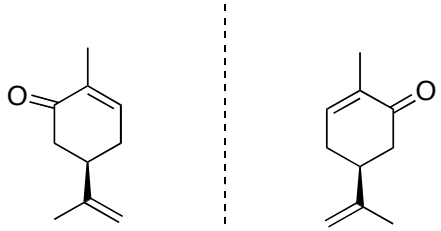
Physical properties of enantiomers

- Same physical properties in achiral agents
  - Melting point, boiling point, solubility in achiral solvents
- Enantiomers behave differently with chiral agents
  - Example: L & D-carvone have different smells (spearmint and caraway, respectively)

CARVONE



SPEARMINT CARAWAY

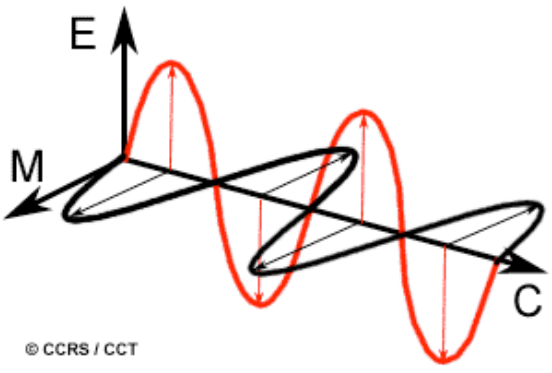
Optical Rotation

- rotation of plane of polarized light
  - dextrorotatory (right)
  - levorotatory (left)
- enantiomers show equal but opposite rotation

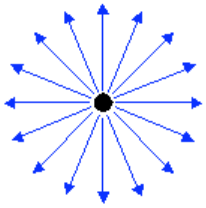
Light: Electromagnetic radiation

Light → $E = h\upsilon = \frac{hc}{\lambda}$

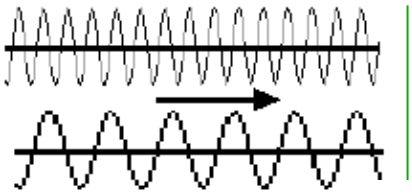
υ = frequency E = energy h = Planck's constant λ = wavelength
c = speed of light



Light has oscillating Electric field (red) combined with magnetic field (black)



