FLOWABLE COMPOSITE

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Composite History

1956	Dr. R.L. Bowen ‘bis-GMA’
1960’s	“Adaptic”
1970’s	Microfilled composite Light-initiated composite
1980’s	Posterior composite
1990’s	Hybrid composite Flowable, packable, etc.
2000’s	Nanocomposite Non-shrink composite ?

Development of Materials

USA

COMPOSITES

UK

GLASS-IONOMERS

BRITISH DEVELOPMENT

VISIBLE LIGHT CURING

AMERICAN DEVELOPMENT

RESIN-MODIFIED GLASS-IONOMERS

Resin Composites & derived materials

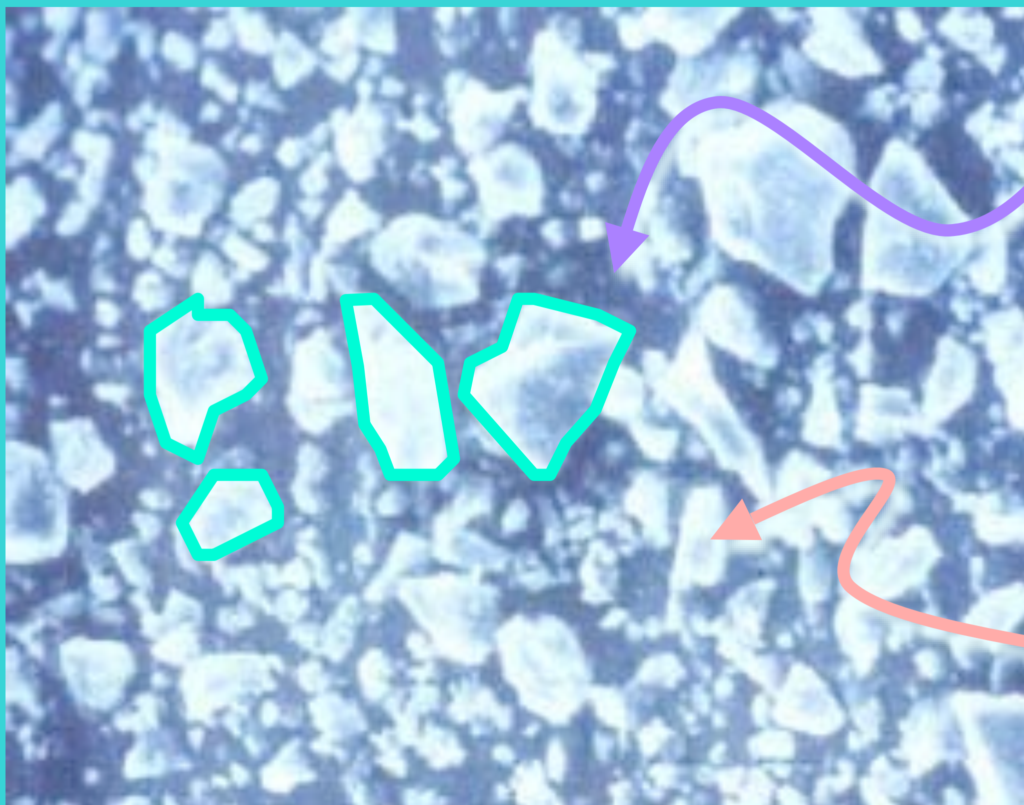
- **Development**
  - Dissatisfaction with silicates/acrylics
  - Development of 'Bowen's resin' – Bis-GMA
  - Introduction of first materials – two paste systems
  - Developments in filler content
    - Smaller particles
    - Microfine particles
  - Command setting – UV cure
  - Single paste – VLC
  - Change in viscosity – flowable/packable
  - Nanocomposites? Low shrinkage materials?

