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Zirconium allergy

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Zirconium [chemical symbol: Zr] is a so-called transition metal that is added to alloys used in the production of items of high durability and corrosion resistance, such as surgical instruments, dental implants, and endoprostheses. It can be found in alloys used to make wristwatch cases. The high reactivity of zirconium with oxygen is exploited in some detonators and primers of explosives, as well as in pyrotechnic compositions – as an amorphous powder it may ignite spontaneously and burn with explosive violence, but can be rendered non-pyrophoric for use in cosmetic products (and in numerous other industrial processes) by a process of "passivation". In the past, zirconium was also used in disposable flashlights, in which the flash was produced by burning the material. It is also used in the production of electron tubes. Zirconium is a by-product of titanium and tin mining and smelting. Commercial zirconium typically contains 1-3% hafnium, another transition metal that can cause sensitization.

Synonyms and names in other languages

CAS 7440-67-7; Circonio; Cyrkon; EC 231-176-9; EC 933-703-4; Zirconio; Zirkonium

Confusion may arise because of the existence of a number of similar-sounding names that refer to different chemical entities:

- zirconium (Polish: cyrkon) - a metal, atomic number 40
- zircon (Polish: cyrkon) - a naturally occurring mineral that consists mainly of zirconium silicate ($ZrSiO_4$), CAS 1344-21-4 or CAS 10101-52-7, used primarily as an opacifying agent in the production of decorative ceramics, and also in refractory (fire proof) materials and foundry molds.
- zirconia (Polish: cyrkonia) - a ceramic material consisting predominantly of zirconium dioxide (ZrO_2), CAS 53801-45-9, which, depending on dopants and physical conditions in the production process, can take the form of a colourless, transparent synthetic ornamental stone referred to as cubic zirconia that is used in jewellery as an imitation of diamonds, or a white ceramic mass of high hardness used as a material in the production of implants and artificial dental crowns.

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Zirconium in dentistry

Zirconia implants seem to be an emerging alternative to titanium with osseointegration comparable to the latter and a superior soft-tissue response, biocompatibility, and aesthetic features (Zreaqat et al. 2017, Sivaraman et al. 2018, Fawakhiri et al. 2023). Successful dental restorations with zirconia-based implants and crowns have been reported in patients with titanium allergy (Oliva et al. 2010). The zirconia used as a material in dental implantology and prosthetics always contains admixtures of other complexed metals, such as yttrium (Y), hafnium (Hf), aluminum (Al), or calcium (Ca). Therefore, when analyzing the risk of allergic reactions to zirconia crowns and implants, it is important to consider not only zirconium but also other metals (Peng et al. 2019).

Zirconium in endoprostheses

Zirconium-based artificial joints are considered as a promising, however not entirely challenge-free, alternative to traditional steel, nickel, chromium and cobalt-based alloys, as well as titanium alloys (Munazzam et al. 2025). Oxinium® is the brand name (Smith+Nephew) of a zirconium-based material used for hip and knee replacement in which a zirconium alloy of the implant transitions into a hard ceramic outer surface formed by zirconium oxide. It was shown to be non-inferior to traditional artificial joints made of other materials, including titanium alloys, and was suggested as an alternative material for use in patients with metal hypersensitivity (Hofer & Ezzet 2014, Puente Reyna et al. 2018, Bulaïd et al. 2022, D'Ambrosi et al. 2023). However, cases of metallosis and failure of oxidized zirconium implants have been reported in literature, demonstrating that metallic zirconium can be released from such implants into surrounding tissues (Frye et al. 2021, Ludwig et al. 2024].

