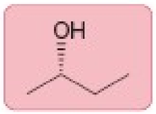
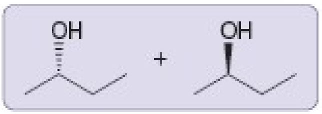
Because a 1:1 mixture of enantiomers is commonly encountered, it has a special name: a **racemic mixture** (or **racemate**).

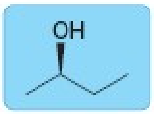
Racemic mixtures are optically inactive ($\alpha = 0°$). When plane-polarized light passes through such a mixture, the light encounters one molecule at a time, rotating slightly with each interaction. The light rotates clockwise when it encounters one enantiomer and counterclockwise with the other enantiomer. Since there are equal amounts of both the levorotatory and dextrorotatory enantiomers, the net rotation will be zero degrees. Although the individual compounds are optically active, the mixture is not optically active. The stereodescriptors (±) or (*dl*) can be used to denote a racemic mixture.



(*S*)-2-butanol
$[\alpha]_D^{20} = +13$



(±)-2-butanol (racemic mixture)
$[\alpha]_D^{20} = 0$

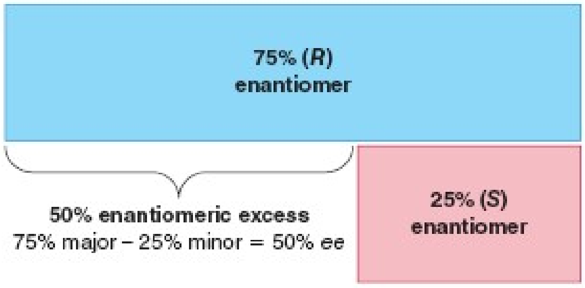


(*R*)-2-butanol
$[\alpha]_D^{20} = -13$

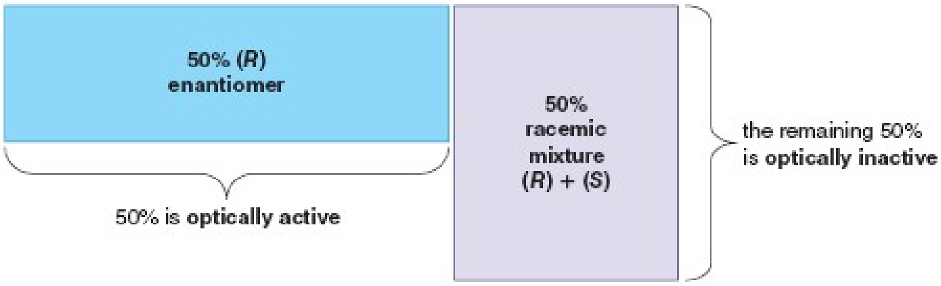
Enantiomeric Excess (*ee*)

If a mixture of enantiomers is not 1:1, then the rotations caused by each enantiomer will not completely cancel one another. Therefore, a sample containing both enantiomers in unequal amounts will be optically active. For example, imagine a sample of 2-butanol that contains 75% (*R*)-2-butanol and 25% (*S*)-2-butanol. In such a case, there is a 50% *excess* of the *R* enantiomer (75% − 25%).

$$ee = \%\text{ major enantiomer} - \%\text{ minor enantiomer}$$



In this case, the enantiomeric excess (*ee*) is 50%. The remainder of the sample is an equal mixture of both enantiomers. In other words, if a sample has 50% *ee*, the remaining 50% is a racemic mixture.



If only 50% of the sample is optically active, then we expect the specific rotation of that sample to be only 50% of the literature value. The specific rotation for pure (*R*)-2-butanol is −13, so the measured rotation for a sample with 50% *ee* will be half that amount (−6.5).

The *ee* of a sample can be measured experimentally by using a polarimeter and the following equation:

$$ee = \frac{[\alpha]\text{ of mixture}}{[\alpha]\text{ of pure enantiomer}} \times 100\%$$