A pinch of sodium

Sodium, ubiquitous on Earth in living organisms, oceans and minerals — all the way to table salt — may seem like one of the more ordinary elements. Margit S. Müller highlights why we, like the fairytale king, should not take it for granted.

In an old eastern European fairy tale a king asks his three daughters to describe their love for him. Whereas two of the daughters compare their affection to diamonds, pearls and gold, the third girl declares, "Father, I love you more than salt". Deeply offended to be likened to something so ordinary, the king banishes her. The princess disappears from the kingdom and, through a bit of witchcraft, so does all the salt. The story goes on to convince the king, and the reader, of the importance of seemingly mundane things in life, like salt. To make the same point without witchcraft, science had to go to much greater lengths.

The elements that make up what we refer to as table salt, sodium and chlorine, are both linked to Sir Humphry Davy. Davy discovered sodium in 1807 by isolating it from sodium hydroxide through electrolysis, and in 1811 he gave chlorine its name after unambiguously recognizing it as a pure element — although discovered in 1774 by the Swedish chemist Carl Wilhelm Scheele, chlorine was at the time considered to be a mixture with oxygen.

Sodium — an alkali metal, extremely reactive with oxygen and water — was thoroughly characterized in the years following its discovery. Reports dating back more than 150 years vividly describe its chemical and physical properties, most notably its bright yellow flame and its oxidation with water that releases hydrogen gas so rapidly that sodium fragments seem to ‘dance’ on the water’s surface. As well as containing valuable chemical information, these early reports illustrate much of the excitement arising from scientific curiosity: the reader can learn, for example, how hitting a spatula on sodium pieces sizzling on water will generate a loud bang along with a fountain of water and shattering of the bowl.

The intense yellow colour sodium imparts to flames went on to make for a beautiful application in fireworks. In fact, disrupting this sodium influx is a very effective way of killing someone.

Tetrodotoxin (TTX), a compound found in pufferfish (or fugu) that blocks voltage-gated sodium channels in nerve cells, is one of the most toxic substances on earth and has no known antidote. Intoxication with a sufficient dose — most commonly ingested through fugu dishes not prepared with enough care — will lead to death by respiratory failure within minutes to hours. The same characteristics, however, make TTX a very valuable research tool for studying neural networks that form the basis of the workings of the brain, of which we are just now beginning to gain an understanding.

Chemists have also recently gained a surprising insight into the nature of sodium itself. Yanming Ma and co-workers demonstrated that compression dramatically changes the optical properties of the metal. Exposing sodium to increasing pressure causes a successive loss of visible light reflection, turning it into a transparent material at about 200 GPa. This transition is ascribed to a hybridization between $p$ and $d$ electrons, repelled by core electrons to occupy the interstices within the sodium lattice.

From fireworks and nuclear reactors to the human brain and structural insights, sodium is undoubtedly part of an exciting history of scientific discovery, with no end in sight just yet.

References

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