The carbon-carbon double bond in alkenes such as ethene react with concentrated sulfuric acid. It includes the conversion of the product into an alcohol.

The reaction with ethene

Alkenes react with concentrated sulfuric acid in the cold to produce alkyl hydrogensulfates. Ethene reacts to give ethyl hydrogensulfate.

\[
\text{CH}_2=\text{CH}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{CH}_3\text{CH}_2\text{OSO}_2\text{OH}
\]

The structure of the product molecule is sometimes written as \(\text{CH}_3\text{CH}_2\text{HSO}_4\), but the version in the equation is better because it shows how all the atoms are linked up. You may also find it written as \(\text{CH}_3\text{CH}_2\text{OSO}_3\text{H}\).

Confused by all this? Don't be! All you need to do is to learn the structure of sulfuric acid. A hydrogen from the sulfuric acid joins on to one of the carbon atoms, and the rest joins on to the other one. Make sure that you can see how the structure of the sulfuric acid relates to the various ways of writing the formula for the product.

The reaction with propene

This is typical of the reaction with unsymmetrical alkenes. An unsymmetrical alkene has different groups at either end of the carbon-carbon double bond. If sulfuric acid adds to an unsymmetrical alkene like propene, there are two possible ways it could add. You could end up with one of two products depending on which carbon atom the hydrogen attaches itself to.

However, in practice, there is only one major product.

\[
\text{CH}_3\text{CH}=\text{CH}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{CH}_3\text{CHCH}_3 \quad \text{CH}_3\text{CH}_2\text{OSO}_2\text{OH}
\]

This is in line with Markovnikov's Rule, which says:

When a compound HX is added to an unsymmetrical alkene, the hydrogen becomes attached to the carbon with the most hydrogens attached to it already.

In this case, the hydrogen becomes attached to the \(\text{CH}_2\) group, because the \(\text{CH}_2\) group has more hydrogens than the \(\text{CH}\) group.
Notice that only the hydrogens directly attached to the carbon atoms at either end of the double bond count. The ones in the CH₃ group are totally irrelevant.

Using these Reactions to Make Alcohols

Making ethanol

Ethene is passed into concentrated sulfuric acid to make ethyl hydrogensulphate (as above). The product is diluted with water and then distilled. The water reacts with the ethyl hydrogensulphate to produce ethanol which distils off.

\[
\text{C}_2\text{H}_4\text{-C}_2\text{-O}_2\text{SO}_2\text{H} + \text{H}_2\text{O} \xrightarrow{\text{heat}} \text{CH}_3\text{-CH}_2\text{OH} + \text{H}_2\text{SO}_4
\]

Making propan-2-ol

More complicated alkyl hydrogensulphates react with water in exactly the same way. For example:

\[
\text{CH}_3\text{-CH}-\text{CH}_3 + \text{H}_2\text{O} \xrightarrow{\text{heat}} \text{CH}_3\text{-CH}-\text{CH}_2 + \text{H}_2\text{SO}_4
\]

Notice that the position of the -OH group is determined by where the HSO₄ group was attached. You get propan-2-ol rather than propan-1-ol because of the way the sulfuric acid originally added across the double bond in propene.

These reactions were originally used as a way of manufacturing alcohols from alkenes in the petrochemical industry. These days, alcohols like ethanol or propan-2-ol tend to be manufactured by direct hydration of the alkene because it is cheaper and easier.

Contributors

- Jim Clark (Chemguide.co.uk)