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The Failure of Asymmetric Synthesis in Cholesteric Liquid Crystals

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The Failure of Asymmetric Synthesis in Cholesteric Liquid Crystals

New Examples of Bimolecular Reactions

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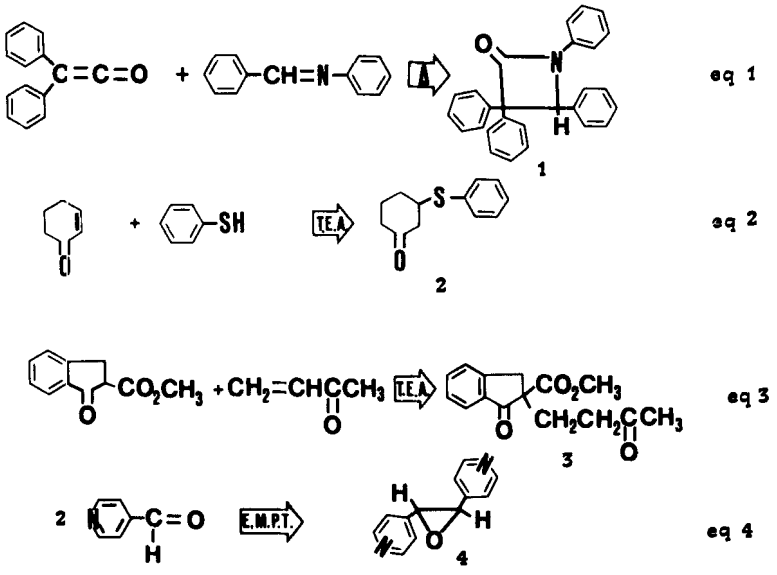
A set of selected bimolecular reactions leading to asymmetric and dissymmetric products was carried out in cholesteric solvents with the aim of obtaining asymmetric syntheses.

In all cases, the products did not show significant optical rotation. The reasons for the lack of asymmetric induction are briefly discussed.

The influence of liquid crystalline solvents on both the stereochemistry and rate of chemical reactions is a subject of increasing interest.[1–5] Various hypotheses have been advanced to justify the expectations that an ordered mesomorphic solvent could exert some stereochemical control on a chemical reaction.[1,6] On this basis, cholesteric liquid crystals have been recently used as solvents for potential asymmetric syntheses, but the first apparent successes were shown by a later reinvestigation not to be reproducible,[7] with one exception, however, where the asymmetric induction was very low.[4]

All the asymmetric syntheses which have been attempted so far in liquid crystals have been unimolecular processes. On the other hand, bimolecular reactions are expected to be more sensitive to the alignment of the reactants imposed by the mesomorphic solvents, as shown by the considerable increase of the average molecular weight in polymerization reactions[5] and of the photodimerization rate of acenaphtylene.[2a]

Hence, we have examined a set of representative bimolecular processes between reactants having at least one prochiral center; these include the cycloaddition between a keten and a Schiff base Eq. (1), two addition reactions to α,β-unsaturated ketones Eq. (2) and (3), and the condensation of two molecules of aldehyde to yield an oxirane derivative Eq. (4). The rotary power of the β-lactame 1 is not known,[8] but is likely to be quite strong due to the carbonyl chromophore surrounded by the dissymmetrically disposed phenyl rings. Reactions 2 and 3 were specifically selected since they afford considerable enantiomeric excess in the presence of chiral catalysts and the optical rotatory power of products 2 and 3 are well known.[9,10] Finally, the rotatory power of the oxirane 4 is particularly strong.[11]



The reactions were carried out at room temperature in two different cholesteric mesophases with solute concentrations less than 5% wt. in order not to disturb the anisotropic arrangement. The reaction products were separated properly from the liquid crystal and then *carefully* purified to eliminate any further contamination from the chiral phase. In all cases, the products did not show significant optical rotation,[12] this indicating the

formation of racemic mixtures and the absence of asymmetric induction by cholesteric crystals. These results are in line with the findings of Kagan and Co-workers[7] and are not unexpected if one takes into account the following points:

i) The pitch of the cholesteric helices is very large (normally $\geqslant$ 4000 A°) with respect to the molecular dimensions, and practically, the molecules see in their neighbourhoods a nematic achiral structure;

ii) The orientation of the molecules, such as rod-shaped ones, with their long axis parallel to the local nematic director, is defined only with respect to their direction, and two orientations rotated by 180° are equally possible;

iii) There is considerable free rotation along the long molecular axis; each 'guest' molecule, therefore, shows different enantiotopic cross-sections.

Therefore, on the basis of the present results and those of Kagan *et al.*,[7] we believe that in general there is little hope of obtaining a significant asymmetric induction using cholesteric solvents, at least for molecules of limited dimensions.

EXPERIMENTAL

Optical rotations were measured using a Bendix NPL or a Perkin Elmer 241 Polarimeter.

