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The effect of boron addition on the prosthetic dental materials: A review

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Abstract
Boron plays a crucial role and is likely to be important element for human body. Boron is present in the human system, with the highest concentration in bones and teeth. In recent years, there has been increasing research interest in the use of boron in human biological systems, particularly in applications of boron compounds for oral health in dental field. Additionally, studies have demonstrated that boron plays important role in development of new methods for immersion of boron compounds in dental materials. Dental materials that incorporate boron have the potential to be next generation class of biomaterials. Despite extensive research on boron's biological effect, more knowledge is required to comprehend it mechanism of action in oral environment and dental materials in long term clinical effect. This review aims to provide an overview of recent developments in boron research in prosthetic dentistry and to explore the effect on available dental materials and potential applications in the future.

Keywords: Boron, prosthetic dentistry, dental materials, antibacterial effect

1. Introduction

Boron is predominantly not naturally occurring element that belongs to the group of elements known as semiconductors, prossessing properties that lie between those of metal and non-metals, showed by the symbol B. The term ‘‘buraq’’ originally referred to borax in Arabic, and it is from this word that the name is derived [1, 2]. Situated in group 13 of the periodic table with atomic number 5 and an atomic mass 10.811 g/mol [2]. Out of the light elements, boron stands out as the sole element that possesses two most stable isotopes, namely ^{10}B and ^{11}B. ^{10}B is known for its considerable capture cross-section, which makes it a highly efficient absorbent of neutrons [3]. Despite the fact that boron compounds have been recognized for centuries, initially, boron was discovered as an element by three scientists independently, Joseph Louis Gay-Lussac, Louis Jacques Thenard, and Humphry Davy, in the year 1808. Originally, the isolation of boron was achieved through the combination of boric acid with potassium, resulting in its separation from other substances. However, today the preferred method for obtaining boron is by heating borax with carbon, unless a high degree of purity is required [4]. High purity crystalline boron can be obtained through vapor phase reduction, where boron trichloride or boron tribromide react with hydrogen on electrically heated filaments. Although boron is commercially available at 99.9% purity, its production is challenging due to its tendency to form refractory material containing carbon and other impurities [5].

Turkey and the USA contain the primary global boron reserves, with additional reserves found in various countries such as Russia, Chile, Argentina, Peru, Iraq, Syria, Morocco, and Libya. Boron has a divers range of applications, including its use in ceramics, body armors, super hard materials, fertilizers, glass manufacturing, detergents, fire retardants and as aircraft fuselage reinforcement. As a consequence, it can enter the environment through the release of boron from these products or during their production process [5, 6].

Boron has several commercial products, including boric acid, boric oxide and colemanite. Boric acid is commonly used in medicine and dentistry due to its antibacterial properties. Additionally, boron compounds have been incorporated into dental materials to improve their mechanical and physical properties [7]. Nevertheless, usage of boron containing dental composites has shown promising antibacterial properties that could potentially prevent the formation of secondary caries [8].

2. Boron element and boron-bearing minerals

Boron is not found in its pure form in nature; instead, it is typically found in conjunction with oxygen and other elements as salts known as ‘’borates’’. Boron exhibits a strong attraction towards oxygen, resulting in the formation of robust covalent boron oxygen bonds in borate compounds. Borates are compounds consisting of the elements boron and oxygen [9]. Boron has a tendency to react with other elements as well, possess either triangular or tetrahedral structural coordination units. These borate units can undergo polymerization, leading to the identification of over 230 naturally occurring borate minerals. Although borates can combine with any cation and form double salt with other anions, the most abundant minerals typically contains calcium, sodium or both elements. The presence of borate minerals is notably extensive, but only a few of them hold significant commercial value [9, 10, 11].

At room temperature, elemental boron appears as a solid and can take the form of black monoclinic crystals or a impure yellow or brown amorphous powder. Amorphous boron is typically produced by reducing boron oxide using sodium or florborate with potassium. The earliest known borate mineral, sodium tetraborate decahydrate, commonly known as borax, has been used for various purposes throughout history. Borax was initially utilized for making perborate, a bleaching agent once widely used in household detergents. In addition to borax, ulexite, colemanite, and kernite are other essential boron containing minerals. These minerals provide over 90% of the global boron demand [12]. Tincal or borax, a naturally occurring sodium borate decahydrate, serves as the primary source of commercial boron. Furthermore, ulexite, which is a mixed sodium-calcium borate, is extensively utilized for commercial purposes. Due to their ability to reduce bacteria, dissolve readily in water, and effectively soften water, borax and boric acid are commonly utilized in the manufacturing of various products [10].

