Review

Biodegradation of acrylic based resins: A review

Ana F. Bettencourt, Cristina B. Neves, Marise S. de Almeida, Lídia M. Pinheiro, Sofia Arantes e Oliveira, Luís P. Lopes, Matilde F. Castro

Research Institute for Medicines and Pharmaceutical Sciences (iMED.UL), Faculty of Pharmacy, University of Lisbon, Lisbon, Portugal
Biomedical and Oral Sciences Research Unit (UICOB), Faculty of Dentistry, University of Lisbon, Lisbon, Portugal

Abstract

Objectives. The development of different types of materials with application in dentistry is an area of intense growth and research, due to its importance in oral health. Among the different materials there are the acrylic based resins that have been extensively used either in restorations or in dentures. The objective of this manuscript was to review the acrylic based resins biodegradation phenomena. Specific attention was given to the causes and consequences of materials degradation under the oral environment.

Data and sources. Information from scientific full papers, reviews or abstracts published from 1963 to date were included in the review. Published material was searched in dental literature using general and specialist databases, like the PubMED database.

Study selection. Published studies regarding the description of biodegradation mechanisms, in vitro and in vivo release experiments and cell based studies conducted on acrylic based resins or their components were evaluated. Studies related to the effect of biodegradation on the physical and mechanical properties of the materials were also analyzed.

Conclusions. Different factors such as saliva characteristics, chewing or thermal and chemical dietary changes may be responsible for the biodegradation of acrylic based resins. Release of potential toxic compounds from the material and change on their physical and mechanical properties are the major consequences of biodegradation. Increasing concern arises from potential toxic effects of biodegradation products under clinical application thus justifying an intensive research in this area.

© 2010 Academy of Dental Materials. Published by Elsevier Ltd. All rights reserved.

Contents

1. Introduction ................................................................................................................. e172
2. Causes for biodegradation .......................................................................................... e172
   2.1. Saliva components ............................................................................................... e172
   2.2. Chewing force ..................................................................................................... e173
   2.3. Thermal and chemical dietary changes ............................................................... e173

* Corresponding author at: Faculty of Pharmacy, University of Lisbon, CBT Lab, Av. Prof. Gama Pinto, 1649-003 Lisbon, Portugal.
Tel.: +351 217946400; fax: +351 217946470.
E-mail address: asimao@ff.ul.pt (A.F. Bettencourt).
0109-5641/$ – see front matter © 2010 Academy of Dental Materials. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.dental.2010.01.006
3. Consequences of biodegradation ................................................................. e173
  3.1. Release of compounds from acrylic based resins ..................................... e173
    3.1.1. Biological effects of release ............................................................... e174
  3.2. Changes on the physical and mechanical properties ............................... e175
    3.2.1. Inner properties of acrylic based resins ............................................. e175
    3.2.2. Bond strength between denture base and reline resins ..................... e175
  4. Unexplored topics and areas for future research ........................................ e176
  5. Conclusions ............................................................................................. e176
References ........................................................................................................ e177

1. Introduction

Acrylic based resins consist of polymeric materials based on polymethylmethacrylate. These dental materials are the result of a free radical polymerization reaction. They can be classified as chemical, heat or light activated depending on the factor that initiates the reaction. Chemical or autopolymerized materials involve a chemical activator like N,N-dimethyl p-toluidine [1]. For heat-polymerizing materials, heat can be generated by hot water bath or microwave energy, while the light polymerizing uses visible light as energy source [2–4].

Acrylic based resins are frequently used in daily dental practice, as they are able to provide the essential properties and necessary characteristics to be used in diverse functions. Most common use of the materials includes denture bases and denture liners, orthodontic appliances and temporary crowns [4–6].

