This page describes the reaction between alcohols and metallic sodium, and introduces the properties of the alkoxide that is formed. We will look at the reaction between sodium and ethanol as being typical, but you could substitute any other alcohol and the reaction would be the same.

### The Reaction between Sodium Metal and Ethanol

If a small piece of sodium is dropped into ethanol, it reacts steadily to give off bubbles of hydrogen gas and leaves a colorless solution of sodium ethoxide: \((\text{CH}_3\text{CH}_2\text{ONa})\). The anion component is an alkoxide.

\[
2\text{CH}_3\text{CH}_2\text{OH}_{(l)} + 2\text{Na}_{(s)} \rightarrow 2\text{CH}_3\text{CH}_2\text{O}^-_{(aq)} + 2\text{Na}^+_{(aq)} + \text{H}_2(g)
\]

If the solution is evaporated carefully to dryness, then sodium ethoxide \((\text{CH}_3\text{CH}_2\text{ONa})\) is left behind as a white solid. Although initially this appears as something new and complicated, in fact, it is exactly the same (apart from being a more gentle reaction) as the reaction between sodium and water - something you have probably known about for years.

\[
2\text{H}_2\text{O}_{(l)} + 2\text{Na}_{(s)} \rightarrow 2\text{OH}^-_{(aq)} + 2\text{Na}^+_{(aq)} + \text{H}_2(g)
\]

If the solution is evaporated carefully to dryness, then the sodium hydroxide \((\text{NaOH})\) is left behind as a white solid.

We normally, of course, write the sodium hydroxide formed as \((\text{NaOH})\) rather than \((\text{HONa})\) - but that's the only difference. Sodium ethoxide is just like sodium hydroxide, except that the hydrogen has been replaced by an ethyl group. Sodium hydroxide contains \((\text{OH}^-)\) ions; sodium ethoxide contains \((\text{CH}_3\text{CH}_2\text{O}^-)\) ions.

Note

The reason that the ethoxide formula is written with the oxygen on the right unlike the hydroxide ion is simply a matter of clarity. If you write it the other way around, it doesn't immediately look as if it comes from ethanol. You will find the same thing happens when you write formulae for organic salts like sodium ethanoate, for example.

There are two simple uses for this reaction:

- **To safely dispose of small amounts of sodium:** If you spill some sodium on the bench or have a small amount left over from a reaction you cannot simply dispose of it in the sink. It tends to react explosively with the water and comes flying back out at you again! It reacts much more gently with ethanol. Ethanol is, therefore, used to dissolve small quantities of waste sodium. The solution formed can be washed away without problems (provided you remember that sodium ethoxide is strongly alkaline - see below).

- **To test for the -OH group in alcohols:** Because of the dangers involved in handling sodium, this is not the best test for an alcohol at this level. Because sodium reacts violently with acids to produce a salt and hydrogen, you would first have to be sure that the liquid you were testing was neutral. You would also have to be confident that there was no trace of water present because sodium reacts with the -OH group in water even better than with the one in an alcohol. With those provisos, if you add a tiny piece of sodium to a neutral liquid free of water and get bubbles of hydrogen produced, then the liquid is an alcohol.
Ethoxide Ions are Strongly Basic

If you add water to sodium ethoxide, it dissolves to give a colorless solution with a high pH. The solution is strongly alkaline because ethoxide ions are Brønsted-Lowry bases and remove hydrogen ions from water molecules to produce hydroxide ions, which increase the pH.

\[ CH_3CH_2O^- + H_2O \rightarrow CH_3CH_2OH + OH^- \]

Ethoxide Ions are Good Nucleophiles

A nucleophile is a chemical species that carries a negative or partial negative charge that it uses to attack positive centers in other molecules or ions. Hydroxide ions are good nucleophiles, and you may have come across the reaction between a halogenoalkane (also called a haloalkane or alkyl halide) and sodium hydroxide solution. The hydroxide ions replace the halogen atom.

\[ CH_3CH_2CH_2Br + OH^- \rightarrow CH_3CH_2CH_2OH + Br^- \]

In this case, an alcohol is formed. The ethoxide ion behaves in exactly the same way. If you knew the mechanism for the hydroxide ion reaction, you could work out exactly what happens in the reaction between a halogenoalkane and ethoxide ion.

Compare this equation with the last one.

\[ CH_3CH_2CH_2OH + CH_3CH_2Br \rightarrow CH_3CH_2CH_2OCH_2CH_3 + Br^- \]

The only difference is that where there was a hydrogen atom at the right-hand end of the product molecule, an alkyl group is now present. Two alkyl (or other hydrocarbon) groups bridged by an oxygen atom is called an ether. This particular one is 1-ethoxypropane or ethyl propyl ether. This reaction is known as the Williamson Ether Synthesis and is a good method of synthesizing ethers in the lab.

Contributors

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