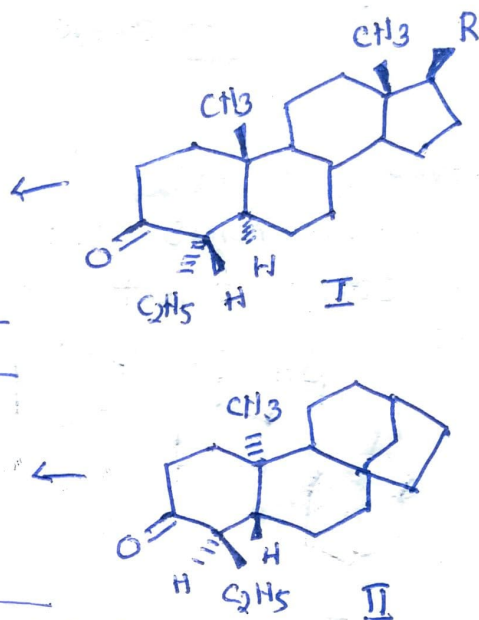
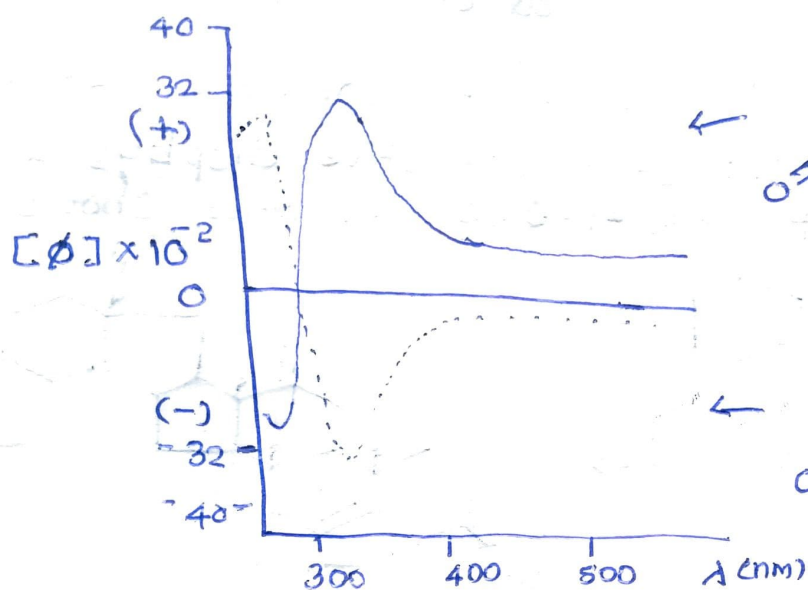


Applications of ORD, CD and octant rule for ketones

① Study of the absolute configⁿ and stereochemistry - Comparison method.

The sign of Cotton effect gives information about the stereochemistry in the nearby environment of the chromophore. eg: Carbonyl group ($n \rightarrow \pi^* = 280 \text{ nm}$) act as a probe of the chirality of its environment.

