s*, $3CH_3$); 0.85 (*s*, $3CH_3$). MS.: 321(12), 278(15), 174(100), 147(22), 131(40). M.W.: Calc. 321.1728, Found 321.1712. Anal. calc. for $C_{21}H_{23}NO_2$: N 4.36; found: 4.26.

REFERENCES

[1] *D. Ginsburg,* Tetrahedron *39,* 2095 (1983).
[2] *A. Bax & R. Freeman,* J. Magn. Reson. *44,* 542 (1981).
[3] *R. Benn, A. Rufińska & G. Schroth,* J. Organomet. Chem. *217,* 91 (1981).
[4] *Cf. M.C. Böhm, R.V.C. Carr, R. Gleiter & L.A. Paquette,* J. Am. Chem. Soc. *102,* 7218 (1980) and additional references given in [1].