Review Article

Indian Journal of Dental Education
Volume 10 Number 2, April - June 2017
DOI: https://dx.doi.org/10.21088/ijde.0974.6099.10217.10

Metals Used In Restorative Dentistry

Prashanth Kumar Katta

Abstract

Dentistry without metals is impossible. It is used for various reasons like posts, crowns, orthodontic braces and brackets. Tooth coloured materials like ceramics also have different metallic oxides as part of their composition. Even the so called resin composites used in dentistry as tooth coloured restorative materials have traces of metals in them which serve various purposes. It is impossible to imagine metal free dentistry. This article provides an in detail review of the various metals and alloys used in dentistry.

Keywords: Alumina; Alloys; Metals; Zinc Oxide.

Introduction

Porcelain

Lithium is an alkaline metal which is a component of porcelain mixture used in dentistry; it is a hard metal, Zirconium resistant to corrosion and similar to steel. Alkaline Glasses is composed primarily of silicon dioxide, but also includes a fraction of alkaline oxides such as barium oxide (BaO) and strontium oxide (SrO), which integrate into the silica network. Aluminum oxide (Al2O3), titanium dioxide (TiO2), zinc oxide (ZnO), and zirconium oxide (ZrO2) [1].

Fluxes

Fluxes are alkaline metal oxides such as sodium, potassium, lithium, boron, and lead. They dissolve silica. Pure quartz melts at 1713°C. The addition of 25 % sodium oxide lowers the melting temperature of quartz to 793°C.

Alumina Alumina (aluminum oxide) is found combined with silicon in naturally-occurring glasses called feldspars. It is used as a stabilizer to toughen glass. Alumina acts as a sort of framework or skeleton. This framework stiffens glass during firing and makes it less likely to slump. The inclusion of crystalline structures transforms glass into porcelain which is much tougher and less prone to fracture than glass without such a matrix. Alumina is in clay and nearly all ceramic products such as dinnerware and china. It is added to dental porcelain in the form of aluminum oxide. Trace metals give glass color. Cobalt imparts a blue color; gold imparts red, and copper, green. These metals are added as oxides. They have fluxing qualities, but they are not alkaline metals.

Cobalt, gold, and copper are added in such small amounts that they are not considered fluxes for purposes of calculating glass formulas. Zirconium and titanium oxides add opacity to glass. They form a crystalline structure within otherwise translucent glass. This structure diffuses light and creates a milky or pure white appearance depending on the amount of zirconium or titanium oxide used [3].

How Metals Affect the Properties of Dental Materials?

Metal oxide nanoparticles were synthesized from tantalum ethoxide and zirconium isopropoxide and subsequently surface grafted with vinyl silane and silyl methacrylate coupling agents. The nanoparticles were then dispersed into a commercial dental resin, and the composite was photocured into rigid three-point bend and fracture

Author's Affiliation: Assistant Professor, Department of Restorative Dental Sciences, Al Farabi Dental College, Jeddah, Kingdom Of Saudi Arabia.

Reprints Requests: Prashanth Kumar Katta, Assistant Professor, Department of Restorative Dental Sciences, Al Farabi Dental College, Jeddah, Kingdom of Saudi Arabia.
E-mail:drprashanthkumar@yahoo.com

Received on 18.03.2017, **Accepted on** 07.04.2017

toughness specimens. The optically transparent/ translucent cured composites demonstrated strength, toughness, and elastic modulus inferior to the unfilled material.

Ceramic Stains

Metal oxides are often added into porcelain powders as pigments for them to be tooth coloured, as metal oxides are stable during fusion temperature. This gives porcelain an advantage over other materials as they can match the shade of the adjacent tooth closely and gives a realistic appearance.

Some feldspathic porcelain is supplied as opalescent porcelains, which contains small amounts of metallic oxides. These metallic oxides have high refractive index and particle size near to that of the wavelength of light, thus, they have a light scattering effect. This resembles the natural teeth, which is also display some degree of opalescence, and further improves the aesthetics of the fabricated prostheses.

