ADHESIVE DENTISTRY AND COMPOSITE RESIN MATERIALS

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ADHESIVE DENTISTRY

Adhesion or bonding to the natural substances of teeth, enamel and dentin

Success in adhesive dentistry means long lasting composite resin restoration

The ability of composite to bond reliably to enamel is now well accepted, but adhesion of restorative materials to dentin has proved to be more elusive

(Andrea Frassetto et.al., 2016)

PROBLEMS IN BONDING TO DENTIN

- Dentin is a dynamic tissue that shows changes due to ageing, caries or restorative procedures
- Dentinal tubules are filled with dentinal fluid which constantly flow outward from the pulp
- Dentin has a considerable amount of organic material and water
- Dentin is close to pulp, so different chemical used for bonding and etching may iritate the pulp

HOW MATERIALS ADHESION TO ENAMEL AND DENTIN?

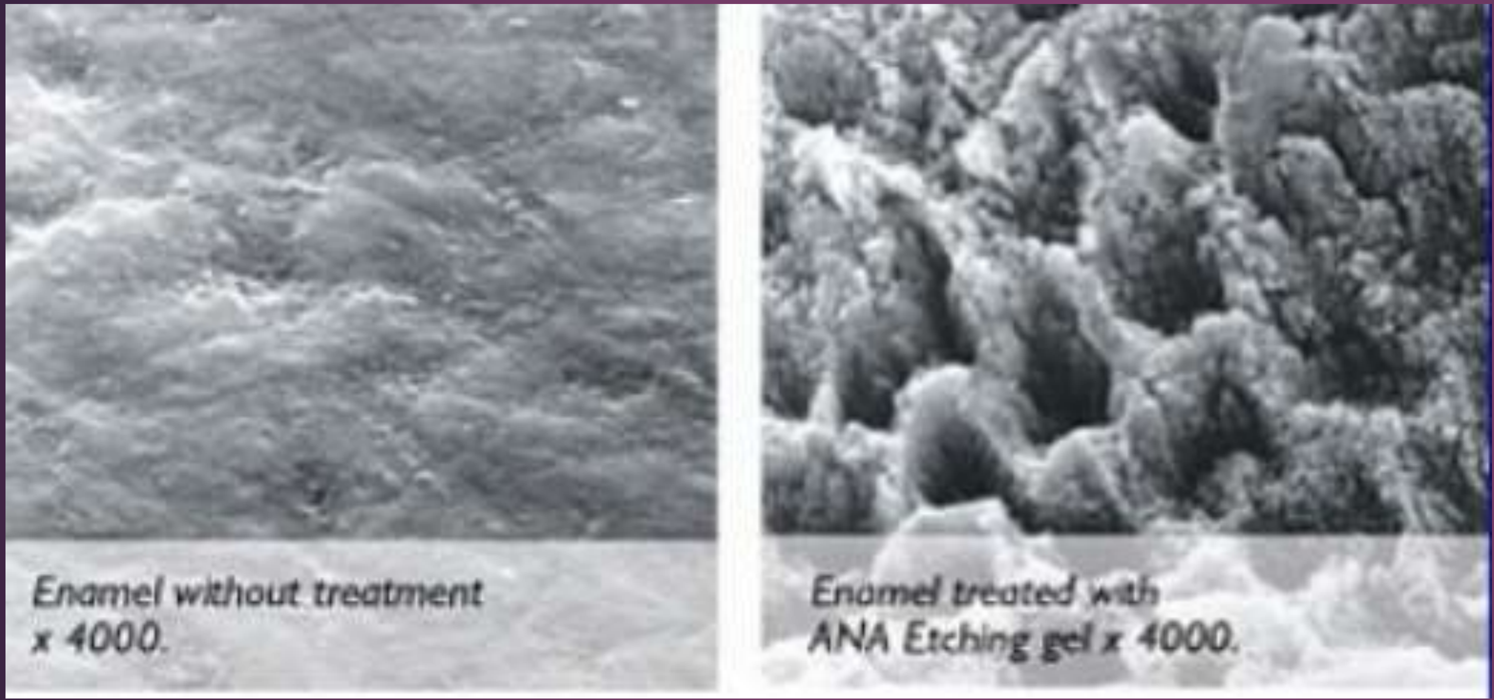
Adhesive bonding to enamel

ACID ETCHING

Benefits of acid etching
- Creating surface micro-irregularities
- Increases the bonding surface area
- Increase the surface free energy

Types of acids to be used
- 30-50% phosphoric acid
- 10% maleic acid
- 2.5% nitric acid
- 18% hydrochloric acid