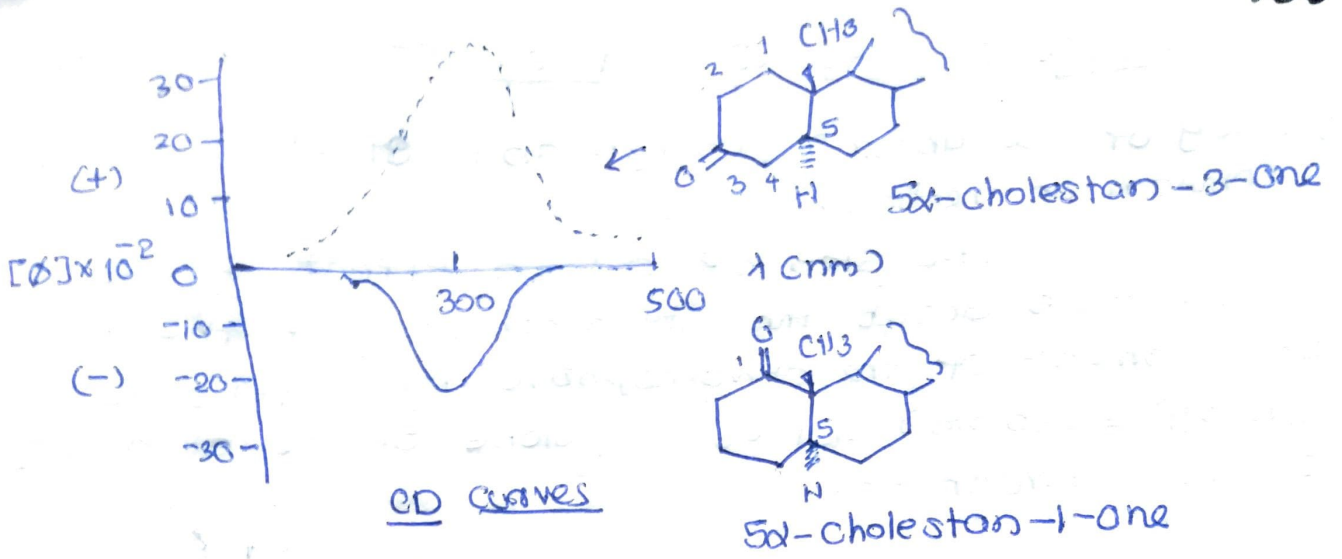


→ when two compounds display curves of the same sign and shape, the stereochemical features near the chromophore are same.

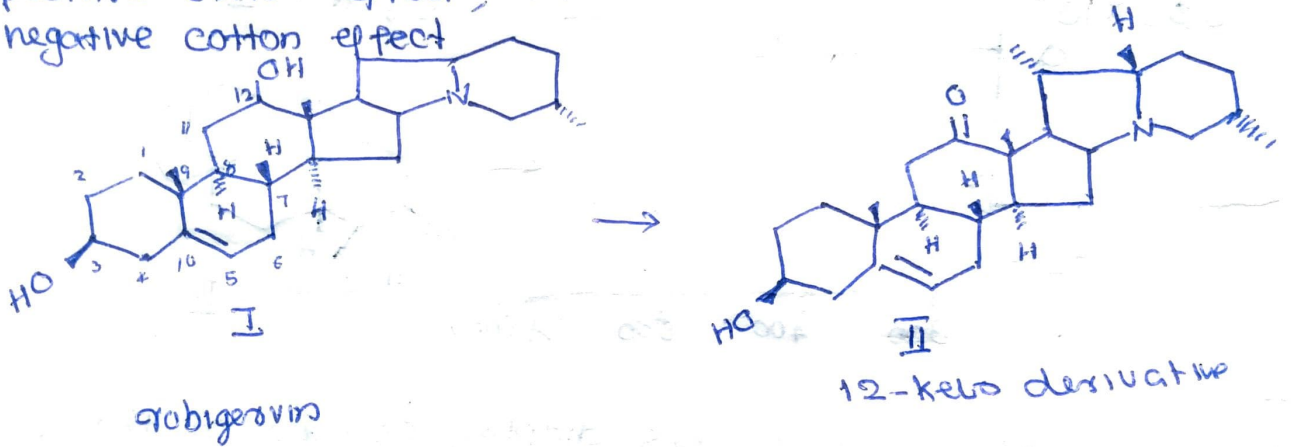
→ when two compounds show Cotton effects of opposite sign then the stereochemical features near the chromophore are mirror image type.

→ The compound (I and II) are not enantiomers, however their ORD curves have almost mirror image relationship in the immediate vicinity of the carbonyl group.

② Position of functional groups - Comparison method



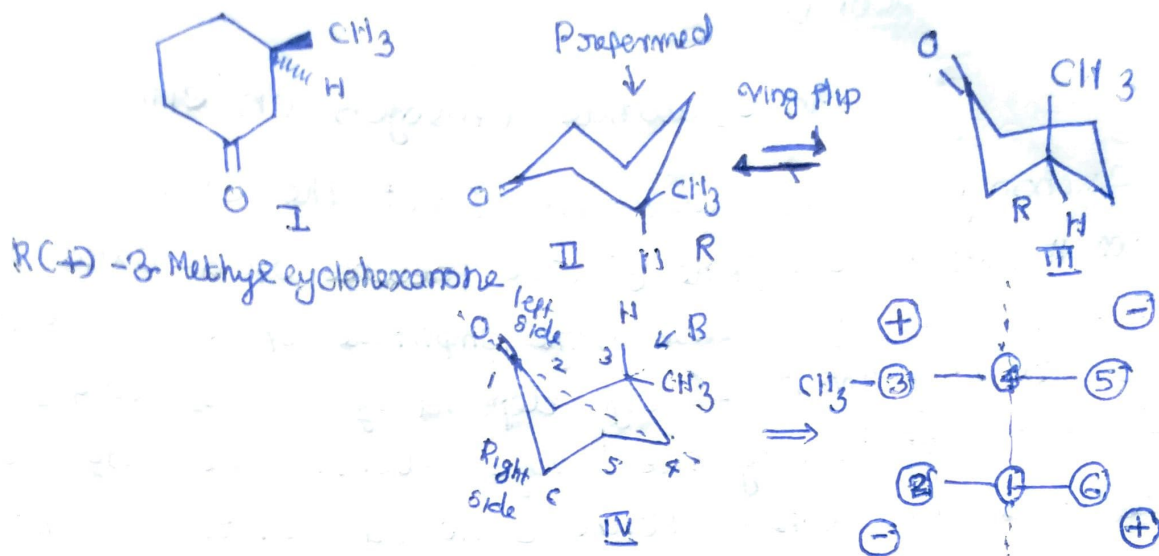
CD curves give clear distinction of isomeric 1,2- and 3-oxo-5α-steroids. The 3-oxo derivative displays a positive cotton effect, while 1-oxo derivative shows a negative cotton effect.