TECHNOLOGY

Alter the Paradigm

Review

Dental composite



Resin matrix

Ceramic fillers

Silane coupling agent

Fillers

Variations

- Type

  SiO_2 , barium glass, ZrO_2

- Size

  macrofills (>10 μm); midifills (1-10 μm)
  minifills (0.1-1 μm); microfills (0.04-0.1 μm);
  nanofills (0.02-0.07 μm)

- Content

  40% - 80^{+}% by weight

  Note : vol % is 15-20 % lower

Classification

Based on filler size
Lutz & Philips, 1983

- **Traditional ('macrofilled')**

  Glass particles ; size 1-15 μm

- **Microfilled**

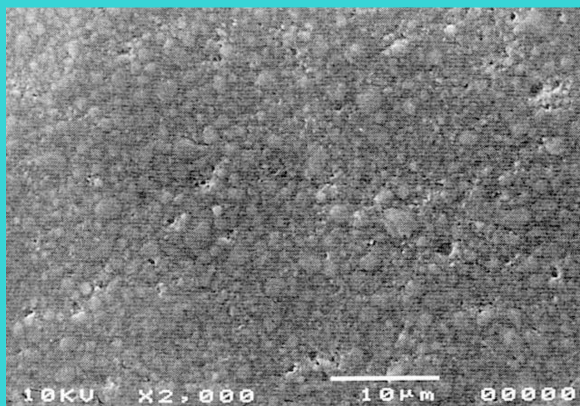
  Amorphous silica ; size ~ 0.04 μm

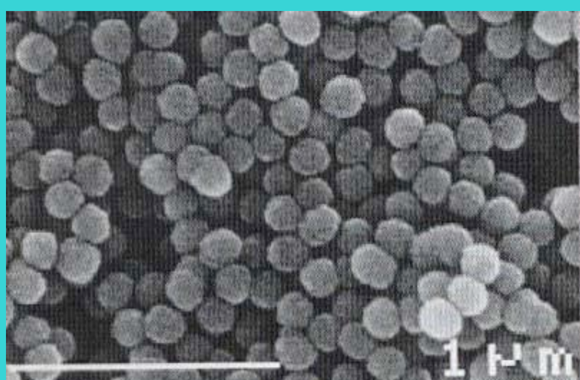
- **Hybrid** Filler load ~ 80 wt%

  Glass particles (Avg size ~ 5 μm)
  + microfillers

Fillers

Zirconia/silica





Z100, Z250, Palfique
(3M ESPE) (Tokuyama)

- sol-gel process
- spherical
- polishability
- continuum in sizes

⇩

high packing density
(85 wt %)

Review

Resin matrix (light-activated composite)