ACID ETCHING TO ENAMEL



www.nordiskadental.se/ana_etchi...composite

ACID ETCHING TO DENTIN

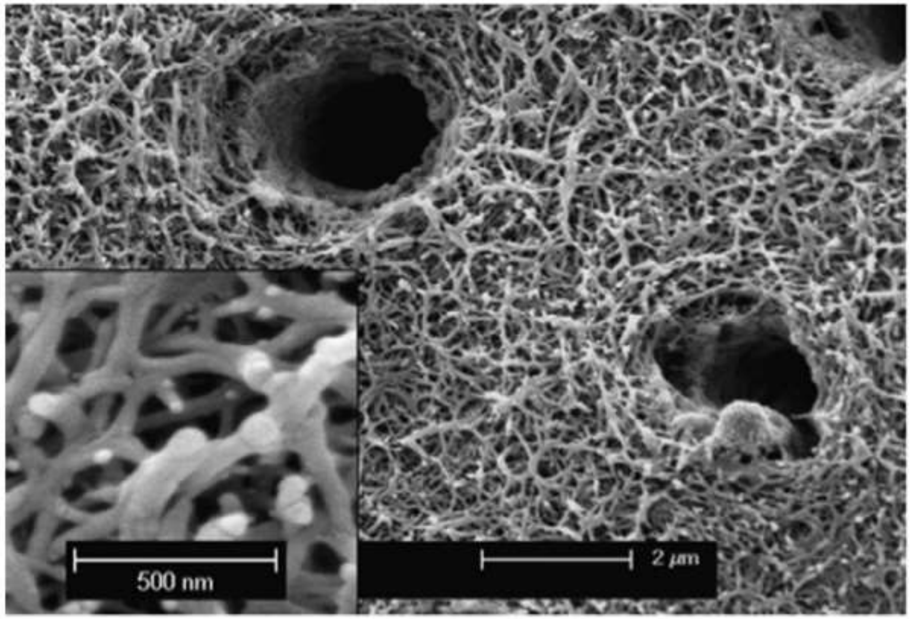


Fig. 1 – Scanning electron micrograph of acid-etched dentin showing two dentinal tubules containing remnants of peritubular dentin matrix. INSERT: High magnification of branching collagen fibrils (ca. 75 nm in diameter) separated by interfibrillar spaces that serve as channels for resin infiltrations during bonding. Reproduced from Pashley et al., Dent Mater 2011;27:1–16, with permission.

(Andrea Frassetto et.al., 2016)