Denture bases are composed of pre-polymerized polymethylmethacrylate (PMMA) or polyethylmethacrylate (PEMA) powder particles along with a pigment, which are mixed with methacrylate monomers (methylmethacrylate, hexamethyleneglycoldimethacrylate, hydroxylethylmethacrylate, n-butylmethacrylate, tetrahydrofurfurylmethacrylate) and cross-linking agents such as ethylenealgoldimethacrylate, trimethylolpropane trimethacrylate or 1,6-hexanediol dimethacrylate [1,7–9].

Denture liners are used to improve the fit of denture bases, thus re-establishing the retention, support and stability of removable prostheses [10]. Several types of these materials are available, they can be hard reline resins or soft lining materials. Soft lining materials can be divided into two groups [4].

The polymeric materials were classically recognized as large stable structures with a high degree of resistance to biodegradation. However, several studies conducted especially with composites materials, showed that polymers may be subject to a myriad of degradation processes in the oral cavity [19,20].

Polymer degradation does not occur as a result of isolated processes, multiple factors as saliva, chewing, thermal and chemical dietary changes may be responsible for the biodegradation processes [20].

2. Causes for biodegradation

The polymeric materials were classically recognized as large stable structures with a high degree of resistance to biodegradation. However, several studies conducted especially with composites materials, showed that polymers may be subject to a myriad of degradation processes in the oral cavity [19,20].

Polymer degradation does not occur as a result of isolated processes, multiple factors as saliva, chewing, thermal and chemical dietary changes may be responsible for the biodegradation processes [20].

2.1. Saliva components

Water is the most abundant component of saliva as such is one of the main factors to cause biodegradation. The oral environment necessarily facilitates water sorption from the saliva to the resin, which is a polar material. Water molecules can easily penetrate the polymer network allowing the diffusion of unbound/uncured monomers and/or additives from the material network [4,15,21].

There are two conditions that influence the amount of water diffusion to denture resins. One is the water diffusion....
coefficient of the material that affects the time needed for its saturation with water. The other one is the amount of residual components that are release for the medium and replaced by water molecules [19–21].

Water sorption has been shown by several authors to follow Fickian diffusion kinetics [22–24]. Therefore, one might expect a typical polymeric dental material to become saturated with its aqueous environment within 1–2 months after placement.

Polymeric structures and dental materials in particular may also be chemically degraded in aqueous solutions essentially through two mechanisms: hydrolysis and enzymatic reaction [19,20]. Salivary enzymes can degrade polymers through attacks on the side chains, producing both potentially harmful by-products as well as a deterioration of the properties of the network. The composition of the monomers producing the network is a major factor in determining the extent of degradation, especially when enzymes are responsible. Various esterases that have been shown to be present in saliva can promote esterification of methacrylates. The effect of enzyme degradation on mechanical properties has been manifested as a reduction in surface hardness and wear resistance [19,20,25–31].

Interactions between oral microbes and the polymer dental materials may also occur, although little information is available regarding this possibility. An in vitro study conducted by Willershausen et al. [32] has shown that bacteria can colonize the surfaces of resin-based dental materials. They have also found an increase in the roughness, suggesting some surface degradation effect caused by bacteria colonization.

2.2. Chewing force

Biodegradation of the materials in the oral cavity can also be induced by fatigue, which is caused by relatively weak repetitive loads such as ordinary chewing force. A continuous application of mechanical and environmental loads leads to progressive degradation and crack initiation and growth, resulting in catastrophic failure of the resins. This process is further assisted by pre-existing voids introduced during the material processing and residual stresses [33]. Chewing can also apply shear and compression forces on denture teeth causing wear [34].

The mechanical loading developed on the material is usually study by means of cyclic loading. A chewing simulator designed to imitate the chewing forces that are produced during function is used. It has been realized that static evaluation of a material may not be as important as cyclic fatigue values for materials utilized in the oral cavity. The simulator usually acts in a frequency of 2 Hz with sinusoidal loads cycling for 11,000 and 100,000 cycles at a load level of 60% of the fracture load of non-cycled specimens [33].