Table 1 contains a list of some of the boron containing minerals of commercial importance (Ref.10).

3. Effect of boron on the mechanical properties of materials

Acrylic resins are the most commonly used and studied dental materials. Meaning, they are a popular choice for denture base material due to their aesthetic appeal, low water absorption, and smooth surface properties. However, their main drawback is their poor mechanical properties, which can result in denture fracture, a common complaint among patients who wear removable prostheses [13]. A recent study conducted by Ozdemir *et al*. (2021) [13], examined the impact of incorporating different types of B (Borax, Boric Acid and Colemanite) into the acrylic mass of poly-methyl methacrlyate (PMMA). The mechanical properties were assessed by varying the proportions of B used in the experiment. The results showed that the addition of borax and colemanite positively influenced the mechanical properties of PMMA, with enhanced resistance to bending impact. When borax, boric acid, and colemanite were added, they reported a notable improvement in surface hardness value compared to the form without B [13]. Alqahtani (2020) [14, 15], recently improved the mechanical properties of cold-cured PMMA by incorporating hexagonal boron nitride (h-BN) nanopowder, which increased the elastic modulus and bending strength. Additionally, the addition of zirconia oxide (ZrO2) enhanced surface hardness. The study suggested that a hybrid reinforcement utilizing both ZrO2 and h-BN could significantly enhance the stiffness and strength of PMMA, making it suitable for long lasting fabrication of fixed dentures, crown restorations, and repairs. However, due to the presence of residual monomers and heat generated by exothermic polymerization, cold cured PMMA is not recommended for prolonged oral applications [14, 15].

The use of titanium (Ti) alloys in various industries is limited due to their higher cost compare to other metals. Therefore, enhancing the processebility of Ti alloys can greatly reduce the overall cost of the final product, thereby expanding their use in different industrial sectors [16]. Zhu *et al*. (2003) [16], conducted a study where various alloys were used including, pure Ti, Ti with 0.5% Si, and Ti with 6%Al and 4% V, all of which had different levels of boron addition. The boron powder with nominal size of 1mm was used, and the samples were prepared by mixing the boron powder using a ball milling method. This study was performed to determent the optimal addition of B (<0.57 wt%) to improve the microstructure and tensile properties of cast Ti alloys intended for dental application. Researcher reported that the addition of B led to a significant refinement of the cast structure in the Ti alloys. Following the initial report, extensive research was conducted to investigate the impact of B on the microstructure and mechanical behavior of Ti and other metal alloys [16].

The clinical application of dental cements are limited by their prolonged setting time and low mechanical properties. These factors represent significant limit on their practical use in dentistry [17]. Sopcak at al. (2023) [17], carried out a research on the B addition on dental cement. In this particular study, a biphasic calcium magnesium silicate cement (CaMgSi) composed of larnite/bredigite was synthesized. The impact of B addition (at 0.25 and 0.5 mol) on the mechanical and physic- chemical features of CaMgSi cement and boron-modifed CaMgSi/0.25B and CaMgSi/0.5B cements were assessed using several characterization techniques. The findings suggested that the incorporation of B in the cement resulted in improved hydration, self setting, and mechanical properties, which increased with an increase in B content. They suggested that the improved mechanical strengths observed in the boron modified cement can be attributed to their more tight microstructure with fewer pores, possible due to the presence of borate clusters, which is in contrast to the B free cement [17].

In the field of dentistry, boron nitride nanoplates (BNNPs) have been recognized as a biocompatible reinforcement material for dental materials. This two-dimensional nanomaterial shares a comparable structure with graphene and boats exceptional chemical, mechanical, and physical properties. Unlike the black color of graphene, BNNPs has a white powder appearance, making it a more practical choice for use in dentistry [18]. Hence, Lee at al. (2020) [18], presented the application of BNNPs as a reinforcement material for dental materials. To prepare BNNPs for use in dental material, researchers used high energy ball-milling to exfoliate h-BN, followed by dispersion on a zirconia matrix. Flexural strength, fracture toughness, and wear resistance were key mechanical properties investigated. By dispersing BNNPs on zirconia, research team showed that there was notable improvement in strength (up to 27.3%) and fracture toughness (up to 37.5%) with the addition of 1-1.5 vol.% of BNNPs. Moreover, the tribolocigal properties were also enhanced due to the incorporation of BNNPs [18]. In another study, Bustillo *et al*. (2017) [19], used the stereolitography technique to produce 3D printed polymer material reinforced with boron nitride nanosheets (BNNSs). Different concentrations (0%,0.5%, and 1%) were utilized, and the team subsequently analyzed the compression strength, damping properties, and microhardeness of the resulting materials. The researchers found that the 1% reinforced samples exhibited twice the damping force of the pure structures. Additionally, the compression strength of the 1% added polymers was found to be 23.8% higher than that of 0.5% reinforced specimens [19].

