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APPLICATION OF POLYMERIC CHEMICAL IN DENTISTRY

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ABSTRACT
The application of polymeric chemical has increased in dentistry. PMFs(polymeric material films such as acrylic acid copolymers are adhesive material in dental treatment; polylactic acids are used for dental pulp and dentin regeneration, and bioactive polymers are used as advanced drug delivery systems. Dental biomaterials are used in preventive, restorative, and regenerative treatments. A large number of these materials ranging from dental cements, resins, metals, and alloys to ceramic materials are used in dentistry. Metals and alloys commonly used in dentistry include titanium (Ti) and their alloys such as nickel-titanium (NiTi), stainless steel, cobalt-chrome alloys, nickel-chrome, gold-based alloys, or dental amalgam.

INTRODUCTION

Polymeric chemical material areused in preventive, restorative, and regenerative treatments. A large number of these materials ranging from dental cements, resins, metals, and alloys to ceramic materials are used in dentistry. Metals and alloys commonly used in dentistry include titanium (Ti) and their alloys such as nickel-titanium (NiTi), stainless steel, cobalt-chrome alloys, nickel-chrome, gold-based alloys, or dental amalgam. Despite the wide availability of biomaterials, no material has ideal physical, mechanical, biological, and surface characteristics. Therefore, selecting a biocompatible material for dental use depends on numerous factors such as their corrosion behavior, mechanical properties, cost, availability, and esthetics.

Polymers play a major role in different aspects of dentistry, such as preventive, restorative, and regenerative therapies.

Polymers are high-molecular-mass macromolecules consisting of repeating structural units derived from their respective monomers. Polymers commonly used in dentistry are polyethylene (PE) $[-(CH_2-CH_2)-]$, polymethyl methacrylate (PMMA) [−{CH2−C(CH3)−CO − OCH3}−], polycarbonate (PC) [−{O−(CO)−O}−], polyethylene glycol (PEG) $[-\{CH_3(O)-CH_3(O)\}-]$, polydimethylsiloxane [−{(CH3) 2−Si−O}−], polyurethane (PUR) [−(NH–COO)−], polylactic acid (PLLA) $[-\{O-CH(CH_3)-O\}-]$, poly(e-caprolactone) (PCL) $[-\{CO(CH_2)_5-O\}-]$, polypyrrole (PPy) [−{CH4H5−N}−], and hexamethyldisilazane (HMDC) $[-\{C_6H_{19}-N_5-Si_2\}-]$, N-isopropylacrylamide $[-\{C_6H_{11}-NO)\}-]$, N-tert-butylacrylamide $[-\{C_7H_{13}-NO)\}-]$, and hydrogel [−{C3H3−NaO2)}−]. Although the mechanical properties of these biomaterials are dictated by their bulk properties, their tissue biomaterial interactions are governed by their surface properties which can be easily tailored to specific requirements. Thus, polymer coatings may be used to increase the biocompatibility of a bulk material. PMs are used in dentistry covering their antimicrobial properties, drug delivery, and tissue regeneration and for reducing corrosion and friction.

Classification of PMFs in dentistry

PMFsclassification in dentistrywhich is based ontheirapplication. ASfollows:

Antimicrobial PMFs in dentistry

PMFs for preventing biofilm and dental caries development
PMFs for preventing tooth erosion
PMFs for drug delivery
PMFs in restorative dentistry
PMFs in prosthetic dentistry
PMFs in implantology
PMFs in periodontics
PMFs for reducing corrosion in dentistry
PMFs for reducing friction in dentistry

Antimicrobial PMFs in dentistry

Biofilms cause common dental diseases that involve microbes adhering to teeth or restorative materials. Microbial adhesion is followed by bacterial growth and colonization, resulting in the formation of a compact biofilm matrix This matrix protects the underlying bacteria from the action of antibiotics and host defense mechanisms. The biofilm formed on teeth, prostheses, or implant-anchored restorations contains aciduric organisms such as Streptococcus mutans (S. mutans) and lactobacilli that secrete acid causing enamel and dentin demineralization Biofilm formation on dental implants can result in serious infection leading to dental implant failure. Adding different antibacterial agents such as, quaternary ammonium compounds inorganic nanoparticles (NPs) or fluoride varnish with natural productsinto the dental materials prevents biofilm formation and bacterial growth. Dental varnishes containing fluoride with natural products including miswak, propolis, and chitosan have been shown to be an effective approach for caries prevention. Newer techniques include the use of antibacterial polymer coatings for preventing bacterial growth on artificial tooth surfaces in other dental materials and dental composite kits increasing the restoration's longevity. Examples of such antibacterial coatings include copolymers of acrylicacid, alkylmethacrylateand polydimethylsiloxane copolymers pectin coated liposomes, and carbopol.

