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REACTION OF TOSYLAZOCYCLOHEXENE WITH DIENOPHILES

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Abstract—The stereochemistry of the 1:1 adducts of tosylazocyclohex-1-ene with various dienophiles (Δ^1-pyrazolines) is discussed on the basis of chemical and physico-chemical evidence. The structure of the Δ^2-pyrazolines and the spirocyclopropanes arising from the adducts, is also discussed.

THE Δ^1-pyrazoline structure (I) of the 1:1 adducts of tosylazocyclohex-1-ene with dienophiles has been recently reported by us in preliminary form[1]: in the present paper the stereochemistry of these compounds is discussed and the experimental data reported.

Maleic anhydride. A benzene solution of tosylazocyclohex-1-ene and maleic anhydride gave within a few hours a white precipitate **1**, shown to have structure II by chemical and physico-chemical evidence,[1] as well as by X-ray diffraction studies.[2] Diazocompounds are known to yield Δ^1-pyrazolines, *via* cycloaddition:[3] compd **1** can formally be considered an example of the general reaction between a dienophile (maleic anhydride) and a hypothetical 2-tosyldiazocyclohexane. Although the hypothesis of the rearrangement of tosylazocyclohex-1-ene to 2-tosyldiazocyclohexane remains at present purely speculative, it can be utilized to predict the outcome of the reaction from tosylazocyclohex-1-ene and various dienophiles. In this paper the structure of these adducts is discussed and their stereochemistry emphasized, the mechanism of the reaction will be the subject of a future communication. Since most of the evidence rests on the NMR spectra, some further comments on the spectrum of **1** (Table 1), already reported,[1] seem to be appropriate. The pair of doublets centered at 4·28 δ has been assigned to C<u>H</u>—Ts†; the high value of one of the vicinal coupling constants indicates that the proton is *axial*[4a] (tosyl group equatorial)‡. The protons H_3 and H_4 give rise to doublets (J = 9·0 Hz) at 6·29 and 4·49 δ: the low field signal has been assigned to H_3 since it is a diazo-allylic proton and therefore is more deshielded than H_4. Owing to the symmetry of the five-member ring, both protons are subjected, to the same extent, to the influence of the CO groups; moreover in the case of H_4, a large effect due to the tosyl group is to be expected, owing to the particular

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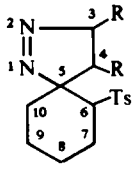
† Throughout this paper Ts indicates the tosyl group.

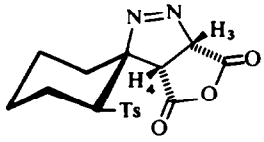
‡ In the NMR spectra of all the adducts examined (Table 1), a similar pattern is present in the range 3·34–4·28 δ and it has been accordingly assigned to an axial C<u>H</u>—Ts.

configuration of the molecule that brings H_4 very close to Ts. As it will be later shown, the tosyl group exerts, in these conditions a deshielding effect of about 1 ppm.

N-phenylmaleimide. When a benzene solution of N-phenylmaleimide was treated with one equivalent of tosylazocyclohex-1-ene, a heavy precipitate formed within a short time: by column chromatography two adducts were isolated, compds **2** and **3**. The NMR spectra of both show a signal at about 4 δ, assigned, as previously, to an *axial* CH—Ts. The general pattern of the spectrum of compd **2** and in particular the chemical shifts of H_3 and H_4 are practically identical to those of compd **1** and therefore the structures should also be very similar. Since the configuration of **1** (II) has been established by X-ray diffraction, the same configuration has been confidently assigned, by analogy. to compd **2** (formula III). The structure of **3**, however, was unpredictable since different formulae (e.g. IV or VII) are equally possible,* the only point so far ascertained being the equatorial position of the tosyl group. In order to reduce the number of asymmetric centres and consequently the number of isomers, **2** and **3** were



I



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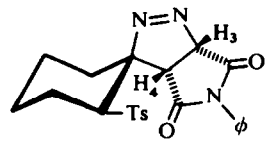
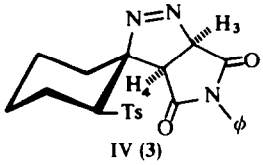


