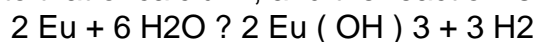


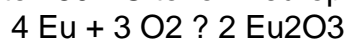
= 7 / 2) suppresses the superconductivity , which is induced by eliminating this local moment (J = 0 in Eu³⁺) .

== Chemical properties ==

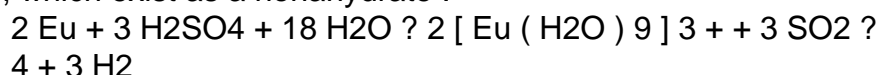
Europium is the most reactive rare earth element . It rapidly oxidizes in air , so that bulk oxidation of a centimeter @-@ sized sample occurs within several days . Its reactivity with water is comparable to that of calcium , and the reaction is



Because of the high reactivity , samples of solid europium rarely have the shiny appearance of the fresh metal , even when coated with a protective layer of mineral oil . Europium ignites in air at 150 to 180 ° C to form europium (III) oxide :



Europium dissolves readily in dilute sulfuric acid to form pale pink solutions of the hydrated Eu (III) , which exist as a nonahydrate :



== Eu (II) vs. Eu (III) ==

Although usually trivalent , europium readily forms divalent compounds . This behavior is unusual to most lanthanides , which almost exclusively form compounds with an oxidation state of + 3 . The + 2 state has an electron configuration 4f⁷ because the half @-@ filled f @-@ shell gives more stability . The + 2 state is highly reducing . In terms of size and coordination number , europium (II) and barium (II) are similar . For example , the sulfates of both barium and europium (II) are also highly insoluble in water . Divalent europium is a mild reducing agent , oxidizing in air to form Eu (III) compounds . In anaerobic , and particularly geothermal conditions , the divalent form is sufficiently stable that it tends to be incorporated into minerals of calcium and the other alkaline earths . This ion @-@ exchange process is the basis of the " negative europium anomaly " , the low europium content in many lanthanide minerals such as monazite , relative to the chondritic abundance . Bastnäsite tends to show less of a negative europium anomaly than does monazite , and hence is the major source of europium today . The development of easy methods to separate divalent europium from the other (trivalent) lanthanides made europium accessible even when present in low concentration , as it usually is .

== Isotopes ==

Naturally occurring europium is composed of 2 isotopes , ¹⁵¹Eu and ¹⁵³Eu , with ¹⁵³Eu being the most abundant (52 @. @ 2 % natural abundance) . While ¹⁵³Eu is stable , ¹⁵¹Eu was recently found to be unstable to alpha decay with half @-@ life of 5 + 11

? 3 × 10¹⁸ years , giving about 1 alpha decay per two minutes in every kilogram of natural europium . This value is in reasonable agreement with theoretical predictions . Besides the natural radioisotope ¹⁵¹Eu , 35 artificial radioisotopes have been characterized , the most stable being ¹⁵⁰Eu with a half @-@ life of 36 @. @ 9 years , ¹⁵²Eu with a half @-@ life of 13 @. @ 516 years , and ¹⁵⁴Eu with a half @-@ life of 8 @. @ 593 years . All the remaining radioactive isotopes have half @-@ lives shorter than 4 @. @ 7612 years , and the majority of these have half @-@ lives shorter than 12 @. @ 2 seconds . This element also has 8 meta states , with the most stable being ^{150m}Eu (t_{1/2} = 12 @. @ 8 hours) , ^{152m1}Eu (t_{1/2} = 9 @. @ 3116 hours) and ^{152m2}Eu (t_{1/2} = 96 minutes) .

The primary decay mode for isotopes lighter than ¹⁵³Eu is electron capture , and the primary mode for heavier isotopes is beta minus decay . The primary decay products before ¹⁵³Eu are isotopes of samarium (Sm) and the primary products after are isotopes of gadolinium (Gd) .

=== Europium as a nuclear fission product ===

Europium is produced by nuclear fission, but the fission product yields of europium isotopes are low near the top of the mass range for fission products.

Like other lanthanides, many isotopes, especially isotopes with odd mass numbers and neutron-rich poor isotopes like ^{152}Eu , have high cross sections for neutron capture, often high enough to be neutron poisons.

^{151}Eu is the beta decay product of samarium ^{151}Sm , but since this has a long decay half-life and short mean time to neutron absorption, most ^{151}Sm instead ends up as ^{152}Sm .

^{152}Eu (half-life 13.516 years) and ^{154}Eu (half-life 8.593 years) cannot be beta decay products because ^{152}Sm and ^{154}Sm are non-radioactive, but ^{154}Eu is the only long-lived "shielded" nuclide, other than ^{134}Cs , to have a fission yield of more than 2.5 parts per million fissions. A larger amount of ^{154}Eu is produced by neutron activation of a significant portion of the non-radioactive ^{153}Eu ; however, much of this is further converted to ^{155}Eu .

