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CHIROPTICAL STUDIES OF LABILE OR DIFFICULT TO RESOLVE MOLECULES GENERATED BY CHIRAL LASER PHOTOCHEMISTRY.1. (1S,5R)-1-METHOXYBICYCLO[3.2.0]HEPTA-3,6-DIEN-2-ONE

Marino Cavazza,[ϕ] Maurizio Zandomeneghi,[o] Crescenzo Festa,[o] Enrico Lupi,[o]
Manuela Sammuri,[o] and Francesco Pietra[◇]

([ϕ]Istituto di Chimica Generale, Università di Pisa, [o] Istituto di Chimica Quantistica ed Energetica Molecolare, CNR, Pisa, 56100 Pisa, and [◇]Laboratorio di Chimica, Libera Università di Trento, 38050 Povo-Trento, Italy)

Summary The optical activity of (1S,5R)-1-methoxybicyclo[3.2.0]hepta-3,6-dien-2-one (**1**) is determined by partial photoresolution of the racemate with circularly polarized laser light, although a rearranged, optically active product was also formed, isolation of the **1** enantiomers was note required

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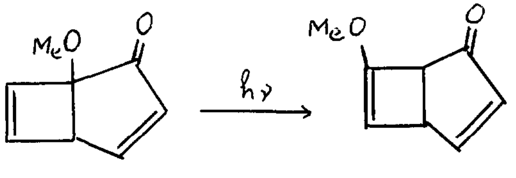
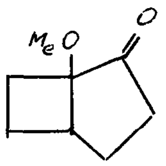
Labile or difficult to resolve chiral molecules impose severe limits upon chiroptical studies. Because of the wide scope of such spectroscopy, we have managed to avoid these difficulties and we report here on a special application, for chiroptical studies, of the partial resolution of racemates with circularly polarized light (CPL)[1]. With simple processes it is unnecessary to isolate pure enantiomers, whilst with complex processes the same situation can be approached through simple chemical manipulations.

Let us first examine the case of a straightforward preferential photodestruction of the more strongly CPL absorbing enantiomer of a racemate. Here, the resulting differential circular-absorbance spectrum depends on both the extent of the enantiomeric enrichment and the specific CD of the less strongly CPL absorbing enantiomer. Therefore, the CD of the pure enantiomer can be conceivably obtained from the measurement of both the differential absorption of CPL by the enantiomerically enriched sample and the extent of the reaction.[2] No practical example is given here because this is simply a particular case of the more general, subsequent one.

In fact, the process, and the procedure, become more complex when, for example, the product of the chiral photoreaction is optically active. The **1** → **2** process is a case in point. In a typical experiment, irradiation of a 0.034 M solution of racemic **1** in methanol with left, laser-produced CPL,[3] gave up to 15% conversion of **1** into **2** (as measured by ^1H NMR spectroscopy)[4]. The resulting mixture (M_I) showed optical activity, $\alpha^{436} = -0.024$, giving the differential circular-absorbance spectrum of Fig. 1a. The negative band at 355 nm in Figure 1a corresponds to a UV absorption band, at the same frequency, which can be attributed to the $n \rightarrow \pi^*$ transition of



1 2



3

enone chromophores

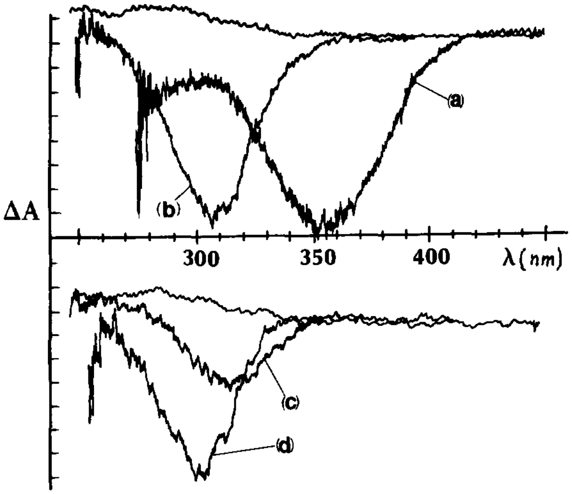


Fig 1 - Differential circular-absorbance spectra in CH_3OH (elongation 1 cm/division) for (a) mixture M_I (see text) (c = 0.034 M; X = 0.5 cm, s = $2x10^{-6}$), (b) mixture M_{II} (see text) (c = 0.14 M, X = 0.2 cm, s = $2x10^{-6}$), (c) 3 (c = 0.11 M, X = 0.2 cm, s = $2x10^{-6}$), (d) mixture M_{III} (see text) (c = 0.09 M; X = 0.2 cm, s = $2x10^{-6}$) taken with a Jobin-Yvon Mark III circular dichrograph

