Some Composite Materials to Reduce Galvanic Current

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Abstract

Infrared spectroscopy and x-ray diffraction analysis indicate the crystalline nature of zinc Polycarboxylate. Setting time characteristics are associated with the reaction rates and affect the practical applications of materials. In the present study zinc polycarboxylate has a value in the range 5.5 to 6.5 minutes. Electrical resistivity is high making it useful as a base material in avoiding galvanic pain in restorative dentistry.

Keywords: Zinc polycarboxylate, infrared spectroscopy, x-ray diffraction, galvanic current

1. Introduction

Dental treatment necessitates filling of tooth cavities with cement or attachment of indirect restorations and appliances to the teeth by means of cement. These include metal, resin, metal-resin, metal-ceramic, and ceramic restoration; provisional or interim restorations; laminate veneers for anterior teeth; orthodontic appliances; and pins and posts for retention of restorations. Dental cements are supplied as powder and liquid and must be properly manipulated by the dentist before their intended use. Working and setting time are important as there should be sufficient time for mixing and that the properties of the cement are affected by improper manipulation. If metallic restorative materials are used, galvanic current associated with electro galvanism will be present in the oral cavity. Cement base materials used under metallic restorations, should be good electrical insulators to minimize galvanic current.

Infrared spectroscopy is one of the most powerful analytical techniques which offer the possibility of chemical identification. This technique when coupled with intensity measurements can be used for quantitative analysis. Structure analysis of molecules can be carried out by infrared spectroscopy and x-ray diffraction among others. Chemical substances show marked selective absorption in the infrared region. Absorption of infrared radiation leads the molecules of a chemical substance to vibrate at many rates of vibration, giving rise to closed-packed

absorption bands, called an infrared absorption spectrum. Various bands present in the infrared spectrum correspond to the characteristic functional groups and bonds present in a chemical substance. Infrared spectrum of a chemical substance is a finger print for its identification. Crisp et al (1978) studied the development of crystallinity in dental zinc phosphate cement by infrared spectroscopy. It was reported that crystallization in the bulk of cement is prevented only by the incorporation, in the liquid, of aluminium which forms complexes with phosphoric acid and that the development of surface crystallinity is related to the chemical composition of the cement and the speed of the reaction.

The x-ray diffraction pattern of a crystal is unique, and it is only necessary to measure diffraction angles and intensities of the peaks of the diffractogram of the sample concerned and to compare the results with those from a sample of the pure substance. Infrared spectroscopy and x-ray diffraction may be used as potential tools to provide valuable information in the study of biological systems.

2. Materials and methods

The dental materials used for infrared spectroscopy analysis and x-ray diffraction studies were zinc polycarboxylate (Carboco-Germany), zinc phosphate (Harvard cement-Berlin), glass ionomer (G C Fuji II-Tokyo) cement and milk tooth. The milk tooth of children in the age group of 7 to 11 years were collected and washed with distilled water. The dried samples were ground in a porcelain dish and stored in glass bottles.

Infrared spectrum was recorded in K Br phase in a Perkin-Elmer FTIR-1605 spectrophotometer. The powdered dental samples mixed with K Br were pressed into a clear disc which were then mounted and examined directly. Shimadzu x-ray diffractometer XRD-6000 was used for x-ray analysis. X-rays were produced by a copper target at about 40,000 volts. The width of the receiving slit was 0.3 mm. General scan of the powder samples was taken with a scanning speed of 8 degree per minute for characterization whereas for the intensity measurements, diffractograms were taken with a slower scanning speed of 2 degree per minute.

The resistance and hence the resistivity of the fully set cement was determined. For this immediately after mixing, the cement mixture was condensed into aluminium mold of a fixed diameter and thickness. To avoid cavities, smooth flat glass plates were placed above and below the mold and a uniform hand pressure was applied. Any extruded bulk cement was removed and the disc shaped samples were stored at room temperature. The prepared

disc shaped specimens were coated on the top and bottom surface with silver powder mixed in amyl acetate to improve surface contact with the sample holder. The cell for the measurement of resistance and hence its resistivity consists of two parallel circular plates made of brass with a diameter of 2.5 cm each. The distance between the two circular plates can be varied by means of a micrometer fixed to the upper circular plate. Electrical contact to the two circular plates is established through electrodes which are connected to them. The current through the samples was measured by a DC Nano meter (DE 125-perfect electronics) by varying the voltage in the regulated power supply (PS48-Elico).