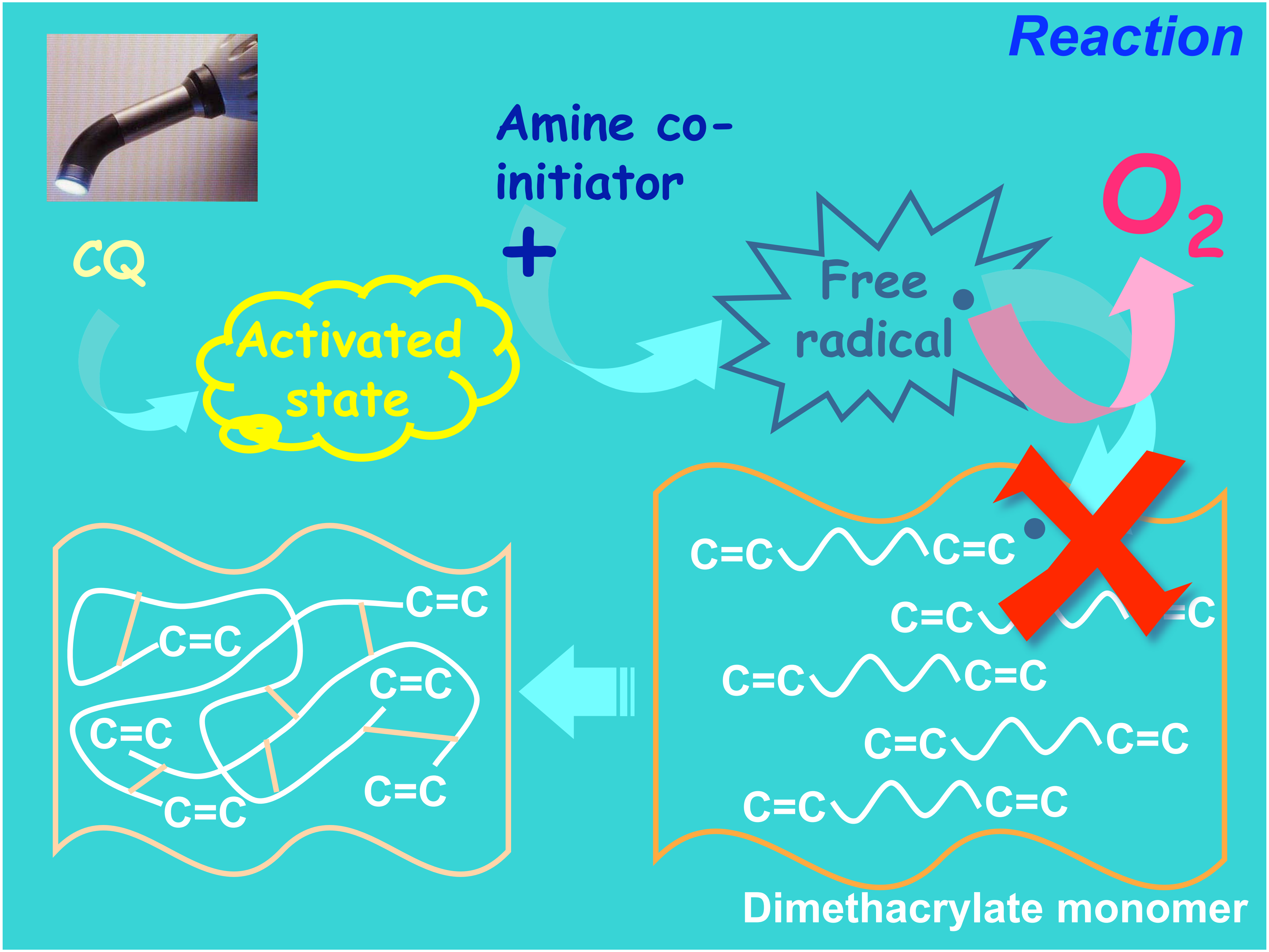
Monomer : bis-GMA, bis-EMA, UDMA

Dimethacrylate

Diluent : TEGDMA

Photoinitiator : camphorquinone

Co-initiator : tertiary amine



Reaction
CQ
Activated state
Amine co-initiator
+
Free radical
O2
C=C C=C
C=C C=C
C=C C=C
C=C C=C
C=C C=C
Dimethacrylate monomer
C=C
C=C
C=C
C=C
C=C
C=C

Polymerization shrinkage

Current systems : 2-3 % vol shrinkage

- Methacrylate-based monomers
- Free radical, addition polymerization

Products in development : 'no shrinkage'

- Ring-opening reaction

  → expand

Resin matrix

O_2 inhibition layer

= uncured monomer film at the surface

- film thickness ~ 10 μm
- not biocompatible ➔ should be removed
- ? between increments ?

Biocompatibility

'Most monomers have some biologic activity ………but … biocompatible when reacted into polymer…'