Clinical symptoms of zirconium allergy

Historically, the first reported cases of zirconium hypersensitivity, referred to as "zirconium granuloma" were due to zirconium-containing deodorants and zirconium-based treatments for Rhus dermatitis (Hurley & Shelley 1958, Epstein et al. 1962, Epstein et al. 1963, LoPresti & Hambrick 1965, Elias & Epstein 1968, Skelton et al. 1993). A case of "contact allergic gastritis" has been reported with itchy gingival lesions surrounding ceramic crowns on a metal bridge that emerged within 2 weeks after their placement, accompanied by nose swelling and gastrointestinal symptoms (gastric and colic pain, diarrhoea) and gastroscopy-confirmed eosinophilic gastritis. On patch tesing, the patient reacted to gold, palladium and zirconium which were the components of the bridge and crowns, and their replacement resulted in a rapid spontaneous remission of the symptoms (Pföhler et al. 2012). An atypical allergic reaction after total hip replacement with the use of an alumina-zirconia ceramic head in a woman who developed paresthesia throughout the entire right lower extremity, swelling, and ecchymosis within the first week after the surgery, followed with polyarthralgia and continued diffuse swelling and sensitivity in the right lower extremity that eventually involved most of her body, as well as hair fall (alopecia areata) and impaired vision. The implanted endoprosthesis remained functional over the entire observation period. The diagnosis of zirconium allergy was based on the lymphocyte stimulation test (stimulation index of 8.6), a method with debatable diagnostic value. Nevertheless, the symptoms completely resolved within a week following the replacement of the alumina-zirconia ceramic head and the patient remained symptom-free during following 24 months (Dawson-Amoah et al. 2020). Immunoreactivity to zirconium was also observed in a subgroup of sarcoidosis patients with a specific, fibrotic phenotype (Beijer et al. 2020, Beijer et al. 2021). This condition, also referred to as sarcoid granulomatosis may take a course with multiple organ involvement after zirconium exposure (Werfel et al. 1998).

Zirconium in cosmetic products / toiletries

Globally, zirconium and its compounds are used in cosmetics and toiletries, their ascribed functions including antiperspirant, astringent, bulking, deodorant, opacifying (in sunscreen products), and skin conditioning. In Europe, restrictions and prohibitions apply. According to entry 391, Annex II (List of Prohibited Substance in Cosmetic Products) of Regulation (EC) No 1223/2009 on cosmetic products, zirconium and its compounds are prohibited "with the exception of the substances listed under reference number 50 in Annex III, and the zirconium lakes, pigments or salts of the colouring agents when listed in Annex IV". More specifically, Aluminium zirconium chloride hydroxide complexes, and AlxZr(OH)yClz and the aluminium zirconium chloride hydroxide glycine complexes are allowed in antiperspirants, and the various substances identified by their CI number are allowed as colourants. The following INCI names have been registered with the Personal Care Products Council:

- INCI: Zirconium Bis(Hydrogen Phosphate) - prohibited in the EU
- INCI: Zirconium Chlorohydrate - prohibited in the EU
- INCI: Zirconium Dioxide - ?prohibited in the EU
- INCI: Zirconium Oxide Acetate Trimesicate - ?prohibited in the EU
- INCI: Zirconium Powder - prohibited in the EU
- INCI: Zirconium Silicate - prohibited in the EU
- INCI: Zirconium Silver Phosphate - prohibited in the EU
- INCI: Zirconium Terephthalate - prohibited in the EU
- INCI: Zirconyl Chloride - prohibited in the EU
- INCI: Aluminum Iron Calcium Magnesium Zirconium Silicates - ?prohibited in the EU
- INCI: Aluminum Zirconium Octachlorohydrate
- INCI: Aluminum Zirconium Octachlorohydrex Gly
- INCI: Aluminum Zirconium Pentachlorohydrate
- INCI: Aluminum Zirconium Pentachlorohydrex Gly
- INCI: Aluminum Zirconium Tetrachlorohydrate
- INCI: Aluminum Zirconium Tetrachlorohydrex Gly
- INCI: Aluminum Zirconium Tetrachlorohydrex Peg
- INCI: Aluminum Zirconium Tetrachlorohydrex Pg
- INCI: Aluminum Zirconium Trichlorohydrate
- INCI: Aluminum Zirconium Trichlorohydrex Gly
- INCI: Calcium Magnesium Zinc Zirconium Phosphosilicate - ?prohibited in the EU
- INCI: Ceramic Extract - ?prohibited in the EU
- INCI: Diallyloxyneohexyl Zirconium Tridecanoate - prohibited in the EU
- INCI: CI 10316 / Acid Yellow 1
- INCI: CI 12085 / Pigment Red 4
- INCI: CI 15510 / Acid Orange 7
- INCI: CI 15630 [Red]
- INCI: CI 15850 / Pigment Red 57
- INCI: CI 15865 / Pigment Red 48
- INCI: CI 15985 [Yellow]
- INCI: CI 16255 / Acid Red 18
- INCI: CI 17200 / Acid Red 33 [Red]
- INCI: CI 19140 / Acid Yellow 23
- INCI: CI 42051 / Acid Blue 3
- INCI: CI 45370 / Solvent Red 72
- INCI: CI 45380 / Acid Red 87
- INCI: CI 45410 / Acid Red 92
- INCI: CI 45430 / Acid Red 51 ; erythrosine

Numerous zirconium-containing cosmetic products and toiletries are to be found listed on INCIDecoder

INCI: International Nomenclature of Cosmetic Ingredients — In the UK, the European Union, and in other global regions, manufacturers of cosmetic products are legally required to list ingredients on product labels / packaging using standardised INCI nomenclature. The Personal Care Products Council cautions that "The designation of an INCI name for a cosmetic ingredient is an essential part of ingredient identification; however, the assignment of an INCI name does not mean that the ingredient has been approved for cosmetics."

