



PHYSICO-CHEMICAL PROPERTIES OF HEAVY METAL IONS, THEIR PRESENCE IN ENVIRONMENTAL OBJECTS AND EFFECTS ON THE HUMAN BODY

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ABSTRACT

Heavy metals have a significant impact on plant growth and development, as well as atmospheric and water quality. Such contaminants are important and worrying as the demand for food safety increases. There are a variety of sources for heavy metal, such as natural and man-made, industrial and air sources. Toxic heavy metals have a negative impact on plants, animals, humans and ultimately on the environment, as well as on all living organisms, including food. This is dangerous for human life.

KEY WORDS: cadmium, zinc, mercury, ion, toxicity, phosphate, chloride, electron, nitrate, sulfate, heavy metal.

Аннотация: Контроль содержания тяжелых металлов в объектах окружающей среды на уровне их предельно допустимых концентраций является важной экологической задачей. Подробным образом токсичность кадмия проявляется сильнее в системе с дефицитом цинка, а токсичность свинца усугубляется недостаточным поступлением кальция.

Ключевые слова: кадмий, цинк, ртуть, ион, токсичность, фосфат, хлорид, электрон, нитрат, сульфат, тяжелый металл.

Cadmium. In the periodic system of elements of D. I. Mendeleev, cadmium is in side subgroup of group II between zinc and mercury. The structure of electronic shells is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2$. Group II elements are characterized by the formation of positive doubly charged cations as a result of the loss of two valence electrons [1].

The Cd^{2+} ion is in many respects similar to Zn^{2+} ; it is also colorless and can exist in neutral and acidic media. Upon dissolution of cadmium salts in

water, as well as during the interaction of CdO , $Cd(OH)_2$ with acids, stable aquatic complexes $[Cd(H_2O)_6]^{2+}$ are formed. Of the simple salts of cadmium, chlorides, bromides, iodides, nitrates, and sulfates are readily soluble in water. Slightly soluble, like zinc, sulfide, carbonate, fluoride, phosphate, arsenate, chromate, oxalate, silicate, cyanide. As with zinc, a large number of basic salts are known. The stereochemistry of copper compounds is given in the table [2,3].

Table 1.3 - The oxidation state and stereochemistry of cadmium compounds

Oxidation state	Coordination number	Geometry	Connection Examples
Cd(II) d^{10}	2	Linear	$Cd(C_2H_5)_2$
	4	Tetrahedron	$[CdCl_4]^{2-}$
	5	Trigonal bipyramid	$[CdCl_5]^{3-}$
		Square pyramidal	$[Cd((C_2H_5)_2NCS_2)_2]_2$
6	Octahedral	$[Cd(NH_3)_6]^{2+}$	



Cd is characterized by an increase in covalent interaction with elements - donors of electron pairs in heteroatomic compounds as a result of an increase in the deformability of the electron shell. The manifestation of the specific effects of complex formation in cadmium is a consequence of the growth of polarization interactions [4]. Cadmium, like zinc, has a filled outer d-shell and in many ways behaves like zinc, but it forms more stable complexes already with N- and S-donor than with O-donor ligands. It also forms stronger coordination compounds with halide ions and CN-, Cd (OH)₂ no longer has amphoteric properties.

Cadmium, like to zinc, is found in compounds exclusively in the form of the divalent Cd²⁺ ion. The cadmium ion is larger than the zinc ion; in size, it is closer to calcium ion, which allows the use of the so-called Ca-sample [5]. However, by the nature of the complexation of cadmium, it is closest to zinc; as a result, compared with zinc, the number of poisonings is much more common. Acute cadmium poisoning manifests itself in the form of a headache, intestinal cramps, and vomiting. The reason for its occurrence can even be drinking water or other liquids, especially acidic ones, which come into contact with cadmium-containing objects. Once orally ingested in mammals, cadmium binds to hemoglobin of red blood cells and glutathione [6].