End on view of vector components of normal light

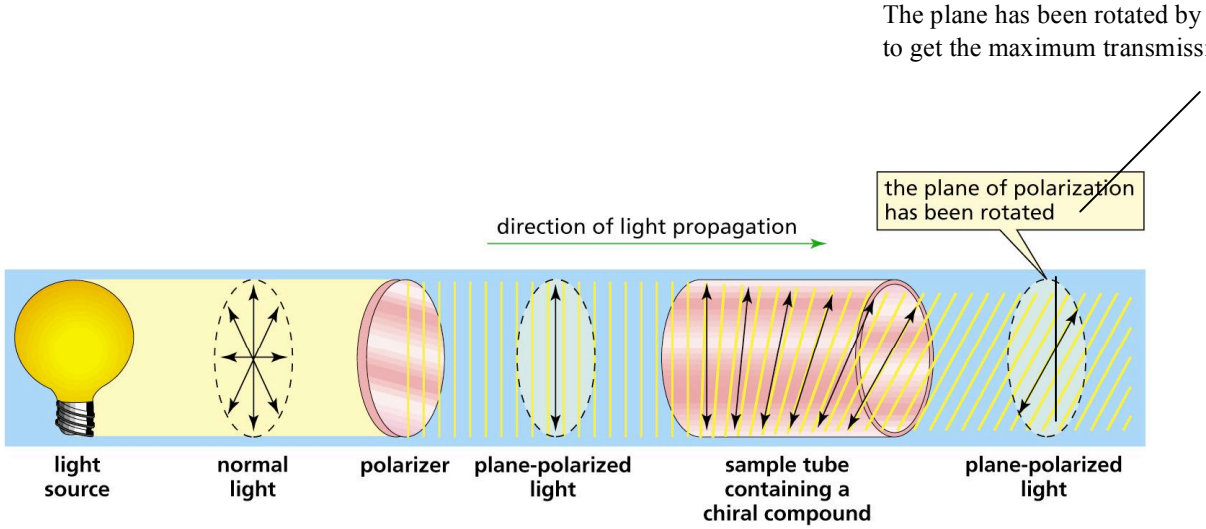


short wavelength = high frequency

long wavelength = short frequency

High energy

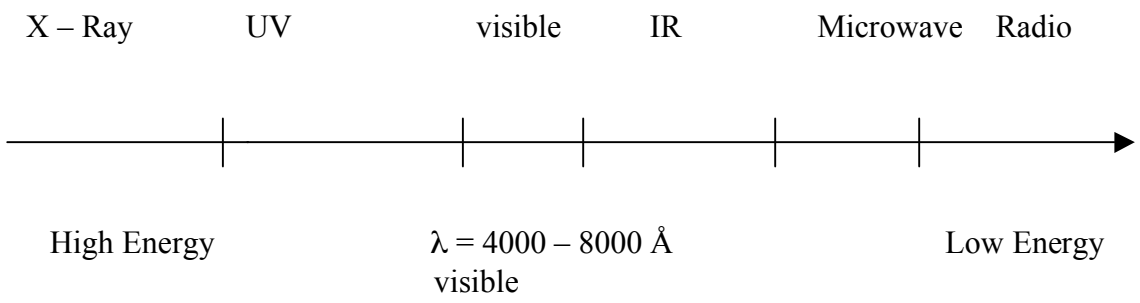
Low energy



$$[\alpha]_D = \frac{\alpha}{c \bullet l}$$

α = measured rotation c = concentration (mol/L) l = path length (cm)

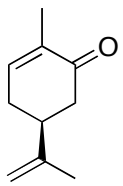
D = D-line of sodium light [α] = absolute rotation



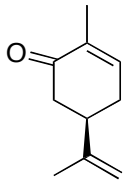
Optical Rotation

$[\alpha]_D$ = Absolute Rotation

Pure enantiomers rotate in equal but opposite direction



$[\alpha]_D$ = +100
Dextrorotatory
d



$[\alpha]_D$ = -100
Levorotatory
l

Optical Purity = enantiomeric excess

↑ ↑

Measured Reality

- excess of one enantiomer over the other
-

Eg. Assume pure enantiomer has 100^o rotation (pure R isomer = -100^o ; S isomer = $+100^o$)

R	S	Rotation (^{o})	Optical purity
100%	0%	-100	100%
75%	25%	-50	50%
50%	50%	0	0%
25%	75%	+50	50%
0%	100%	+100	100%

Racemic Mixture = Racemate

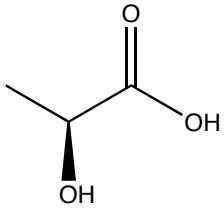
50 : 50 mixture of enantiomers $[\alpha]_D = 0$

$$\text{Optical purity} = \frac{[\alpha]_{observed}}{[\alpha]_{pure-enantiomer}} \times 100\%$$

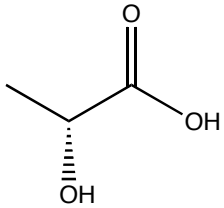
Resolution: Separation of enantiomers.

- Always need chiral agents
- Physical separation (crystallization of specific enantiomer)
- "reaction" with chiral substance to get 2 diastereomers, which can be separated.

Ex) Lactic Acid – mixture of R and S



(S) - Lactic acid



(R) - Lactic acid

Resolution by reaction to diastereomers (these can be separated by conventional means)

RACEMATE

$Acid_{RR}$ + $Acid_{SS}$ 50/50 mix

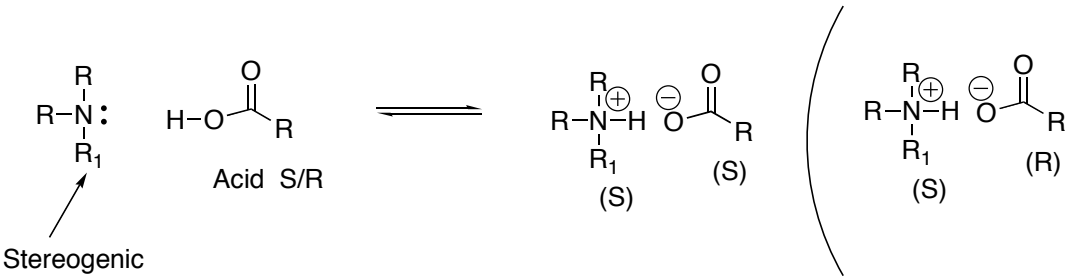
reaction (S-enatiomer reactant) ← optically pure