^{155}Eu (half-life 4.7612 years) has a fission yield of 330 parts per million (ppm) for uranium ^{235}U and thermal neutrons; most of it is transmuted to non-radioactive and nonabsorptive gadolinium ^{156}Gd by the end of fuel burnup.

Overall, europium is overshadowed by caesium ^{137}Cs and strontium ^{90}Sr as a radiation hazard, and by samarium and others as a neutron poison.

=== Occurrence ===

Europium is not found in nature as a free element. Many minerals contain europium, with the most important sources being bastnäsite, monazite, xenotime and loparite.

Depletion or enrichment of europium in minerals relative to other rare earth elements is known as the europium anomaly. Europium is commonly included in trace element studies in geochemistry and petrology to understand the processes that form igneous rocks (rocks that cooled from magma or lava). The nature of the europium anomaly found helps reconstruct the relationships within a suite of igneous rocks.

Divalent europium (Eu^{2+}) in small amounts is the activator of the bright blue fluorescence of some samples of the mineral fluorite (CaF_2). The reduction from Eu^{3+} to Eu^{2+} is induced by irradiation with energetic particles. The most outstanding examples of this originated around Weardale and adjacent parts of northern England; it was the fluorite found here that fluorescence was named after in 1852, although it was not until much later that europium was determined to be the cause.

== Production ==

Europium is associated with the other rare earth elements and is, therefore, mined together with them. Separation of the rare earth elements is a step in the later processing. Rare earth elements are found in the minerals bastnäsite, loparite, xenotime, and monazite in mineable quantities. The first two are orthophosphate minerals LnPO_4

4 (Ln denotes a mixture of all the lanthanides except promethium), and the third is a fluorocarbonate LnCO_3F . Monazite also contains thorium and yttrium, which complicates handling because thorium and its decay products are radioactive. For the extraction from the ore and the isolation of individual lanthanides, several methods have been developed. The choice of method is based on the concentration and composition of the ore and on the distribution of the individual lanthanides in the resulting concentrate. Roasting the ore and subsequent acidic and basic leaching is used mostly to produce a concentrate of lanthanides. If cerium is the dominant lanthanide, then it is converted from cerium (III) to cerium (IV) and then precipitated. Further separation by solvent extractions or ion exchange chromatography yields a fraction which is enriched in europium. This fraction is reduced with zinc, zinc/amalgam, electrolysis or other methods converting the

europium (III) to europium (II) . Europium (II) reacts in a way similar to that of alkaline earth metals and therefore it can be precipitated as carbonate or is co -@-@ precipitated with barium sulfate . Europium metal is available through the electrolysis of a mixture of molten EuCl_3 and NaCl (or CaCl_2) in a graphite cell , which serves as cathode , using graphite as anode . The other product is chlorine gas .

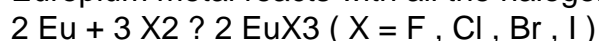
A few large deposits produce or produced a significant amount of the world production . The Bayan Obo iron ore deposit contains significant amounts of bastnäsite and monazite and is , with an estimated 36 million tonnes of rare earth element oxides , the largest known deposit . The mining operations at the Bayan Obo deposit made China the largest supplier of rare earth elements in the 1990s . Only 0 @.@ 2 % of the rare earth element content is europium . The second large source for rare earth elements between 1965 and its closure in the late 1990s was the Mountain Pass rare earth mine . The bastnäsite mined there is especially rich in the light rare earth elements (La @-@ Gd , Sc , and Y) and contains only 0 @.@ 1 % of europium . Another large source for rare earth elements is the loparite found on the Kola peninsula . It contains besides niobium , tantalum and titanium up to 30 % rare earth elements and is the largest source for these elements in Russia .

= = Compounds = =

Europium compounds tend to exist trivalent oxidation state under most conditions . Commonly these compounds feature Eu (III) bound by 6 ? 9 oxygenic ligands , typically water . These compounds , the chlorides , sulfates , nitrates , are soluble in water or polar organic solvent . Lipophilic europium complexes often feature acetylacetonate @-@ like ligands , e.g. , Eufod .

= = = Halides = = =

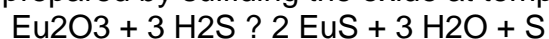
Europium metal reacts with all the halogens :



This route gives white europium (III) fluoride (EuF_3) , yellow europium (III) chloride (EuCl_3) , gray europium (III) bromide (EuBr_3) , and colorless europium (III) iodide (EuI_3) . Europium also forms the corresponding dihalides : yellow @-@ green europium (II) fluoride (EuF_2) , colorless europium (II) chloride (EuCl_2) , colorless europium (II) bromide (EuBr_2) , and green europium (II) iodide (EuI_2) .