III (2)



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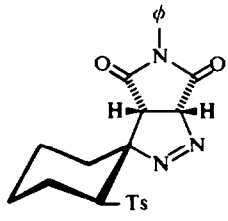
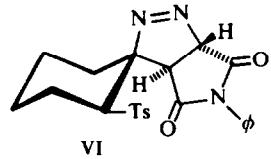


V



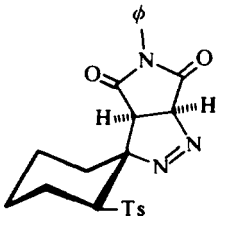
VI

photolyzed in MeOH: it is known[3] that under these conditions Δ^1-pyrazolines yield cyclopropanes in a stereospecific way. In our case, as a result of the photolysis the number of possible structures was considerably reduced because the cyclopropane dicarboxyimides can only exist in the *cis, meso,* form.

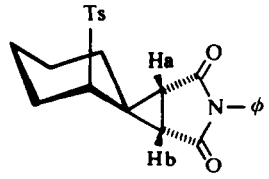
The photolysis of **2** (III) afforded only one cyclopropane **11**, to which formula VIII has been assigned on chemical grounds and on the basis of the NMR spectrum (Table 2). In particular it can be observed that the signal due to CH—Ts (an incompletely resolved multiplet) has a half-band width of about 7 Hz indicating that the proton is equatorial:[4a] the preferred conformation of the tosyl group is therefore *axial,* as shown in formula VIII.† The photolysis of **3** yielded a *single* and *different* cyclopropane,

* For sake of simplicity only one (VI) of the possible structures embodying a *trans* junction of the penta-atomic rings has been drawn.

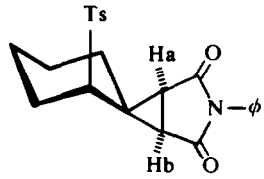
† It has been reported that in the case of methylenecyclohexane the conformation of the allylic substituents are largely axial, owing to the allylic strain.[5] A similar explanation can be advanced in this case, to justify the preferred axial conformation of the tosyl group, on the basis of the analogy of steric requirements for cyclopropane ring and ethylenic bond.



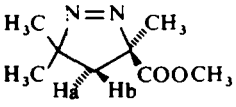
VII



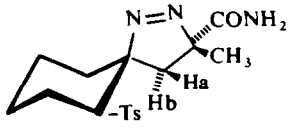
VIII (11)



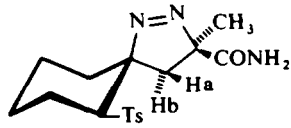
IX (12)



X



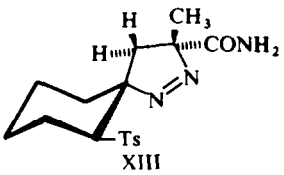
XI (4)



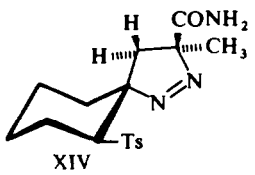
XII (5)

to which, by exclusion, structure IX can be assigned.* The fact that 3 gave IX and not VIII or a mixture VIII and IX, shows that 3 cannot be represented either by V (which would yield VIII) or by VI and related structures with a *trans* dicarboxyimide function (which would give a mixture of VIII and IX).† Finally, of the two remaining possibilities, IV and VII, one (VII) could be discarded because it was found that 2 and 3 had the same configuration at C_5, inasmuch as both gave the same Δ^2-pyrazoline XXXIII by alkaline treatment. By exclusion formula IV was hence assigned to 3. It can now be observed, and it is highly relevant for the discussion that follows, that the chemical shift of H_4 is strongly influenced by the tosyl group, which, when close to H_4 (*e.g.* III), has a deshielding effect of about 1 ppm.

