

## **THE USE OF GOLD IN COSMETIC AND MEDICINAL PRODUCTS**

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### **ABSTRACT**

The use of gold as a cosmetic and medicinal ingredient has a long history that is still developing. Their introduction into use was based on observing the body's reaction after treatment with these metals, today their action is based on modern, wide-scale scientific research. Scientific literature presents gold as having anti-inflammatory, antibacterial and anti-aging properties, but its metabolic functions are still under investigation. The development of technology has led to the production of Au in the form of nanoparticles, which results in their greater efficiency compared to standard forms and new applications. The aim of the study was to analyze the composition of cosmetic and medicinal products containing gold available on the Polish market. In addition, an attempt was made to find an answer to the question what forms of gold are most often used by producers of cosmetics and medicinal products. In the period from September 2023 to February 2024, information was collected on cosmetic and medicinal products containing gold available on the Polish market. Information was obtained on 61 cosmetic products containing gold and 10 medicinal products containing gold.

#### **Conclusions**

Gold is more often an ingredient of cosmetic products than medicinal products. Medicinal and cosmetic products with gold most often contain it in the form of nanoparticles.

**Keywords:** Gold, cosmetic products, medicinal products.

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## INTRODUCTION

Gold (Au, Latin: *aurum*) is a chemical element that can be found in the periodic table of elements in group 11 (the copper group) and period 6. It is marked with the abbreviation Au. Its atomic number is 79 and its atomic mass is 196.97. It occurs in oxidation states I and II. The simplified electron notation for gold is written as: [Xe] 4f145d106s1. This precious metal does not oxidize in water or air. It is resistant to acids and dissolves only in aqua regia and alkaline cyanide solutions. It is only slightly reactive, only noble gases are less reactive than gold. As one of 30 elements, it occurs in its native form. Gold is obtained by reacting sodium cyanide with copper ores, or it is obtained from anode slime by electrolytic refining of silver. Of all metals, gold is the most malleable element. It is soft, has a characteristic yellow color with a distinct shine. Due to its properties, gold is used in many different industries, such as: jewelry, photography, electrical engineering, and in medical and cosmetic products.

Gold owes its properties to malleability, resistance to high temperatures (its melting point is 1064°C) and corrosion resistance to numerous applications. Another aspect that is extremely important is the lack of allergy to gold. Due to the possibility of creating alloys with this noble element, additives to these alloys are responsible for possible allergic reactions. Gold also has amazing antibacterial and anti-inflammatory properties. In addition, it has anti-aging properties. Additionally, gold-containing preparations have been used to treat immunological diseases such as rheumatoid and psoriatic arthritis, lupus, allergies and other connective tissue diseases. Despite such widely known uses of gold, its exact metabolic function is still unknown [1,2,3].

Thanks to the above-mentioned properties, gold is widely used in dentistry. It is possible to model well-tolerated dental fillings of the appropriate shape with the guarantee that the filling will be long-lasting, non-toxic and corrosion-resistant [4]. It is also used to produce fixed and removable dentures. Gold in these products finds its place in the palatal plates in complete dentures, is an element of the removable skeleton in partial dentures, and is also used as an element of precise maintenance. Dentistry uses several forms of gold, which are: gold leaf, used to supplement the tooth in its central part; gold leaf combined with platinum foil, which is used to recreate the angles and edges of teeth; and gold in sponge form used with gold leaf to eliminate its brittleness. A contraindication to the use of gold in dental problems is susceptibility to caries and severe periodontal disease. Gold fillings or dentures with their elements will not be used if the patient's oral hygiene is not properly maintained [4]. The antibacterial properties of gold are also used in cosmetology and homeopathy. There are products available on the market that have bactericidal properties anti-inflammatory, dedicated to the care of problematic skin. Experimental research proves that gold has a moisturizing effect on the skin and improves its ability to regenerate. Therefore, preparations containing gold are recommended for use on scars to stimulate the skin's repair and regeneration processes. Moreover, an important aspect of the metal in cosmetology is its ability to slow down skin aging. It improves tension, firms and smoothes the skin. For this

reason, in addition to those struggling with acne, products containing gold will be used by people struggling with the process of wrinkles. This metal and its anti-wrinkle effect are also used in aesthetic medicine. Doctors perform treatments using threads made of gold. Using a thin needle, they are implanted to a depth of 3 to 5 mm (depth of the dermis). The treatment induces skin remodeling processes - it increases the production of basic proteins influencing skin firmness and elasticity, such as collagen and elastin. As a result, the skin is smoother and wrinkles are reduced [5,6,7]. Medicine also uses gold to treat regurgitation of the eyelid fissure. A person suffering from this dysfunction is unable to close his or her eyelids completely. The effects of the disease include frequent conjunctivitis, defects in the corneal epithelium and corneal ulcers. Vision deteriorates and even loss of an eye is possible.