The effect of chewing on the release of substances from acrylic based resins is controversial. Simulation of mastication by dynamic cycling did not produce any significant increase in the leaching of phthalate esters in soft polymers except those with ethanol [35]. Nevertheless Graham et al. [36] has shown that clinically tested denture lining materials appeared to lose significantly more plasticizer than materials stored statically in vitro over the same time frame.

2.3. Thermal and chemical dietary changes

Intraoral temperature changes may be induced by routine eating and drinking. These temperature changes produce a hostile environment for the materials as they have a different coefficient of thermal expansion compared to natural tooth. Thermal fluctuations encountered in vivo can induce surface stresses due to the high thermal gradients near the surface. Mechanical stresses induced by different thermal changes can directly induce crack propagation through bonded interfaces influencing the bond strength between denture base and reline materials [37,38].

The thermal changes are simulated in research through thermocycling. The specimens are immersed in almost extreme temperatures baths: 5 ± 2 and 55 ± 2 °C with a dwell time that varies between 30 s and 1 min each [39].

Foods and drinks can also affect dental materials by the direct effect of their additives, like ethanol, and their capacity of changing the intraoral pH values [40].

3. Consequences of biodegradation

A major clinically significant consequence of acrylic based resins biodegradation is the release of potential toxic unbound/uncured monomers or/and additives from the polymer network. The released compounds may have a toxic effect on the oral cavity. With respect to materials stability, biodegradation may induce significant changes in materials physical and mechanical properties that may ultimately lead to the catastrophic failure of the material.

3.1. Release of compounds from acrylic based resins

The release of compounds from different types of acrylic based resins has been widely investigated [41]. The majority of studies refer to denture [7,18,42–49] and relining [4,12,36,47,50–53] materials of different chemical composition. Some few studies analyze orthodontic appliances [54], restorative materials [21,55] and tissue conditioners [52,56]. Generally the experimental conditions consists in incubating polymer specimens of different shapes (disks, rectangular, cylinders) and sizes prepared according to manufactures instructions in a liquid, at room temperature or 37 °C, for periods of time ranging from hours to 1 or 2 months. Zissis et al. [47] conducted a longer study (38 months) on the release of residual monomer from denture base resins.

In most studies water is used as the leaching media [3,4,7,18,36,45,47–49,52,54,55,57–59]. Ethanol [21] and mixtures of ethanol/water [18,52,59] has also been used in order to increase the solubility of water insoluble compounds like phthalates [12].

The diffusion of residual monomers and other leachables components from acrylic based materials into human and artificial saliva has been investigated in some studies [6,12,18,41,42,44,52,53,60]. Kedjarune et al. [44] used unstimulated whole human saliva to evaluate the release of MMA from heat-cured and autopolymerized resins. Munksgaard [12] concluded that artificial saliva composed of an aqueous buffer with an esterase enzyme increased the rate of diffusion of phthalates from a soft lining acrylic material.
Very few investigators have concentrated on evaluating the release of compounds from acrylic based materials in clinical studies. Baker et al. [60] have evaluated the concentration of residual monomer leached from autopolymerized resins in a clinical study. Residual monomer in saliva was detected for up to 1 week wearing either an autopolymerized acrylic appliance or a heat polymerized appliance but they only measured the percentage of one monomer: methylmethacrylate (MMA). Graham et al. [36] evaluated the release of phthalates from two soft denture lining materials based on FEMA polymers by an in vivo and in vitro study. The results have shown that a higher loss of plasticizer occurred in vivo, compared with the in vitro study. Phthalates were identified in saliva samples collected from patients wearing dentures [61] and orthodontic appliances [62]. Tsuchiya et al. [43] found significant amounts of formaldehyde and MMA in human saliva under in vivo conditions leaching from acrylic autopolymerized resins.

Recently, Gonçalves et al. [41] evaluated the in situ levels of residual MMA monomer of an autopolymerized acrylic resin in forty volunteers. High concentrations of residual monomer during the first 24h of use were observed.