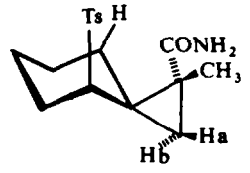
Methacrylonitrile. The structure of the adducts between tosylazocyclohex-1-ene and methacrylonitrile, was next investigated. To simplify the isolation procedure the reaction mixture was treated with H_2SO_4 at room temp and the crystalline amides 4 and 5 isolated by chromatography. The NMR spectra of these compounds (Table 1) show that in this case also, the tosyl group is equatorial: this still leaves open the choice among formulae XI to XIV. Photolysis of 4 and 5 yields the spirocyclopropanes

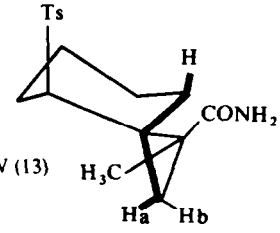


XIII

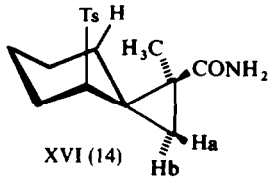


XIV

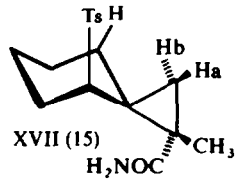




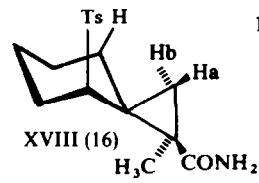
XV (13)



XVI (14)



XVII (15)



XVIII (16)

* The tosyl group has also, in this case, an axial conformation, as shown by the value of the half-band width of the CH—Ts signal.

† Furthermore the identity of $J^{H_3H_4}_{vic}$ in the spectra of compds 2 and 3 strongly suggests that in both cases the two protons have the same *cis* configuration. Therefore any structure with a *trans* dicarboxyimide function (e.g. VI) seems unlikely both on spectroscopic and mechanistic grounds.

TABLE 1. PHYSICAL DATA OF Δ^1-PYRAZOLINES

No	Formula	m.p.	Yield %	PMR data (chemical shifts (ppm) and coupling constants (Hz))				
				Solvent	δH_3	δC_3—C<u>H</u>$_3$	δH_4	δC<u>H</u>—Ts
1	II	163°	80	DMSO-d_6	6·29 d (J_{vic} = 9·0)	—	4·49 d (J_{vic} = 9·0)	4·28 dd (J_{vic} = 11·5, 4·0)
2	III	195°	40	DMSO-d_6	6·19 d (J_{vic} = 8·5)	—	4·25 d (J_{vic} = 8·5)	4·20 dd (J_{vic} = 11·0, 3·5)
3	IV	163°	40	DMSO-d_6	6·19 d (J_{vic} = 8·5)	—	3·28 d (J_{vic} = 8·5)	4·12 dd (J_{vic} = 8·5, 5·5)
4	XI	195°	20	C_5D_5N	—	2·10 s	2·82 d 2·59 d (J_{gem} = 13·0)	3·88 dd (J_{vic} = 10·5, 3·5)
5	XII	215°	20	C_5D_5N		1·77 s	3·32 d 1·47 d (J_{gem} = 13·5)	3·79 dd (J_{vic} = 9·0, 3·5)
6	XIX	166°	20	$CDCl_3$	—	1·86 s	2·62 d 1·99 d (J_{gem} = 13·0)	3·38 dd (J_{vic} = 11·0, 4·0)
7	XX	171°	35	$CDCl_3$	—	1·63 s	2·80 d 1·34 d (J_{gem} = 13·5)	3·34 dd (J_{vic} = 7·0, 4·0)
8	XXI	121°	75	$CDCl_3$	—	—	3·08 d 2·13 d (J_{gem} = 14·0)	3·41 dd (J_{vic} = 8·0, 5·5)
9	XXVII	158°	84	DMSO-d_6	—	1·97 s	4·41 s	4·24 dd (J_{vic} = 11·0, 3·5)
10	XXVIII	135°		DMSO-d_6	—	1·81 s	3·33 s	4·02 dd (J_{vic} = 9·0, 6·0)

