NZASE resource

How chemistry helps us

In this resource for students, NZASE Science Communicator Mike Stone summarises the many ways in which chemistry and chemists serve the community – benefiting our food, our health, our environment, criminal justice, as well as creating valuable new materials.

Work in a crime scene laboratory.

Chemistry and health

Almost everything in our bodies is either a chemical or a chemical reaction – and there is still a huge amount we do not understand.

The National Screening Unit (NSU) of the Ministry of Health tests blood from the 60,000 babies born in Aotearoa/NZ each year, to check they have the right levels of certain amino acids, **enzymes**, sugars, steroids, hormones and proteins. This involves measuring chemicals with other chemicals.

Four big drops of blood are collected from each baby onto a Guthrie card (left) and sent to the NSU from all over the country. This blood is tested for five different diseases. In most cases where there is more or less of something than needed, problems can be identified and sorted out right from birth.

One of these tests finds out how much phenylalanine a baby has, by whether there is enough to allow a certain kind of bacteria to grow. This amino acid is the building block of protein, but when there is a certain chemical missing from the liver, the phenylalanine cannot be used and it collects in the body.

This can cause severe brain damage, a condition called phenylketonuria (PKU). Only a few babies a year have PKU; finding out early and putting these babies on a low-protein diet can prevent any serious effects.

Chemistry and food

The food section of Environmental Science and Research (ESR) analyses food to make sure it is both fit for human consumption and includes what the label says it does.

ESR scientists make sure no **toxic** substances have got into the food at any stage. For instance, **trace metals** like zinc, tin, iron or copper, and heavy metals like lead, cadmium and mercury can sometimes be found in fresh and canned food.

Raw chicken may contain toxins.

One of the main problems in testing food is reducing the sample to a solution. You can't just put a whole meat pie or chicken piece in the instruments. You also have to be sure that any small amounts you find haven't come from something you yourself used in the testing process.

So, to test, say, chicken for mercury, it first must be dissolved in a solution. **Subcutaneous** pieces of flesh are put in a beaker with nitric, sulphuric and hydrochloric acids and heated. This produces a concentrated solution of the protein, leaving the fat floating on the top. Any mercury will also be in the solution, and can then be detected using an atomic absorption spectrometer.

Chemistry and new materials

Many manufacturing companies employ chemists to research and experiment, to produce new and better products.

The **epoxy resin** used on the hull of our 2021 America's Cup boat *AC75* is a classic example of the role of chemistry in developing new products. First used on the *KZ7* boat in 1987, it took two chemists six months' work to produce the new epoxy resin.

AC75, New Zealand's 2021 America's Cup entry.

It was designed for use on large surfaces of glass-reinforced fabric, tailor-made to withstand stresses and allow for working time and building procedures used to construct that boat. Now it is used widely by New Zealand boat builders and sold overseas.

Three chemists work in Epiglass Paint's New Zealand marine division, on quality control and developing new and improved products.

Chemistry and crime

Police work closely with ESR forensic chemists to solve many crimes. For example, they test and identify suspected drugs using chemical techniques and procedures. Samples come in from Police and Customs and the scientists at ESR have to find out what the substances are.

They deal with cannabis, heroin and cocaine powders, amphetamine tablets and valium. Even when a scientist thinks they know what a substance is by looking at it,

Fire investigator. Photo: Career Thoughts.

they still have to prove it chemically, so the evidence will stand up in court. This is done by first dissolving a powder or tablet in an acid solution and carrying out *ultraviolet (UV) spectroscopy*. The amount of UV light the substance absorbs is the clue to what the active ingredient is.

For instance, in the case of a valium tablet the active ingredient is diazepam. This is then extracted by putting the substance in an alkaline solution and adding an organic solvent. Then an *Infrared spectroscopy* is run, which can show up the unique fingerprint of any given substance.

Testing for the presence of blood with phenolphthalin.

Forensic scientists at ESR also work on explosives and arson cases, and match paint, blood and clothing samples found at the scene of a crime. Each substance is dealt with differently. In one recent case, seven black wool fibres found on a woman who had been attacked were compared with the suspect's black wool jersey. Even under a microscope the fibres looked the same. But chemical tests on the dyes of each sample showed that they were made of different compounds.

The three most common substances dealt with by forensic scientists are glass, debris from suspected arson, and paint.

When a burglar smashes a window to get into a building they almost invariably pick up tiny glass fragments. This glass is shaken from a suspect's clothing and *tested for its refractive index*. This test will show whether or not it came from the window in question.

After a fire, collected debris will be sent to ESR. This is heated and the **distillate** from the steam collected and analysed. If petrol or some other fuel was used to accelerate the fire, its particular hydrocarbon vapours can be identified.

Many tests are run on paint. For example, paint on a crowbar can be tested to see if it matches paint on a window which had been forced open, using *scanning electron microscopy* to identify the compounds in the paint. The particular mix of titanium, calcium, aluminium, zinc, sulphur, silicon, and sodium is unique for each paint.

Chemistry and environment

Occupational health in factories and offices, air pollution, and hazardous waste management are all the concern of environmental chemists.

Scientists at Worksafe work in occupational health, making sure that workers are protected from any toxic substances they are working with, or that may be present in the workplace. They go into factories and offices and measure indoor air pollution by things like solvents, dust and gases, using a variety of chemical and electronic methods.

Solvents, for instance, are absorbed in charcoal, which is taken back to the laboratory. There the sample is desorbed using carbon disulphide and put through a *gas chromatograph*. This separates out all the different solvents in a sample, and chemists can tell if the levels are dangerous.

To test for metals in the air (e.g., lead levels in a battery factory), dust is collected on a special filter paper by sucking air through it. This is then dissolved in nitric acid and analysed using an *atomic absorption spectrometer*.

The amount of dust in the air in different parts of Auckland is also routinely measured. Scientists monitor the total amount of dust as well as particular substances. Again, it is sucked through a filter, weighed and then dissolved in nitric acid so that lead levels can be calculated. Lead is so dangerous to our health no level is safe to breathe.

Levels of acidic gases in the air are also monitored, mainly sulphur dioxide (the gas that causes acid rain). This monitoring focuses on industrial areas, such as Penrose in Auckland.

Worksafe chemists also carefully identify and measure any gases or liquids leaking out of landfills. They are a potential pollution problem, as many have toxic wastes buried in them. The main worry is that **heavy metals** like mercury, cadmium, chromium or lead will leach out and pollute our waterways.

Smoke-stacks. Photo: Alfred Palmer. Wikimedia Commons.

Activities

1. Find the meaning of each of the 10 terms in **bold** and put them in your own words.
2. **A**. Make a mindmap showing how chemistry is used in the five areas discussed here, including the examples given.
   B. Then, in a different colour, see what you can add from your own knowledge.
   C. Use this mindmap to make a poster about the ways chemistry helps us.
3. **A**. Name five chemicals mentioned in this reading.
   B. Now try to add five more that you or your group know about.
4. Find out about one of the seven instruments and techniques in *underlined italics* mentioned in the article. What is it? How does it work (simply)? And what does it tell us?
5. Are all chemicals harmful? Make the case for and against.

Ngā Kupu

Iheu (~a ~nga) – Distil, distillation
Konganuku taumaha – Heavy metal
Mātai matū – Chemistry
Matū – Chemical, substance
Parahanga hau – Air pollution
Para mōrearea – Hazardous waste
Pūroi taihara – Illegal drug
Ruapara – Landfill, rubbish dump
Tahu whare – Arson
Tāmeha – Solvent
Tāoke – Toxic.

Te Aka Maori Dictionary and *Paekupu*