Boron nitride nanotubes (BNNTs) have emerged as a promising option for enhancing the properties of dental adhesives by serving as innovative fillers [20]. To develop a novel adhesive resin, Degrazia *et al*. (2017) [20], formulated an experimental dental adhesive containing HEMA-BisGMA, following addition of BNNTs fillers at varying concentrations of 0.05, 0.075, 0.1, and 0.15 wt%. Incorporating BNNTs at concentrations of up to 0.15 wt% notable improvements were observed in both the chemical and mechanical properties of studied dental adhesive. In addition, team reported that the presence of BNNTs facilitated the deposition of minerals, resulting in significant advantages over other available materials [20].

Table 2 contains a list of the commonly used boron compounds reporting mechanical properties of dental materials.

4. Antibacterial effect of boron on the properties of materials

The pursuit of international research to develop new antibacterial dental materials that are biocompatible, efficacious, reliable and resistant remains ongoing. In recent research, Demirci *et al*. (2015) [8] investigated, boron containing dental composite for their antibacterial properties. The study, involved the preparation and analyzing a dental composite containing sodium pentaborate pentahydrate at concentrations of 1%, 5%, and 10% (w/w). The composites were evaluated for their antibacterial activity against Streptococcus mutants, and biocompatibility with human dental pulp stem cells (hDPSCs). The researchers findings demonstrated that agar diffusion tests did not reveal any inhibition zone. While, direct contact test of boron modified dental composites exhibited significant greater inhibition as compared to boron free dental composite [8].

In order to enhance the antibacterial properties of dental resin composites, a viable strategy is to incorporate metal oxides like silver, titanium, and zinc oxides into the composite materials. However, some of those metals have showed toxicity. To address this issue, there are several solutions that can be implemented. Due to their promising characteristics, h-BN nanomaterials have been extensively researched for their potential use in biomedical and dental applications [21]. Alansy *et al*. (2022) [21], created an antibacterial dental resin composite involving the synthesis of BNNSs modified with zinc oxide nanoparticles (BNNSs/ZnO). The conducted study showed, that incorporation of BNNSs/ZnO into the dental resin composite resulted in a significant increase in antibacterial activity compared to the control group, with a potential rate of 98% achieved with the addition of just 0.5% BNNSs/ZnO. This finding is significant as it demonstrates the potential of using these novel fillers to create dental resin composite that possess both effective antibacterial properties as well as desirable physicochemical and mechanical characteristics [21]. In early mentioned study conducted by Sopcak *et al*. (2023) [17], the antibacterial effectiveness of the experimental cement was assessed through direct contact testing with three strains of bacteria: Escherichia coli, Staphylococcus aureus, and Enterococcus faecalis. The findings indicated that the cement suspensions exhibited direct antibacterial efficacy against all three tested bacterial strains (20). In a study by Kivanç *et al*. (2018) [22], the efficacy of h-BN nanoparticles against Streptococcus mutans 3.3, Staphylococcus pasteuri M3, Streptococcus mutans ATTC25175, Candida sp.M25 were evaluated in terms of their antimicrobial and antibiofilm activities. The findings of the study demonstrated that these nanoparticles could potentially serve as a safe oral care product at an optimal concentration of 0.1 mg/mL. Concentration of h-BN nanoparticles used did not cause bacterial cell death but instead hindered the growth of bacterial biofilm [22].

PMMA’s inadequate antibacterial properties greatly restrict its use as a prosthetic material in the oral cavity. Due to the frequent occurrence of bacterial biofilm formation in the oral cavity, prosthetic failure is a common outcome [23]. Li *et al*. (2022) [23], analyzed a nanocomposite system consisting of h-BN nanosheets and silver nanoparticles (AgNPs), created by self assembling AgNPs on h-BN nanosheets, resulting in two-dimensional structure (h-BN/AgNPs). Subsequently, h-BN/AgNPs were incorporated into PMMA to prepare a series of samples with varying concentrations of h-BNNSs/AgNPs. The results of their study suggested the experimental group exhibited a significantly stronger antibacterial effect. Moreover, it was observed that as the concentration of h-BNNSs/AgNPs in the experimental material increased, the antibacterial activity also increased. These finding indicates that the experimental material possess promising antibacterial properties. This approach also open up new avenues for the development of dental materials with multifunctional properties [23].

