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Dispersive surface properties of glass-ionomer cements determined by inverse gas chromatography

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Abstract

The surface properties of several glass-ionomer cements (GIC), restorative dental materials, (GC-Fuji, Chemadent G-J, Ketac Fil and Ketac Molar) were investigated for the first time by means of inverse gas chromatography. This method enables characterization of surface activity in dispersive (non-polar) and acid–base interactions. The ability of the surface of glass-ionomers to participate in dispersive interactions was expressed by the use of the dispersive component of surface free energy γ_s^d. This parameter was determined with satisfactory precision, meaning that the values of γ_s^d can be further used in the discussion of the influence of the type of GIC, its preparation and the storage time on the surface properties. The greatest capacity for dispersive interactions was revealed by Ketac Molar and the lowest by GC-Fuji. Dispersive interactions in the surface activity of glass-ionomers increased with increasing storage time after cement preparation.

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Keywords: Glass-ionomers; Surface activity; Inverse gas chromatography; Dispersive interactions

1. Introduction

Glass-ionomer cements (GIC) have become one of the most popular dental materials over the last 20 years. Their good biocompatibility has also made them useful as a material for bone replacement in other disciplines of medicine. Chemically, glass-ionomers belong to a group of materials known as the acid–base cements. They consist of a powdered calcium fluoro–aluminosilicate glass, which is a base in the sense that it accepts protons from acid. Setting involves the neutralisation of acid groups in a water-soluble polymer, mainly poly(acrylic acid). The setting reaction is heterogeneous and involves two phases. The most important feature of GIC as a dental material is its adhesion to the tooth hard tissues, which

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eliminates microleakage between cavity wall and filling material. The presence of a microspace between the two surfaces allows bacteria to occupy that space and damage the dental pulp by products of their metabolism. This mechanism is considered to be the main cause of pulpal involvement following the placement of a dental restoration.

Another positive result of this adhesive property of glass-ionomer cements is the need to remove less tooth substance during cavity preparation. Since the cement adheres to dentine and enamel there is no need to create a cavity with mechanical retention for the filling. Glass-ionomer cements possess another useful property, namely that of being able to leach out fluoride, an element that plays an important role in caries prevention. Also, recently published data on the buffering capacity of glass-ionomer cements suggest that this could be an additional preventive property of glass-ionomers [1–4]. Both laboratory and clinical investigations have revealed differences in the adhesive properties of the glass-ionomer cements produced by different companies. Little data on this subject have come from independent laboratories, since the published information concerning the chemical characteristics of dental materials is mainly supplied by their producers.

Surface properties are crucial in the discussion on the adhesion of this group of dental materials to the enamel and dentine of the tooth. We, therefore decided to carry out a trial involving a laboratory investigation using inverse gas chromatography (IGC) to measure parameters describing the surface ability for dispersive (non-polar) and specific (acid–base) interactions of four glass-ionomer cements produced by different companies.

The aim of this work was to prove the applicability of inverse gas chromatography in the characterisation of the glass-ionomer dental materials and in evaluating the capacity of the glass-ionomer surface to participate in dispersive interactions. The acid–base properties of glass-ionomers as determined by IGC will be discussed in a subsequent paper.

2. Materials and methods

2.1. Materials

IGC was used to evaluate the surface characteristics of the following glass-ionomers: GC-Fuji IX GP (GC Co., Japan), Ketac Fil (ESPE Dental Medizin, Germany), Ketac Molar (ESPE Dental Medizin, Germany) and Chemadent G-J (Glass and Ceramic Co., Poland). All these materials belong to the group of conventional glass-ionomer cements. The samples were prepared according to the ISO/WD–9917–1 standard method. The polyacid component was mixed with the glass component in the ratio indicated by the individual manufacturer: for GC-Fuji 1:3.6; for Ketac Fil 1:3.2; for Ketac Molar 1:3 and for Chemadent G-J 1.254:2.4. The samples were obtained in the form of cylindrical tablets of 1 cm diameter, 4 mm thickness and mass equal to 2 g. After preparation they were stored in distilled water at 37 °C for 1 day, 1 or 6 months.

2.2. Methods

IGC is an extension of conventional gas chromatography in which a non-volatile material to be investigated is immobilised within a column [5]. This stationary phase is then characterised by monitoring the passage of volatile probe molecules of known properties as they are carried through the column by an inert gas. The retention time and peak elution profiles for standard solutes, influenced by the interactions between the solute and stationary phase are used in the respective relationships leading to the quantitative measurement of the physicochemical properties of the material being examined. Dispersive and specific (acid–base) interactions are considered to contribute independently to the sorption of probe molecules. IGC is now used to study synthetic and biological polymers, copolymers, polymer blends, glass and carbon fibres, coal, solid food, modified silicas, surfactants, petroleum pitches, and heavy residues of oil distillation [5–15]. The basic tools for IGC are inexpensive, widely available and well suited for routine laboratory applications. IGC data may be collected quite rapidly over extended temperature ranges.

Inverse gas chromatographic measurements may be carried out both at infinite dilution and at finite solute concentration [6]. In the first case, vapours of testing solutes are injected into the column and their concentrations in the adsorbed layer proceed to zero. Testing substances interact with strong active sites on the examined surface. The retention data are then