

Guest Editorial

Proposed nomenclature for glass-ionomer dental cements and related materials

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The development of the original glass-ionomer cement by Wilson and Kent in 1969¹ was significant in that it made available for the first time a restorative dental material that had long-term adhesion to tooth structure. It also possessed some cariostatic properties due to the sustained release of fluoride.²

More recently, glass-ionomer/composite resin hybrid materials have been introduced into clinical dentistry,^{3,4} and this has led to considerable confusion over nomenclature. The terms "light-cured" (or "light-curable"), "dual cure," "resin-reinforced," and "resin-modified" have all been applied to them; in the worst cases, no qualifying phrase has been used at all. Instead, the term glass-ionomer has been used alone, giving the reader the impression that what is described is simply an accepted variation on the well-established theme of acid-base dental cements known as glass-ionomers. In a recent letter, Mount⁵ has highlighted the difficulties of this state of affairs, and called attention to the need for clear and unambiguous nomenclature in this field. He has also pointed out quite unacceptable examples of manufacturers calling their products light-curable glass-ionomer cements, when in fact their products show no evidence of the recognized setting reaction (ie, neutralization) and, when set, do not exhibit the typical properties of true glass-ionomer cements, such as adhesion or fluoride release.

We have carefully considered the materials available, and in this paper make recommendations concerning the definition of the term "glass-ionomer cement" and the appropriate nomenclature for the newer

hybrid materials. Our recommendations include both formal names suitable for adoption as standard terms, for example by ISO, and trivial names suitable for more informal communication in both the clinic and the dental literature.

Glass-ionomer cement

As invented by Wilson and Kent in 1969,¹ and developed by McLean and Wilson during the 1970s, this class of material has achieved widespread use as translucent materials for restoration of Class V erosion lesions and Class III cavities,⁶ fast-setting liners and bases for attaching composite resins to tooth preparations,⁷ fine-grain luting cements,⁸ fissure sealants, and metal-reinforced core-buildup materials.²

The term applied to these materials, "glass-ionomer" cement (it should be hyphenated), is in some ways unfortunate. The word "ionomer" was coined by the DuPont Company to describe its range of polymers containing a small proportion of ionized or ionizable groups, generally of the order of 5% to 10%.⁹ This definition has been recognized by authorities such as the compilers of *Chemical Abstracts*, and it clearly does not properly apply to the components of the glass-ionomer dental cement. For this reason, the term glass polyalkenoate cement was devised. It is acceptable as a systematic name in *Chemical Abstracts* and elsewhere, but unfortunately it is less euphonious than the original name and has, not surprisingly, failed to become popular among clinicians. Also, unlike the term glass-ionomer cement, it does not apply to the recently developed experimental poly(vinyl phosphonic acid) cements,¹⁰ since these latter cements are properly called glass polyphosphonates. The term glass-ionomer cement is therefore a generic one for all glass polyacid cements, eg, polycarboxylic, polyphosphonate, etc.

Recognizing the confusion that has grown around the term glass-ionomer, we offer the following definition of a glass-ionomer cement: *A cement that consists of a basic glass and an acidic polymer which sets by an*

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acid-base reaction between these components. This material thus belongs to the class of acid-base cements as defined by Wilson and Nicholson.¹¹ We can further consider aspects of this definition as follows:

Glass: This is an acid-decomposable glass, usually ground to a fine powder, that on treatment with aqueous acid releases the cement-forming ions, typically Ca^{2+} , Al^{3+} , and possibly also Sr^{2+} , La^{2+} , or Zn^{2+} depending on the composition.

Acidic polymer: This is typically poly(acrylic acid), but may comprise polymers and copolymers of acrylic, itaconic, maleic, and vinyl phosphonic acids. Acidic functional groups are generally numerous along the polymer backbone, and the successful acids are conventionally water-soluble and are polyelectrolytes (rather than true ionomers).

Acid-base reaction: This must take place as part of the cement-forming process, and not be delayed, for example by the presence of excessive concentrations of organic components. We define the cement-forming reaction as the conversion of the initially viscous paste to a hard solid, and in a true glass-ionomer cement this reaction takes place within a clinically acceptable time, ie, a few minutes.