In spite of the different experimental methodologies the majority of published studies refers the elution of unbound components mainly MMA monomer [3,4,21,42, 44,45,48,49,52–55,58], phthalate esters [21,36,50,56] and additives like benzoyl peroxide [18] as one of the main consequences of material biodegradation.

Unbound monomers and additives are eluted within the first hours after initial polymerization and its release is time-dependent [59]. Generally samples release the highest amount of residual monomers during the first 24h after being processed [44,48] followed by a slow and moderate release over a long period of time [7]. In a long-term study, Sadamori et al. [63] reported that MMA decrease could be expressed in a hyperbola. Residual monomer was detected in dentures used up to 17 years, although the majority of this release occurred in the first 5 years.

Only a small number of studies have been devoted to investigate issues regarding the chemical processes involved in the release of compounds from acrylic based resins. The influence of pH on the biodegradation is reported in some studies [64]. Koda et al. [42] evaluated the influence of salivary acidity on the leaching properties of denture base acrylic resins and found that lower pH showed higher concentrations of MMA monomer.

Tsuchiya et al. [43,57] found significant amounts of formaldehyde, a compound formed as an oxidation product of the residual MMA monomer [65], leaching from autopolymerized denture base acrylic resins.

Methacrylic acid resulting from the hydrolysis of MMA was detected leaching out from acrylic denture base materials [42,59] and from soft lining materials [52] in water, artificial saliva and mixtures of ethanol–water. Benzoic acid derived from the benzoyl peroxide initiator has also been observed [42].

3.1.1. Biological effects of release

Products of acrylic based resins biodegradation have been suspected of being a contributing factor for chemical irritation [52], sensibilization and pain of the oral mucosa [43,46,59,66], ulceration [67], labial edema [68] and oral diseases such as burning mouth syndrome and denture stomatitis [56,67].

Phthalates and other esters of aromatic carboxylic acids used as plasticizers in reline acrylic materials may possess undesirable biological effects, particularly as xenoestrogens [6,12,56,59].

Reported allergic reactions associated with acrylic based resins [69–73] have been attributed to MMA monomer and additives as benzoyl peroxide [18].

Cell culture techniques have provided strong evidence that released compounds from acrylic based resin may induce a series of biological responses on cells. It is beyond the scope of this work to review all the numerous publications that evaluate the effect of acrylic based resins on cells. Some very good reviews related to the subject have already been published [65,74,75].

Most studies have focused on the cytotoxicity of leached MMA monomer and its derivatives [44,51,75–89]. Both permanent (L 929 fibroblast and osteoblast) and primary cells as gingival fibroblast, dental pulp, periodontal ligament and epithelial cells are used in the studies [51,81,84–86]. Test systems vary considerably in the way cytotoxicity is measured but all indicate changes in basic cell structures, such as cell membrane integrity and cell functions like enzyme activities or the synthesis of macromolecules [81].

The mechanism of adverse effect caused by MMA monomer is thought to involve direct toxicity from released or residual MMA and oxidative stress created by free radicals that are released during the resin polymerization [78,81,87,89–91]. In recent years, investigators have been using gene expression analysis for the evaluation of MMA effect on the expression of antioxidant enzymes like glutathione [88,93]. Cell culture techniques have also provided strong evidence that residual MMA monomer in acrylic based resin biomaterials may cause genotoxicity [83,84,94,95] and change in cytokine/growth factor expression of cells [96]. Some studies have addressed the effect of other methacrylate monomers like isobutylmethacrylate and 1,6-hexanedioldimethacrylate [51,96] major components in several relining acrylic materials. Cytotoxic effects on primary gingival fibroblasts and periodontal cells in dose-dependent manners were observed for those monomers [51].