TABLE 2. PHYSICAL DATA OF SPIROCYCLOPROPANES

No	Formula	m.p.	NMR data (chemical shifts (ppm) and coupling constants (Hz))				
			Solvent	δH_c	δH_t	δC<u>H</u>—Ts[b]	δC<u>H</u>$_3$
11[a]	VIII	248°	DMSO-d_6	2·74 d (J_{vic} = 5·0)	2·55 d (J_{vic} = 5·0)	2·98 m (7)	
12[a]	IX	240°	DMSO-d_6	2·86 s		2·94 m (9)	—
13	XV	221°	$CDCl_3$	0·25 dd (J_{gem} = 5·0, J_{tr} = 2·0)	1·12 d (J_{gem} = 5·0)	2·83 m (8)	1·59 s
14	XVI	224°	$CDCl_3$	1·44 dd (J_{gem} = 4·5, J_{tr} = 1·5)	0·48 d (J_{gem} = 4·5)	3·86 m (8)	1·53 s
15	XVII	210°	$CDCl_3$	0·37 d (J_{gem} = 6·0)	1·18 d (J_{gem} = 6·0	2·85 m (9)	1·26 s
16	XVIII	213°	$CDCl_3$	1·23 d (J_{gem} = 6·0)	0·45 d (J_{gem} = 6·0)	3·28 m (8)	1·37 (s)

[a] For solubility reasons the spectrum was recorded at 70°.

[b] For these broad signals the half band width are given in parentheses (Hz).

TABLE 3. PHYSICAL DATA OF Δ^2-PYRAZOLINES

No	Formula	m.p.	UV data[b] λ_{max} (nm) (Ethanol)	NMR data (chemical shifts (ppm) and coupling constants (H_z)) Solvent	δH_3	δH_4	δCH Ts
17	XXIX	145°	290 (ε = 10,000)	DMSO-d_6	—	4·97 s	3·43 dd (J_{vic} = 6·5, 6·5)
18	XXX (R = COOH)	206°	289 (ε = 9,800)	DMSO-d_6	—	3·76 d 2·60 d (J_{gem} = 18·0)	3·57 dd (J_{vic} = 6·5, 6·5)
19	XXX (R=H)	128°	—	C_5D_5N	6·79 d (J_{vic} = 1·5)	3·46 dd 2·54 dd (J_{gem} = 17·5) (J_{vic} = 1·5)	3·6[a]
20	XXXIII	212°	291 (ε = 9,500)	DMSO-d_6	—	5·06 s	3·64 dd (J_{vic} = 6·0, 6·0)
21	XXXIV	196°	-	DMSO-d_6	6·82 d (J_{vic} = 1·5)	5·07 d (J_{vic} = 1·5)	3·6[a]
22	XXXV	236°	308 (ε = 13,300)	DMSO-d_6		5·24 s	3·7[a]
23	XXXII	146°	310 (ε = 14,700)	DMSO-d_6	—	3·72 s	—

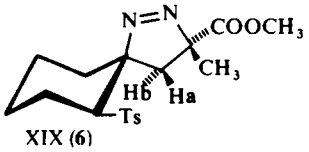
[a] Broad signal partly masked.

[b] Only the absorption due to the 3-substituted-Δ^2-pyrazoline chromphore is reported.

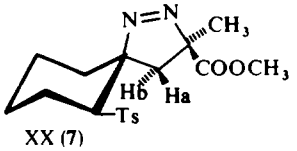
13 and **14**. In the first case (**13**), the *less* deshielded proton (H_a), which is the one *trans* to the carboxamide group, gives a doublet further split by long-range coupling with H_{8ax}. In fact, inspection of molecular models shows that H_{8ax} is the only proton in the molecule that is connected to H_4 through four bonds forming the *quasi*-planar W path (see formula XV) required for appreciable coupling.[6] In the second case (**14**) the *more* deshielded proton (H_a), which is *cis* to the carboxamide group, again presents long-range coupling with H_{8ax}. Formula XVI has therefore been assigned to **14**.* Accordingly formulae XI and XII can be assigned to the Δ^1-pyrazolines **4** and **5**. As a check, the isomeric cyclopropanes XVII and XVIII were prepared by pyrolysis† of either **4** or **5**. The NMR spectra of these compounds (Table 2) are in agreement with the proposed formulae: as expected, the geminal cyclopropane protons do not show long range coupling, since the molecule configuration forbids this.‡

