Tetrahedron Letters,Vol.26,No.19,pp 2365-2368,1985 0040-4039/85 $3.00 + .00
Printed in Great Britain

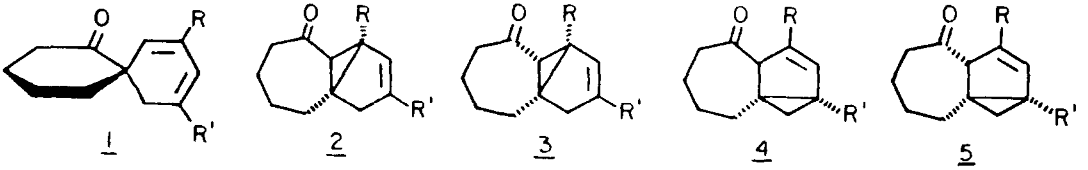
# COMPLETE ENANTIOSPECIFICITY IN THE HIGHLY REGIOSELECTIVE AND STEREOSELECTIVE PHOTO- AND THERMAL REARRANGEMENTS OF SOME HOMOCONJUGATED KETONES

Rossana Viskin, Jakob Oren and Benzion Fuchs*

Department of Chemistry, Tel-Aviv University, Ramat-Aviv, 69 978 Tel-Aviv, Israel

Abstract: The oxa-di-π-methane (ODPM) photorearrangement of 2-(carbomethoxy)spiro [5.5]undeca-1,3-diene-7-one (1d) to 2d and the latter's thermal rearrangement to 3d were shown to be not only fully regio-and stereoselective but also to occur with complete enantiospecificity. An additional example, the 2-hydroxymethyl derivative (1f) was also studied and the two systems were chemically correlated.

In the framework of a systematic study of the photochemical behaviour of homoconjugated ketones[1,2], we are currently investigating the oxa-di-π-methane (ODPM) rearrangement (1,2-acyl shift) and how to steer it by judicious structural variation[1-3]. We have recently unravelled a series of very interesting such photo-rearrangements of spiro(5.5)undeca-1,3-diene-7-ones (1a-c→2+3+4+5a-c)[2], where regioselectivity i.e., ${}_{\sigma}2 + {}_{\pi}2$ vs. ${}_{\sigma}2 + {}_{\pi}4$ intramolecular cycloaddition was found to be high but substitution dependent and stereoselectivity was even higher[3].



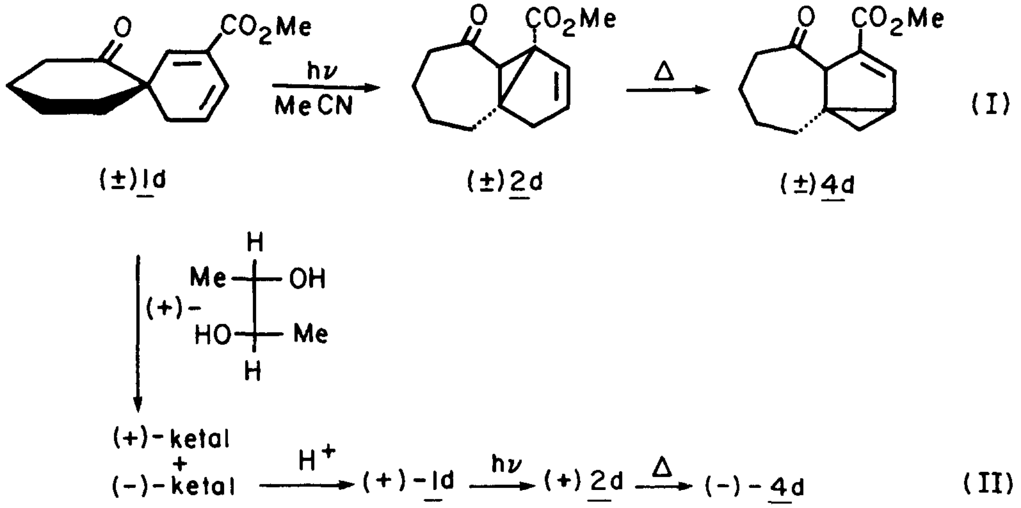
| | a | b | c | d | e | f |
|---|---|---|---|---|---|---|
| R | H | Me | H | $CO_2Me$ | $CO_2H$ | $CH_2OH$ |
| R' | H | H | Me | H | H | H |

A first, apparently completely selective case has been that of the 2-carbomethoxy derivative (1d) (Scheme 1/I)[1] whose irradiation gave *only* 11-carbomethoxy-*trans*-tricyclo[5.4.0$^{7,11}$] undeca-9-en-2-one (2d) which rearranged *thermally* to the *trans*-[5.4.0.0$^{7,9}$] isomer (4d). The latter was found[1] to exhibit a pronounced and variegated chemical reactivity.