Surgical treatment of eyelid regurgitation involves implanting a gold plate into the upper eyelid. The implant is selected individually for each patient and its weight ranges from 1 to 2g. Placing it causes the upper eyelid to weigh down and fall more strongly due to the action of gravity. The treatment improves the closing of the palpebral fissure without disturbing the opening of the eye. After the place where the plate was implanted has healed, the scar is practically unnoticeable. When necessary, the procedure can be reversible, without harming the patient's health. Gold implants used for surgical treatment of eyelid fissure regurgitation have a medical certificate, which means that they do not constitute a contraindication to magnetic resonance imaging [8,9]. Medicine knows another use of gold, or more precisely, its salts. They were given to patients suffering from rheumatoid arthritis. Preparations containing gold salts were often considered the most effective, which made them the basic drugs in the treatment of this disease in the 20th century. Despite their wide use, the mechanism of action is not fully known. The most frequently administered substance was gold sodium thiomalate (Aurothiomalate sodium, Myocrisin), followed by aurothiomalate sodium thiosulfate (Aurotiosulfate sodium, Myochrysin) and a combination of gold salts with L-thioglucoze (Solgial B). Treatment was carried out in the form of intramuscular injections and oral medications. When administering the preparations by injection, doses ranging from 10 to 50 mg per injection were used.

The procedure was repeated once a week. The dose was changed depending on the patient's reaction - the occurrence of fever, the intensity of pain and the occurrence of other side effects were taken into account. Treatment with gold salts had to be carried out under strict medical supervision, it should be initiated in the rheumatology department and continued in the rheumatology clinic. This rule was applied because contraindications to the use of gold preparations in the treatment of rheumatoid arthritis may have appeared during therapy. These included symptoms such as proteinuria, allergic eczema preceded by persistent itching, acute leukopenia and thrombocytopenia, and inflammation of the mucous membranes of the oral cavity, including further sections of the gastrointestinal tract. Due to the possibility of developing these symptoms, before each procedure, the patient underwent a urine test and a blood count, including a platelet count, once a month. In the case of the above-mentioned temporary contraindications, a 1-2 week break from the

drug was used; if the symptoms were acute, the treatment had to be discontinued. Treatment of rheumatoid arthritis with oral preparations containing gold salts lasted at least one year.

Auranofin was used as a drug and was taken at a dose of 3 mg every 12 hours. The effects of oral treatment were visible 3 to 4 months after starting treatment. The results were slightly smaller than with intramuscular treatment, but this type of pharmacotherapy resulted in fewer complications. Medical check-up was just as important. Statistics show that remission or significant alleviation of the disease for a period of six months to several years was achieved in approximately half of patients treated with gold therapy. However, some patients could not be qualified for treatment with this method due to the presence of relative or absolute contraindications, and half of the patients already taking preparations with gold salts had to discontinue their use due to complications. Therefore, significant benefits from this type of therapy are attributed to 25% of those treated. Contraindications to the initiation of treatment of rheumatoid arthritis with gold salts include intolerance of the body (manifested by allergic eczema or exfoliative dermatitis), kidney disease (proteinuria and/or casturia) and liver parenchyma disease [10,11]. Currently, more modern drugs are used for rheumatoid arthritis: methotrexate, leflunomide and biological therapies.

The continuous development of technology and the increase in its availability have given pharmacy and medicine the opportunity to analyze nanomaterials. Understanding their organization, properties and possible applications have enabled enormous development of science. According to the European Commission, nanomaterial contains 50% of particles ranging from 1-100 nm [12]. Carbon materials are most often described as nanomaterials. Nanogold is mentioned much less often. This is most likely due to the difficulty of fitting it into a typical scheme and giving it a structural framework. However, it turns out that gold nanoparticles (AuNPs) have a number of surprising properties that can be used in medicine, pharmacy and cosmetology [13]. The most frequently used substrate in the production of nanogold is tetrachloroauric acid (III) (HAuCl<sub>4</sub>). It is reduced using factors such as formaldehyde, citric acid, oxalic acid or sugars. In order to protect nanoparticles against aggregation, stabilizing factors are attached to their surface, including sulfur, phosphorus and nitrogen groups, surfactants, polymers and dendrimers [14].

The size and shape of the nanoparticles determine their color, which can range from orange, through intense red, brown, to blue-violet. Their size also affects absorption. Obtaining gold nanoparticles is carried out in various processes that produce various shapes of the final product. We distinguish such shapes as nanoshells, nanowires, nanotubes, nanobelts, and nanorods, nanourchins, nanostars, nanotriangles, nanospheres, nanoribbons, nanocubes, nanocages, nanodisks, and atomic aggregates. The same structures are often given different names by different research groups [13]. The surface of nanogold is relatively large and easily modified to give them specific applications. This possibility is due to the negative charge on the surface of the nanomaterial. Modifications involve the attachment of peripheral groups using covalent bonds or non-covalent interactions - most often van der Waals or hydrophobic interactions [15].