PMFs for preventing biofilm and dental caries development

Microbes produce excessive extracellular polymeric substances (EPS) that protect them from their environment and antibiotics, thereby making them antibiotic resistant. Nanotechnology and polymeric nanomaterials have been used to prevent bacterial adhesion and biofilm formation The combination of nanoparticles (NPs) and antibiotics enhances antibiofilm activity. Preventing microbial adhesion and proliferation on dental material surfaces depends on interactions between synthetic polymeric biomaterials and tooth structure.

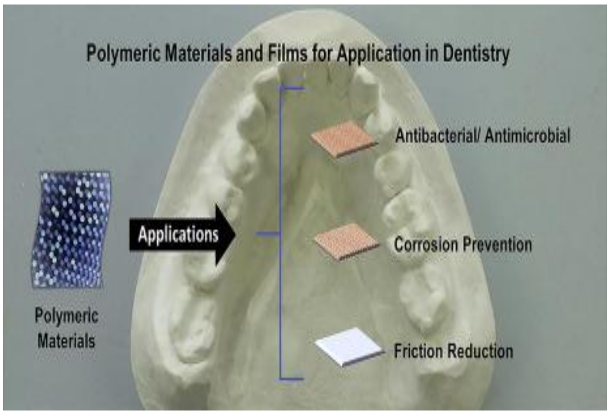

Fig. 1.

Such as liposomes, have been shown to be advantageous because they can reach sites inaccessible to other types of formulations, and can also be site-specifically targeted. Nguyen et al. Found that pectin coated liposomes that formed naturally on tooth surfaces adsorbed the hydroxyapatite (HA) *in vitro* and acted as protective biofilms. The ability of pectin-coated liposomes to remain on enamel suggests their possible use as a protective coating on the teeth. In fact, the use of charged liposomes, either uncoated or coated using electrostatic deposition with polysaccharides (alginate, chitosan and pectin), as bioadhesive systems for the oral cavity was investigated through an *in vitro* study (Fig. 2). It was found that the liposome surface charge was highly important for their stability in saliva and for bioadhesion. The negatively charged liposomes were the most stable in artificial saliva, and the stability of the positively charged liposomes in the film was improved using a negatively charged polysaccharide.

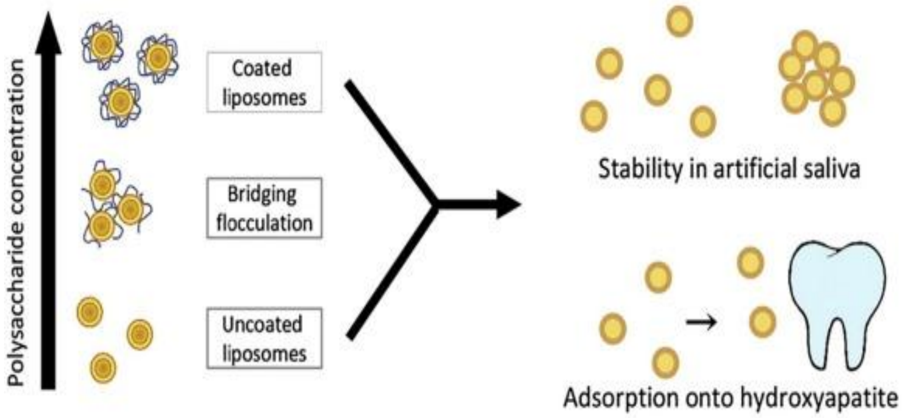

Fig. 2: Pectin-coated liposomes that formed on tooth surfaces used as bioadhesive systems in the oral cavity.