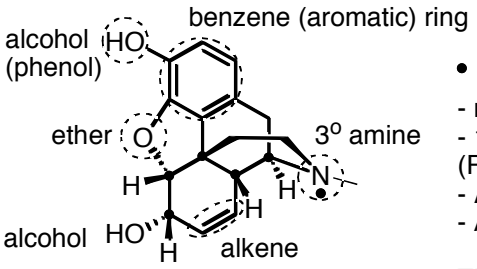
$Reactant(S)\text{-}Acid_{RR}$ S R R

$Reactant(S)\text{-}Acid_{SS}$ S S S

diastereomers

Formation of Diastereomer Salts





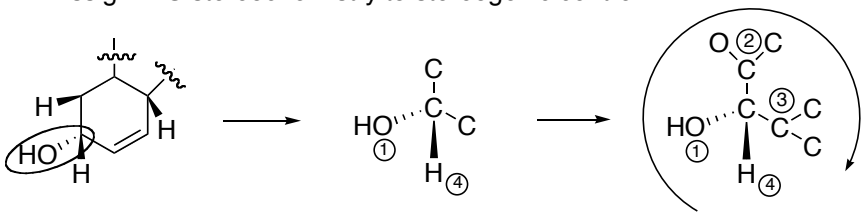
morphine

- stereogenic centers (6)

- morphine from Morpheus (god of sleep)
- 10% opium is morphine, from opium poppy (Papaver somniferum).
- **Alkaloid:** N-containing substance, from plants
- Analgesic and addictive

Theriac - ⟵ Therapeutics
Mithridates - king of Pontus

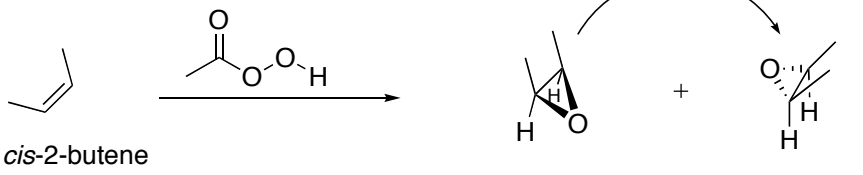
Assign R/S stereochemistry to stereogenic centre



CW rotation (but H is up) = S-configuration

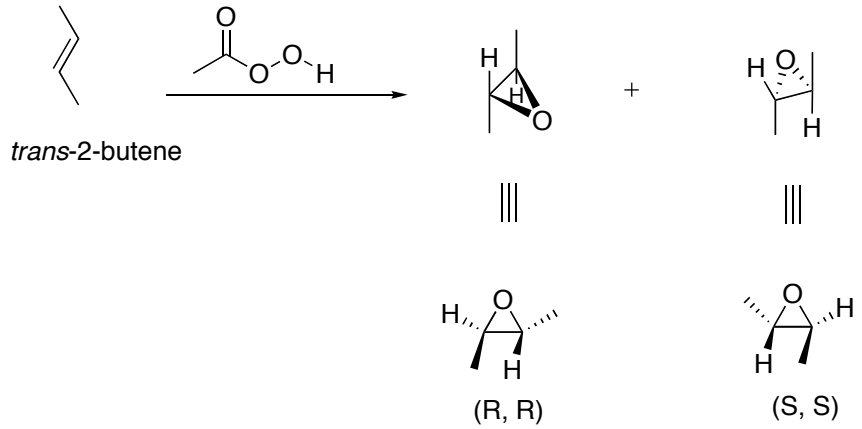
Stereospecific addition reaction: (see reactions of alkenes)

Eg. Epoxidation:



cis-2-butene

achiral - meso compounds
(plane of symmetry)



- both starting materials are achiral (not chiral), but each of the products can be chiral
- however they are formed as a 1:1 mixture of enantiomers – racemic mixture

Generally get pure (or partially pure) chiral products only if one of the reagents is chiral