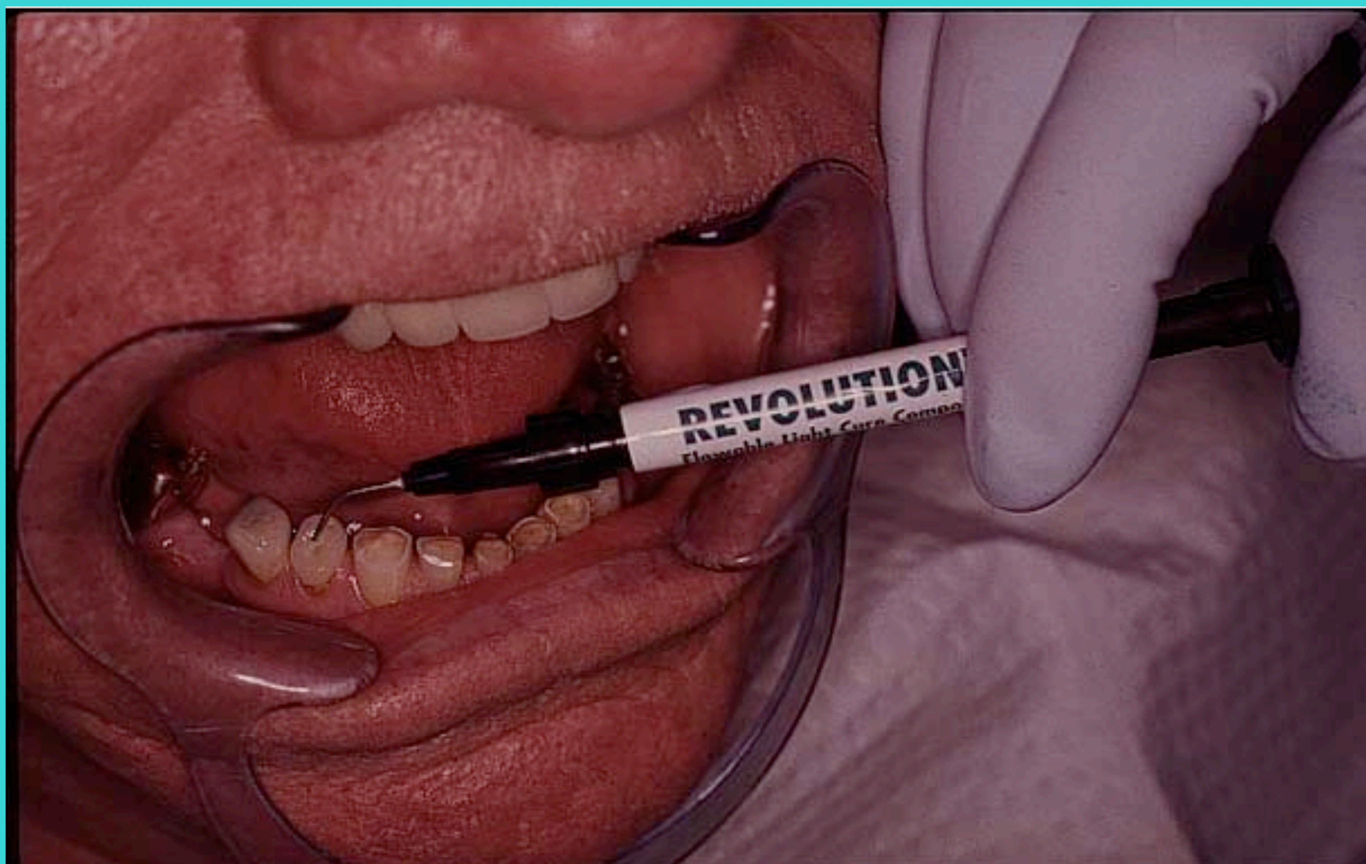
Resin matrix

Recommendations

- Well cured
- Remove O_2 inhibition layer
- Avoid contact with uncured resin

- 5% of dental personel have contact allergy to methacrylates
- Protective gloves are inadequate — **Wallenhammar et al, 2000**
- Estrogenic effect — **Olea et al, 1996**
- Adverse reaction: asthma, blister, rashes — **Hallstrom, 1993**
- Oral lichenoid lesions — **Lind, 1998**

FLOWABLE COMPOSITE



Problems with Paste Composite

- Difficult to use
- Difficult to manipulate
- Sticky, pull back
- Voids
- Porosities
- Unpolymerized areas
- Shrinkage
- Surface and Marginal integrity

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- Easy
- Easy
- Stays put
- Eliminates
- Eliminates
- Less
- Minimizes (technique)
- Best

Rheology

- *Definition*
  - Rheology is the study of the flow and deformation of matter
- *Dental importance*
  - Important for any material placed in the mouth in a fluid state – examples:
    - Impression materials
    - Directly-placed tooth restorative materials