The toxicity of methacrylate monomers differs according to their structure [97]. The structure–toxicity relationship of eighteen acrylic and methacrylic compounds was examined by Lawrence et al. [98] and Bass et al. [99]. They have concluded that acute toxicity correlated with water solubility. Dillingham et al. [100] reported that hemolytic activity of acrylates and methacrylates esters was related to lipophilicity (inversely related to water solubility) and that the mechanism of the action of the esters was membrane mediated and relatively nonspecific. Moreover Yoshii [96] evaluated the cytotoxicity of thirty-nine acrylates and methacrylates. All the acrylates evaluated were more toxic than the corresponding methacrylates. In both the acrylates and methacrylates, a hydroxyl group seemed to enhance the cytotoxicity of the materials.

Some authors have claimed that MMA monomers, by reacting with molecular oxygen may produce formaldehyde [43,57]. Formaldehyde has proved to be cytotoxic at much lower concentrations than MMA [43]. This compound is suspected to
cause hypersensitivity reactions and to be a strong irritant to the mucous membranes even at concentrations as low as 0.63–1.25 mg/m³ [65].

Phthalate esters used as plasticizers that can be released from acrylic based materials have been under evaluation for their cytotoxicity and estrogenic activity being considered as toxic compounds [52, 56, 91, 101]. Moreover some polymerization initiators can also cause toxic problems. For example benzoyl peroxide was found to induce necrosis in human gingival cells [102].

A specific study was realized to examine the effects of pH changes on the cytotoxicity of eluates from denture base resins on oral epithelial cells. Results showed that cytotoxic components leaching were affected by pH [64].

### 3.2. Changes on the physical and mechanical properties

Acrylic based resins are subjected to a complex number of conditions intraorally that can alter its dimension and/or structural integrity. Biodegradation may affect not only the inner properties of the material but also the bond strength between denture bases and reline acrylic resins.

#### 3.2.1. Inner properties of acrylic based resins

Most published studies have concentrated on the implications of water sorption leading to dimensional changes of the materials [103–105]. Its influence on physical and mechanical properties of acrylic polymers such as hardness [103, 106], flexural strength [107–111], resistance to plastic deformation [108] and fatigue limit [112] has also been studied.

The water molecules can penetrate into the spaces between the polymer chains and push them farther apart. Consequently the secondary chemical bonding forces (van der Waals forces) between the polymer chains decline and results in weight and volume increase to cause an expansion. The greater absorption of water by the material, the greater will be the associated dimensional change [113].

With time water molecules can act as plasticizers, altering the mechanical properties of the polymer [114]. It seems obvious that if water has a plasticizing effect on the resins their mechanical properties after water immersion should decrease [106]. The research shows these results in some kind of resins but not in all. The difference in the chemistry of the resins may account for the different effect water immersion has on their mechanical properties. Regarding to strength, if the constituent that leaches out exerts a lesser plasticizing effect than the water molecules, then the strength of the denture polymer should decrease. Conversely, if the constituent that leaches out exerts a more profound plasticizing effect than water molecules, then the strength of the denture polymer should increase [109].

Considering the soft lining materials the plasticizer particles gradually leach out in aqueous environments. As they are responsible of impart flexibility to the soft liners, their release turns the material progressively more rigid and therefore lead to clinical failure [115]. The loss of plasticizer may cause decreased percent elongation and increase hardness values [116, 117].

The amount of dimensional changes due to water sorption can be influenced by the type of resin, their thickness and the amount of cross-linked polymers. For example, a heat polymerized denture acrylic polymer takes a longer time than an autopolymerized polymer for water sorption to reach saturation because of its lower diffusion coefficient of water [109]. Nevertheless when studying water sorption, Arima et al. [118] found no significant differences between highly cross-linked autopolymerizing relining resins and heat-polymerizing denture base resins.

In an attempt to simulate the plasticizing effect that saliva has on denture polymers researchers include in their experimental protocol a period of water immersion prior to testing the strength of denture polymers [106, 108–110]. There seem to be little agreement as to how long denture polymers should be immersed prior to their mechanical testing. Although the international standard guidelines [119] points to 50 h of water immersion Takahashi et al. [110] suggested that the equilibrium strength of some denture polymers may well exceed 30 days. Although they recommend a 4-month water immersion protocol, the mainly water sorption occurs during the initial 14 days [108–110].