3. Results and Discussion

Data on the nature, electrical resistivity and temperature coefficient of resistivity of zinc polycarboxylate, zinc phosphate, glass ionomer cement and milk tooth are presented in Table 1. The electrical resistivity of zinc polycarboxylate is high when compared to zinc phosphate, glass ionomer cement and milk tooth. There is no much variation in the temperature coefficient of resistivity of these cements.

The infrared spectroscopy can yield information relating to the internal structure of biological material. Infrared spectroscopy relies upon the interaction between electromagnetic radiation and oscillating dipoles caused by molecular vibrations. Functional groups have characteristic vibration frequencies and greater the force constant for a particular deformation, the higher the frequency of vibration. Stretching and bending vibrations may be observed but bending vibrations are only observed below 1500 cm^{-1}. Fourier transform infrared spectroscopy studies Nicholson et al (1988) reveals that fully hardened cement is bonded predominantly by zinc carboxylate complexes. Ionic bonds are formed in the initial stages of the reactions but are gradually converted to complex forms.

Infrared spectroscopy studies show that the major constituent of the tooth mineral is carbonate calcium phosphate which is crystalline in nature. X-ray diffractogram reveals information that the tooth mineral is not a single chemical substance of fixed chemical composition but most of it consists of crystals of calcium phosphate in the forms of carbonate calcium phosphate, hydroxyl calcium phosphate, α-tricalcium phosphate and fluro calcium phosphate both in structure and composition. X-ray diffractogram and infrared spectroscopy studies by Leloup et al (1998) shows the presence of water of hydration in zinc polycarboxylate.

Galvanic current or the metallic ions that are liberated from metallic restorations could account for many types of dyscrasias such as lichenoid lesion, ulcers, leukoplakia, cancer and kidney disorder. As long as metallic restorative materials are used, galvanic currents will be present in the oral cavity. Dental cement base materials used under metallic restorations should be good

electrical insulators to minimize galvanic current. Knowledge about the relationship between temperature and electrical resistivity of teeth and dental cements might assist in our

understanding of the process involved in electrical conductance through teeth and dental

Table 1. Nature and electrical resistivity

Material	Nature	Electrical Resistivity ($x10^7 \Omega m$)	Temperature coefficient of resistivity ($x10^{-2}\ ^oC^{-1}$)
Zinc Polycarboxylate	Crystalline	97 ± 7.58	- 1.5 ± 0.071
Zinc Phosphate	Crystalline	0.018 ± 0.004	- 1.4 ± 0.045
Glass Ionomer	Amorphous	0.013 ± 0.002	- 1.4 ± 0.089
Milk Tooth	Crystalline	0.013 ± 0.002	-1.5 ± 0.045

cements. Electrical conductance through teeth material is essentially the result of ionic migration through the electrolyte solution contained within the enamel and dentin pores. The decrease in resistivity may lead to an increase in flow of galvanic currents that are induced when dissimilar metals are in contact. This may result in the clinical phenomenon of galvanic pain. Elliot et al (2004) reported that galvanic current varies with the age of the restoration.

Zins polycarboxylate are adhesive to tooth and form a week bond to gold as reported by Graham Chadwick et al (2011). Since the setting time of this cement is around 6 minutes as determined by Patrick and Adeel Ahmad (2009) and it has high electrical resistivity, metallic restorations can be placed on it without causing the effect of galvanic current.

4. Conclusion

Zinc polycarboxylate is crystalline in nature and also bonds with tooth and metallic restorations. Its setting time being less and having high electrical resistivity it can be a cement of choice as base material when metallic restorations have to be placed on tooth.

References

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