To help clarify the mechanism of the photochemical and thermal rearrangements but also to pursue their potential significance for stereoselective synthesis of natural products, we were anxious to provide additional evidence for their high regio- and stereoselectivity and to check whether and to what extent they are *enantiospecific*.

We are now demonstrating that the sequence 1d→ 2d→ 4d (Scheme 1) is completely enantiospecific throughout. To this end we had first to achieve chiral resolution of racemic 1d. Several attempts to do this by suitable derivatization at the carboxyl or methylol substituents in 1f or 1e, respectively, failed mainly because we could not resolve the diastereoisomeric products, presumably due to the remoteness of R from the chiral center in 1. Eventually, we succeeded (Scheme 1/II)$^5$ by ketalization of racemic 1d using (-)-butane-2,3-diol and chromatographic (Silica gel) separation of the diastereoisomeric ketals. One of these $[(\alpha)_D^{20}$ = = -112.5° (CHCl$_3$, c=4)] was hydrolysed to give (+)-1d $[(\alpha)_D^{20}$ = 6.7°(CHCl$_3$, c=1.9)] and deaerated CHCl$_3$ solutions of the latter were irradiated at $\lambda \geq 340$ nm in NMR tubes with cooling to partial or full conversion to (+)-2d $[(\alpha)_D^{20}$ = 114°(CHCl$_3$, c=0.68)], some of which was then heated to yield the thermal product (-)-4d $[(\alpha)_D^{20}$ = -29° (CHCl$_3$, c=0.68)]. The $^1$H-NMR spectra of all isolated compounds were identical with those of the respective racemic compounds (Table 1).

Scheme 1



The analysis of the enantiomeric purity of the residual starting material ((+)-1) and the products 2d and 4d was done using a chiral shift reagent [tris(3-heptafluoropropylhydroxymethylene-d-camphorato) europium(III)]. The vinylic protons in all of them were the best probes and appeared by comparison with the racemic compounds (see Table 1), to belong to single isomers of complete enantiomeric purity (within the precision limits of the NMR spectroscopic measurement, viz. 6%).

Table 1. $^1H$-NMR of relevant protons[a]

| Comp. | Protons | racemate or pure enantiomers | racemate +LSR[b] | enantiomer +LSR[b] |
|---|---|---|---|---|
| 1d | $OCH_3$ | 3.78(s) | 5.83(s), 5.87(s) | 5.63(s) |
| | $H_3$ | 6.32(ddd) | 8.59(d), 8.69(d) | 8.96(d) |
| 2d | $H_1$ | 3.15(s) | | |
| | $H_9$ | 5.59(ddd) | 7.81(ddd), 7.97(ddd) | 7.90(db) |
| | $H_{10}$ | 6.10(ddd) | 6.48(ddd), 6.69(ddd) | 6.47(db) |
| 4d | $OCH_3$ | 3.68(s) | 4.79(s), 4.85(s) | 4.68(s) |
| | $H_{10}$ | 6.97(dd) | 7.99(dd), 8.21(dd) | 8.09(b) |
| 2f | $H_9$ | 5.45(ddd) | | |
| | $H_{10}$ | 5.90(ddd) | | |
| 3f[c] | $H_9$ | 5.52(ddd) | | |
| | $H_{10}$ | 6.00(ddd) | | |
| 3d | $H_1$ | 1.71(s) | | |
| | $H_9$ | 5.57(ddd) | | |
| | $H_{10}$ | 6.16(ddd) | | |

a) Relevant protons are those, the NMR signals of which were structurally diagnostic or discernibly resolved by the chiral shift reagent[b]. The data are at 90 MHz, in $CDCl_3$, $\delta_{ppm}$(multiplicity); s = singlet, d = doublet, b = unresolved signal.