Rheology of Resin Composites

VERY WIDE RANGE OF MATERIALS

SEALANTS

MICROFILL

FLOWABLE

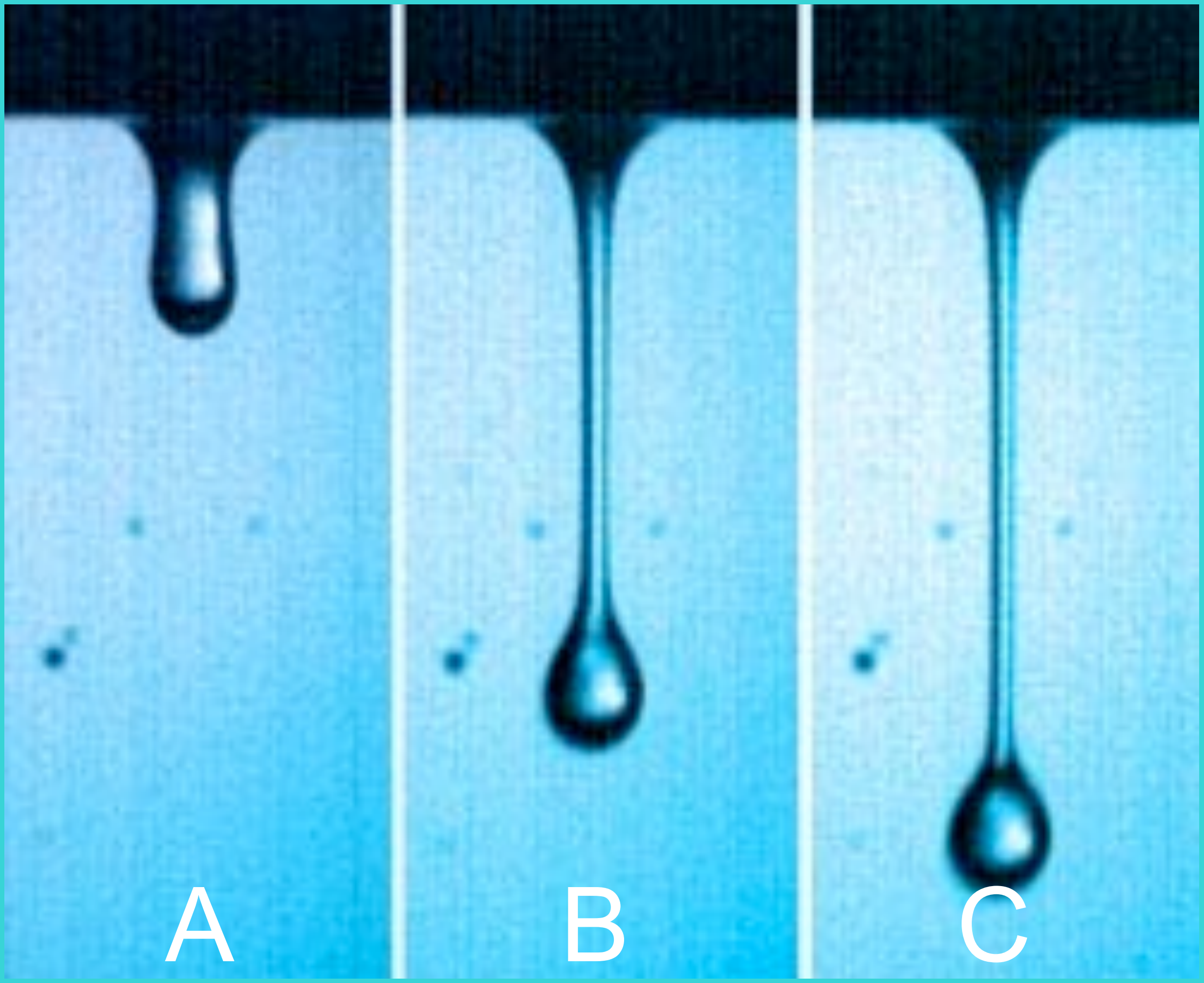
HYBRID &
RELATED MATERIALS

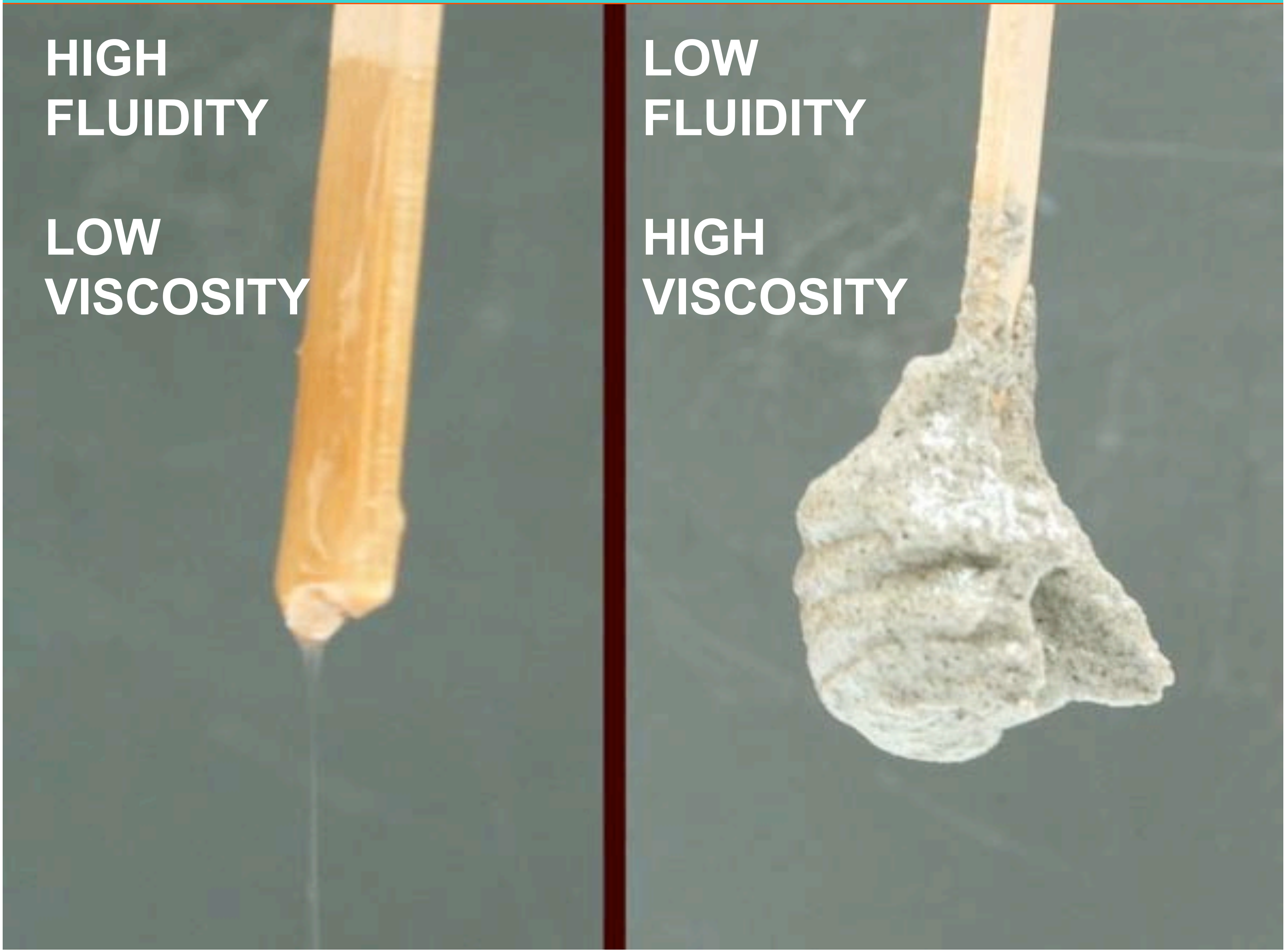
PACKABLE or
CONDENSABLE

INCREASING VISCOSITY

Viscosity

A has highest viscosity
C is the most fluid
B is inter-mediate




HIGH
FLUIDITY
LOW
VISCOSITY
LOW
FLUIDITY
HIGH
VISCOSITY