PMFs for Preventing Tooth Erosion

Soft drinks with low pH causes tooth erosion and dental caries. Erosive enamel demineralization results in surface ability of a polymer modified citric acid solution of propylene glycol alginate to reduce tooth erosion. Chitosan is a natural polymer derived from the deacetylation of chitin. They found that the toothpaste containing F/Sn/chitosan showed promising results in reducing tooth surface loss from erosion and abrasion. Chitosan, due to the presence of a cationic amino group, has a high positive zeta-potential and readily adsorbs onto materials such as enamel of strong negative zeta potential through electrostatic forces The preventive potential of chitosan against erosion and enamel demineralization is attributed to its ability to form a protective multilayer on the tooth surface in the presence of mucin from saliva. Carbopol, a high-molecular-weight acrylic acid polymer, has been used as a thickening agent in many formulations such as gels, suspensions, and emulsions. It also prevents or controls the enamel demineralization causing no deleterious effects on the tooth. A carbopol film combined with sodium fluoride has demonstrated an improved protective effect against tooth demineralization.

Pmfs For Drug Delivery

Drug delivery via the oral mucosa can occur through keratinized mucosa (gingival and hard palate), and nonkeratinized mucosa (sublingual and buccal) The bioadhesive formulations protect fragile drugs and improve the retention time of active substances ranging from days to months improving the efficacy of the treatments resulting in patient comfort and compliance. The use of nanocapsules as carriers allows for targeted drug delivery, controlled/sustained release drug delivery systems, transdermal drug delivery systems, and improved drug stability and bioavailability. The NPs incorporated with polyethylene glycol (PEG), or subjected to ‘PEGylation’ improved the efficiency of drug and gene delivery to target cells and tissues. Such NPs-PEGs protect the NPs surface from aggregation, opsonization, and phagocytosis prolonging systemic circulation time. Polycarbonate, a naturally transparent amorphous thermoplastic that has good heat resistance, high toughness and impact strength, can be combined with polyethylene glycol (PEG) and antimicrobial agents for controlled drug release applicable.

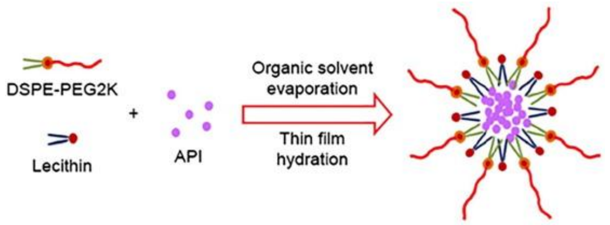

Fig. 3: Polymeric micelles mixed with amphotericin B. DSPE-PEG2K: 1,2-disteroyl-sn-glycerol-3-phosphoethanolamine-N-methoxy(poly(ethylene glycol)-2000; API: Active Pharmaceutical Ingredients.

PMFs in Restorative Dentistry

Resin composite restorations are technique sensitive, and achieving good isolation is very important. Saliva contamination during restoration curing disrupts the bonding of the composite restoration with the tooth structure In addition, composites may degrade in the oral cavity. The catechol-functionalized polymer can function as a dental adhesive for wet dentin surfaces, potentially eliminating the complications associated with saliva contamination. It has been shown that some dental cements are antibacterial Various anti-bacterial polymeric coatings such as acrylic acid, alkylmethacrylate, and polydimethylsiloxane copolymer, Carbopol, N-halaminebasedpolymer additive and Ti oxide-chitosan/ heparin multilayers have been used to prevent biofilm formation and to increase restoration longevity.

PMFs in Prosthetic Dentistry

Polymethyl methacrylate (PMMA) is widely used as biomedical material to make various types of prostheses in medicine and dentistry. PMMA is a strong, tough, lightweight material with good impact strength compared with glass and polystyrene, and its environmental stability is superior to most other plastics such as PE and polystyrene. However, PMMA has certain disadvantages; it swells and dissolves in many organic solvents and chemicals due to its easily hydrolyzable esters groups Reducing biofilm formation on dental materials, such as denture base, is a key to oral health. Various additives such as zirconium oxide nanoparticles (ZrO_2-NPs), Yamani henna power, silver nanoparticles (Ag-NPs) or platinum nanoparticles (Pt-NPs) have been incorporated into PMMA to reduce bacterial or fungal colonization. The addition of ZrO_2-NPs to cold-cured PMMA reduced C. albicans adhesion to denture bases and cold-cured removable prosthesis. The PMB polymeric film inhibited sucrose-dependent *S. mutans* biofilm formation on PMMA denture base, indicating that this biocompatible PMB polymer film may reduce biofilm formation on PMMA surfaces. Polymers have been used to fabricate nanosilver nanocomposites with better properties and enhanced antibacterial activity.