= = = Chalcogenides and pnictides = = =

Europium forms stable compounds with all of the chalcogens , but the heavier chalcogens (S , Se , and Te) stabilize the lower oxidation state . Three oxides are known : europium (II) oxide (EuO) , europium (III) oxide (Eu_2O_3) , and the mixed @-@ valence oxide Eu_3O_4 , consisting of both Eu (II) and Eu (III) . Otherwise , the main chalcogenides are europium (II) sulfide (EuS) , europium (II) selenide (EuSe) and europium (II) telluride (EuTe) : all three of these are black solids . EuS is prepared by sulfiding the oxide at temperatures sufficiently high to decompose the Eu_2O_3 :



The main nitride is europium (III) nitride (EuN) .

= = History of study = =

Although europium is present in most of the minerals containing the other rare elements , due to the difficulties in separating the elements it was not until the late 1800s that the element was isolated . William Crookes observed the phosphorescent spectra of the rare elements and observed spectral lines later assigned to europium .

Europium was first found in 1890 by Paul Émile Lecoq de Boisbaudran , who obtained basic fractions from samarium @-@ gadolinium concentrates which had spectral lines not accounted for by samarium or gadolinium . However , the discovery of europium is generally credited to French

chemist Eugène @-@ Anatole Demarçay , who suspected samples of the recently discovered element samarium were contaminated with an unknown element in 1896 and who was able to isolate it in 1901 ; he then named it europium .

When the europium @-@ doped yttrium orthovanadate red phosphor was discovered in the early 1960s , and understood to be about to cause a revolution in the color television industry , there was a scramble for the limited supply of europium on hand among the monazite processors , as the typical europium content in monazite is about 0 @. @ 05 % . However , the Molycorp bastnäsite deposit at the Mountain Pass rare earth mine , California , whose lanthanides had an unusually high europium content of 0 @. @ 1 % , was about to come on @-@ line and provide sufficient europium to sustain the industry . Prior to europium , the color @-@ TV red phosphor was very weak , and the other phosphor colors had to be muted , to maintain color balance . With the brilliant red europium phosphor , it was no longer necessary to mute the other colors , and a much brighter color TV picture was the result . Europium has continued to be in use in the TV industry ever since as well as in computer monitors . Californian bastnäsite now faces stiff competition from Bayan Obo , China , with an even " richer " europium content of 0 @. @ 2 % .

Frank Spedding , celebrated for his development of the ion @-@ exchange technology that revolutionized the rare earth industry in the mid @-@ 1950s , once related the story of how he was lecturing on the rare earths in the 1930s when an elderly gentleman approached him with an offer of a gift of several pounds of europium oxide . This was an unheard @-@ of quantity at the time , and Spedding did not take the man seriously . However , a package duly arrived in the mail , containing several pounds of genuine europium oxide . The elderly gentleman had turned out to be Herbert Newby McCoy who had developed a famous method of europium purification involving redox chemistry .

= = Applications = =

Relative to most other elements , commercial applications for europium are few and rather specialized . Almost invariably , they exploit its phosphorescence , either in the + 2 or + 3 oxidation state .

It is a dopant in some types of glass in lasers and other optoelectronic devices . Europium oxide (Eu_2O_3) is widely used as a red phosphor in television sets and fluorescent lamps , and as an activator for yttrium @-@ based phosphors . Color TV screens contain between 0 @. @ 5 and 1 g of europium oxide . Whereas trivalent europium gives red phosphors , the luminescence of divalent europium depends on the host lattice , but tends to be on the blue side . The two classes of europium @-@ based phosphor (red and blue) , combined with the yellow / green terbium phosphors give " white " light , the color temperature of which can be varied by altering the proportion or specific composition of the individual phosphors . This phosphor system is typically encountered in helical fluorescent light bulbs . Combining the same three classes is one way to make trichromatic systems in TV and computer screens . Europium is also used in the manufacture of fluorescent glass . One of the more common persistent after @-@ glow phosphors besides copper @-@ doped zinc sulfide is europium @-@ doped strontium aluminate . Europium fluorescence is used to interrogate biomolecular interactions in drug @-@ discovery screens . It is also used in the anti @-@ counterfeiting phosphors in euro banknotes .

An application that has almost fallen out of use with the introduction of affordable superconducting magnets is the use of europium complexes , such as $\text{Eu}(\text{fod})_3$, as shift reagents in NMR spectroscopy . Chiral shift reagents , such as $\text{Eu}(\text{hfc})_3$, are still used to determine enantiomeric purity .

A recent (2015) application of europium is in quantum memory chips which can reliably store information for days at a time ; these could allow sensitive quantum data to be stored to a hard disk @-@ like device and shipped around the country .

= = Precautions = =

There are no clear indications that europium is particularly toxic compared to other heavy metals . Europium chloride , nitrate and oxide have been tested for toxicity : europium chloride shows an acute intraperitoneal LD50 toxicity of 550 mg / kg and the acute oral LD50 toxicity is 5000 mg / kg . Europium nitrate shows a slightly higher intraperitoneal LD50 toxicity of 320 mg / kg , while the oral toxicity is above 5000 mg / kg . The metal dust presents a fire and explosion hazard .