Characteristics of glass-ionomer cements thus defined are²:

- Hard substance upon setting
- Low-reaction exotherm
- No polymerization shrinkage
- No free monomer present
- Dimensional stability at high humidity
- Filler-matrix interaction
- Adhesion to enamel and dentin
- Fluoride release
- Early moisture sensitivity requiring protection (eg, with varnish) immediately after placement

Glass-ionomer hybrid materials

A variety of terms have been used for the hybrid cements. These set partly via an acid-base reaction, as defined above, and partly via a photochemical polymerization. We prefer the term used originally by Antonucci et al,³ and therefore recommend *resin-modified glass-ionomer* as the trivial name, and *resin-modified glass-polyalkenoate* as the systematic name for use where more precise chemical nomenclature is appropriate, such as in ISO standards.

We prefer these terms for the following reasons. First, the alternative of "light-cured" (or "light-curable") incorrectly implies that the acid-base process

may be photo-initiated. Second, the term "dual cure" has become discredited by the use of the term "tricure" to describe one novel cement system. It is not really a three-mechanism cure, but rather a two-mechanism cure in which one of the processes, the polymerization, has two possible modes of initiation, ie, generation of free radicals both chemically and photochemically. However, the use of such nomenclature by some workers in the field allows for the possibility of a so-called dual-cure material involving both types of free radical initiation, but no acid-base reaction.

A further advantage of the term *resin-modified* to qualify these new materials is that it is also extendable to materials in which the resin component sets via a chemically induced polymerization, ie, is not light-cured. Such materials have been made experimentally and have similar properties to those that set partly by photopolymerization.³ It is thus applicable to all of these new cements in which the acid-base reaction of true glass-ionomer cements is supplemented by a polymerization reaction, whether of monomer, such as bis-GMA or 2-hydroxyethyl methacrylate, or of side-chains grafted onto the main polyacid molecule.^{3,4}

We further recommend that the term resin-modified glass-ionomer cement always be used when such a material is referred to, and that the term glass-ionomer cement, unqualified, be reserved exclusively for the simple acid-base material defined earlier. We call upon editors of dental journals to insist on this distinction and to ensure that authors observe it, including in the titles of their research papers and published abstracts.

To apply the term glass-ionomer it is necessary that the acid-base reaction contribute to the setting process. Thus, a resin-modified glass-ionomer cement is one that has sufficient acid and base to allow that reaction to take place within a reasonable time. Materials such as "Variglass" (Dentsply) that do not set in the dark are not in any sense glass-ionomer cements and should never have been marketed as such.

An essential feature, therefore, of resin-modified glass-ionomer cements is that they will set in the dark, albeit more slowly and yielding a material that is inferior to that obtained by photocuring. Dark setting alone is not sufficient to define a resin-modified glass-ionomer cement as such, though failure to set in the dark is sufficient proof that a material is not any sort of glass-ionomer cement. In addition, it is necessary that the acid-base reaction be critical to the cure. As such, it should be possible to monitor pH change on setting as neutralization takes place. It should also be possible to detect a reduction in the free-acid content and the for-

mation of the corresponding carboxylate salt in the infrared spectrum of the setting material.

Other photopolymerizable restorative materials

This leaves a third class of material, in which the correct ingredients are present (ie, acid-decomposable glass; possibly some polymeric acid) but in insufficient amounts to promote acid-base cure in the dark. We suggest the new term *polyacid-modified composite resins* for these materials. This term recognizes the fact that we now have a spectrum of materials, stretching from the true glass-ionomer cement at one end to the true composite resin at the other. In between are a variety of blends, employing different proportions of acid-base and free-radical reactions to bring about cure. For the sake of clarity and to ensure appropriate materials selection by practicing clinicians, we must distinguish between those materials that are wholly or mainly glass-ionomer cements, with their characteristic properties, and those materials that are entirely or predominantly composite resins, with their quite different set of properties. The aim of this treatise has been to do just that, and we have made clear proposals for the naming of these materials, which we hope the wider research community in dental materials science will adopt.

Conclusions and summary of recommendations

The unqualified term *glass-ionomer cement* should be reserved exclusively for a material consisting of an acid-decomposable glass and a water-soluble acid that sets by a neutralization reaction.

The term *glass-ionomer cement* covers two subgroups: the glass-polyalkenoates and the glass-polyphosphonates.

The preferred term for the hybrid materials is *resin-modified glass-ionomer*. Such materials retain a significant acid-base reaction as part of their overall curing process.

Materials that may contain either or both of the essential components of a glass-ionomer cement but at levels insufficient to promote the acid-base cure reaction in the dark should be referred to as *polyacid-modified composite resins*.

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