A steroidal alkaloid robigervine (I) on preferential oxidation gives 12 keto derivative (II) whose ORD curve matches with that of a 12-oxo steroid to show which indicate the position of keto group is at C12

③ Study of conformation

When the absolute configuration of a conformationally mobile system is known, the preferred conformation can be determined by the application of octant rule. Consider (+)-3-Methylcyclohexanone (R config)

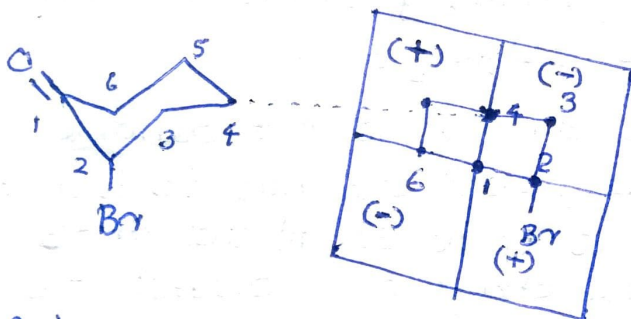


Octant rule projections for equatorial conformer.

- In R(+)-3-methylcyclohexanone equatorial methyl group would be energetically favoured over the conformer with axial methyl group.
- The conformation II as drawn is not suitable to the application of octant rule, because one has to look at the carbonyl group, which is to be so placed that it occupies the head of the chair and closest to the observer. Thus the formula-II is reoriented by rotating it 180° to give IV.
- The representations (II, III, and IV) are the same compound R(+)-3-methylcyclohexanone.
- In the octant projection of conformation after ignoring equal and opposite contributions of axial H atoms at C-2 and C-6, one finds that below C-3 and C-5, the positive contribution of methyl group outweighs the negative contribution at C-5. Thus the compound shows a positive $n \rightarrow \pi^*$ Cotton effect. The compound R(+)-3-methylcyclohexanone therefore exists in a conformation with C-3 methyl group equatorial.
- The C-3 axial methyl conformer on the other hand would have shown a negative $n \rightarrow \pi^*$ Cotton effect.

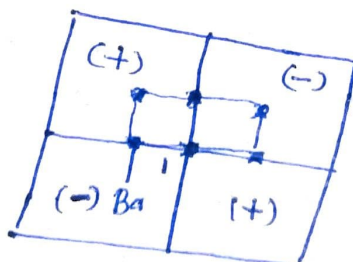
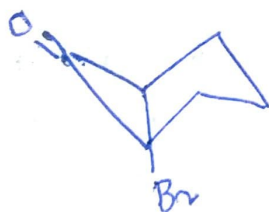
④ Axial haloketone rule

An equatorial α -halogen on either side of the carbonyl group does not affect the ORD parameters (since it will be on plane B). The presence of α -axial substituents not only causes an increase in the amplitude of Cotton effect, but also may invert its sign depending on the configuration of the carbon bearing the halogen atom. According to axial haloketone rule when a ketone is viewed for the application of octant rule, if the axial α -halogen (Cl, Br or I) is found on the right of the observer, then a positive Cotton effect is found, if the axial halogen is on the left, a negative Cotton effect is displayed.



S-2-bromocyclohexanone (Br axial)

A positive CE.



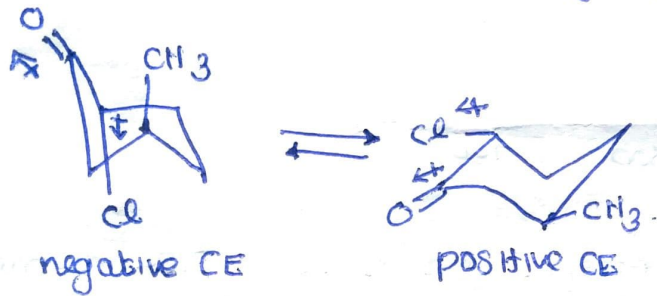
R-2-bromocyclohexanone (Br axial)

A negative CE.

