



The dental materials degradation

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Abstract

In this paper the tooth degradation were examined. The subject of simultaneous diffusion and decomposition reaction were examined. Organic substance diffusion through the dental materials is occurred. Behind that, diffusion increases reaction of the tooth decomposition. Adding a corresponding monomer can be stopped decomposition of the tooth and inhibited the tooth degradation. The decomposition rate and diffusion rate has received considerable attention. The contribution of this paper is increasing periodontal health.

Keywords: tooth, diffusion, decomposition, saliva interaction, degradation rate.

1. INTRODUCTION

Composite materials have been used in posterior teeth, but the lack of wear resistance has restricted their application to situations in which aesthetics is essential. Composites with higher filler content and wear resistance have been developed, and restoration of posterior teeth with composites has increased [1]-[5].

Diffusion phenomena was subject many authors. Diffusional substance transfer rate between the solid and the liquid phase has been investigated in various manner [6]-[8].

Most of the reported research on solid-liquid mass transfer has been done with closely sized simple-geometry of slowly dissolving solute. Operations that involve sorptive mass transfer between a liquid and the surface of a solid are an important means of liquid purification, dissolved solute recovery, and solute separation. These are adsorptive systems.

Composite materials have been used in posterior teeth, but the lack of wear resistance has restricted their application to situations in which aesthetics is essential. Composites with higher filler content and wear resistance have been developed, and restoration of posterior teeth with composites has increased [9],[10].

Composites are used as cores in severely broken-down teeth and, in combination with the acid – etch technique, as veneers on severely discolored or deformed anterior teeth.

Adsorption from the saliva medium makes changes in composites.

Mathematical modelling diffusion and polymerization reactions was studied in the previous works [9],[10].

Diffusion and decomposition reaction in the tooth were studied in the papers [11], [12].

In this paper simultaneously diffusion with decomposition reaction of the tooth in the saliva medium was examined.

To stop the tooth degradation was studied.

2. Composites and polymers

Disfunctional oligomers and monomers, sometimes mixed with fillers, are used to fill, developmental pits and fissures in the occlusal surfaces of enamel to prevent caries.

Before placement, the enamel is etched with acid, rinsed, and dried. Etching provides for mechanical retention of the sealant. The sealants are formulated to be polymerized in situ by a chemical activated or light activated free radical mechanism. The treatment is most successful on the teeth of children soon after eruption.

Anterior teeth with to moderate fractures or decay can be restored with composites. They contain an inorganic filler of various particle sizes, as well as disfunctional acrylate oligomers and monomers. Composites are available as two pastes for the chemically activated type and a single paste for the light activated type. After cavity preparation, peripheral enamel is etched with acid, rinsed and dried. Equal volumes of the chemically activated type are mixed, syringed or packed into the preparation, and allowed to polymerases. For the light activated type, the paste is placed into the cavity preparation and polymerases by exposure to light. Setting occurs promptly, and final finishing to proper contour is done. When the proper shade is used, the boundary between the restoration and the tooth is difficult to detect.

Cervical caries or eroded areas of teeth are generally restored with glass ionomers. They consist of a powder and a liquid. The exposed dentin is cleaned, and any peripheral enamel is etched with acid. The components are spatulated to a thick paste and packed into the prepared area. Leached metal ions from the powder and the polymer acid react, a similar reaction may occur between the calcium from the tooth and the polymer acid to form an adhesive bond. Finishing is delayed for 24h because of the slow completion of the reaction. This method is most successful for cervical restoration, its functions are to restore the contour of the tooth. Thus, that is increasing periodontal health, and to reduce the sensitivity of the tooth.

Agents are available to bond enamel and dentin with composite. The bonding agents are organic compounds with variety of functional groups. They are applied to the cavity preparation before the composite, but the adhesive bond is weak and disfunction is occurred.

3. Dental waxes

Waxes and wax compositions have been important to the dental restoration for many years. In the discussion of dental waxes, two characteristics are repeatedly mentioned, flow and thermal expansion. A brief description of these two widely used tests may make the discussion of waxes more meaningful [5].

Flow testing is a means of defining the plasticity characteristics versus temperature for waxes. Most dental waxes find application within the oral cavity during some phase of their use. Direct inlay waxes and base plate waxes must be rigid and distort, or show plasticity, at mouth temperatures. At the same time, the direct inlay waxes must be completely plastic and adaptable within a temperature range that can be comfortably tolerated and will not injure the oral tissues. Impression waxes must be completely plastic and moldable at mouth temperatures, and chill to a rigid nonplastic mass upon being cooled a few degrees below mouth temperature. The plasticity characteristics of wax are determined by running a series of tests at selected temperatures and plotting the flow against the test temperatures.