Because 1 and 2 hardly could have been separated unaltered from one another,[5] mixture M_I above was hydrogenated on 5% Pd-C in ethanol[4] to give, after work-up, mixture M_{II}, which showed both CD and UV absorption at 305 nm, typical of saturated ketones (Fig. 1b) Preparative GLC separation of mixture M_{II} gave pure 3 as an oil[6] (showing a negative CD at 312 nm, Fig 1c) and mixture M_{III} (showing a negative CD at 303 nm, Fig 1d) which, from analytical GLC, was shown to contain a main product,[7] besides 3

The above data allow a straightforward calculation of the contribution (56%) given by 3 to the negative CD of mixture M_{II} at 305 nm Making the reasonable assumption that the same relative contribution holds for the optical activity of 1 at 355 nm in mixture M_I, then from $\Delta A_1(\lambda_o)=0.56\Delta A_{1+2}(\lambda_o)= -9.1\ 10^{-5}$, $\varepsilon_1(\lambda_o) = 61$, and $\delta_c = 0.005$ M (where $\lambda_o = 355$ nm is the "mean" UV laser wavelength), the circular dichroism of 1 is calculated[2] as $\Delta\varepsilon_1(355)=2.1$. From this, the optical purity of 1 is estimated as 0.3%.

Now the octant rule can be applied to 3,[8] which is simplified by the conformational rigidity of this compound In fact, the sign of the dichroic activity of the $n\rightarrow\pi^*$ ketone band must depend on the relative orientation of the four and five membered rings only, because the methoxyl group, being close to the nodal plane that separates the outwards from the inwards octants, can only have a minor influence on the CD spectrum Therefore, we relate the absolute configuration of Fig. 2 to the negative sign of the CD band in Fig 1c.

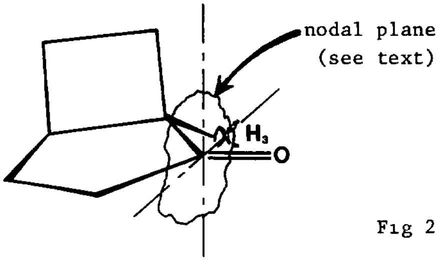


Fig 2 (1*S*,5*R*)-1-Methoxybicyclo[3.2.0] heptan-2-one (3)

The octant rule can be applied with less confidence to α,β-unsaturated ketones However, since the hydrogenation of mixture M_I above is very unlikely to have changed the configurations at the bridgeheads, we assign to 1, also characterized by a negative CD band, the same absolute configuration as for 3

It is interesting to have established the absolute configuration for 1 In fact, any correlation of the chirality of the asymmetric instrument used (here the helicity of the light) to the chirality of the resulting asymmetric object (here 1) is generally difficult to make. This is often the case, for example, in asymmetric inductions by chiral molecules.

In conclusion, we hope that the present case will stimulate further chiroptical studies along these lines of other labile or difficult to resolve ketones The photochemically active long-wavelength UV absorption of ketones occurs just at the emissions of currently available UV lasers,[9] and a further dimension to the work lies in the fact that ketones are known to be particularly prone to a variety of phototransformations into other chiral compounds

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REFERENCES AND FOOTNOTES

1) G Balavoine, A Moradpour and H.B. Kagan, J Am Chem.Soc., 96, 5152, 1974

2) Calling the concentrations of enantiomers preferentially absorbing left and right CPL c_ℓ and c_r, respectively, and calling the molar extintion coefficients of the ℓ enantiomer with respect to left and right CPL ε_ℓ and ε_r, respectively (the converse holds for the r enantiomer), we obtain $dc_\ell/dt = -\Phi I_\ell\{c_\ell\varepsilon_\ell(\lambda_o)/[c_\ell\varepsilon_\ell(\lambda_o) + c_r\varepsilon_r(\lambda_o)]\}$

and $dc_r/dt = -\Phi I_\ell\{c_r\varepsilon_r(\lambda_o)/[c_\ell\varepsilon_\ell(\lambda_o) + c_r\varepsilon_r(\lambda_o)]\}$

