



PROPANETHIAL S-OXIDE

The lachrymatory factor in onions



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Molecule of the Month - September 2007

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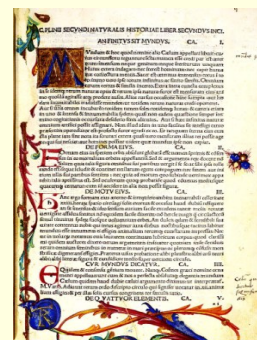
INTRODUCTION

The onion (*Allium cepa*) is a very popular vegetable which is grown in at least one hundred and seventy five different countries. It is a member of the lily family, *Liliaceae*, and is related to garlic, leeks, chives and scallions. The onion plant has a two year life cycle, it is a biennial plant. In the first year the plant forms the bulb, the part we harvest as food, as an energy store. The energy is used by the plant to form a flower and seeds in its second year and so reproduce. It has been used in food for thousands of years. Indeed, the vegetable is known to have been cultivated in ancient Egypt.



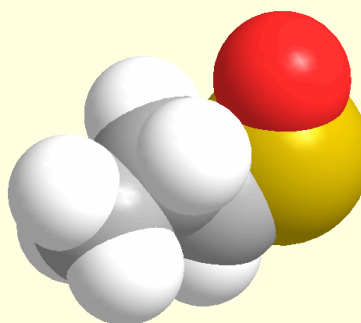
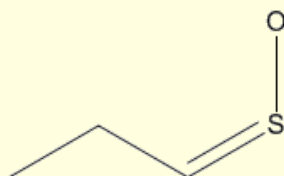
The Egyptians valued onions highly and they were used as a form of currency to pay workers who built the pyramids. They were also a symbol of eternity, because of their concentric layer structure, and a basket of onions was considered a very respectable funeral offering. Many of the pharaohs were buried with onions and archaeologists discovered small onions in the eye sockets of King Ramesses IV's mummy.

The Romans also valued onions and employed them for a variety of therapeutic applications. These have been recorded by Pliny the Elder in his *Naturalis historia* and include the treatment of dog bites, ulcerations of the mouth and alopecia, a disease which causes the hair to fall off the body. Many of these medical uses involve onions being mixed with other substances such as honey, vinegar or wine. Perhaps the most bizarre combination is a mixture of onions and "woman's milk" which was used to treat affections of the ears. Pliny incorrectly believed that onions could be employed to aid vision. The patient was to smell the onion until tears formed, or, better still, have their eyes rubbed with the juices!



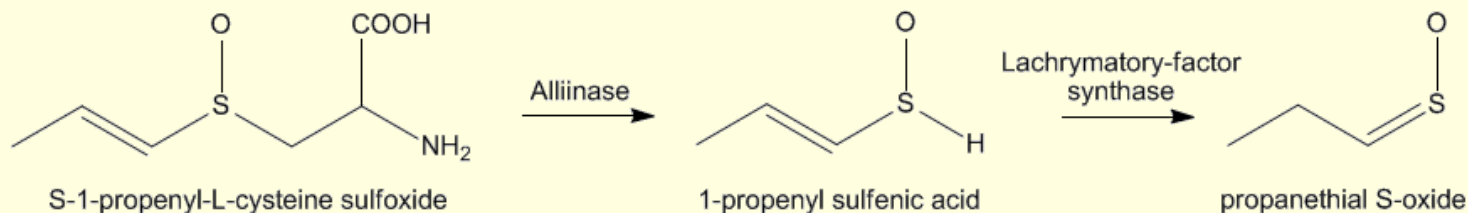
EYE WATERING CHEMISTRY

It is well known that people 'cry' when chopping onions but why is this so? The answer is that propanethial S-oxide (often referred to as thiopropanal S-oxide) is released into the air during chopping. Propanethial S-oxide is a lachrymator, an irritant that causes the eyes to fill with tears without damaging them. When a lachrymator comes into contact with the surface of the eye, the cornea, it is detected by the nervous system and triggers a response from the lachrymal (tear) glands. Tears are then produced in order to dilute the irritant. Propanethial S-oxide is relatively volatile and when its vapours come into contact with the eye a small amount reacts to form sulfuric acid, causing the burning and itching sensations that accompany the tears.



Propanethial S-oxide, C_3H_6SO

Interestingly, onions do not contain propanethial S-oxide and it is thought that onions produce this tear inducing compound to protect the plant from herbivores. It is the product of a series of chemical reactions, shown below, that occur once the onion has been damaged. Onions have many sulfur containing molecules within them, but the precursor to propanethial S-oxide has been identified as the amino acid S-1-propenyl-L-cysteine sulfoxide (which is very similar to the chemical [alliin](#), found in garlic). Cells are broken open as the onion is cut and this releases the enzyme alliinase and water, which react with S-1-propenyl-L-cysteine sulfoxide forming a mixture of products. These products are the precursors for a variety of compounds that form the flavour of onions and include 1-propenyl sulfenic acid. The lachrymator propanethial S-oxide is formed from 1-propenyl sulfenic acid in an enzyme catalysed reaction. It was originally thought that alliinase was responsible for this reaction. However, five years ago scientists in Japan identified another enzyme present in onions that carried out this process and named it lachrymatory-factor synthase.



Reaction scheme for the production of propanethial.

NO MORE TEARS?

Now that scientists understand the pathway for the production of propanethial S-oxide, research is being focussed on the production of genetically modified onions that do not contain the lachrymatory-factor synthase enzyme and hence will lead to tear-free cutting. However, many people have devised their own techniques to prevent 'crying'. These include trying to breath in the lachrymator to prevent it from reaching the eyes. For example, cutting an onion while holding an object, such as a teaspoon or a piece of bread, in the mouth.



Another suggestion is to cool the onion prior to chopping. The theory behind this method is that less of the volatile propanethial S-oxide will evaporate, reducing the amount that reaches the eye. Alternatively, heating the onion prior to chopping may also reduce tearing by denaturing the enzymes present, preventing the formation of the irritant. A method for those who fancy a challenge is to hold the onion under water whilst chopping it. Allowing any propanethial S-oxide formed to react before it reaches the eyes. Opinion on the efficacy of these methods is varied and they have been discounted by many people. So much so that one American company, [Broadway Panhandler](#), has developed onion goggles (pictured above). These glasses have a foam seal to prevent any vapours from entering the eye. Perhaps the most sensible suggestion is to use a very sharp knife so as to minimise cell damage. A step-by-step guide to chopping is available [here](#).

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