⑤ Study of conformational mobility

Conformational mobility can be studied as a function

Solvent polarity. In octane (solvent) 2-chloro 5-methyl cyclohexanone exist in the trans form with both chlorine and methyl group in axial positions and this conformation shows a negative cotton effect. In methanol the compound adopts a diequatorial conformation. The diequatorial conformer is predicted to show a positive cotton effect. In the octane solution the dipoles of C=O and C-Cl bonds are kept apart. However in methanol, which is a solvent of high dielectric constant, the dipoles lie parallel. So by studying octant rule and cotton effect conformational mobility can be studied

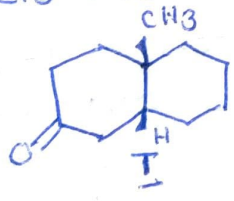


2-chloro-5-methylcyclohexanone

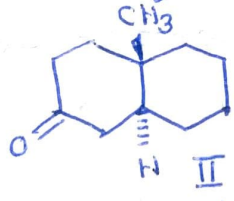
[Ref - google search chapter 19 - More on stereochemistry Page no - 890]

ORD Curves of cis and trans Decalones

Considers the rotatory dispersion curves for enantiomers of cis and trans-10-methyl-2-decalones I and II.



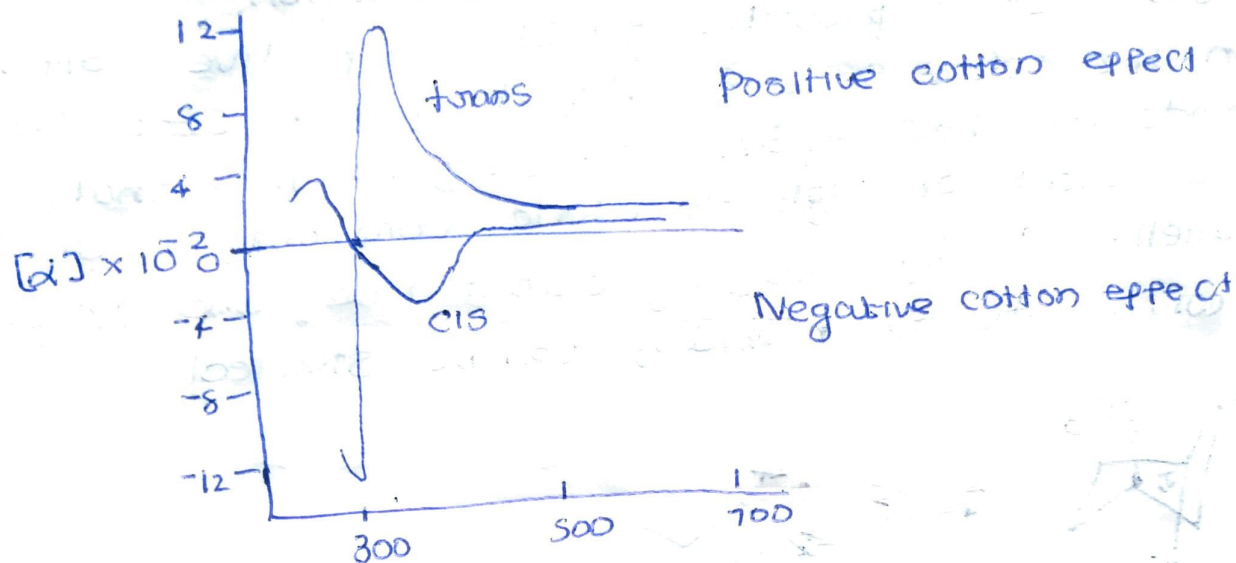
Cis decalone



trans decalone

Trans decalone shows positive cotton effect (ie if we measure the rotations as a function, wavelength - and if we approach shorter wavelength the rotation rises to a maximum before changing sign), whereas the cis isomer shows a negative cotton effect. The wavelength at the centre point for the very rapid change in rotation for

trans isomer is 300nm and which corresponds 142 to the $n \rightarrow \pi^*$ absorption maximum of the carbonyl group in the ultraviolet absorption curve of the same compound.