Metals in GIC

Alumina is considered to be a ''conditional network former'' in glasses. This means that it will not form a glass on its own, but will do so in association with sufficient amounts of another oxide. In alumina containing glasses, aluminum ions may be found in 4-, 5- and 6-coordination. The 4-co-ordinate structures correspond to those forced on aluminum by the presence of large amounts of silica 1, but the existence of the 5- and 6-coordinate units shows that not all the aluminum ions are forced into silica-like tetrahedra. For those Al ions forced into aluminate tetrahedral, mutual sharing of corners is unfavorable because of the instability of the AlO4 species. Hence they are found only in association with SiO4 tetrahedra [2].

Adverse Effects of Aluminium

Aluminum needs to be excluded from cells because of its affinity for phosphate species 3. It is a small ion of high charge density and consequently binds strongly to anionic O-donor ligands, such as HPO2 [4]. Were it to do this inside the cells, it would interfere with energy transduction, a process that involves the phosphate species adenosine triphosphate (ATP) and adenosine diphosphate (ADP). Complexation with aluminum ions would slow down reactions of these compounds to rates that could not sustain life. Hence aluminum is toxic to a wide range of animals and plants [4].

Zinc oxide is present in dental amalgam, zinc phosphate cement, zinc polycorboxylate cement, zinc oxide eugenol cement, and even dental composites. It gives hardness, improves physical properties and has antibacterial properties [5,6]. Composites containing ZnO-NPs were found to moderately inhibit S. sobrinus biofilm formation for periods of three days when compared to composites without ZnO nanoparticles [5].

Apart from alumina and zinc oxide magnesium oxide is also a part of composition of various dental cements and ceramics used in dentistry. Not just these, traces of other metal oxides like bismuth and barium oxides are part of various cements, ceramics and composites used in dentistry.

Dental Composites

Many metals have been used as fillers in dental composites. Thes include barium, quartz and silica [7]. Barium-containing glasses were re prone to leaching of this ion from well polymerized composite resin in water, but quartz fillers were substantially stronger and remained steadfast in an aqueous environment [8,9,10,11].

Conclusion

The bottom line is that, there is nothing called as metal free dentistry. Metals and metal oxides are part of the composition of all the materials used in dentistry. These metals significantly improve the physical properties of the material without which the material would be too weak to sustain the forces of mastication. But the percentage of the metal used must be carefully chosen so that it does not adversely affect the biocompatibility of the material.

Conflict of Interest

None

Source of Funding

Self

Acknowledgements

None

Ethical Clearance

Not applicable

References

1. Paul, A. The Chemistry of Glasses, London, Chapman and Hall, 1982.p.5–9.
2. Fyfe, C.A., Thomas, J.M., Klinowski, J. and Gobbi, G.C. Magic-AngleSpinning NMR (MAS-NMR) Spectroscopy and the Structure of Zeolites, Angew. Chem. Int. Edit. Engl., 1983: 22:259–275.
3. Williams, R.J.P. What is Wrong with Aluminium? J. Inorg. Biochem., 1999: 76:81–88.
4. Swaddle, T.W. Silicate Complexes of Aluminium (III) in Aqueous Systems, Coord. Chem. Revs., 2001: 219–221, 665–686.
5. Antibacterial Activity of Dental Composites Containing Zinc Oxide Nanoparticles Berdan Aydin Sevinç and Luke Hanley, J Biomed Mater Res B Appl Biomater. 2010 July; 94(1):22–31.
6. Metal-oxide nanoparticles for the reinforcement of dental restorative resins. Furman B[1], Rawls HR, Wellinghoff S, Dixon H, Lankford J, Nicolella D. Crit Rev Biomed Eng. 2000; 28(3-4):439-43.
7. Schweiz Monatsschr Zahnmed, Composite materials: Composition, properties and clinical applications A Literature Review, 2010; 120(11).
8. Ohsaki A, Imai Y. Analysis of major components contained in Bis- GMA monomer. Dent Mater. 1999; 18:425–9.
9. Soderholm KJ, Zigan M, Ragan M, Fischlschweiger W, Bergman M. Hydrolytic degradation of dental composites. J Dent Res. 1984; 63:1248–54.
10. Oysaed H, Ruyter IE. Water sorption and filler characteristics of composites for use in posterior teeth. J Dent Res. 1986; 65:1315–8.
11. Mousavinasab SM. Biocompatibility of composite resins. Dental Research Journal. 2011; 8(Suppl1): S21-S29.