Chewing may also be responsible for changes in the viscoelastic properties of the materials. Muraoaka et al. [120] showed that cyclic loading influenced the viscoelastic properties especially the delayed deformation of acrylic based soft lining materials. The decrease of delayed deformation indicated reduced stress distribution effects of soft lining materials. Moreover the water absorption per surface area was suggested to increase after cyclic loading [120].

Clinical changes in the viscoelasticity of acrylic based soft lining materials are characterized by a more rapid and increase reduction on compliance than in vitro media such as water, artificial saliva or denture cleansers. A possible explanation for these differences is a solvent effect due to dietary [40].

Mixtures of ethanol and water are considered solvents which serve as food simulating liquids [121]. The monomer matrix is hydrophilic and absorbs substantial amounts of ethanol and water molecules. The solvent penetrates the resin matrix that becomes less hard and less fracture resistant [121]. Nevertheless Jepson et al. [40] found that none of the dietary simulating solvents showed clinical changes in compliance except the corn oil or heptanes that simulate the effect of fatty foods.

#### 3.2.2. Bond strength between denture base and relining resins

Degradation processes not only changes the inner properties of the resins but also affects the bond strength between the denture base resin and the relining material [111]. Polyzois [122] found a statistically significant reduction in bond strength between soft lining materials and denture base resins after 4 months in water storage. They reported that this reduction is the result of absorption of water and consequence of swelling and stress build up at the bond interface. This fact is corroborated by the weak bond between the PMMA based net of the denture base resin and non-MMA based net of the relining resin. This bond is achieved by penetration and diffusion of the relining monomer into the denture base resin and formation of an interpenetrating polymer network. MMA modified
molecules are largest and heavier than pure MMA molecules and that fact could affect bonding. When the material swells, not only stress builds between the bonding surfaces but also the viscoelastic properties of the liners changes. The material becomes brittle and transfers the external loads to the bond area.

Other studies have similar results [106,109,110,123] showing a decrease in tensile bond strength of reline denture base resins submitted to water storage. Cucci et al. [105] found that tensile bond strength between hard reline and denture base resins can be affected by 30 days of storage in water but not in all the resins. Nevertheless other researchers like Minami et al. [39] showed that shear bond strengths of autopolymerizing resin to denture base resins were not significantly influenced by water content of the denture base polymer. Also El-Haday and Drummond [124] found no difference on tensile bond strength of a acrylic based soft lining material submitted to 12 weeks storage. A failure in bonding of reline materials can harbor bacteria, promote staining and cause complete delamination and failure of the lining. A weak bond will also decrease the strength of the denture and cause fractures [109].

The temperature also has effects on the bond strength of a lining material to the denture base resin. Minami et al. [39] showed that bond strengths of autopolymerizing resin to denture base resins are influenced by thermal cycling.

Water absorption has been reported to reach saturation earlier with a higher water temperature [125]. Once the network is saturated with water and becomes softened the polymer structures stabilizes and there is no further reduction in properties [109]. Dootz et al. [117] reported highest values of tensile bond strengths for resilient lining materials after thermocycling. Other researchers [111,116,126] had the same kind of results and associated it with the continual polymerization of the material or with the release of plasticizer agents during thermal cycling. The increase in the rigidity of the material compensates the decrease in tensile strength caused by water sorption allowing an increase of the shear tensile bond between the liner and the acrylic resin.

4. Unexplored topics and areas for future research

Biodegradation of acrylic based resins under the oral environment has been so far uncompleted studied. Some questions that need to be investigated include: which enzymes are involved in the in vivo process of acrylic resins degradation? What are their co-factors? Is the saliva of one individual more likely to degrade certain materials than that from another person? What is the level of the different products in vivo?