Rheology of Resin Composites

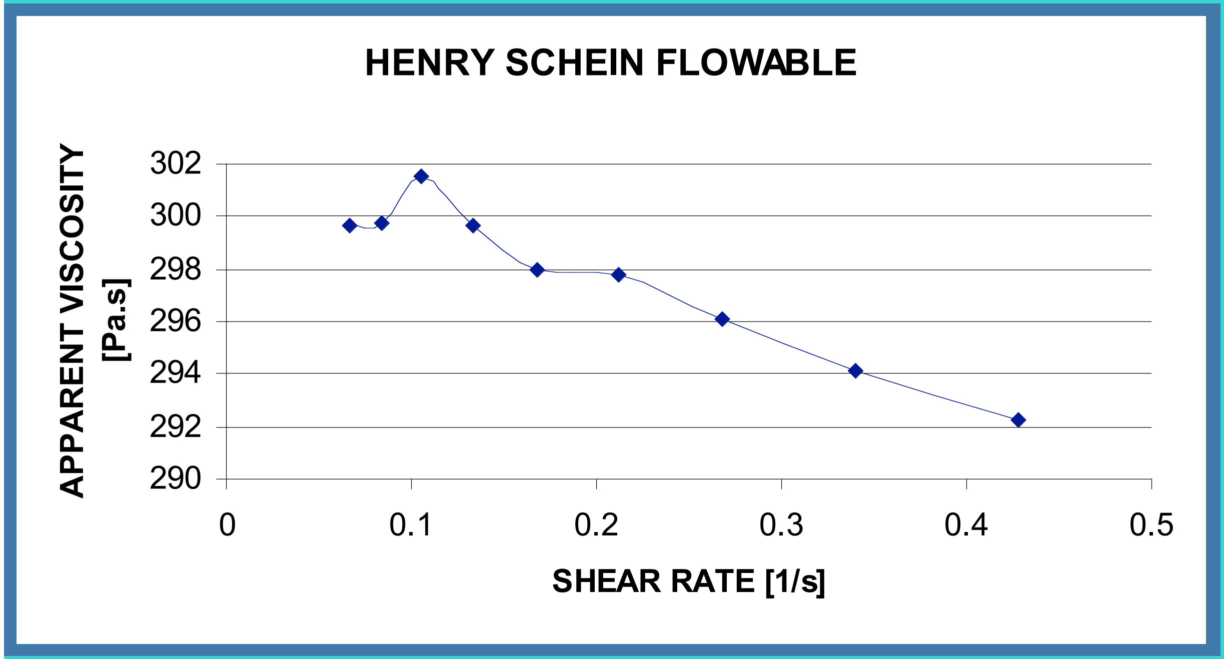
- General idea - lower filler content - usually hybrid filler. Includes fumed silica, claimed to give thixotropy*
- Original claims (patent literature) - recommended for Class I, II, III, IV and V cavities
- Now being recommended for many applications (e.g. fissure sealing – discussed later)
- *What is **thixotropy**?