A further confirmation of the structure of **4** and **5** can be obtained from the analysis of their NMR spectra. In fact, the signals due to the geminal protons show strikingly different chemical shifts and this can be related to the large deshielding effects of the carboxamide and tosyl groups. In the case of **5** (XII), H_a is subject to the deshielding effects of *both* tosyl and amide groups, whereas H_b is not directly influenced by any of these: accordingly the chemical shift difference of H_a and H_b (1·85 ppm) is the sum of the deshielding effect of the tosyl group (previously shown to be about 1 ppm) and that of the carboxamide group, which therefore must amount to about 0·8 ppm.§ In the case of **4** (XI), H_a is subject to the deshielding effect of the tosyl group and H_b to that of the amide group: the chemical shift difference (0·23 ppm) is equal to the difference of the deshielding effects.

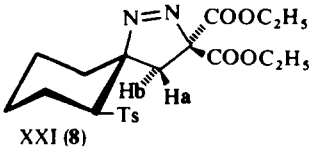
Methyl methacrylate. Methyl methacrylate was found to react in the same way as methacrylonitrile: two adducts were isolated (**6** and **7**) to which the formulae XIX and



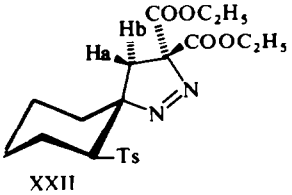
XIX (6)



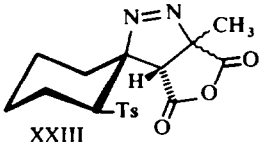
XX (7)



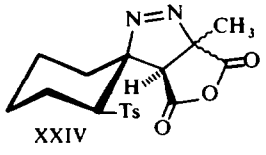
XXI (8)



XXII



XXIII



XXIV

* The half-band width of the C<u>H</u>—Ts signal shows that the proton is equatorial and therefore the preferred conformation of the tosyl group is axial, as in compds **11**, **12**, **15** and **16**.

† The pyrolysis is known to be non-stereospecific.[3]

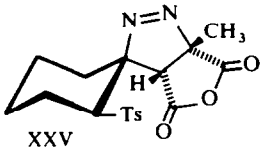
‡ The assignement of configuration XVII and XVIII, to **15** and **16** respectively, is based on the following assumption: a carboxamide group close to C<u>H</u>—Ts exerts on this proton a large deshielding effect (compare the spectra of **13** and **14**), therefore compd **16**, which has the C<u>H</u>—Ts signal at lower field, must have formula XVIII.

§ This value seems to be acceptable since it has been reported[7] that in compd X the desheidling effect of the ester group on H_b is 0·80 ppm.

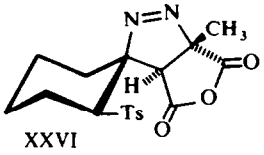
XX were assigned, on the basis of their conversion into **4** and **5** by amonolysis and in accordance with their NMR spectra (Table 1).

Ethyl methylenemalonate. Ethyl methylenemalonate and tosylazocyclohex-1-ene afforded a single adduct **8** to which structure XXI was assigned on the basis of the following considerations: the chemical shift difference of H_a and H_b due only to the large deshielding effect of the tosyl group on H_a, is 0·95 ppm. This value is close to that previously established (about 1 ppm) for **4**, **5**, **6** and **7** and therefore it must be expected that the spatial relationship between the tosyl group and H_a is of the same type. Hence structure XXI rather than XXII, has been proposed for **8**.

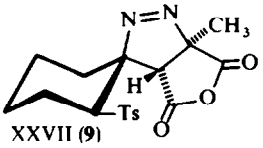
Citraconic anhydride. The reaction between tosylazocyclohex-1-ene and citraconic anhydride gave to compounds **9** and **10**, easily interconvertible by crystallization from the appropriate solvent ($CHCl_3$ or DMSO). In the presence of D_2O, the conversion was accompanied by the disappearance, in the NMR spectrum, of the H_4 singlet and therefore **9** and **10** must be C_4 epimers. Since, as previously shown, the tosyl group has a deshielding effect of about 1 ppm (*c.f.* **2** and **3**), partial structure XXIII has been assigned to **9**, since its NMR spectrum shows the H_4 signal at lower field (4·41 δ). Little can be said about the stereochemistry at C_3: the easy epimerization at C_4 requires the free energy difference between **9** and **10** to be very small. This in turn requires that the increase in energy in passing from a *cis* to a *trans* junction is roughly equivalent to the decrease in energy achieved through relief of the repulsive strain between the anhydride ring and the tosyl group. In the case of structures XXV and XXVI this seems improbable, whereas the assumption is acceptable in the case of XXVII and XXVIII.



