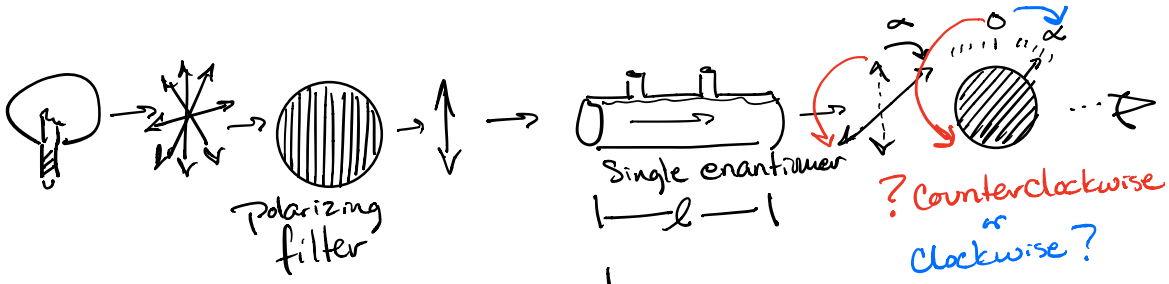
Optical Activity

Chemed. study

Last time we did Configration

R & S Cahn - Ingold - Prelog rules

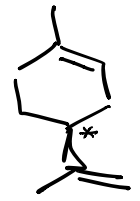
Optical Activity ⟹ Physical Property
How molecule reacts w/
Plane Polarized light



Polarimeter

$$\text{Specific Rotation} = [\alpha]_D^T = \frac{\alpha}{c\,l}$$

α = observed rotation
c = Concentration g/mL
l = path length in dm
D = Sodium D line 589nm
T = °C



(R)-(+)-Limonene

Solution made from hexane

C = 100 mL of 12.3 g limonene

20°C

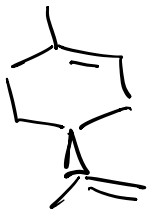
10 cm tube = 1 dm

α = 15.60° rotation

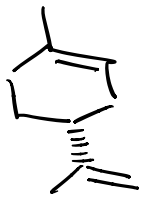
$[\alpha]$ =

$$[\alpha]_D^{20} = \frac{15.60^\circ}{1\ \text{dm} \times \frac{12.30\ \text{g}}{100\ \text{mL}}} = 126.8^\circ \frac{\text{mL}}{\text{dm g}}\ (\text{C } 0.123; \text{hexane})$$

$$[\alpha]_D^{20} = 126.8^\circ\ (\text{C } 0.123; \text{hexane})$$



(R)-(+)-Limonene



(S)-(-)-Limonene

(R)-(+)-Limonene

↑ Configuration ↑ Sign of Rotation of light

Absolute Configuration

What is our measure of purity?

How do we know we have a pure sample?

- Bp or Mp
- Chromatography TLC or Column or GC
- Spectroscopy IR, NMR, Mass Spec

work for Regular Compounds

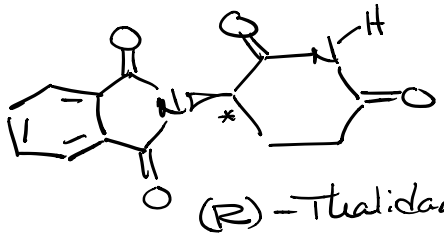
Enantiomers have all factors the same

Have same Mp & Bp

Have same Polarity ~~Chromatography~~

Have same Structure (atom connectivity) ~~Spectroscopy~~

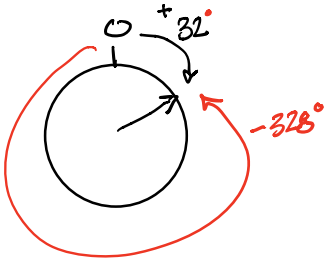
Leaves only optical Activity



(R)-Thalidamide

What if the molecule is new, never before measured, how do we know if + or − ?

*Molecule 23.2g / 100mL MeOH
20°C
1dm tube
$\alpha = 32°$ or $-328°$



Consider running polarimeter again cutting the conc. in half

23.2g / 200mL
1dm tube
20°C

observed Rotation

$$[\alpha]_D^T = \frac{\alpha}{c\,l}$$

$$[\alpha]_D^T = \frac{\alpha}{\frac{1}{2}c\,l}$$

Same

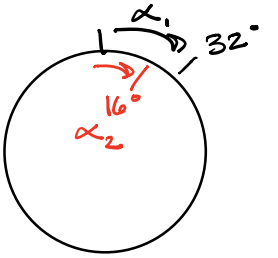
$$\frac{\alpha_2}{\frac{1}{2}c\,l} = \frac{\alpha_1}{c\,l}$$