Rheology of Resin Composites

- **Thixotropy** is a reversible structural breakdown of a material that occurs when the material is stressed
- **Flowable composites** were designed to be **thixotropic**
- This means that when the material is being syringed, the high stress from syringing breaks down some of the structure (e.g. hydrogen bonding), so the material flows
- But when the material is placed into the cavity, it will not flow (‘non-drip’) because the hydrogen bonding structure quickly recovers

Flowable Composites

THERE ARE *SIGNIFICANT* 'FLOW' PROPERTY DIFFERENCES BETWEEN DIFFERENT PRODUCTS



VERY FLUID; VIRTUALLY NEWTONIAN: NO "THIXOTROPY"

-- contrast with ....

Flowable Composites

THERE ARE *SIGNIFICANT* 'FLOW' PROPERTY DIFFERENCES BETWEEN DIFFERENT PRODUCTS

…contrast HIGHER VISCOSITY; SHOWS "SHEAR THINNING" DIFFERENT TECHNIQUE AND APPLICATIONS?

Flowable Composites

THERE ARE *SIGNIFANT* COMPOSITIONAL DIFFERENCES BETWEEN DIFFERENT PRODUCTS

Material	Filler content (mass %)
Henry Schein	41
Starflow	61
Revolution	60
Florestore	50

Flowable Composites

- SOME MATERIALS (at least 34!) – examples -
  - Florestore (Den-Mat)
  - Flowable composite (Henry Schein)
  - Revolution – Formula 2 (Kerr)
  - Starflow (Danville Materials)

Flowable Composites

- There is no such thing as a standard flowable material
- 34 brands (some identical); many with different formulations, handling characteristics, properties and applications
- Confusion because of untested materials - no track record of clinical success

1. Philosophy

- 1. Dental materials do not naturally belong in the mouth!
- 2. All synthetic materials evoke a host response
- 3. Synthetic materials not as good as health tooth substance
- 4. Best treatment is the least treatment
- 5. Best treatment is the most durable treatment

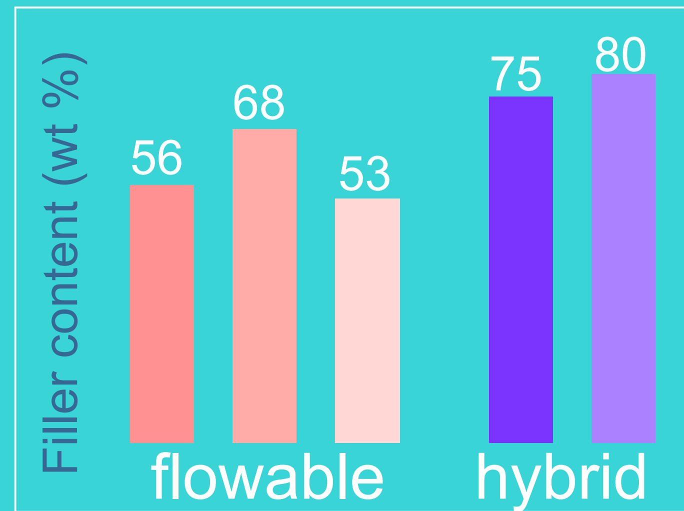
THEREFORE – there is an obligation to prevent dental disease, and where treatment is necessary, to choose the best materials, and manipulate them in such a way that optimum properties are obtained.