CI: Colour Index, a unique number of a dye in the Colour Index™ International (CI) reference database, published online by the Society of Dyers and Colourists and American Association of Textile Chemists and Colorists.

Available diagnostic methods and materials

At present, the only validated method of detecting zirconium allergy is patch test performed in line with the current guidelines by national or international scientific societies, e.g., European Society of Contact Dermatitis (Johansen et al. 2015). Patch test material available for testing includes:

- Zirconium(IV) chloride 1% pet. [Chemotechnique Diagnostics, cat. number Z-008]
- Zirconium Dioxide 0.1% pet. [Chemotechnique Diagnostics, cat. number Z-009]

Please note: Blood tests for zirconium allergy (mostly advertised as "lymphocyte transformation tests"), although popular in some countries, have not been approved as a diagnostic tool, and their use in allergy diagnosis is controversial.

Positivity rate

1 in 44 (2.2%) patients with suspected metal allergy (Spiewak 2018).

Cross-reactivities, co-positivities, and co-sensitizations

To date, there is insufficient data regarding possible cross-reactivities, co-positivities, and co-sensitizations of zirconium.

References

- Beijer E, Meek B, Bossuyt X, Peters S, Vermeulen RCH, Kromhout H, Veltkamp M (2020) Immunoreactivity to metal and silica associates with sarcoidosis in Dutch patients. Respiratory Research 21(1): 141. doi: 10.1186/s12931-020-01409-w
- Beijer E, Kraaijvanger R, Roodenburg C, Grutters JC, Meek B, Veltkamp M (2021) Simultaneous testing of immunological sensitization to multiple antigens in sarcoidosis reveals an association with inorganic antigens specifically related to a fibrotic phenotype. Clinical and Experimental Immunololgy 203(1): 115-124. doi: 10.1111/cei.13519
- Bulaïd Y, Djebara AE, Belhaouane R, Havet E, Dehl M, Mertl P (2022) Beneficial effect of a zirconium-nitride-coated implant in total knee arthroplasty revision for suspected metal hypersensitivity. Orthopaedics & Traumatology: Surgery & Research 108(5): 103320. doi: 10.1016/j.otsr.2022.103320
- D'Ambrosi R, Ursino N, Mariani I, Corona K, Anghilieri FM, Franchi E, Monti L (2023) Similar clinical and radiographic outcomes after two different hypoallergenic medial unicompartmental knee in patients with metal allergy. European Journal of Orthopaedic Surgery & Traumatology 33(4): 1315-1328. doi: 10.1007/s00590-022-03295-y
- Dawson-Amoah KG, Waddell BS, Prakash R, Alexiades MM (2020) Adverse reaction to zirconia in a modern total hip arthroplasty with ceramic head. Arthroplasty Today 6(3): 612-616.e1. doi: 10.1016/j.artd.2020.03.009
- Elias PM, Epstein WL (1968) Ultrastructural observations on experimentally induced foreign-body and organized epithelioid-cell granulomas in man. American Journal of Pathology 52(6): 1207-1223. url: PMC2013514