Here, I_ℓ is the intensity of the absorbed CPL, which is assumed to be totally left polarized, Φ is the quantum yield of the photoreaction, and λ_o is the laser-light wavelength. The above equations give us $dc_\ell/\varepsilon_\ell c_\ell = dc_r/\varepsilon_r c_r$, which, at zero time, when $c_\ell = c_r = c/2$, becomes $\delta c_\ell = (\varepsilon_\ell/\varepsilon_r)\delta c_r \simeq (\varepsilon_\ell/\varepsilon_r)\delta c/2$ The measured differential circular-absorbance ΔA of left and right CPL ($\Delta A = A_\ell - A_r$) of the partially reacted mixture is related to the above quantities by $\Delta A = \chi(c_\ell - c_r)[\varepsilon_\ell(\lambda) - \varepsilon_r(\lambda)]$, where χ is the optical path length and $\varepsilon_\ell - \varepsilon_r = \Delta\varepsilon$ is the CD of the optically pure ℓ enantiomer Consequently, $\Delta A(\lambda)/\chi = (\delta c_\ell - \delta c_r)\Delta\varepsilon(\lambda) = [\varepsilon_\ell(\lambda_o) - \varepsilon_r(\lambda_o)]\delta c_r \Delta\varepsilon(\lambda)/\varepsilon_r(\lambda_o) \simeq \Delta\varepsilon(\lambda_o)\delta c \Delta\varepsilon(\lambda)/2\varepsilon(\lambda_o)$ and, for $\lambda = \lambda_o$ $\Delta\varepsilon(\lambda_o) \simeq (2\varepsilon(\lambda_o)\Delta A(\lambda_o)/\chi(\delta c))^{1/2}$, in terms of the increments of ΔA with the change of the concentration (δc) of the racemate

3) Obtained by polarizing, through a Fresnel rhomb, the UV emissions of an Argon-ion laser at both 350 and 363 nm (0 25 W). In a previous work (M. Zandomeneghi, M. Cavazza, A. Gozzini, A Alzetta, E Lupi, M Sammuri, and F. Pietra, Lett. Nuovo Cimento, **30**, 189 (1981)) "left CPL" has to be read "right CPL". The error arose from a wrong end-of-scale indication of the circular dichrograph. The dichrograph served to find the CD sign of a circular dichroic plate, made of a quarter-of-wave plate plus a linear one, which was transparent to our CPL (F S Grawford Jr., in Berkeley Physics Course, vol 3 (Waves) chap. 8, pag 433, Ed. Development Center Inc., Newton, Massachusetts 1968)

4) W.G Dauben, K Koch, S L Smith and O L. Chapman, J.Am Chem Soc **85**, 2616 (1963).

5) M. Miyashi, M. Nitta and T Mukai, Tetrahedron Lett., 3433 (1967)

6) ν (liquid film) 1740 cm^{-1}, $\delta^1_{H(TMS)}$ ($CDCl_3$) 3 28 (s, 3H, OCH_3) 3 0-1.3(m, 9H), $\delta^{13}_{C(TMS)}$ (C_6D_6) 218 99 (s, C=O), 81 72 (s, quaternary carbon), 52 11, (q, OCH_3), 39.51 (d, CH), and triplets for the methylene carbons at 35 66, 25.77, 25.49, and 17.46 p.p.m., M^+ 140 (25%).

7) Although, according to the literature,[4] this compound is expected to be the saturated analogue of **2**, knowledge of the specific nature of this compound is immaterial for the main conclusions in this work.

8) W. Moffitt, R.B. Woodward, A. Moscowitz, W Kline, and C. Djerassi, J.Am Chem.Soc , **83**, 4013 (1961), C. Djerassi, R Records, E. Bunnenberg, K Mislow and A. Moscowitz, J Am.Chem Soc , **84**, 870 (1962)

9) M. Zandomeneghi, M. Cavazza, L. Moi, and F Pietra, Tetrahedron Letters, 213 (1980)

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