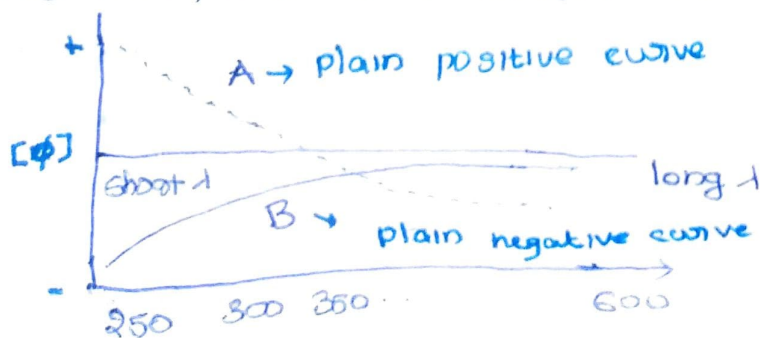


[Optical rotatory dispersion curves for cis-10-methyl-2-decalone and trans-10-methyl-2-decalone.]

Types of Optical Rotatory Dispersion Curves

Simple ORD Curves

Simple ORD curves may either be plain or normal dispersion curves. If measurement of rotation is restricted to wavelengths away from λ_{max} region, a solid curve results, showing a steady increase or decrease in optical rotation with decrease of wavelength. Such a plot is called plain curve. It may or may not cross zero rotation line, but it is devoid of inflections or extrema.



The curve A is referred to as the plain positive dispersion curve, bec² the molecular rotation increases in the positive direction in going to shorter wavelength. The curve B is referred to as plain negative dispersion curve (molecular rotation increases in the negative direction). The plain dispersion curve obeys a one term Drude equation.

$$d = \frac{k}{\lambda^2 - \lambda_0^2}$$

k and λ_0 are empirical constants

λ = wavelength at which the Specific rotation is measured

λ_0 = wavelength due to absorption maximum.

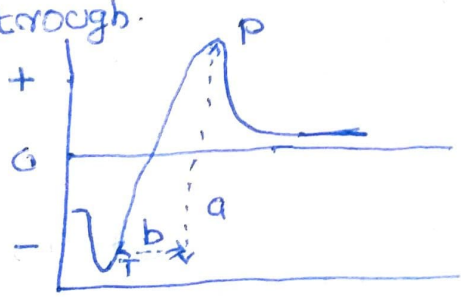
Anomalous ORD curves

The ORD curves containing both the peak (crest) and the trough are called anomalous curves. The 'term' 'anomalous' is used bec² the curves do not obey the one term Drude equation. Anomalous curves are of two types.

- (1) Single Cotton effect curves.
- (2) Multiple Cotton effect curves.

Single Cotton effect curve

Single Cotton effect curves are defined as positive or negative, depending upon whether the peak occurs respectively at longer or shorter wavelength than the trough.

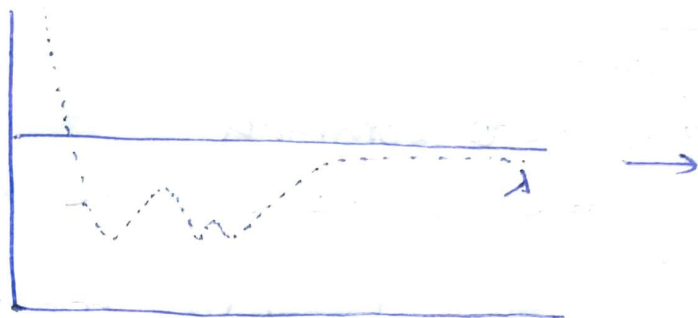


positive single cotton effect curve

The various points on the curve are designated as ¹⁴⁴ peak (P) and the trough (T). The vertical distance 'a' b/w the peak and trough is the amplitude and the horizontal distance b is the breadth.

Multiple Cotton effect curve

A multiple cotton effect curve exhibits several peaks and troughs with shoulders and inflections.



A multiple cotton effect curve.

The optical rotatory dispersion curves are described in terms of the mathematical expression known as the Drude equation.

$$[\phi] = \frac{k_1}{\lambda^2 - \lambda_0^2} + \frac{k_2}{\lambda^2 - \lambda_1^2} + \dots + \frac{k_n}{\lambda^2 - \lambda_{n-1}^2}$$

k_1, k_2, \dots, k_n = Constants characteristic of the chromophores responsible for the observed rotations.

λ = wavelength of measurement.

$\lambda_0, \lambda_1, \dots, \lambda_{n-1}$ = wavelengths of absorption maxima of the compound.

Determination of conformation of (+)-cis-10-methyl-2-decalone

(+) cis-10-methyl-2-decalone may exist in either of the two conformations (I and II) which exhibit

different contributions (positive or negative) to the Cotton effect and hence can be identified. The application of the Cotton effect reveals that the conformation I should give the negative Cotton effect, while the structure II displays a positive Cotton