The compounds that can be attached to the surface of gold nanoparticles include: antigens, monoclonal antibodies, peptides, vitamins, aptamers, and some drugs (methotrexate, folic acid, doxorubicin), as well as polymers and oligonucleotides. The ease of modifying the surface of nanogold also has a negative aspect in relation to its technological applications. Namely, in a physiological environment, the so-called "protein crown". This process involves the attachment of protein substances that occur in a given environment. As a result, the diameter of the nanoparticle is enlarged, resulting in greater exposure to contact with macrophages. The attached protein complexes "cover" the previously added groups that give the nanoparticle the appropriate property, which results in the abolition of the effect.

To avoid this unwanted process, the surface of the nanogold is modified using polymers (most often polyethylene glycol). This action prevents the formation of non-specific protein bonds. The risk of uptake by macrophages is reduced, and the chance of longer circulation in the circulatory system and providing a therapeutic effect is extended [13]. The reactive surface of nanogold, which interacts by binding specific groups, is used by laboratory diagnosticians during tests detecting biomarkers of heart diseases, infections, cancers, and during enzyme immunoassay tests, among others. pregnancy or drug tests. In therapeutic therapies, nanogold is used to facilitate the delivery of drugs to the interior of target cells. This method is often used to fight cancer cells. Moreover, after irradiation with light with a wavelength of 700 to 800 nm, nanogold particles emit heat, which is why they are used in photodynamic therapies against cancer cells as a photothermal agent. When using radiotherapy, gold nano-objects enhance its dose. Imaging diagnostics uses gold nanoparticles as markers. They have light-scattering abilities and the ability to take on various colors [16].

## PURPOSE OF THE WORK

The wide spectrum of activity of gold compounds and modern possibilities of their use in cosmetic and medicinal products for antibacterial, regenerative and anti-wrinkle purposes raise the question whether the products available on the market contain Au. The aim of the study was to analyze the composition of cosmetic and medicinal products containing gold available on the Polish market. In addition, an attempt was made to find an answer to the question what forms of gold are most often used by producers of cosmetics and medicinal products.

## MATERIALS AND METHODS

In the period from September 2023 to February 2024, information was collected on cosmetic and medicinal products containing gold and silver available on the Polish market. Three "Rossmann" drugstores were visited and the online offer of the drugstore was searched, and three "Hebe" drugstores, whose offer available on the Internet were also taken into account. Two "DOZ" pharmacies and one private pharmacy were also visited. When searching for offers available on the Internet, the words "cosmetics with gold", "gold", "nanogold" were entered.

## RESULTS AND DISCUSSION

Data was collected on 61 cosmetic products and 10 medicinal products containing gold. The collection of cosmetic preparations includes: 44.3% face creams, 13.1% eye creams, 8.2% face masks, 6.6% micellar fluids, 3.3% body milks, 9.9% creams -serum, 4.9% serum, 6.6% eye patches, 1.6% make-up bases, 1.6% foot masks. The forms of gold in the analyzed products are: Colloidal Gold or Gold. The collection of medicinal preparations with gold includes throat sprays which constitute 20%, colloidal gold solutions and gels which constitute 30% each, and nasal sprays and sprays for canker sores which constitute 10% each. The forms of gold in the products presented in the collection are: 50% nanogold, 30% aXonnite gold, 20% dimethyl sulfoxide gold complex III.

The healing properties of gold have been known in Europe since 1890, when Robert Koch discovered the inhibition of tuberculosis bacteria by gold cyanide. The development of technology and access to gold nanostructures offers their increasingly widespread use, which differs from the form of gold on a macro scale [17]. *Ex vivo* experiments show that nanogold particles have the ability to penetrate the skin deep into the epidermis and dermis. The results of the conducted research prove the penetration of 22 nm nanoparticles and their accumulation in the epidermis, below the stratum corneum. Other studies comparing gold nanoparticles of the order of 6 and 15 nm show deeper penetration of smaller particles. They reached the stratum corneum, but hydrophobic molecules were also found in the granular layer [16].

These studies prove the penetration of nanogold into the skin, which is a key property of ingredients used in cosmetology. Gold nanoparticles in cosmetic products are allowed in sizes ranging from 10 to 400 nm. This size results from the ability to form agglomerates and increase the volume after adding active ingredients. Additionally, this size is consistent with the range of molecules in cosmetics and preparations. The possibility of modifying the surface of nanogold allows it to be supplemented with skin nutrients, such as vitamins, moisturizing and anti-wrinkle substances. It also has anti-free radical, antiseptic and blood circulation-accelerating properties. Additionally, gold nanoparticles act as a cofactor for enzymes that help in the production of collagen in the skin and other tissues. Thanks to these properties, gold nanoparticles are an ingredient of cosmetic products for home and office use, and are a common active ingredient in cosmetology procedures [18].