PMFs in Implantology

The osseointegration of cpTi/Ti alloy implants used for dental, craniofacial and orthopedic purposes is related to their composition and surface roughness. Rough surfaced implants increase osseointegration and biomechanical stability.[76] Implant surface treatment methods include Ti plasma-spraying, grit-blasting, acid-etching, anodization and calcium phosphate coatings. A favorable environment is necessary for implant osseointegration. The reduced oxygen concentration from the poor vasculature at the implant surface interface promotes a buildup of host-cell-related electrons as free radicals and proton acid that can encourage infection and inflammation causing implant failure. To provide a favorable environment for osseointegration and overcoming the problems associated with Ti implants, surface modifications can be performed using high-strength fiber-reinforced and complex fillers/additives including hydroxyapatite or antimicrobial incorporation via thermoset polymers, which cure at low temperatures. The polymer/carbon-fiber-reinforced composite produced successful osseointegration. Thermoset polymer matrix and carbon fibers generate covalent bonds providing strong bone structure support with excellent osseointegration.

Researchers are also focusing on developing bioactive coatings on dental implants to enhance osseointegration by interactions between proteins, cells and tissues, and implant surfaces. The local release of bone stimulating or resorptive drugs in the peri-implant region may result in long-term dental implant success. Biomimetic coated Ti surfaces with nano-hydroxyapatite (n-HA) and poly(lactic-co-glycolic acid) (PLGA)/collagen nanofibers have been studied for dental and bone implant surfaces to enhance osseointegration. This coating enhanced initial cell adhesion, cell proliferation, differentiation and mineralization on the implant surface.

The use of antibiotic-containing nanofiber-based polymeric films on dental implants has been investigated to minimize implant loss, especially in periodontally compromised patients. Bioactive polymers such as hydrogels, hydroxypropyl methylcellulose (HPMC), poly(lactic/glycolic acid) and poly(ε-caprolactone), have been used for the sustained release of antimicrobial drugs such as metronidazole, ciprofloxacin, and minocycline Polylactic acid (PLLA), a popular low-cost biodegradable polymer has excellent biocompatibility and good mechanical properties (particularly tensile Young's modulus, tensile strength, and flexural strength) compared with polyethylene and polysulfide PLLA has wide applications in medical sciences and is used in a range of devices, including degradable sutures, drug releasing micro-particles, nano-particles, and porous scaffolds for cellular applications Shahi et al. used a tetracycline hydrochloride PLLA, poly(e-caprolactone), and gelatin polymer solution to synthesize tetracycline-containing fibers. These fibers inhibited the growth and biofilm formation of peri-implantitis associated pathogen such as Fusobacterium nucleatum, Porphyromonas gingivalis, Prevotella intermedia and Aggregatibacter actinomycetemcomitans. They suggested that tetracycline-containing fibers have potential to use as an antibacterial film on dental implants. However, the elongation at break and impact strength of PLLA are lower than that of polyethylene, polyethylene terephthalate and polyamide (PA), and PLLAS's poor toughness limits its use in applications requiring plastic deformation at higher stress levels; this requirement has stimulated investigation on toughening PLLA.

PMFs in periodontics

Inhibiting biofilm formation on tooth enamel is an important technique for preventing dental and periodontal diseases. The 2-methacryloyloxyethyl phosphorylcholine (MPC) is a polymer that is water-soluble, biocompatible and has good hemocompatibility. MPC reduced the retention of human pathogenic microorganisms. Kang et al. immobilized MPC on the tooth surface to prevent oral bacterial adhesion. The synthesized MPC-ran-2-methacryloyloxyethyl phosphate (PMP) copolymer with zwitterionic and Ca^{2+} binding moieties formed a highly effective biofilm inhibiting surface on the HA of the tooth surface. It showed that HA surfaces coated with a copolymer containing 50% MPC (PMP50) reduced protein adsorption and subsequent cell adhesion and *S. mutans* adhesion compared with other polymer combinations. Thus, highly stable anti-adsorptive and anti-bacterial PMP films can be used in dentistry and medicine.

Polysaccharides and copovidone is a non-ionic copolymer. These polymers transport F to the enamel surface.