Glass ionomer cement (GIC) has emerged as a popular dental material in clinical settings owing to its ability to combat caries, strong bond with dentin, and biocompatibility. Moreover, its easy of use has made it a preferred choice. Nonetheless, GIC suffers from certain drawbacks, such as an initial dehydration and high swelling rates, which negatively impact its mechanical and antibacterial properties, thereby limiting its effectiveness [24]. In a specific study, Ma *et al*. (2022) [24], explored the potential synergy between h-BN and titanium oxide (TiO2) nanoparticles, combining their remarkable mechanical properties and inherent antibacterial activity. Afterwards, the h-BN-TiO2 nanocomposite was synthesized and incorporated into GIC in a specific ratio (h-BN-TiO2/GIC). The study finding indicated that GIC alone exhibited some antibacterial activity, the h-BN-TiO2/GIC composites (0.3, 0.7, 1.1, and 1.5 wt%) demonstrated significantly enhanced antibactreial properties. This was evident when compared to the non bacterial control group. The researchers indicated that the addition of h-BN-TiO2 nanoparticle to GIC led to a more pronounced antibacterial effect against Streptococcus mutans. This was demonstrated by the significant reduction in the viability of Streptococcus mutans. The study’s findings suggest that the proposed method for enhancing the performance of GIC could lead to the development of new and improved materials for dental use. It is important to continue experimenting and testing these materials to ensure their safety and effectiveness in various applications [24].

Table 3 contains a list of the commanly used boron compounds reporting antimicrobial/ antibacterial properties of dental materials.

5. Toxic effect of boron compounds

Boron plays a critical role in the growth and development of people, plants and animals. However, when its level becomes deficient or excessive, it can have harmful effects on their metabolic processes. In a similar vein, metalloids are toxic to biological systems due to their ability to disrupt various cellular mechanisms. To deal with the toxicity caused by metalloids, cells have evolved different coping mechanisms, such as storage of metalloids in intracellular organelles, expulsion of metalloids out of cell, and limiting their import through proteins and peptides. These adaptive responses help to reduce the negative impact of metalloids on biological systems. Understanding these mechanisms can help in developing strategies to mitigate metalloid toxicity in people, plants and animals [4].

Numerous studies have investigated the toxic effects of boron compounds in animals, in laboratory environment. Boric acid and boric oxide are the most commonly administered forms of boron in such testing [25]. The lethal dose LD50 value for boron containing compounds have been determined to be between 400 and 700 milligram of boron per kilogram of body weight for mice and rats. Meanwhile, for dogs, cats, rabbits and guinea pigs, the LD50 value fall in the range of 250 to 350 milligrams of boron per kilogram of body weight [6]. Studies of human cases have revealed that boron can be deadly when ingested orally at high levels in a short period. However, estimating the dose accurately can be quite challenging, and the individual response to acute exposure can vary significantly. According to reports, the minimum lethal dose of boron, in the form of boric acid, was found to be around 2-3 gram for infants, 5-6 gram for children, and 15-20 gram for adults [26]. Human studies have reported an average boron level of 241 µg B/L in blood and 1130 µg B/L in urine. The concentrations of boron in different tissues have been observed to range from 0.06 to 1.2 mg B/kg. When humans are exposed to excessive levels of boron, acute symptoms can manifest as nausea, diarrhea, vomiting, and lethargy. Chronic boron toxicity can be identified by various symptoms such as decreased sexual activity, sperm count, seminal volume, and motility, along with nausea, weight loss, and poor appetite [27].

Individuals employed in industries that involve boron mining and processing, fertilizer and pesticide production, as well as cleaning and laundry products, are likely to be exposed to boron compounds. The data obtained from such exposure sites can serve as a valuable means of assessing the upper limits of boron exposure. Duygu *et al*. (2012) [28] highlighted that the average blood boron levels among boric acid mining workers in Turkey were 223.89 ng/g. At these recorded levels, no harmful effects on the reproductive system were observed among the exposed workers [28].

It should also be emphasized that, The European Food Safety Authority in 2013 evaluated boric acid and borax as food additives [29]. At adequate levels, various type of boron and its compounds can have beneficial effects on human health. Consequently, the use of boron as a food supplement has gained popular in recent years to prevent boron deficiency in the body.