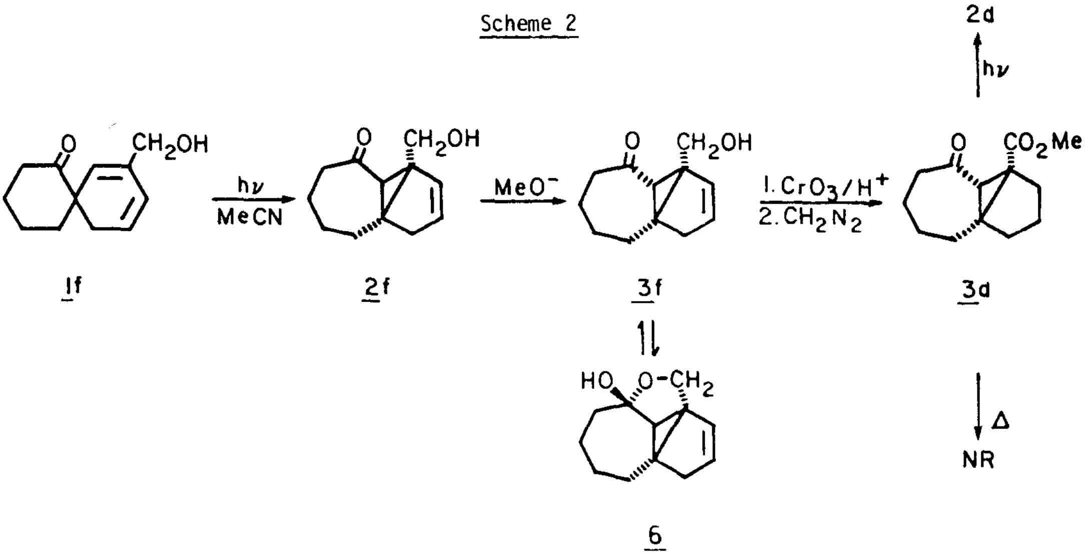
b) Optimized amounts of chiral shift reagent (see text).

c) In presence of traces of trifluoroacetic acid to exclude 6 (see text).

Turning to stereoselectivity, we felt compelled to secure and examine the missing cis isomer (3d), which had been conspicuously elusive previously[1], mainly due to the fast thermal decay of 2d to 4d and both their tendency to aromatize readily[1].

We eventually succeeded while working on an additional example of high regio- and stereoselectivity. Thus (Scheme 2), irradiation of the methylol derivative (1f)[4] ($\lambda \geq 340$ nm in MeCN[3]) gave exclusively 11-(hydroxymethyl)-trans-tricyclo[$5.4.0^{7,11}$]-undeca-9-en-2-one (2f). This readily underwent base catalysed isomerization to its cis isomer (3f) which exists in neutral solution in equilibrium with its hemiketal form (6) which crystallizes as such (m.p.120-122°). 3f is, however, stable in acid media and was oxidized by Jones' reagent to the carboxylic acid (3e) followed by esterification to the hitherto elusive *cis* ester (3d). Interestingly, while 3d is thermally stable, unlike the original *trans*-isomer (2d), it photorearranges to the latter on sensitized irradiation (acetone, 300 nm).

Scheme 2



The above described sequences of events unequivocally suggest that homoconjugated ketones of type 1, bearing electronegative substituents (R = e.g. $CO_2Me$,$CH_2OH$), rearrange photochemically and subsequently thermally in a clearly regioselective, diastereoselective and enantiospecific manner. This may have far-reaching significance in further studies for mechanism elucidation as well as for the use of such systems in securing synthons for stereoselective synthetic work[6].

## References and Notes

1. Photochemical Studies, 27. For Part 26 see J. Oren, L. Schleifer, U. Shmueli and B. Fuchs, *Tetrahedron Letters*, **1984**, 25, 981.
2. a) J. Zizuashvili, S. Abramson and B. Fuchs, *J. Chem. Soc., Chem. Commun.*, **1982**, 1372.
   b) J. Oren and B. Fuchs, J. Org. Chem., in press.
3. A pronounced solvent effect on regio- and stereoselectivity was recently observed: J. Oren, unpublished observation.
4. J. Zizuashvili, S. Abramson and B. Fuchs, *J. Org. Chem.*, **1982**, 47, 3474.
5. All new compounds gave (IR, UV, MS, NMR) spectral data in complete agreement with the structural assignments shown.
6. See, for example M. Demuth and K. Schaffner, *Angew. Chem.*, **1982**, 94, 809 and previous papers cited there.

(Received in UK 13 March 1985)