The pattern waxes are used to construct the prototype or pattern from which a finished dental restoration is produced.

Inlay waxes are used to produce the wax patterns for the lost wax casting process, in the production of cast gold inlays, crowns, and bridges. A limited amount of inlay wax is also used to produce patterns for acrylic restorations.

Base plate waxes are used to substitute for, or be used in conjunction with, a base plate, to form a pattern for the production of a full or partial denture restoration and certain orthodontic appliances, to be modeled of acrylic resin, modified vinyl, or other denture - base material.

The extensive amount of handwork and craftsmanship that is necessary in the fabrication of most dental restorations and appliances has created a need for several types of wax compositions. Originally, most of these compositions were developed to fulfill a specific need. However, many of the compositions have proven quite versatile and find many applications by the dental technician.

Boxing wax, as the name implies, was developed to box impressions. This operation is simply to construct a retaining ring of wax, around an impression, to confine the plaster or stone when the cast is poured.

4. How occurs diffusion in tooth?

Diffusion may be viewed naively as the tendency for a group of particles initially concentrated near a point in space to spread out in time, gradually occupying an ever larger area around the initial point. Herein the term particles refer not only to physical particles, but to any other identifiable units as well.

However, such a definition of diffusion is liable to invite confusion. For example, consider a number of particles released simultaneously from a point on a plane, each heading straight with its own speed and direction. Clearly, the particles will spread and occupy ever-increasing areas. However, such a process is not called diffusion.

Diffusion is a phenomenon by which the particle group as a whole spreads according to the irregular motion of each particle. Rephrasing, when the microscopic irregular motion of each particle gives rise to a regularity of motion of the total particle group, macroscopic regularity, the phenomenon of diffusion arises.

Taking into account nutrition and thermal diffusion, microscopic description in the saliva-tooth shown in Fig.1 [11], can be described by equations (1) and (2). In this case interphase change can be neglected [11].

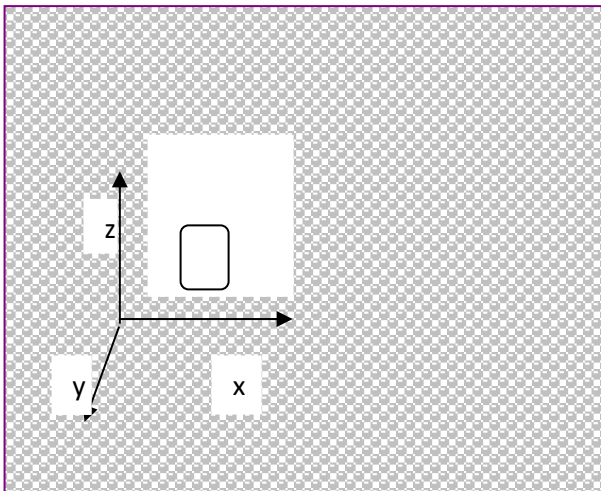


Fig.1 Mass and heat diffusivities to a tooth

Nutrition component transfer,

$$\frac{\partial c_i}{\partial t} + v_x \frac{\partial c_i}{\partial x} + v_y \frac{\partial c_i}{\partial y} + v_z \frac{\partial c_i}{\partial z} = D_i \left(\frac{\partial^2 c_i}{\partial x^2} + \frac{\partial^2 c_i}{\partial y^2} + \frac{\partial^2 c_i}{\partial z^2} \right) \tag{1}$$

Heat transfer,

$$c_p \rho \left(\frac{\partial T}{\partial t} + v_x \frac{\partial T}{\partial x} + v_y \frac{\partial T}{\partial y} + v_z \frac{\partial T}{\partial z} \right) = \lambda \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} \right) \tag{2}$$

where c_i nutrition, T the temperature, x, y, z are space coordinates and t is time, v is geometrical velocity, ρ density, c_p specific heat of material, D_i diffusion coefficient of nutrition and λ the thermal diffusivity or heat conductivity. If mixing effects can be neglected equation (2) can be transformed:

$$\frac{\partial T}{\partial t} + v_x \frac{\partial T}{\partial x} = \lambda \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} \right) \quad (3)$$

If diffusion can be neglected in y and z direction equation (2) can be restarted in the form:

$$\frac{\partial T}{\partial t} + v_x \frac{\partial T}{\partial x} = \lambda \left(\frac{\partial^2 T}{\partial x^2} \right) \quad (4)$$

where $\left(\frac{\partial T}{\partial t}\right)$ means speed of temperature change into the tooth, $\left(\frac{\partial T}{\partial x}\right)$ is heat transfer rate in x direction, and

$\left(\frac{\partial^2 T}{\partial x^2}\right)$ heat transfer acceleration in x direction which can regulating by parameter λ .