$$\frac{\alpha_2}{\frac{1}{2}} = \alpha_1$$

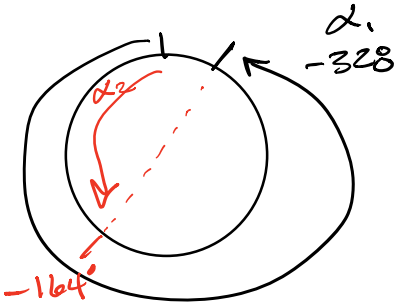
$$2\alpha_2 = \alpha_1$$

$$\alpha_2 = \frac{1}{2}\alpha_1$$

if Rotation was +



if Rotation was −



Enantiomeric Excess

Single isomer = Enantiomerically pure = Optically pure

50/50 mixture = Racemic ⇒ non-optically active mixture
mixture will not rotate light
$\alpha = 0°$ (+) & (−) Cancelling

non-racemic - Excess of one isomer over the other

%ee = % Enantiomeric excess

The amount of enantiomeric excess can be calculated in a number of ways:

Using observed optical activity

$$\%ee = \frac{|\text{observed } \alpha|}{|\alpha \text{ pure enantiomer}|} \times 100$$

Ex $\frac{50^\circ}{100^\circ} \times 100 = 50\%ee$

Using %

$$\%ee = |\%R - \%S|$$

Using Moles

$$\%ee = \frac{|\text{mole}_R - \text{moles}_S|}{\text{mole}_R + \text{moles}_S} \times 100$$

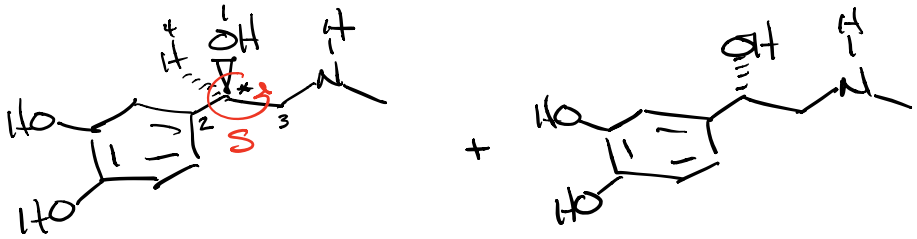
Thus

Mixture 75% R & 25% S

$$\%ee = |75\%R - 25\%S| = 50\%ee$$

$$5\%ee = |52.5\%R - 47.5\%S| = 5\%ee \text{ of } R$$

of the + isomer



(S)-epinephrine
Biologically active

+

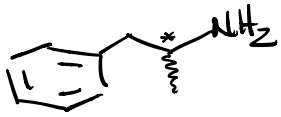
(R)
Enactive

0% ee Racemic
50/50 mix

Enantioselective → Chemical Rxn that make more of 1 isomer than other

Resolution → is the process of isolating single isomers from a racemic mixture

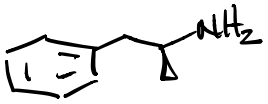
Chiral Resolution

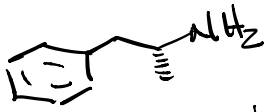
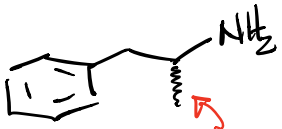
Racemic Mixture amphetamine 

▲ out

|||||| in

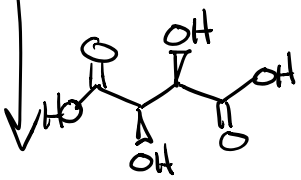
~~ both (Racemic at stereocenter)



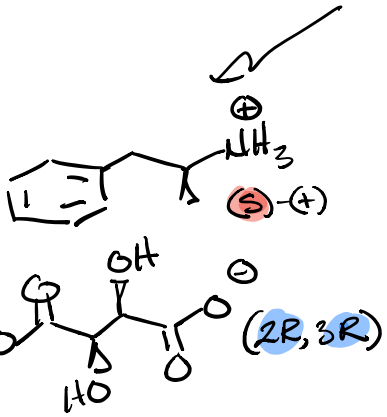
(S)-(+)-amphetamine 50/50  (R)-(-)-amphetamine = 

(±) Racemic

Resolving Agent



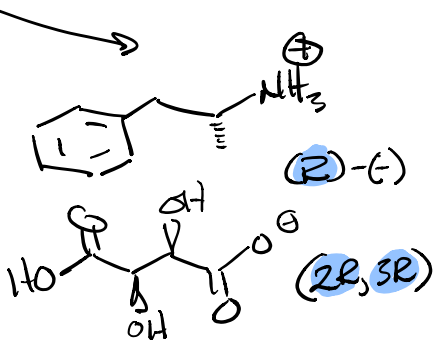
(2R,3R)-(+)-Tartaric Acid



(S)-(+) (2R,3R)

Salt Complex

[(S) + (2R,3R)](aq)



(R)-(-) (2R,3R)

[(R) + (2R,3R)] (S)

Relationship between salts

Enantiomers or Diastereomers?

⟹ Diastereomeric Salts

Stereochemical Symbols & Meanings

+ − Rotations of light

d l dextrorotatory = + levorotatory = −

R S Configuration based on Cahn-Ingold-Prelog

D L Used for Sugars & Amino acids

(Small Caps)