Studies have been conducted on the efficacy of toothpastes and topical creams containing casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) with fluoride in preventing erosive tooth wear from acidic beverages or solutions A randomized controlled trial was conducted by Maden et al. To investigate the effect of acidulated phosphate F (APF) gel and CPP-ACP on the dental erosion in primary teeth. They found that artificial saliva, CPP-ACP, and 1.23% APF treatments reduced erosive enamel loss produced by carbonated drinks in primary teeth. The 1.23% APF gel showed the highest protective effect against erosive enamel loss. The PA coating seals the NiTi surface preventing corrosion and nickel ion release. The average decrease in Ni ion release due to this coating is approximately 85%.Graphene film coatings have been used for lubrication and reducing friction. The tribiologic properties of GO were investigated by adding GO monolayer sheets to water-based lubricants that were applied to a sintered tungsten carbide ball and stainless steel flat plate. Hydrogels comprise a group of PMs, the hydrophilic structure of which renders them capable of holding large amounts of water in their 3D networks. Their properties include biodegradation, and chemical and biological response to stimuli However, hydrogels have disadvantages such as higher water absorption capacity and high stability, which is not favorable when degradation is desired. In addition, single component hydrogels have low mechanical strength, and recent studies have used composite or hybrid hydrogel membranes to increase the hydrogel strength. Hydrogels have also been used in biomedical technology, tissue engineering, NiTi implants, and orthodontics because these polymers are viscoelastic and permeable, and their mechanical properties mimic those of many natural tissues, poly-vinyl alcohol with various amounts of zwitterionic polymer film, poly([2-(methacryloyloxy)ethyl] dimethyl-(3-sulfopropyl) ammonium hydroxide), demonstrating that biocompatible zwitterionic polymers reduced friction up to 80%.

Pmfs for Reducing Corrosion In Dentistry

Corrosion is a diffusion interfacial electron-transfer process that occurs on the surface of metals, and metal corrosion is an important factor in biocompatibility. The Ni released from NiTi and stainless steel orthodontic wires is a known allergen. The oral signs and symptoms resulting from Ni released from orthodontic appliances include gingival hyperplasia, stomatitis, angular cheilitis, perioral rash, erythema multiforme, burning sensation, and loss of taste. Another common metal used in dentistry is Ti and its alloys. Soft tissue inflammation with black extracellular deposits and Ti particles within histocytes and foreign body giant cells resulting from the rough surfaces of Ti alloy medical prostheses or those that have loosened have been observed. It is known that Ti ions are responsible for monocyte infiltration in the oral cavity by elevating the sensitivity of gingival epithelial cells to microorganisms.

PMFs for reducing friction in dentistry

Frictional force is an important consideration in dentistry, especially in orthodontic treatment because it results in the loss of applied force. Orthodontic arch wires that can deliver light forcesover time would be useful to clinicians during the initial alignment phase of fixed appliance treatment. The PA coating seals the NiTi surface preventing corrosion and nickel ion release. The average decrease in Ni ion release due to this coating is approximately 85%.

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CONCLUSIONS

Polymeric chemicals are very useful in denstry. and their properties are make the surface modification coating, it is rare to find an ideal biomaterial that possesses excellent surface characteristics and is biocompatible for clinical applications.