Principles of Selection

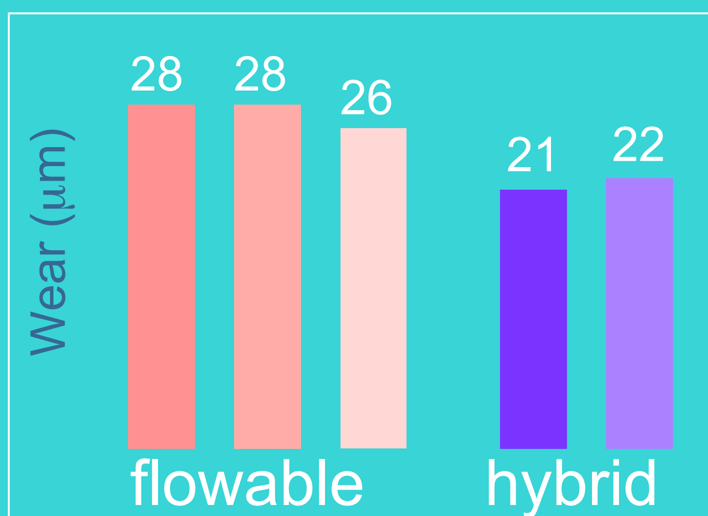
- (i) Evidence from laboratory data
- (ii) Clinical performance
- (iii) Esthetic considerations
- (iv) Clinical needs
- (v) Patient's preferences
- (vi) Operator's preferences
- (vii) Cost effectiveness
- (viii) Environmental considerations

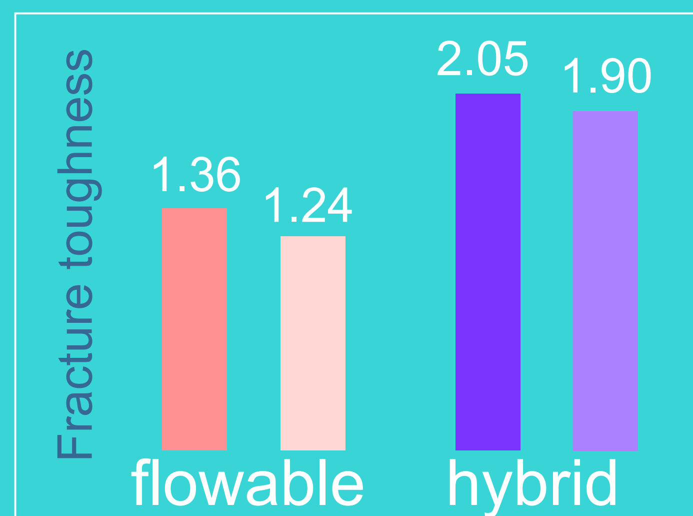
Flowable composites

Filler contents have Caught up



- higher shrinkage
- compromised mechanical properties





Conclusion

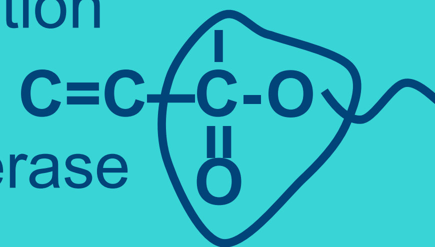
- The criteria for choice of a material include not only factors such as physical and mechanical properties, but also include ease of manipulation.
- Note that there are no standard specifications for these materials, and that they differ considerably in their flow properties.

Need improvements?

B Biocompatibility — cured vs uncured

I Interfacial properties — adhesive system

C Chemical properties — Biodegradation, esterase



M Mechanical & physical properties

E Esthetic consideration — & Polishability

P Practical questions — Flowable / Packable

Failure Zone

- Biofilm
- Improper Etching
- Thick Layers
  - Unpolymerized areas
- Porosities
- Voids in the body
- Marginal Integrity
- Surface Integrity
- Shrinkage

FAILURE ZONE

- Biofilm
- Improper Etching
- Improper Curing
- Thick Layers
  - Unpolymerized areas
- Porosities
- Voids in the body
- Marginal Integrity
- Surface Integrity
- Shrinkage