W for tungsten and wolfram

Pilar Goya, Nazario Martín and **Pascual Román** relate how element 74 can be found in lamp filaments or weapon parts and also in literature, and continues to serve many purposes — no matter which of its two names it is given.

Element 74 holds a few records in the periodic table — it has the highest melting point of all metals and has been found to be the heaviest element to be used by living organisms; its carbide also displays a hardness approaching that of diamond. The element also holds a special place in literature, having given its name to a famous uncle[1], and has become a first name in the German language, borne by the knight and epic poet Wolfram von Eschenbach around the 1200s.

An intriguing aspect of element 74's history is the origin of its name — or, rather, its names[2], as it is known as either wolfram or tungsten. In the Spain of 1783, the brothers Juan José and Fausto Delhuyar were the first to isolate it as a pure element from the mineral wolframite (Fe, Mn)WO_4 and decided to name it wolfram[3]. Had they chosen 'hispanium', they might have avoided any confusion around names derived from minerals — but many years would elapse before elements were given names such as francium, polonium or europium.

The confusion occurred because, two years earlier, Scheele and Bergman — with whom Juan José Delhuyar had previously worked — had isolated the trioxide, WO_3, from a different mineral, $CaWO_4$, known as either scheelite or tungsten, from the Swedish *tung* (heavy) and *sten* (stone). Although the Delhuyar brothers went a step further, treating wolframic acid with charcoal in the absence of air and thus obtaining the pure metal, the element became known around the same time as either tungsten or wolfram. Both names persist today in different languages, but it is W that was adopted internationally as the symbol.

In any case, tungsten — as it is known in English — is a rare metal in the Earth's crust. It can be found in the form of oxide and salts in certain minerals, and is generally obtained from its ores as a dull grey powder. After compression and sintering under hydrogen at high temperatures, a grey–white lustrous metallic element, very hard and dense yet ductile, is obtained. It resembles chromium and molybdenum in many of its properties, and resists attack by oxygen, acids and alkalis[4]. It is used in a variety of commonly used objects, in the form of ballpoint pens (carbide materials), and as the metal in electrical components (lamp filaments, electrical resistances and X-ray tubes), hardening alloys (steel), tools for cutting (high-speed steel) or super alloys[5].

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In industry, its compounds are most often used as catalysts. Less known is the fact that, in the eighteenth century, the German geologist Rudolf Erich Raspe proposed that the bright yellow colour of tungsten trioxide could be used by artists, as according to him "in beauty it exceeds Turner's yellow colour by far"[6]; it is currently used as a dye. Tungsten also became a strategic element during the Second World War, as its high thermal resistance and the strength of its alloys made it an attractive component for use in penetrating projectiles[5].

Tungsten oxides were the first to be identified as electrochromic materials, when Satyen Deb noticed in 1969 that WO_3 reversibly changed colour on application of an external potential[7], and are still by far the most extensively studied for electrochromic applications. WO_3 is an amorphous phase composed of clusters of a few WO_6 octahedra, arranged in a corner-sharing perovskite-like manner, in which all of the metal centres are of the same type of W(VI). It is transparent as a thin film but, on electrochemical reduction, W(V) sites are formed that produce a blue colour — giving rise to the electrochromic effect.

Although still controversial, the mechanism behind this colouration is thought to involve electrons and protons or alkali metal ions (Li^+, Na^+ or K^+) being injected into and extracted from the material. In any case, a material needs to have an amorphous structure to exhibit good electrochromic behaviour. Polycrystalline films also show considerable optical modulation — but mostly in the near-infrared region.

The commercial opportunities for the development of electrochromic materials are enormous, with applications in displays, for example, and in smart windows, which are able to limit the amount of light and heat passing through. Some smart windows are already on the market, and are soon to be present in the most technically advanced cars and buildings. From electrical components to construction sites, be it tungsten or wolfram, element 74 is continuously proving to be a versatile element. ❐

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