There is currently no special therapy for the treatment of cadmium poisoning, and chelating agents (CaH₂EDTA + Na₂H₂EDTA, 2,3-dimercapto-pro-panol-1) can contribute to the redistribution of cadmium to the kidneys, which is also dangerous. Abundant intake of phosphate, vitamin D, zinc, calcium and a protein diet can somewhat reduce cadmium poisoning. It should also be borne in mind that absorbed cadmium is excreted very slowly from the body, and the half-life is more than 10 years. Therefore, during the course of a person's life, the cadmium content in the kidneys increases and averages from 0 at birth to a load of 20 mg in old age. The cadmium content in drinking and natural waters, in food products is tightly controlled by analytical services. The maximum permissible concentrations of cadmium are established in the relevant legislative acts and in drinking water are 0.001 mg / l [13], in marine - 0.01, in fishery reservoirs - 0.001 mg / l [9] and in food 0.02 - 0.05 mg / kg. Extensive distribution of cadmium in fuel, ore dumps, fertilizers, leads to a gradual increase in the concentration of this element in the environment. Its initially low level can increase significantly, especially in the vicinity of industrial enterprises, such as smelting. As a result, workers in this industry, as well as the people living nearby, suffer from high concentrations of cadmium, and cadmium poisoning in this area is becoming a major problem. The main sources of cadmium release into the atmosphere are steel production, waste incineration

(cadmium pigments and stabilizers, nickel-cadmium batteries, plastics); in the hydrosphere - polymetallic ores and the non-ferrous metal industry.

Cement production wastes, wastewater, municipal waste, and ash generated during fuel combustion are all the main sources of cadmium in the soil. Phosphate fertilizers used in agriculture also contribute cadmium to arable land. In fact, it is practically not bound by humic substances, however, clay and silty clay exhibit a high capacity in relation to cadmium; medium capacity - sandy loam; lower - silty loam, sandy loam, sandy loam, sand. Its content in contaminated soils can vary from 57 mg / kg to 160 mg / kg.

In modern industry, cadmium is used very widely: in the production of phosphors, cermets, polymers, pigments for porcelain and glass, color television and X-ray screens, artificial leather, galvanic coatings. Despite the high toxicity of the element, more than half of its world production is used in anticorrosion coating, since cadmium plating of steel products protects them from corrosion much more effectively than nickel plating, galvanizing and tinning.

Outside of the production of cadmium, it enters the human and animal body mainly through food and water. Also, smoking may be one of the means of cadmium supply. Organic substances contained in water reduce the availability of cadmium to the body. At the same time, the assimilation of the element by water organisms is increased by some complexing substances forming hydrophobic complexes with heavy metals (for example, dithiocarbamates and xanthates). The absorption and toxicity of cadmium increases with increasing temperature, and the increase in hardness or salinity of the water decreases. Many microorganisms, algae and mollusks easily accumulate cadmium; the bio concentration coefficients of which are of the order of ~ 10³ - 10⁵.

Lead. In the periodic system of elements of D. I. Mendeleev, lead is in the main subgroup of group IV; its serial number 82. The structure of the electronic shells – $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 4f^{14} 5s^2 5p^6 5d^{10} 6s^2 6p^2$. Four electrons are located in the outer electron layer of the lead atom, and unpaired electrons are located on each p-orbit in accordance with the Hund rule, which relatively easily transfer to the orbitals of the element interacting with it. On the 6s orbitals with opposite spins are two s-electrons. Although they are also binding electrons, their removal requires significantly higher energy costs.

For lead, the most characteristic oxidation state is +2: PbO, PbS, PbSO₄, PbCO₃, PbCrO₄, Pb(NO₃)₂, PbC₂O₄ and others. Pb (IV) compounds are less stable and not numerous: PbO₂, PbF₄, Pb(SO₄)₂, Pb(CH₃COO)₄.