They are most often used to care for skin in need of regeneration, in cases of active inflammation, sunburn, and when the skin is hypersensitive to other active ingredients. Due to its ability to stimulate collagen synthesis, nanogold is dedicated to mature skin [19]. Gold and nanogold itself also have certain antibacterial properties, which is why they are used in preparations for acne skin, treatment of abscesses, chronic rashes, burns and lichen. The anti-inflammatory effect of NCZ gold is recommended for use in the case of allergic diseases. Colloidal gold is also recommended for people struggling with hair loss [17]. Scientists are working on introducing technology using gold nanoparticles to color hair. They have already managed to produce gold NCz in human gray hair. In the tested hair, a color change from gray to yellow was observed, and after some time to dark brown. The hair color remained even after a dozen or so washes. This gives hope for the creation of a new method of hair

coloring, perhaps safer for its condition than the existing methods of coloring [20].

The reactive surface of nanogold and its ability to emit heat make it increasingly used in photomedicine for the treatment of dermatological diseases, the treatment of sleep disorders and the treatment of oncological diseases. Photothermal therapy (PTT) is a relatively new field of photomedicine, operating through the use of photosensitizers, the role of which may be played by gold nanoparticles. Stimulation of Au NCz with near-infrared radiation causes the nanogold to emit heat, which increases the temperature of adjacent tissues by several degrees. This overheating disrupts cellular processes and ultimately leads to their death. Application of the photosensitizer directly to the tumor or its accumulation there, through the increased retention and permeability characteristic of tumors, gives a high probability that mainly cancer cells will be killed. Photothermal therapy largely takes into account gold nanoparticles due to their high biocompatibility, small size, ability to convert light into heat and due to the ease of attachment of biologically active compounds. Independent studies have proven the effectiveness of a given method using nanogold. Xue and colleagues prepared gold nanoparticles in the form of nanocages and nanoshells with lanreotide acetate. Their sizes ranged from 120 to 150 nm.

The temperature of NCz was increased using a laser with a beam of 808 nm. Heating brought the nanoparticles to temperatures of 46.08°C and 54.3°C. The effect of laser-heated nanoparticles on the metabolic activity of HeLa cervical cancer cells was assessed. A significant decrease in the metabolism of these cells was observed. *In vitro* studies were also performed using a mouse model. Mice were injected with gold nanoparticles and then exposed to radiation. A rapid increase in the temperature of the tumor surface was noted, lasting 3-5 minutes. The temperature was over 48.3°C. After the procedure, the mice were left for observation, and after 12 days there was a significant decrease in tumor weight, compared to the control group, in which there was no change in tumor weight. These studies proved the usefulness of using gold nanoparticles in photothermal therapy [7,13].

The results of *in vitro* tests show that, when comparing nanogold to gold compounds, the cytotoxicity of nanogold is low and depends on its concentration and size. When using cosmetic preparations with gold nanoparticles, the most common side effect was the formation of dermatoses. These include skin rashes and mouth ulcers with or without pain. Providing the skin with large amounts of nanogold may cause a gray-blue discoloration of the skin (Latin: *chrysois*). It manifests itself on parts of the body exposed to sunlight, most often on the face and skin of the hands. The shape and size of gold nano-objects may be important in terms of cell viability. This is influenced by the physical and chemical interactions they have with cell membranes. Studies on an embryonic human kidney cell line have shown that the spherical shape has a lower toxic effect than the elongated shape. In turn, studies on nanoparticle concentrations show that spherical nanoparticles at concentrations of 1, 6, 8 and 16 µM are characterized by a low degree of toxicity. However, at cross-sectional concentrations of 32, 100 and 300 µM, they cause reduced cell viability.

Nanogold sizes smaller than 10 nm cause greater cytotoxicity because, due to their small diameter,

they can penetrate deeper. However, appropriate modifications of the surface of gold nanoparticles prevent toxic reactions [18,19,20].

The analysis of the compositions of the products collected in this study shows that producers of preparations containing gold compounds mainly choose them in the form whose effects described in the literature and the results of scientific research describe as the most effective of all available forms of gold - nanogold. Half of the collected medicinal products contain NCZ gold. Cosmetic preparations with colloidal gold constitute 60% of the preparations collected in our study. The remaining 40% of preparations contain them in the Gold form. Most

likely, the presence of nanogold in the largest number of cosmetic and medicinal preparations is due to its scientifically proven highest effectiveness.

## CONCLUSIONS

Gold is more often an ingredient of cosmetic products than medicinal products

Medicinal and cosmetic products with gold most often contain it in the form of nanoparticles.

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