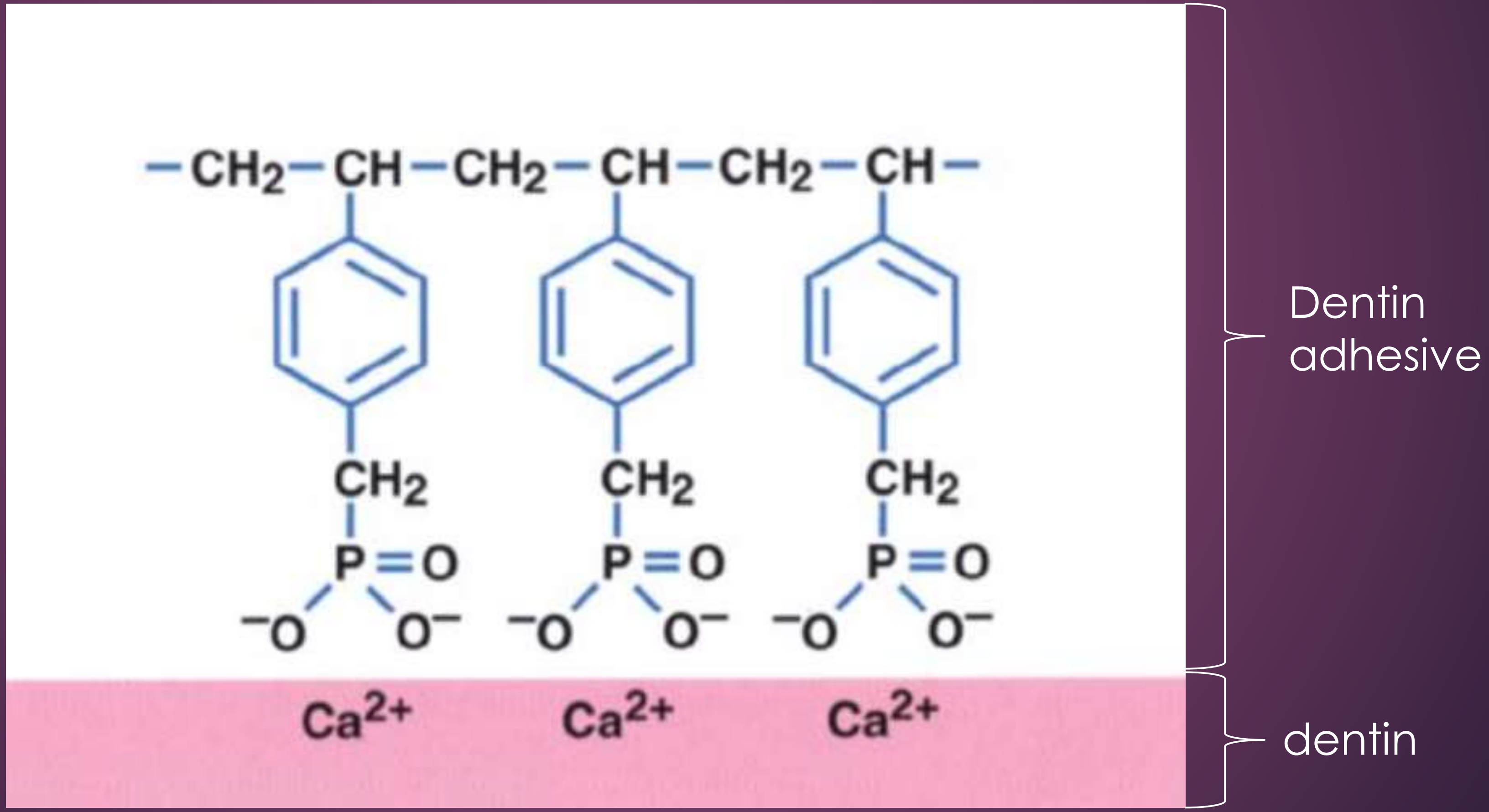
Adhesive bonding to dentin

Chemical bonding

Bonding to the HA (Ca^{2+})
- NPG-GMA (N-phenyl glycine glycidil methacrylate)
- Polymerizing phosphates (glycerophosphoric acid dimethacrylate)
- Poly alkenoic acid (polycarboxilic acid)

Bonding to collagen
- Glutaraldehyde reacts with collagen forming a charged compound that reacts with HEMA molecule
- 4-META (4-methyloxy ethyl trimellitic anhydride) can be used as a potential coupling agent to collagen