For the steady state condition and when velocity in the x direction can be neglected, equation (3) becomes:

$$\lambda \left(\frac{d^3 T}{dx^2} \right) = 0 \quad (5)$$

In the further text the diffusion from the tooth to the saliva was considered.

5. Simultaneously degradation by diffusion and decomposition

The most fundamental description of a reaction system would be based on molecular considerations. The molecular description is distinguished by the fact that it treats an arbitrary system as if it were composed of individual entities, each obeys certain rules. Consequently, the properties and state variables of the system are obtained by summing over all of the macromolecules.

Let the considered degradation reaction occurs:



5.1 Microscopic model of decomposition

Taking into account diffusion, microscopic description in the tooth-saliva phases with decompositional reaction, shown in Fig.2, can be described by equation (9). In this case interphase border change can be neglected.

$$\frac{\partial c}{\partial t} + v_x \frac{\partial c}{\partial x} + v_y \frac{\partial c}{\partial y} + v_z \frac{\partial c}{\partial z} + (-R_d) - D \left(\frac{\partial^2 c}{\partial x^2} + \frac{\partial^2 c}{\partial y^2} + \frac{\partial^2 c}{\partial z^2} \right) = 0 \quad (9)$$

where c is the component concentration, x , y , z are space coordinates and t is time, v is geometrical velocity, R_d is decomposition reaction rate, and D is the diffusivity coefficient of tooth. R_n means macromolecule, R^* is a radical.

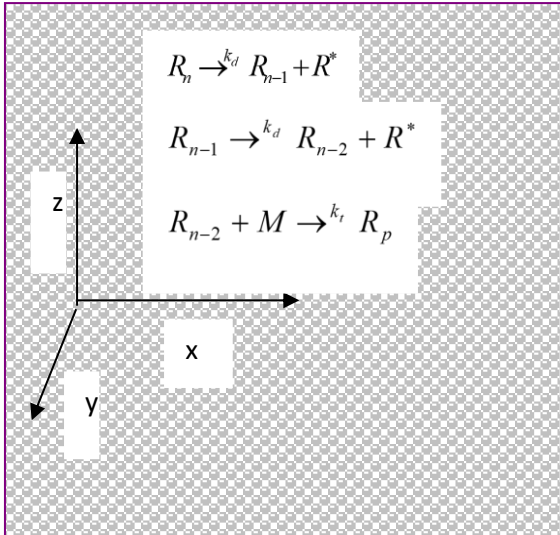


Fig.2 Reaction of depolymerization

If mixing effects can be neglected equation (1) can be transformed

$$\frac{\partial c}{\partial t} + v_x \frac{\partial c}{\partial x} + (-R_d) - D \left(\frac{\partial^2 c}{\partial x^2} + \frac{\partial^2 c}{\partial y^2} + \frac{\partial^2 c}{\partial z^2} \right) = 0 \quad (10)$$

If diffusion can be neglected in y and z direction equation (2) can be restarted in the form:

$$\frac{\partial c}{\partial t} + v_x \frac{\partial c}{\partial x} + (-R_d) - D \left(\frac{\partial^2 c}{\partial x^2} \right) = 0 \quad (11)$$

For the steady state condition and when velocity in the x direction can be neglected, equation (11) becomes:

$$D \left(\frac{d^2 c}{dx^2} \right) - (R_d) = 0 \quad (12)$$

Now, this partial differential equation becomes, ordinary differential equation:

$$D \left(\frac{d^2 c}{dx^2} \right) - R_d = 0 \quad (13)$$

Effective coefficient diffusion and specific decomposition rate constant can be experimental determined.

6. How gene expression

In metabolism of mammals and most lower vertebrates are prototrophic for purines and pyrimidines, i.e., they synthesize purine and pyrimidine nucleotides de novo [13], [14].

In human and other mammals, purine nucleotides are synthesized to meet the needs of the organism for the monomeric precursors of nucleic acids and for those other functions.