Table 1: Commercially available borates (Ref.10)

Minerals	Chemical composition	B2O3 content (weight %)
Colemanite	$Ca_2B_6O_{11}\ 5H_2O$	50.8
Ulexite	$NaCaB_5O_9\ 8H_2O$	43.0
Borax	$Na_2B_4O_7\ 10H_2O$	35.5
Kernite	$Na_2B_{14}O_7\ 4H_2O$	51.0
Pandermite	$Ca_4B_{10}O_9\ 7H_2O$	49.8
Hydroboracite	$CaMgB_6O_{11}\ 6H_2O$	50.5

Table 2: Commonly used boron compounds reporting mechanical properties on dental materials

Author	Publication journal/year	Objective	Used boron and/or compounds	Studied dental materials	Evaluated mechanical properties	Conclusions
Ozdemir *et al.*	Eur Oral Res 2021	To improve flexural and impact strengths, and surface hardness of polymethyl methacrylate by adding boron	Borax, Boric Acid and Colemanite	Heat-cured poly-methyl methacrlyate (PMMA)	- Flexural strength - Impact strength - Hardness tests	The addition of 1% Colemanite to polymethyl methacrylate improved the mechanical properties of PMMA
Alqahtani	Materials 2020	To evaluate the effect of biocompatible hexagonal boron nitride (h-BN) nanopowder reinforcement with different concentrations on the structural and mechanical properties of fabricated self-cured polymethyl methacrylate (PMMA)	Hexagonal boron nitride (h-BN) nanopowder	Cold-cured poly-methyl methacrlyate (PMMA)	- Vickers Hardness (VH) - Flexural Strength (FS)	Ultrasonic mixing method combined with h-BN nanopowder increases VH numbers to 300% and FS values to 550% with respect to the unmodified sample made by hand mixing
Alqahtani	J. Mech Behav Biomed Mater 2020	To evaluate self-cured acrylic polymethyl methacrylate (PMMA) reinforced with hexagonal boron nitride (h-BN) and stabilized zirconia (8Y ZrO2) nanopowders	Hybrid compound of Zirconium oxide (ZrO_2) and Hexagonal boron nitride (h-BN)	Self-cured poly-methyl methacrlyate (PMMA)	- Vickers Hardness (VH) - Flexural Strength (FS) - Young's modulus (YM)	Ultrasonic mixing of PMMA with a 5 wt% h-BN increased the flexural strength (FS) and the modulus of elasticity or Young's modulus (YM) values to about 550% and 240%, respectively. However, a similar concentration of 8Y ZrO2 increased the Vickers Hardness

						numbers (VH) to about 400%
Zhu *et al.*	Mater Sci Eng A 2003	To evaluate As-cast titanium alloys prepared using a dental cast machine with a series of boron additions	Boron powder	Titanium (Ti) alloy	- Hardness test - Tensile test	Cast Ti-B alloys with a good combination of greater tensile ductility and strength can be obtained with very low boron addition
Sopcak at al.	Ceramics International 2023	To evaluate the effect of boron incorporation on the structural and physico-chemical properties of experimental cement	Boron (B)	Experimental Calcium magnesium silicate cement (CaMgSi)	- Compression shear test (CST) - Diametral tensile strengths (DTS)	The compressive (CST) and diametral tensile strengths (DTS) increased almost twice to the highest values of 85 ± 9 MPa and 8.8 ± 1 MPa, respectively
Lee at al.	Dent Mater 2020	To evaluate boron nitride nanoplatelets (BNNPs),mechanical properties and biocompatibility of dispersion on a zirconia matrix	Boron nitride nanoplates (BNNPs)	Zirconia	- Fracture toughness - Strength test	The BNNPs dispersed zirconia exhibited improved strength (up to 27.3%), and fracture toughness was also increased (up to 37.5%) with the addition of 1–1.5 vol.% BNNPs
Bustillo *et al.*	Polym Compos 2017	The influence of the BNNP addition on the curing, and the resulting microhardness, damping, and compressive strength	Boron nitride nanosheets (BNNSs)	3D printed photopolymer	- Vickers microhardness - Vibrational damping - Compressive fracture strength	The 3D printed PSP/BNNP composites were found to exhibit enhanced damping behavior. Reduced compressive strength in the 3D printed PSP/ BNNP scaffolds
Degrazia *et al.*	J Dent 2017	To evaluate the physical-chemical properties of experimental dental adhesives containing boron nitride nanotubes (BNNTs) as inorganic fillers	Boron nitride nanotubes (BNNTs)	Experimental adhesive resin	- Knoop microhardness - Tensile strength test	Microhardness and solvent degradation strength increased after incorporation of 0.075, 0.1 and 0.15 wt% BNNTs

