The development of organic chemistry as a science

Specification references

- *3.3.1*

Introduction

As a science, organic chemistry is less than 200 years old. Most historians of science date its origin to the early part of the 19th century, a time in which a mistaken belief was dispelled.

Originally the word ‘organic’ applied to those substances that were produced by living organisms. Berzelius wrote in 1815 that ‘the essential difference between inorganic and organic compounds was that the formation of organic compounds could only be achieved by the influence of a ‘vital force’ which was present in nature’. It was thought that no organic material could be synthesised in the laboratory. Sugar, dyes, starch, oils, alcohol, known since the earliest times, were thought to only be made by nature.

Learning objectives

After completing the worksheet you should be able to:

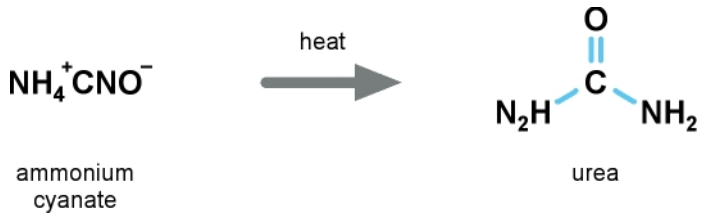
- recognise the contribution some scientists have made to the discipline of organic chemistry
- be aware of how scientists have been influenced by their own beliefs and the effect this had on the way they approached their work.

Background

Vitalism

Scientists first began to distinguish between organic compounds and inorganic compounds during the 1780s. Organic compounds were defined as ‘compounds that could be obtained from living organisms’. Inorganic compounds were those that came from non-living sources. Along with this distinction, a belief called ‘vitalism’ grew. According to this idea, a special influence known as a ‘vital force’ was necessary for the synthesis of an organic compound. Such synthesis, chemists held then, could take place only in living organisms. It could not take place in the test tubes and flasks of a chemistry laboratory

Between 1828 and 1850 a number of compounds that were clearly ‘organic’ were synthesised from sources that were clearly ‘inorganic’. Friedrich Wöhler accomplished the first of these syntheses in 1828. Wöhler found that evaporating an aqueous solution of the inorganic compound, ammonium cyanate, produced the organic compound, urea (a constituent of urine).



Followers of Berzelius argued that ammonium cyanate was not truly inorganic and, even if it were, the change from ammonium cyanate to urea was merely the result of an alteration of the positions of the atoms within the molecule. The molecule of urea was not, in any real sense, built up of a completely different substance.

If Wöhler's synthesis of urea did not settle the matter of the vital force, Kolbe's synthesis of acetic acid did. In 1845, Adolph Wilhelm Hermann Kolbe (1818–84), a pupil of Wöhler's, succeeded in synthesising acetic acid, unquestionably an organic substance. Furthermore, he synthesised it by a method which showed a clear line of chemical change from the constituent elements, carbon, hydrogen, and oxygen, to the final product, acetic acid.

With a growing number of preparations of other organic substances in the laboratory, it became increasingly evident that organic substances were subject to the same chemical laws as inorganic substances.

Although ‘vitalism’ died slowly and did not disappear completely from scientific circles until 1850, its passing made possible the flowering of the science of organic chemistry that has occurred since 1850.

Organic chemistry today

For the sake of convenience, we still use the term ‘organic chemistry’ to designate the study of carbon compounds. There are about 100 known elements, and the question naturally arises as to why the element carbon should be assigned such a unique place of honour as a separate branch of chemistry, whereas all the other elements and their compounds are put together to constitute the other branch called ‘inorganic chemistry’.

Over two million compounds are known that contain the element carbon, and about 80 000 new carbon compounds are made each year. It is therefore convenient to study the compounds of carbon separately, and this branch of chemistry is known as organic chemistry.

Questions

1 Describe why supporters of ‘vitalism’ believed it was not possible to synthesise organic compounds. (*2 marks*)

2 Suggest where chemists thought the ‘vital force’ came from. (*1 mark*)

3 **a** Give the *molecular* formulae for ammonium cyanate and urea. (*1 mark*)

b What can you deduce from their molecular formulae? (*1 mark*)

4 With Wöhler’s synthesis of urea, the original distinction between organic chemistry and inorganic began to fade. Explain why there was initial scepticism to Wöhler’s claims. (*3 marks*)

5 Kolbe was the first chemist to truly synthesise an organic substance from its elements. The compound's 'trivial' name is acetic acid. Find out its systematic name. (*1 mark*)

6 Draw the structural formula of ethanoic acid. (*1 mark*)

7 Ethanoic acid cannot be made directly from its elements; but it can be made indirectly from its elements in three steps:

- produce carbon monoxide;
- react the carbon monoxide with hydrogen to produce, methanol, CH_3OH;
- finally, react methanol with more carbon monoxide to produce ethanoic acid.

Suggest an equation for each step in the synthesis of ethanoic acid. Use structural formulae to represent the organic molecules (*3 marks*)