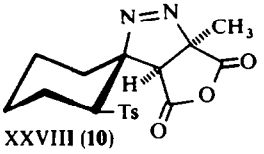
XXV



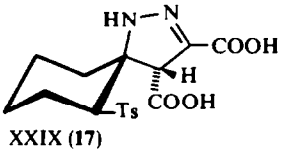
XXVI



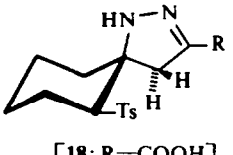
XXVII (**9**)



XXVIII (**10**)



XXIX (**17**)



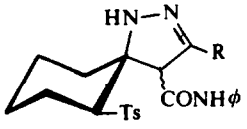
XXX [**18**; R=COOH; **19**; R=H]

Δ^2-*Pyrazolines*

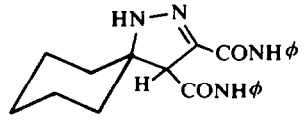
It is known[8] that Δ^1-pyrazolines easily yield Δ^2-pyrazolines by mild acid or alkaline treatment. Since in the course of this process one asymmetric centre is eliminated, a selected number of the above reported Δ^1-pyrazolines was subjected to alkaline treatment at room temp as part of the process for their structure elucidation. The physico-chemical data of the resulting Δ^2-pyrazolines are reported in Table 3.*

Treatment of **1** with NaOH afforded **17** which by heating in nitroethane was

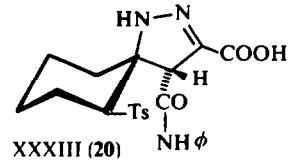
* The pair of doublets at about 3·5 δ, assigned to CH—Ts, show that in all the compounds examined this protons is axial, as in Δ^1-pyrazolines.



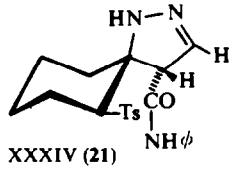
XXXI



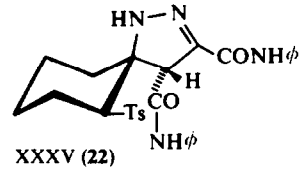
XXXII (23)



XXXIII (20)



XXXIV (21)



XXXV (22)

partially decarboxylated to **18**, to which structure XXX (R = COOH) was assigned since no olefinic proton is present in the NMR spectrum.*

Alkaline treatment of both N-phenylmaleimide adducts (**2** and **3**) yielded the same Δ^2-pyrazoline **20** and by heating in nitrobenzene lost CO_2 to give **21**, whose NMR spectrum showed the presence of an olefinic proton (H_3) coupled with a vicinal proton (H_4). Therefore the partial formulae XXXI (R = COOH) and XXXI (R = H) have been assigned to **20** and **21**, respectively. The stereochemistry at C_4 was determined as follows: **20** was treated with aniline and dicyclohexylcarbodiimide to give the bis-anilide **22**, then reduced with Na in liq NH_3 to give **23** (XXXII).

On examination of the NMR spectra of **20**, **21**, **22** and **23**, it was observed that the chemical shift of H_4 is, in the case of **23**, about 1·4 ppm upfield: this means that in the other cases (**20**, **21** and **22**) H_4 must be deshielded by the tosyl group and therefore the stereochemistry of **20** and **21** is represented by formulae XXXIII and XXXIV. It follows that structure XXIX can be assigned to **17**, since in this case also, H_4 is deshielded by the tosyl group.