The binary cholesteric A mixture was obtained from cholesteryl chloride (ChCl) and cholesteryl nonanoate (ChN) in a 5:7 wt. ratio, clearing point 73°; the ternary *B* mixture was obtained from cholesteryl oleate (ChO), ChN and ChCl in a 60:27:13 wt. ratio, clearing point 52°. The mixtures were prepared by mixing the commercially available materials (Hoechst) at room temperature and then warming them to their isotropic state. The A mixture solidified within 2–3 hours.

Cycloaddition of diphenylketen (DPK) to N-benzylidenaniline (BZDA). A solution of 194 mg. (0.001 moles) of DPK in 5 gr. of the B mixture was added, with stirring, to a solution of 180 mg. (0.001 moles) of BZDA in 5 gr. of the same liquid crystalline solvent under N_2. A control by t.l.c. (silica, *n*-hexane-benzene, 60:40) showed the formation of the β-lactame 1 as the only reaction product. After standing overnight, the reaction mixture was chromatographed (silica, *n*-hexane-benzene, 60:40) to give the cholesteryl derivatives and the cycloadduct 1, 150 mg., m.p. 162–163° (from *n*-hexane) (lit.[8], 161–162°).

Product 1 did not show appreciable value of rotatory power ($c = 1$, $CHCl_3$). The reaction was carried out also in the A mixture with the same concentrations of reactants. Also in this case the adduct showed no optical rotation.

Addition of thiophenol to cyclohexen-1-one. A solution of thiophenol (300 mg., 0.0027 moles) in 10 gr. of the B mixture was added dropwise to a solution of 2-cyclohexen-1-one (270 mg., 0.0028 moles) and diethanolamine (T.E.A.) (4 mg.) in 10 gr. of the same mesomorphic solvent. The reaction mixture was stirred at room temperature for about 24 hours, dissolved in CH_2Cl_2, washed with NaOH 5% and water and then chromatographed twice (silica, light petroleum-ethyl ether, 9:1 and then 7:1). The reaction product, isolated in 40% yield, had the same physical characteristics as the compound described by Wynberg and coll.[9] and showed no significant optical rotation. The reaction was repeated in the A mixture and gave identical results.

Addition of methyl vinyl ketone to 2-carbomethoxy indan-3-one. The reaction of methyl vinyl ketone (280 mg., 0.004 moles) with 2-carbomethoxy indan-3-one (380 mg., 0.002 moles) catalized by diethanolamine (5 mg.) was carried out in the B mixture (20 gr.) with the same procedure as above. The resulting mixture was chromatographed twice (silica, light petroleum-ethyl ether, 9:1 and then 7:3) to give the addition product 3 in a 35% yield, m.p. 101–3° (lit.[10] 104–6°) and $[\alpha]_D = -2.9$ ($c = 3.7$, benzene), but after additional chromatographing, 2x, as above no optical rotation was detected.

Trans 1,2-di-4-pyridyloxirane. The reaction of pyridine-4-carbaldehyde (430 mg., 0.004 moles) with hexamethyl phosphorous triamide (E.M.P.T.) (400 mg., 0.0025 moles) was carried out in the B mixture at 50° as described.[11] The reaction mixture was dissolved in chloroform and treated with water; the oxirane was separated from the organic layer by extraction with 10% hydrochloric acid. No detectable optical rotation was shown either by the crude *trans*-1,2-di-4-pyridyloxirane hydrochloride obtained from the acid extract or by the oxirane itself isolated by treatment with Na_2CO_3 from the hydrochloride. Racemisation in acid media of the optically active oxirane has been ruled out following the C.D. spectra reported in Ref.[11]

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References and notes

1. W. E. Bacon, *Pramana*, Suppl. n. 1, 455 (1975).
2. (a) J. M. Nerbonne and R. G. Weiss, *J. Am. Chem. Soc.*, **100**, 2571 (1978); (b) *J. Am. Chem. Soc.*, p. 5953.

3. E. I. Kovshev, L. M. Blinov, and V. V. Titov, *Russian Chem. Rev.*, **46**, 395 (1977) and references therein.
4. M. Nakazaki, K. Yamamoto, and K. Fujiwara, *Chem. Lett.*, 863 (1978).
5. W. E. Bacon, *J. Physique Coll. C1*, **36**, 409 (1975).
6. M. J. S. Dewar and B. D. Nahlovsky, *J. Am. Chem. Soc.*, **96**, 460 (1974).
7. C. Eskenazi, J. F. Nicoud, and H. B. Kagan, *J. Org. Chem.*, **44**, 995 (1979).
8. (a) W. Kirmse and L. Horner, *Chem. Ber.*, **89**, 2759 (1956); (b) H. B. Kagan and J. L. Luche, *Tetrahedron Lett.*, 3093 (1968).
9. R. Helder, R. Arends, W. Bolt, H. Hiemstra, and H. Wynberg, *Tetrahedron Lett.*, 2182 (1977).
10. H. Wynberg and R. Helder, *Tetrahedron Lett.*, 4057 (1975).
11. G. Gottarelli and B. Samori, *J. Chem. Soc. Perkin II*, 1998 (1972).
12. Crude products from the first chromatographic separation showed in some cases a very small rotatory power which, however, reduced to zero after further purification.