REFERENCES

1. A.C. Fornell, K. Sköld-Larsson, A. Hallgren, F. Bergstand, S. TwetmanEffect of a hydrophobic tooth coating on gingival health, mutans streptococci, and enamel demineralization in adolescents with fixed orthodontic appliances. Acta Odontol Scand, 2002; 60: 37-41. View Record in ScopusGoogle Scholar
2. D.M. da Silva Ávila, R.F. Zanatta, T. Scaramucci, I.V. Aokic, C.R.G. Torres, A.B. BorgesInfluence of bioadhesive polymers on the protective effect of fluoride against erosion. J Dent, 2017; 56: 45-52. Google Scholar.
3. M. RoachBase metal alloys used for dental restorations and implants. Dent Clin North Am, 2007; 51: 603-627. ArticleDownload PDFView Record in ScopusGoogle Scholar.
4. M. Navarro, A. Michiardi, O. Castaño, J.A. PlanellBiomaterials in orthopaedics. J R Soc Interface, 2008; 5: 1137-1158. CrossRefView Record in ScopusGoogle Scholar.
5. M. Saini, Y. Singh, P. Arora, M.N. KLumarImplant biomateri als: a comprehensive review. World J Clin Cases, 2015; 3: 52-57. CrossRefView Record in ScopusGoogle Scholar.
6. M.F. MaitzApplications of synthetic polymers in clinical medicine. Biosurf Biotribol, 2015; 1: 161-176. ArticleDownload PDFView Record in ScopusGoogle Scholar.
7. S. DebPolymers in dentistry. Proc Inst Mech Eng H, 1998; 21: 453-464. View Record in Scopus Google Scholar.
8. J.L. Ong, L.C. Lucas Auger electron spectroscopy and its use for the characterization of titanium and hydroxyapatite surfaces. Biomaterials, 1998; 19: 455-464. Article Download PDF View Record in ScopusGoogle Scholar.
9. T. Kuill, S. Bhadra, D. Yao, N.H. Kim, S. Bose, J.H. LeeRecent advances in graphene based polymer composites, Prog Polym Sci., 2010; 35: 1350-1375, Google Scholar.
10. M. Øilo, V. BakkenBiofilm and dental biomaterials, Materials (Basel), 2015; 8: 2887-2900. CrossRefView Record in ScopusGoogle Scholar
11. R.M. DonlanBiofilms: microbial life on surfaces, Emerg Infect Dis., 2002; 8: 881-890, CrossRefView Record in Scopus Google Scholar.
12. P.R. Schiroky, V.C.B. Leitune, I.M. Garcia, F.A. Ogliari, S.M.W. Samuel, F.M. Collares Triazine compound as copolymerized antibacterial agent in adhesive resins, Braz Dent J., 2017; 28: 196-200. CrossRefView Record in Scopus Google Scholar.
13. F.W. Degrazia, V.C.B. Leitune, I.M. Gracia, R.A. Arthur, S.M.W. Samuel, F.M. CollaresEffect of silver nanoparticles on the physicochemical and antimicrobial properties of an orthodontic adhesive,

J Appl Oral Sci., 2016; 24: 404-410, CrossRefView Record in Scopus Google Scholar.
14. S. Tavassoli Hojati, H. Alaghemand, F. Hamze, F. Ahmadian Babaki, R. Rajab-Nia, M.B. Rezvani, *et al.* Antibacterial, physical and mechanical properties of flowable resin composites containing zinc oxide nanoparticles, Dent Mater, 2013; 29: 495-505, ArticleDownload PDFView Record in ScopusGoogle Scholar.
15. M.O. Wassel, M.A. KhattabAntibacterial activity against Streptococcus mutans and inhibition of bacterial induced enamel demineralization of propolis, miswak, and chitosan nanoparticles based dental varnishes, J Adv Res., 2017; 8: 387-392. ArticleDownload PDFView Record in ScopusGoogle Scholar.
16. N. Zhang, C. Chen, M.A. Melo, Y. Bai, L. Cheng, H .H. XuA novel protein-repellent dental composite containing 2-methacryloyloxyethyl phosphorylcholine, Int J Oral Sci., 2015; 7: 103-109. Cross Ref View Record in ScopusGoogle Scholar.
17. S. Nguyen, M. Hiorth, M. Rykke, G. Smistad Polymer coated liposomes for dental drug delivery – Interactions with parotid saliva and dental enamel Eur J Pharm Sci., 2013; 50: 78-85. ArticleDownload PDFView Record in ScopusGoogle Scholar.
18. G. Bonacucina, M. Cespi, M. Misici-Falzi, G.F. Palmieri Rheological evaluation of silicon/carbopol hydrophilic gel systems as a vehicle for delivery of water insoluble drugs, AAPS J., 2008; 10: 84-91. CrossRefView Record in ScopusGoogle Scholar.
19. S. Qayyuma, A.U. KhanNanoparticles vs. biofilms: a battle against another paradigm of antibiotic resistance Med Chem Commun, 2016; 7: 1479-1498. Google Scholar.
20. R.P. Allaker The use of nanoparticles to control oral biofilm formation J Dent Res., 2010; 89: 1175-1186. Cross Ref View Record in ScopusGoogle Scholar.
21. M. Hannig, C. Hannig Nanomaterials in preventive dentistry Nat Nanotec.