EXPERIMENTAL

M.ps are uncorrected. The NMR spectra were recorded with a Varian A 60 A spectrometer, in the solvents indicated, with TMS as internal reference. The coupling constants were obtained directly from the spectra and were approximated to the nearest half Hz*. Elemental analysis of all the adducts gave results (C, H, N) which were within ±0·4% of the theoretical values and are not reported here.

1,2-*Diazaspiro*[4,5]*dec*-1-*enes. General procedure for the preparation of the adducts* (**1**, **2**, **3**, **6**, **7** and **8**). Tosylazocyclohex-1-ene (0·0038 mol) was added slowly at room temp. to a soln of the dienophile (0·004 mol) in dry C_6H_6 (10 ml). The soln was left standing overnight at room temp, filtered and the precipitate was either crystallized from CH_2Cl_2-pet. ether or chromatographed on silica gel.

3-*Methyl*-3-*carboxyamido*-6-*tosyl*-1,2-*diazaspiro*[4,5]*dec*-1-*enes* (**4** and **5**). Tosylazocyclohex-1-ene (5 g) and methacrylonitrile (1·35 g) in C_6H_6 (10 ml) gave a crude adduct (3·6 g) treated with conc H_2SO_4 (7·5 ml) at room temp for two hr. The soln was poured on ice, the white precipitate collected by filtration (3·4 g) and chromatographed on silica gel to give **4** (1·3 g) and **5** (1·2 g). The same products were obtained by treating respectively **6** and **7** (0·15 g) with NH_3 aq (20 ml) for 3 days at room temp and filtering the precipitate.

* Further heating in nitrobenzene afforded the completely decarboxylated pyrazoline **19** (XXX; R=H).

† Some comments on the *J* values seem appropriate. The J_{gem} values of C_4 protons in Δ^1-pyrazolines (**4** to **8**) and Δ^2-pyrazolines (**18** and **19**) and that of the cyclopropane protons (**13** to **16**) fit well with the published data.[9] The J_{vic} values of C<u>H</u>—Ts are also in agreement;[4a] it can however be observed that in the case of Δ^2-pyrazolines the $J_{ax,ax}$ and $J_{ax,eq}$ values are outside the quoted ranges indicating the presence of a strained conformation. The $J_{vic}^{H_aH_b}$ of the cyclopropane system VIII has a value (5·0 Hz) somewhat different from that reported in the literature[4b] for non-spiranic cyclopropanes (7·0–12·6 Hz).

3-Methyl-6-tosyl-1,2-diazaspiro[4,5]dec-1-en-3,4-dicarboxylic anhydrides (**9** and **10**). Tosylazocyclohex-1-ene (2 g) and citraconic anhydride (1·7 g) in C_6H_6 (15 ml) gave 2·7 g of a mixture of adducts. A sample either of the mixture or of **10** was crystallized from $CHCl_3$-pet. ether to give **9**. Crystallization of **9** from DMSO-H_2O, gave **10**.

Spiro[2,5]octanes, general procedure. A saturated soln of a Δ^1-pyrazoline in diglyme MeOH 5:1 (**2** and **3**) or in methanol (**4** and **5**) was irradiated at room temp with a Hanau PL 313 lamp until complete disappearance of the starting material, (TLC). The soln was concentrated *in vacuo* and the residue chromatographed on silica gel (about 50% yield).

2-Methyl-2-carboxamide-4-tosyl-spiro[2,5]octanes (**14** and **15**). A soln of **4** (1·5 g) in nitrobenzene (25 ml) was heated at 160° and when N_2 evolution had subsided, the soln was concentrated *in vacuo* and the residue chromatographed on silica gel. Three compds were collected: **13** (0·5 g), **15** (0·15 g) and **16** (0·02 g).

Likewise **5** (1 g) gave: **14** (0·3 g), **15** (0·05 g) and **16** (0·06 g).

6-Tosyl-1,2-diazaspiro[4,5]dec-2-en-3,4-dicarboxylic acid (**17**). A suspension of **1** (2 g) in dioxane (30 ml) was treated, stirring and at room temp, with NaOH 30% (1·5 ml). The thick precipitate was filtered, dissolved in water (30 ml) and acidified with HCl. The soln was evaporated *in vacuo* and the residue taken up in acetone. Compd **17** was isolated by concentration of the acetone soln and recrystallized twice from acetone-pet. ether (80% yield).