- Epstein WL, Skahen JR, Krasnobrod H (1962) Granulomatous hypersensitivity to zirconium: localization of allergen in tissue and its role in formation of epithelioid cells. Journal of Investigative Dermatology 38(4): 223-232. doi: 10.1038/jid.1962.40
- Epstein WL, Skahen JR, Krasnobrod H (1963) The organized epithelioid cell granuloma: differentiation of allergic (zirconium) from colloidal (silica) types. American Journal of Pathology 43(3): 391-405. url: PMC1949808
- Fawakhiri HA, Abboud S, Kanout S (2023) A 3-year controlled clinical trial comparing high-translucency zirconia (cubic zirconia) with lithium disilicate glass ceramic (e.max). Clinical and Experimental Dental Research 9(6): 1078-1088. doi: 10.1002/cre2.790
- Frye BM, Laughery KR, Klein AE (2021) The Oxinium arthrogram: a sign of oxidized zirconium implant failure. Arthroplasty Today 8: 103-109. doi: 10.1016/j.artd.2021.02.001
- Hofer JK, Ezzet KA (2014) A minimum 5-year follow-up of an oxidized zirconium femoral prosthesis used for total knee arthroplasty. The Knee 21(1): 168-171. doi: 10.1016/j.knee.2013.08.015
- Hurley HJ, Shelley WB (1958) The zirconium deodorant granuloma: an allergic disorder. Henry Ford Hospital Medical Bulletin 6(3): 279-290. url: scholarlycommons.henryford.com
- Johansen JD, Aalto-Korte K, Agner T, Andersen KE, Bircher A, Bruze M, Cannavó A, Giménez-Arnau A, Gonçalo M, Goossens A, John SM, Lidén C, Lindberg M, Mahler V, Matura M, Rustemeyer T, Serup J, Spiewak R, Thyssen JP, Vigan M, White IR, Wilkinson M, Uter W (2015) European Society of Contact Dermatitis guideline for diagnostic patch testing - recommendations on best practice. Contact Dermatitis 73(4): 195-221. doi: 10.1111/cod.12432
- LoPresti PJ, Hambrick GW (1965) Zirconium granuloma following treatment of Rhus dermatitis. Archives of Dermatology 92(2): 188-191. doi: 10.1001/archderm.92.2.188
- Ludwig M, Faschingbauer M, Reichel H, Freitag T (2024) Dramatic failure of an OXINIUM total knee arthroplasty with a massive pseudotumor formation. Arthroplasty Today 30: 101479. doi: 10.1016/j.artd.2024.101479
- Munazzam SW, Rai V, Nousheen S, Ullah B, Sharif S, Mohammed C (2025) A Narrative review of advancements in knee Arthroplasty: Analyzing diverse prosthetic materials and their implications. Journal of Clinical Orthopaedics and Trauma 66(Apr 24): 103034. doi: 10.1016/j.jcot.2025.103034
- Oliva X, Oliva J, Oliva JD (2010) Full-mouth oral rehabilitation in a titanium allergy patient using zirconium oxide dental implants and zirconium oxide restorations. A case report from an ongoing clinical study. European Journal of Esthetic Dentistry 5(2): 190-203. url: www.quintessence-publishing.com
- Peng TY, Shimoe S, Tanoue N, Akebono H, Murayama T, Satoda T (2019) Fatigue resistance of yttria-stabilized tetragonal zirconia polycrystal clasps for removable partial dentures. European Journal of Oral Sciences 127(3): 269-275. doi: 10.1111/eos.12615
- Pföhler C, Körner R, Vogt T, Müller CSL (2012) Contact allergic gastritis: an underdiagnosed entity? BMJ Case Reports 2012: bcr2012006916. doi: 10.1136/bcr-2012-006916
- Puente Reyna AL, Fritz B, Schwiesau J, Schilling C, Summer B, Thomas P, Grupp TM (2018) Metal ion release barrier function and biotribological evaluation of a zirconium nitride multilayer coated knee implant under highly demanding activities wear simulation. Journal of Biomechanics 79: 88-96. doi: 10.1016/j.jbiomech.2018.07.043
- Sivaraman K, Chopra A, Narayan AI, Balakrishnan D (2018) Is zirconia a viable alternative to titanium for oral implant? A critical review. Journal of Prosthodontic Research 62(2): 121-133. doi: 10.1016/j.jpor.2017.07.003
- Skelton HG, Smith KJ, Johnson FB, Cooper CR, Tyler WF, Lupton GP (1993) Zirconium granuloma resulting from an aluminum zirconium complex: a previously unrecognized agent in the development of hypersensitivity granulomas. Journal of the American Academy of Dermatology 28(5 Pt 2): 874-876. doi: 10.1016/0190-9622(93)70122-a
- Spiewak R (2018) Assessment for metal allergy: patch testing. In: Chen JK, Thyssen JP (eds) Metal Allergy. From dermatitis to implant and device failure. Cham: Springer. pp. 107-124. doi: 10.1007/978-3-319-58503-1_11
- Werfel U, Schneider J, Rödelsperger K, Kotter J, Popp W, Woitowitz HJ, Zieger G (1998) Sarcoid granulomatosis after zirconium exposure with multiple organ involvement. European Respiratory Journal 12(3): 750. doi: 10.1183/09031936.98.12030750
- Zreaqat M, Hassan R, Hanoun AF (2017) A CAD/CAM zirconium bar as a bonded mandibular fixed retainer: a novel approach with two-year follow-up. Case Reports in Dentistry 2017: 1583403. doi: 10.1155/2017/1583403