The biosynthetic pathway for the synthesis of purine nucleotides can be summarized in the following steps. The first step in the synthesis of purine nucleotides is the formation of 5'-phosphoribosyl-1'-pyrophosphate (*PRPP*). The conversion of ribose 5-phosphate and *ATP* to *AMP* + *PRPP* is not however unique to the synthesis of purine nucleotides. *PRPP* also serves as a precursor of the pyrimidine nucleotides and required for the synthesis of *NAD* and *NADP*, 2 - coenzymes derived from niacin.

PRPP then react with glutamine in a reaction catalysed by phosphor ribosylpyrophosphate aminotransferase to form 5'-phosphoribosyl amine. The reaction is accompanied by the displacement of pyrophosphate and the formation of glutamate. Although other mechanism has been proposed for the synthesis of 5'-phosphoribosylamine, the physiological important reaction in mammalian tissues is that catalysed by the amidotransferase. 5'-phosphoribosylamine, then reacts with glycine to produce glycinamide ribosylphosphate. Synthesis of purine and pyrimidine deoxyribonucleotides occurs

by direct reduction at the 2'- carbon in the ribose moiety of the corresponding nucleotide, not by synthesis of the entire nucleotide utilizing 2'-deoxy analog of *PRPP*.

Several antimetabolites that are glutamine analogs are effective inhibitors of purine biosynthesis.

Conversion of *AMP* and *GMP* to their respective nucleoside diphosphates and nucleoside triphosphates occurs in 2 successive steps. The successive transfers of phosphate groups from *ATP* are catalysed by nucleoside monophosphate kinase and nucleoside diphosphate kinase, respectively. The enzyme that phosphorylates adenylate is also called myokinase.

The pharmacologic approach has been to use an analog in which either the heterocyclic ring structure of the sugar moiety has been altered in such a way as to induce toxic effects when the analog becomes incorporated into various cellular constituents. Many of these effects results from inhibition by the drug of specific enzyme activities necessary for nucleic acids synthesis or from the incorporation of metabolites of the drug into the nucleic acids where they alter the base pairing essential to accurate transfer of information [14].

After mRNA leaves the nucleus, it moves to a ribosome, which consists of mRNA and proteins. The ribosome reads the sequence of codons in mRNA, and molecules of tRNA bring amino acids to the ribosome in the correct sequence.

After transcription in the nucleus, the mRNA exits through a nuclear pore and enters the cytoplasm. At the region on the mRNA containing the methylated cap and the start codon, the small and large subunits of the ribosome bind to the mRNA. These are then joined by a tRNA which contains the anticodons matching the start codon on the mRNA. This group of molecules (mRNA, ribosome, tRNA) is called an initiation complex.

tRNA keep bringing amino acids to the growing polypeptide according to complementary base pairing between the codons on the mRNA and the anticodons on the tRNA. As a tRNA moves into the ribosome, its amino acid is transferred to the growing polypeptide. Once this transfer is complete, the tRNA leaves the ribosome, the ribosome moves one codon length down the mRNA, and a new tRNA enters with its corresponding amino acid. This process repeats and the polypeptide grows.

At the end of the mRNA coding is a stop codon which will end the elongation stage. The stop codon doesn't call for a tRNA, but instead for a type of protein called a release factor, which will cause the entire complex (mRNA, ribosome, tRNA, and polypeptide) to break apart, releasing all of the components.

At the purine and pyrimidine nucleotides recombination can be occur interruption, substitution, insertion and deletion of DNA sequences [15].

The opposite reaction can be terminate to insert a monomer. In decomposition reaction the entire complex can break to insert monomer thymin. So, this method can use for gene therapy to terminate the tooth decomposition.

7. Discussion

- The tooth and dental materials degradation have discussed.
- The simultaneously decomposition reaction and diffusion of the dental materials have analyzed.
- How gene express in the teeth degradation have discussed.
- In decomposition reaction the entire complex can terminate by insertion of monomer.

8. Conclusion

In the frame of the examination of this paper composite degradation was studied. The tooth and dental material decomposition rate and coupled effects of diffusion and decomposition were examined.

The diffusion rate of the nutrition in the tooth was discussed.

This is the first work which studies how the teeth decomposition reaction can be terminated.

Notation

D - diffusivity coefficient of the tooth, m / s

D_i - diffusion coefficient of nutrition, m / s

c - concentration, mol / m^3

R_d - reaction decomposition rate, mol / s

t - time, s

x, y, z - space coordinate

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