6-Tosyl-1,2-diazaspiro[4,5]dec-2-en-3-carboxylic acid (**18**). A sample of **17** (1 g) was dissolved in nitroethane (20 ml) and the soln refluxed for 4 hr. The solvent was evaporated *in vacuo* and the residue crystallized from acetone-pet. ether to give **18** in quantitative yield.

6-Tosyl-1,2-diazaspiro[4,5]dec-2-ene (**19**). A nitrobenzene soln (30 ml) of **17** (1·6 g) was refluxed until CO_2 was no longer evolved. The soln was evaporated *in vacuo*, the residue chromatographed on silica gel and the main fraction crystallized from CCl_4 to give **19** (20% yield).

4-Carboxanilido-6-tosyl-1,2-diazaspiro[4,5]dec-2-en-3-carboxylic acid (**20**). A suspension of either **2** or **3** (2 g) in dioxane (25 ml) was treated, stirring and at room temp, with NaOH 30% (0·86 ml). After 2 hr the precipitate was filtered, dissolved in water and the soln acidified with HCl. Compd **20** was separated by filtration and recrystallized from acetone-pet.ether (60% yield).

4-Carboxanilido-6-tosyl-1,2-diazaspiro[4,5]dec-2-ene (**21**). A nitroethane soln (100 ml) of **20** (2 g) was refluxed for 4 hr. The solvent was removed *in vacuo* and the residue crystallized twice from $CHCl_3$-pet. ether to give **21** (80% yield).

3,4-Dicarboxanilido-6-tosyl-1,2-diazaspiro[4,5]dec-2-ene (**22**). To a soln of **20** (1 g) in DMF (10 ml), dicyclohexylcarbodiimide (0·6 g) and aniline (0·35 g) were added. After standing for two days at room temp, the soln was filtered and the filtrate evaporated *in vacuo*. The residue was crystallized from acetone-pet.ether to give **22** (90% yield).

3,4-Dicarboxanilido-1,2-diazaspiro[4,5]dec-2-ene (**23**). To a suspension of **22** (5 g) in liq NH_3 (150 ml), Na was slowly added in portions until a blue coloration stable for 15 min was obtained. $AcONH_4$ was added, NH_3 evaporated, the residue taken up in $CHCl_3$ and the soln washed with H_2O. The $CHCl_3$ soln was evaporated *in vacuo* and the residue chromatographed on silica gel to give **23** (400 mg) (Found: C, 70·0; H, 6·4; N, 14·5. $C_{22}H_{24}N_4O_2$ requires: C, 70·2; H, 6·4; N, 14·9%).

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REFERENCES

[1] W. Barbieri, L. Bernardi, P. Masi, L. Caglioti and G. Rosini, *Tetrahedron Letters* 1343 (1970)

[2] L. Caglioti, E. Foresti and L. Riva di Sanseverino, *Tetrahedron Letters*, 1347 (1970)

[3] G. W. Cowell and A. Ledwith, *Quart. Rev.* **24**, 119 (1970)

[4] L. M. Jackman and S. Sternhell, *Applications of NMR Spectroscopy in Organic Chemistry*, Pergamon Press, London, [a] p. 288, [b] p. 286 (1969)

[5] F. Johnson, *Chem. Rev.* **68**, 375 (1968)

[6] S. Sternhell, *Quart. Rev.* **23**, 236 (1969)

[7] S. D. Andrews, A. C. Day and A. N. McDonald, *J. Chem. Soc.* (*C*) 787 (1969)

[8] C. H. Jarboe, *Pyrazolines and Pyrazolidines*, in *Pyrazoles, Pyrazolines, Pyrazolidines, Indazoles and Condensed Rings* (A. Weissberger Ed.), pp. 177–278, Interscience Publishers, New York (1967)

[9] R. C. Cookson, T. A. Crabb, J. J. Frankel and J. Hudec, *Tetrahedron* Suppl. 7, 355 (1966)