EDTA is used to prevent coagulation in blood samples as it removes the calcium ions that are an essential part of the clotting process.

Magnificent molecules

EDTA

Philip Robinson *investigates the molecular claw that purifies water, keeps food fresh and mops up poisonous metals*

Ethylenediaminetetraacetic acid, or EDTA, is a polyamino carboxylic acid. Its structure is like the four-fingered claws found in fairground 'crane games'. And its chemistry is pretty similar too: in all of its uses, EDTA acts as a chelating agent, a term derived from the Greek word for claw. But rather than grabbing cuddly toys, the EDTA claw is expert at grabbing metal ions.

Water softener

The term 'chelate' was originally coined in 1920 to describe interactions where a ligand molecule coordinates a metal ion through two of its atoms, in a pincer-like arrangement similar to the claws of a lobster. It now applies generally to any ligand capable of multiple coordination. When EDTA is fully deprotonated, its two amino nitrogen atoms and four carboxylate groups provide six points with which to bind a metal ion, and this enables it to wrap itself around the ion, enveloping it in an octahedral embrace. The molecule was first synthesised in the 1930s by a German chemist called Ferdinand Munz. To reduce the Nazi government's reliance on foreign chemical imports, Munz was working to find a replacement for citric acid. Citric acid (itself a chelating agent) was used as a water softener – removing calcium ions from water during textile dyeing. Munz noticed that an amine polycarboxylic acid performed much better than citric acid (which is a polycarboxylic acid), and suspected that a polyamine polycarboxylic acid might be even better. He was right.

Multi-functional

EDTA is still used as a water softener today, but that was just the beginning. EDTA's ability to sequester a range of metal ions makes it useful for removing metal ions wherever they are found. And they are found everywhere.

But it's not just about removal – as it grasps the metal, EDTA restricts the access of other species to the metal. So catalytically active metals can be isolated and prevented from interfering with other reactions. This use is particularly important in the paper industry, where EDTA will prevent manganese ions catalysing the breakdown of hydrogen peroxide – the bleaching agent used to whiten paper.

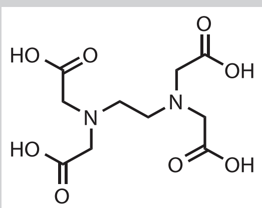
Similarly, EDTA acts as a preservative by removing metal cofactors required by enzymes that would otherwise cause food to spoil. This anti-enzymatic function also finds EDTA a use as an anticoagulant: by removing the calcium ions that are an essential part of the cascade of reactions leading to blood clotting, EDTA can be used to prevent the coagulation of blood samples and fouling of clinical or surgical equipment.

Cleaning up poisons

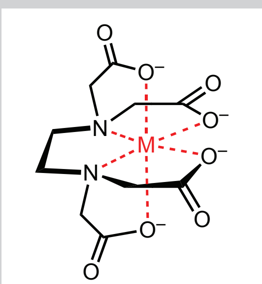
It also has medical applications in the field of chelation therapy. Chelation therapy uses chelating agents to remove poisonous metals from the body, and it began during the second world war when chemists at the University of Oxford developed a chelating agent to use as an antidote to the arsenic-based chemical weapon, lewisite. Other chelating agents were soon being investigated and EDTA was found to be particularly effective in the removal of lead.

After the second world war, EDTA was used to treat the workers who had painted US Navy vessels with lead-based paints, and it remains one of the first-choice treatments for acute lead poisoning.

As a metal-grabbing chemical claw, EDTA may be something of a one-trick molecule. But EDTA has certainly mastered that trick and made the most of it, making it a very useful – and memorable – compound, from the lab to the emergency medical kit.



Structure of EDTA



EDTA binds to a metal ion at six points to form an octahedral complex