A gap in the published literature exists regarding in vitro studies that allow a good knowledge of the biodegradation mechanisms and its consequences. Improvements in the experimental design should be done in order to better simulate the intraoral conditions. Using artificial saliva that include in its composition salivary enzymes and mucines and extending the studies in time will allow a more complete evaluation of the biodegradation process. Analytical techniques as gas chromatography/mass spectrometry (GC–MS) that provides means of identifying and quantifying more accurately the products of biodegradation at low concentrations should be more often used in the studies.

Basic research on the effect of biodegradation products on cells should proceed. The detailed mechanisms necessary to initiate apoptosis or necrosis by the materials remain to be elucidated [51]. The mechanism of interaction of MMA monomers with cell membranes remains unknown with respect to cytotoxicity and calcium release [86]. The MMA effect on dental pulp cells, in spite of its great clinical relevance, has rarely been studied [92]. Possible involvement of oxidative enzymes in cytotoxicity induced by MMA remains to be studied [88]. The biological impact of acrylic based resins biodegradation on cells caused by salivary enzymes, mucines or bacteria has not been addressed so far.

The clinical consequences of biodegradation are still poorly understood. Assessing what may be the extent of the biological effects as a result of the long-term release of biodegradation products still requires extensive study. The gap that exists between the results published by research laboratories and clinical reports should be shortened. Further well-controlled clinical studies are necessary to improve the knowledge about materials biocompatibility in intraoral conditions [7] including their potential to cause chronic local adverse effects on/and systemic side effects over time.

Evaluation of biodegradation aspects of acrylic based resins should be widened and considered not only as negative aspects regarding loss of mechanical properties and adverse toxic effects but can also be explored towards a positive interaction with the oral environment. The incorporation of products like antioxidant molecules intending to enhance the biocompatibility of the materials has been recently explored with promising results [89]. The use of acrylic based resins as drug delivery polymer systems could be an innovative new strategy for extending the use of these materials in the clinical dental practice.

5. Conclusions

The following conclusions are draw from this review:

1. Acrylic based resins are intensively used in dentistry practice as restorative, liners or as denture base materials. These substances are made by polymerization of methacrylate related monomers. Materials can be classified as chemical, heat or light polymerizing depending on the factor that initiates the polymerization reaction.
2. Increasing concern arises regarding the safe clinical application of these materials due to their biodegradation under the oral environment.
3. The number and diversity of processes by which acrylic based resins may be degraded in the oral cavity are huge and are now recognized as a complex interplay of interactions. Causes for biodegradation comprise several factors such as saliva characteristics, chewing or thermal and chemical dietary changes.
4. Consequences of materials biodegradation refer mainly to the release of potential toxic compounds from the polymer network and changes in materials physical and mechanical properties.
5. There is a sizeable literature on in vitro release studies concerning the elution of residual monomers, mainly MMA, in water. Considerable less studies use ethanol or artificial saliva as the leaching media. Experiments using human saliva are rare and few in vivo studies have been reported.

6. Products of acrylic based resins biodegradation have been suspected of having undesirable biological effects particularly as xenoestrogens and allergens. Reviewed cell based studies indicate that different compounds eluted from acrylic base resins (MMA and derivatives, phthalates, formaldehyde) have the potential to induce cytotoxicity, genotoxicity, change in cytokine/growth factor expression and oxidative stress on permanent and primary cells.

7. Degradation processes not only changes the inner properties of the resins but also affects the bond strength between the denture base resin and the relining material.

8. There is opportunity for future research in different areas related to the evaluation of acrylic based resins biodegradation. This will lead to a more concise definition of biocompatibility issues related to these dental materials. The information acquired from such studies can also provide investigators with alternative polymeric chemistries that can be used in a new generation of materials able to induce favorable reactions in the living tissues.

REFERENCES


an orthodontic patient. Am J Orthod Dentofacial Orthop