Table 3: Commonly used boron compounds reporting antimicrobial/antibacterial properties on dental materials

Author	Publication journal/year	Objective	Used boron compound	Studied dental material/s	Evaluated antibacterial tests	Conclusions
Demirci *et al.*	Turk J Biol 2015	To evaluate dental composites having 1%, 5%, and 10% (w/w) sodium pentaborate pentahydrate	Sodium pentaborate pentahydrate	Dental resin composite	- Differentiation of hDPSCs - Immunocytochemistry analysis - Real-time PCR analysis - von Kossa Staining	Bacterial growth was significantly suppressed on boron-incorporated dental materials according to the direct contact test results
Alansy *et al.*	Dent Mater 2022	To evaluate synthesize boron nitride nanosheets modified with zinc oxide nanoparticles (BNNSs/ZnO) and incorporate them into dental resin composite	Boron nitride nanosheets (BNNSs) modified with Zinc oxide nanoparticles (ZnO)	Dental resin composite	- Biofilm Evaluation - Planktonic Bacteria Evaluation	Compared to the control composite, the experimental dental resin composites modified by 0.3% BNNSs or BNNSs/ZnO respectively both possessed good mechanical and excellent antibacterial properties.
Sopcak at al.	Ceramics International 2023	To evaluate the effect of boron incorporation on the structural and physico-chemical properties of experimental cement	Boron (B)	Experimental Calcium magnesium silicate cement (CaMgSi)	- Direct contact with the cement powders	No additional effect of boron incorporation on the antibacterial activity of the tested cements.
Kivanç *et al.*	Mater Sci Eng C Mater Biol Appl 2018	To evaluate the antimicrobial and antibiofilm activities of hBN nanoparticles	Hexagonal boron nitride (h-BN) nanoparticles	Cell culture	- Microdilution broth technique with a 96-well microplate - Minimum inhibitory concentration (MIC)	Hexagonal boron nitride (h-BN) nanoparticles inhibited bacterial growth and do not kill bacteria at used concentration
Li *et al.*	Biomimetics 2022	To achieve antibacterial effects while significantly improving the mechanical properties of PMMA	Boron nitride nanosheets (h-BNNs) and Silver nanoparticles (AgNPs)	Poly-methyl methacrlyate (PMMA)	- Bacterial plate counting method - Bacteria viability	- hAP nanocomposites demonstrated attractive antibacterial properties

Ma *et al.*	Front Mater 2022	To evaluate the mechanical properties and antibacterial properties of hexagonal boron nitride and titanium dioxide (h-BN-TiO2) nanocomposite modified traditional glass ionomer cement	Hexagonal boron (h-BN) and Titanium oxide (TiO2) nanoparticles	Glass ionomer cement (GIC)	- Direct Contact Test	Different concentrations of the h-BN-TiO2 nanocomposite, had a better antibacterial effect than pure GIC without h-BN-TiO2 nanocomposite

6. Conclusions

The main of this review was to offer a brief summary of the dental materials perspective on incorporating boron element. Recent advances have shown that there is increasing interest in substituting boron into the structure of dental base materials such as alloys, ceramics, cement, composite materials, 3d printed polymers, or combined material systems due to its close relationship with oral cavity. These boron containing materials can be used in a range of dental application, similar to their boron free forms. This review highlights that the use of various types of boron compounds can enhance both the mechanical and antibacterial properties of dental materials, resulting in several clinical benefits, such as improved physical properties, prevention of tooth decay and advance material surface properties as well. Reviewed studies indicated that the addition of boron to the dental materials led to preferable properties, and the level of improvement was found to be directly proportional to the concentration of boron added. Moreover, it is possible to combine the known properties of boron with the functional ions of other elements, to create materials with unique properties. In summery, boron compounds are advantageous due to their affordability, safety, and effectiveness in creating antibacterial materials. By developing new generation dental materials with the incorporation of boron, they could become the preferred choice for dental restorations, bringing them to the forefront of dental treatments. Even though, it can be concluded that boron in appropriate concentrations have the potential to serve as safe oral material, in order to expand the clinical application of boron incorporated materials, *in vivo* properties should be investigated.

7. Conflict of Interest

Not available

8. Financial Support

Not available

9. References

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