As a p-element of group IV and one of the great periods, it has an 18-electron pre-external and incomplete external level. The consequence of this is its high polarizability and a tendency to complexation, including the formation of hydroxocomplexes, for soluble lead salts, significant light absorption in the UV region. In almost all compounds, the coordination number of lead exceeds the oxidation state. The presence of energetically accessible vacant p and nd orbitals creates the conditions for the manifestation of various values of the coordination number up to 12.

The state of lead in solutions is due to hydrolysis and the formation of poly-nuclear hydroxocomplexes, and therefore this should be taken into account when comprehending the results obtained and choosing the conditions for analysis. The Pb^{2+} ion in aqueous solutions is characterized by the formation of a hexaqua complex - $[Pb(H_2O)_6]^{2+}$, however, in recent years there have been serious discussions about the aqua-environment of a doubly charged lead cation. So, the authors of [21] point to the possibility of the existence of intrasphere complexes $[Pb(H_2O)_n]^{2+}$, where $n = 6 \dots 12$.

Lead (II) forms the most stable complexes with $S_2O_3^{2-}$ and $P_2O_7^{4-}$ ions, and relatively less stable ones with halide and nitrite ions. The least durable are fluoride and nitrate complexes.

Lead with organic substances forms simple and complex compounds, which for the most part are more stable than inorganic ones. Compounds of various classes of organic substances are used as lead reagents, the main place among which is occupied by nitrogen and sulfur-containing reagents. Lead is one of the important metals widely used in technology, on which the development of modern civilization largely depends. It takes the fourth place in the group of non-ferrous metals in terms of industrial production after aluminum, copper and zinc. Lead is used in the chemical, electro-technical and nuclear industries. A large amount of metal goes to the manufacture of batteries, as well as compounds, of which the first place belongs to a large-capacity product - tetraethyl lead.

Millions of tons of this metal are produced annually to meet the existing needs of world production. As a result, an impressive amount of lead with exhaust gases and other industrial wastes is scattered into the environment. The practical use of lead compounds and many natural products containing lead leads to the same results. As a result, lead penetrates into all areas of habitat - not only in the vicinity of industrial centers, but also in the most remote, almost uninhabited corners of our planet. Ultimately, it enters the body of plants, animals, and humans.

The lead content in drinking and natural waters, in food products is also controlled by analytical services. The maximum permissible

concentration of lead in various food objects is 0.1–10 mg / kg [20], in drinking water - 0.03 mg / l, in marine - 0.1 mg / l and fishery water bodies - 0.01 mg / l.

Lead has been known for almost five thousand years, and Greek and Arab scholars already knew about its harm to humans. Lead is a powerful toxicant that affects all living organisms. Ions of this element are dangerous not only by pathogenic influence, but also by cumulateness, with a high coefficient of accumulation in the body [3], low speed and incomplete elimination.

The absorbed lead accumulates in the bone tissue, from where it is then released due to osteoporosis, becoming the cause of “delayed” toxicity. On average, the modern human body contains about 120 mg of lead. Acute lead poisoning leads to vomiting and loss of appetite; chronic poisoning gradually leads to anemia, kidney disorders, and affects the nervous system. Its effect is enhanced by a lack of calcium and iron in the body. Unlike cadmium, some forms of lead poisoning are effectively treated with Ca-EDTA-based drugs. The toxic effect of lead is not limited to inhibition of the nervous and blood-forming systems, it is also known that it has a nephrotoxic effect, affects blood pressure control through the renin-angiotensin system, and affects reproductive function.

Conclusion For humans and animals, cadmium and lead, as well as toxins currently accumulated for their compounds, have a pathogenic effect, albeit in relatively small amounts, so in some industrial plants the content of these toxicants are determined by appropriate methods should be observed. Currently accumulated data on the toxicity to humans and animals of cadmium and lead, as well as their compounds, indicate the manifestation of pathogenic effects even in relatively small quantities, which requires reliable control of the content of these toxicants at or below the MPC in specific industries and environmental facilities.

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