Organic Chemists: Contributing to Food Production

Introduction for teachers

This story is one of a number of case studies that show how chemistry studied at A-level is used by organic research chemists and how and why their work is important.

This case study describes how a synthetic compound based on a naturally occurring compound has become the world's largest agricultural fungicide. It is used on more than 120 different crops and had sales worth about £8,000 in 2011.

More detail for students about the importance of crop protection chemicals and how the fungicide is synthesised are provided below. This document is accompanied by a number of PowerPoint slides than can be used as a 'Starter' to lessons to provide a context when teaching organic synthesis.

Background - Why is this important?

Crop protection chemicals are important to farmers because they lead to increased yields and an improved quality in their crops by helping to control weeds, insects and fungal diseases.

Increasing crop yields also allows land to be set aside for wilderness and woodland, both of which have recreational and environmental value. In the decades ahead protecting crop yields will be even more important, with the world's population predicted to grow to nine billion by 2050.

Chemical science underpins research and development for crop protection products. It is estimated that the development and registering of a new plant protection product takes at least 9 years and costs upwards of £150 million. **Azoxystrobin** is the world's leading agricultural fungicide. It is a fully synthetic compound, whose invention was inspired by the structure and activity of the naturally-occurring fungicide strobilurin A.

Figure 1 Azoxystrobin is highly active against Soybean rust - treated (L) and untreated (R)

What did the organic chemists do?

"A reliable supply of food for the growing world population is critically important. Agricultural fungicides, of which azoxystrobin is the leading example, make a key contribution to the yield and quality of numerous crops."

John Clough, Organic Chemist

Nature, through evolution, produces many compounds with fungicidal activity, and optimises them for its own purposes. One example of such a compound is strobilurin A, which is produced by the mycelia of various Basidiomycete fungi that grow in rotting wood. Although it is fungicidal, strobilurin A has no practical use in agriculture because its activity is too weak and it is unstable in sunlight.

Armed with knowledge of the structure and activity of strobilurin A, a team of organic chemists in the UK began a programme of analogue synthesis. Their aim was to invent a fully synthetic compound with a broad spectrum of potent fungicidal activity, suitable physical properties for a systemic foliar-applied fungicide, and an excellent safety and environmental profile. This was a major project that finally culminated in the invention of **azoxystrobin**.

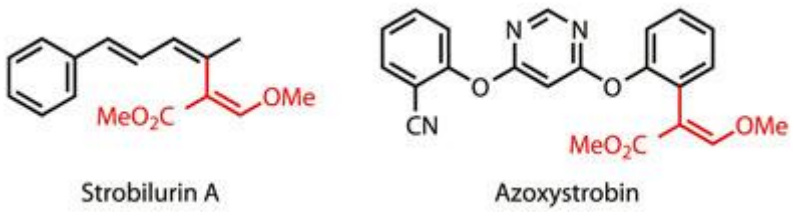

Figure 2 Azoxystrobin is the world's biggest selling fungicide

Azoxystrobin retains the 3-methoxypropenoate group that is found in strobilurin A, but also contains some additional chemical groups. The (Z)-olefinic bond of the natural product has been replaced by an ortho-disubstituted benzene ring, and the side-chain has been replaced by a substituted phenoxypyrimidinyloxy-group. By using specific chemical reactions, the organic chemists were able prepare azoxystrobin, in which the fungicidal activity and physical properties have been fine-tuned.

What is the impact?

Azoxystrobin is the world's largest agricultural fungicide, and is the leading member of a family of commercial synthetic strobilurins. It is used on more than 120 types of crop including potatoes, cotton, fruit, leafy vegetables, soya beans and wheat. It is available in around 100 countries with sales of about £800 million in 2011. Importantly, it retains the novel mode of action of strobilurin A, which means that it can be used to control fungi that have become resistant to other classes of fungicide.

Without organic synthesis, it would have been impossible to capture the potential of the natural compound and to optimise it to form a novel agricultural fungicide that is now widely used in the service of mankind.