Glass-ionomer cements: Current Status and Future Trends

John Nicholson

University of Greenwich
Glass-ionomer cements: Current Status and Future Trends

- Composition
- Setting
- Physical properties
- Chemical behaviour
- Resin-modified glass-ionomers
- ART technique and future trends
Uses of glass-ionomer cements:

- Liners
- Bases
- Full restorations
- Endodontic sealant
- Orthodontic bracket fixation
Glass-ionomer cements: Composition

• *Speciality glass*

• *Water-soluble polymer*
  – (polyacrylic acid or maleic acid/acrylic acid copolymer)

• *Water*
Glasses for glass-ionomer cements:

- Made from SiO$_2$:Al$_2$O$_3$:CaO:CaF$_2$ plus possibly AlPO$_4$ and/or Na$_3$AlF$_6$ by fusion above 1000°C

- Partially phase-separated

- Ground to fine powder
Glasses for glass-ionomer cements:

• *Key property:* Basic

• Arises from presence of Al

• *Also:* Slightly translucent
In glasses:

SiO$_4$ tetrahedra link to form chains.
Aluminium

• Prefers 6 co-ordination;
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• With excess Si, Al is forced into 4 co-ordination;
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- Formally $\text{Al}^{3+}$ hence charge-deficient;
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• Formally Al$^{3+}$ hence charge-deficient;
• Needs extra ions, e.g. Na$^+$ to balance charge;
Aluminium

- Prefers 6 co-ordination;
- With excess Si, Al is forced into 4 co-ordination;
- Formally Al\(^{3+}\) hence charge-deficient;
- Needs extra ions, \(e.g\). Na\(^+\) to balance charge;
- Makes the structure basic.
Glass-ionomer cements: 

*Setting*

- Neutralization
Glass-ionomer cements: *Setting*

- Neutralization
- Development of Ca and Al carboxylate structures
Glass-ionomer cements:

**Setting**

- Neutralization
- Development of Ca and Al carboxylate structures
- Change in Al co-ordination (less 4; more 6)
Glass-ionomer cements:

Setting

• Neutralization
• Development of Ca and Al carboxylate structures
• Change in Al co-ordination (less 4; more 6)
• Increase in proportion of “bound” water
Glass-ionomer cements:  
*Physical properties*
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*Physical properties*

- Compressive strength 220 MPa
Glass-ionomer cements: 

*Physical properties*

- Compressive strength 220 MPa
- Aesthetic
Glass-ionomer cements: Physical properties

- Compressive strength 220 MPa
- Aesthetic
- Adhesive to dentine and enamel
Glass-ionomer cements:

Chemical behaviour
Glass-ionomer cements: 
*Chemical behaviour*

- Fluoride release
- Fluoride uptake
- Buffering and ion-release
Fluoride release

- Long-term (5 years +)
- Diffusion-based
CUMMULATIVE FLUORIDE RELEASE

- OC Fuji TRIAGE
- Average Glass Ionomer Restorative
- Typical Resin Sealant with Fluoride

mg/cm² vs DAYS
Fluoride uptake

• Suggested by A.W.G. Walls (1986);

• Cements exposed to KF solution release increased amounts of fluoride;

• Experimental fluoride-free cements release fluoride after exposure to KF.
Fluoride uptake

• *Demonstrated experimentally in:*

  **But:** Only a fraction of the F taken up is released after 24 hours
Buffering and ion-release

- Glass-ionomer cements increase the pH of lactic acid;

- Associated with the release of ions: Na\(^+\), Ca\(^{2+}\), Al\(^{3+}\)
Resin-modified glass-ionomer cements:

- Made by adding 2-hydroxyethyl methacrylate (HEMA);

- Generally light-curable;

- Biocompatibility compromised.
Resin-modified glass-ionomer cements:

- Must be able to set by acid-base reaction.

- Promotes ion-exchange bonding.

HEMA:

• Released from RMGICs;

• Diffuses through dentine;

• Causes pulpal inflammation, with possible immune-mediated responses.
HEMA (continued):

- Induces apoptosis in cells;

- A contact allergen (adverse effects may follow a single exposure).

Atraumatic Restorative Treatment (ART):

• Developed for use in 3rd world countries;

• Does not use electrically driven drills;

• Possible only with improved glass-ionomers (conventional).
Future trends:

- Incremental improvements in physical properties;
- Exploitation of bioactivity;
- ART and Minimal Intervention dentistry only possible with GICs.
The End