Electrophilic addition happens in many of the reactions of compounds containing carbon-carbon double bonds - the alkenes.

### The structure of ethene

We are going to start by looking at ethene, because it is the simplest molecule containing a carbon-carbon double bond. What is true of C=C in ethene will be equally true of C=C in more complicated alkenes.

![Diagram of ethene showing sigma and pi bonds.](image)

Ethene, C₂H₄, is often modeled as shown on the right. The double bond between the carbon atoms is, of course, two pairs of shared electrons. What the diagram doesn't show is that the two pairs aren't the same as each other. One of the pairs of electrons is held on the line between the two carbon nuclei as you would expect, but the other is held in a molecular orbital above and below the plane of the molecule. A molecular orbital is a region of space within the molecule where there is a high probability of finding a particular pair of electrons.

In this diagram, the line between the two carbon atoms represents a normal bond - the pair of shared electrons lies in a molecular orbital on the line between the two nuclei where you would expect them to be. This sort of bond is called a sigma bond.

The other pair of electrons is found somewhere in the shaded part above and below the plane of the molecule. This bond is called a pi bond. The electrons in the pi bond are free to move around anywhere in this shaded region and can move freely from one half to the other. The pi electrons are not as fully under the control of the carbon nuclei as the electrons in the sigma bond and, because they lie exposed above and below the rest of the molecule, they are relatively open to attack by other things.

### Electrophiles

An electrophile is something which is attracted to electron-rich regions in other molecules or ions. Because it is attracted to a negative region, an electrophile must be something which carries either a full positive charge, or has a slight positive charge on it somewhere.

Ethene and the other alkenes are attacked by electrophiles. The electrophile is normally the slightly positive (}
Electrophiles are strongly attracted to the exposed electrons in the pi bond and reactions happen because of that initial attraction - as you will see shortly.

You might wonder why fully positive ions like sodium, Na\(^+\), don't react with ethene. Although these ions may well be attracted to the pi bond, there is no possibility of the process going any further to form bonds between sodium and carbon, because sodium forms ionic bonds, whereas carbon normally forms covalent ones.

**Addition reactions**

In a sense, the pi bond is an unnecessary bond. The structure would hold together perfectly well with a single bond rather than a double bond. The pi bond often breaks and the electrons in it are used to join other atoms (or groups of atoms) onto the ethene molecule. In other words, ethene undergoes addition reactions.

For example, using a general molecule X-Y . . .

![Diagram](image)

**Summary: electrophilic addition reactions**

An addition reaction is a reaction in which two molecules join together to make a bigger one. Nothing is lost in the process. All the atoms in the original molecules are found in the bigger one.

An electrophilic addition reaction is an addition reaction which happens because what we think of as the "important" molecule is attacked by an electrophile. The "important" molecule has a region of high electron density which is attacked by something carrying some degree of positive charge.

**Understanding the electrophilic addition mechanism**

The mechanism for the reaction between ethene and a molecule X-Y.

![Diagram](image)

It is very unlikely that any two different atoms joined together will have the same electronegativity. We are going to assume that Y is more electronegative than X, so that the pair of electrons is pulled slightly towards the Y end of the bond. That means that the X atom carries a slight positive charge.
The slightly positive X atom is an electrophile and is attracted to the exposed pi bond in the ethene. Now imagine what happens as they approach each other.

![Diagram showing the approach of X and Y, with arrows indicating the movement of electrons and the formation of a covalent bond.]

You are now much more likely to find the electrons in the half of the pi bond nearest the XY. As the process continues, the two electrons in the pi bond move even further towards the X until a covalent bond is made. The electrons in the X-Y bond are pushed entirely onto the Y to give a negative Y⁻ ion.

**Important term**

An ion in which the positive charge is carried on a carbon atom is called a carbocation or a carbonium ion (an older term).

![Diagram showing the formation of a covalent bond between Y and the carbon.]

In the final stage of the reaction the electrons in the lone pair on the Y⁻ ion are strongly attracted towards the positive carbon atom. They move towards it and form a co-ordinate (dative covalent) bond between the Y and the carbon.
How to write this mechanism

The movements of the various electron pairs are shown using curly arrows.

Don't leave this page until you are sure that you understand how this relates to the electron pair movements drawn in the previous diagrams.

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