CHEMICAL BONDING TO DENTIN

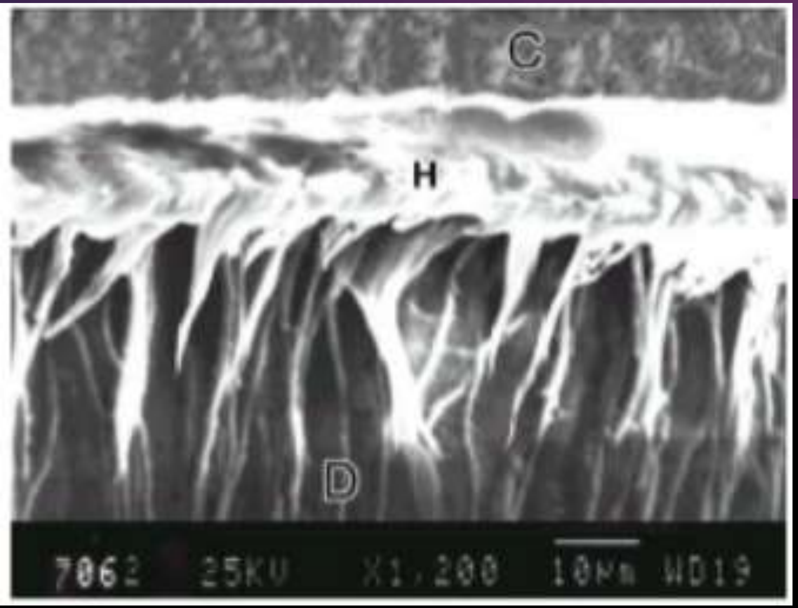


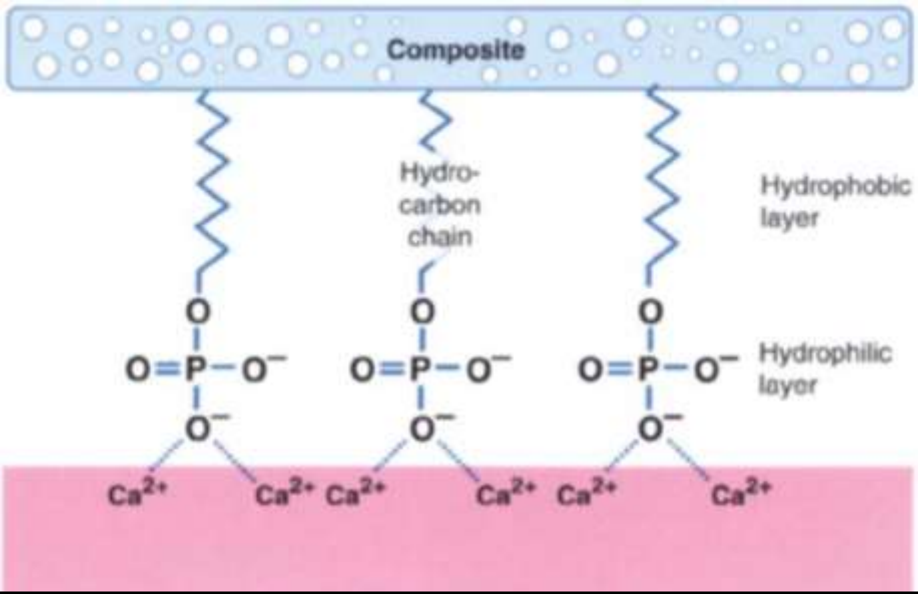
Micromechanical attachment

Retention of resin adhesive could be achieved to irregular dentin surfaces (inter tubular dentin) and to the walls of opened dentinal tubules (intra tubular dentin)

Interpenetration attachment

Hydrophilic resin adhesive is required to penetrate the wet collagen, ex: HEMA, PAA and NPG-GMA





Dentin bonding agent should have both hydrophilic and hydrophobic resin components
- the hydrophilic part is to displace the dentinal fluids and wet surface
- the hydrophobic part is responsible for bonding to composite filling

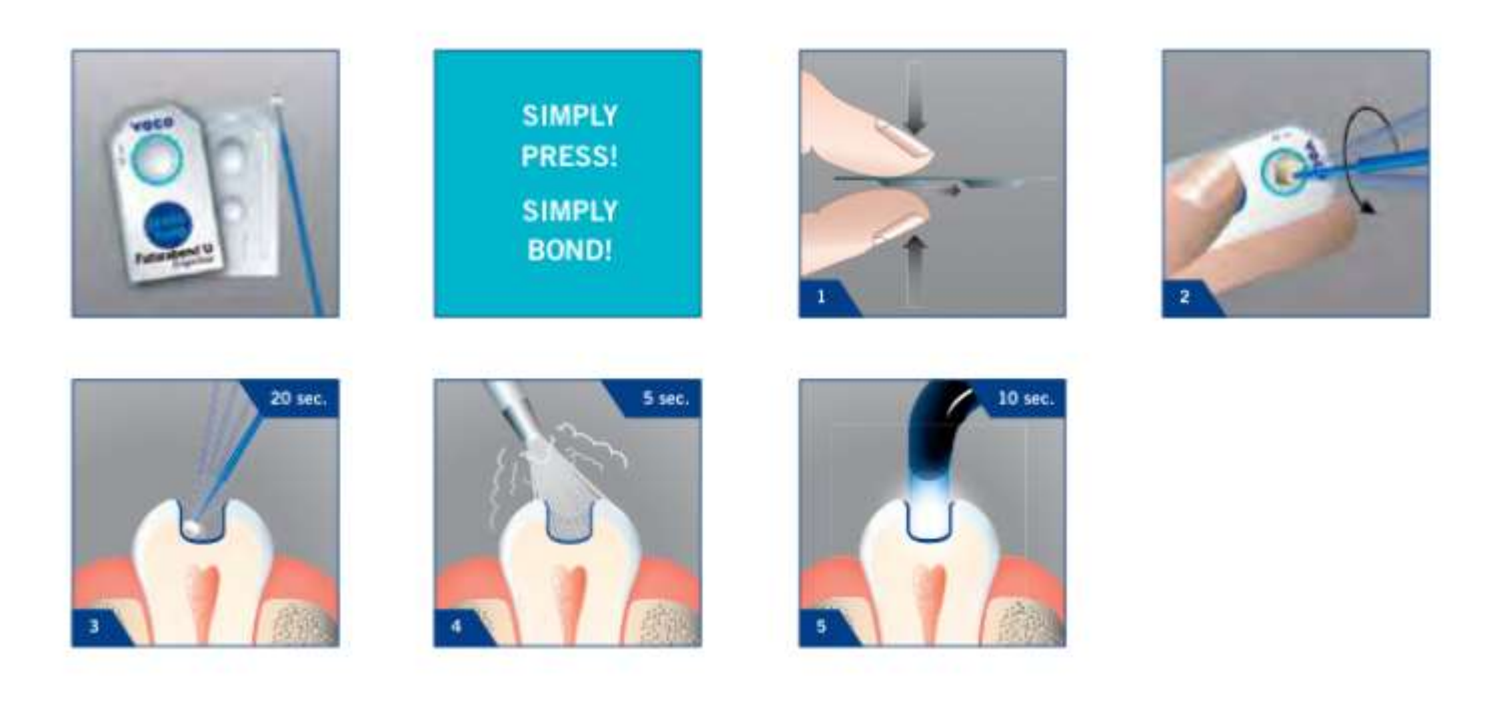
(Jukka Matilinna, 2013)

Classification dentin adhesive

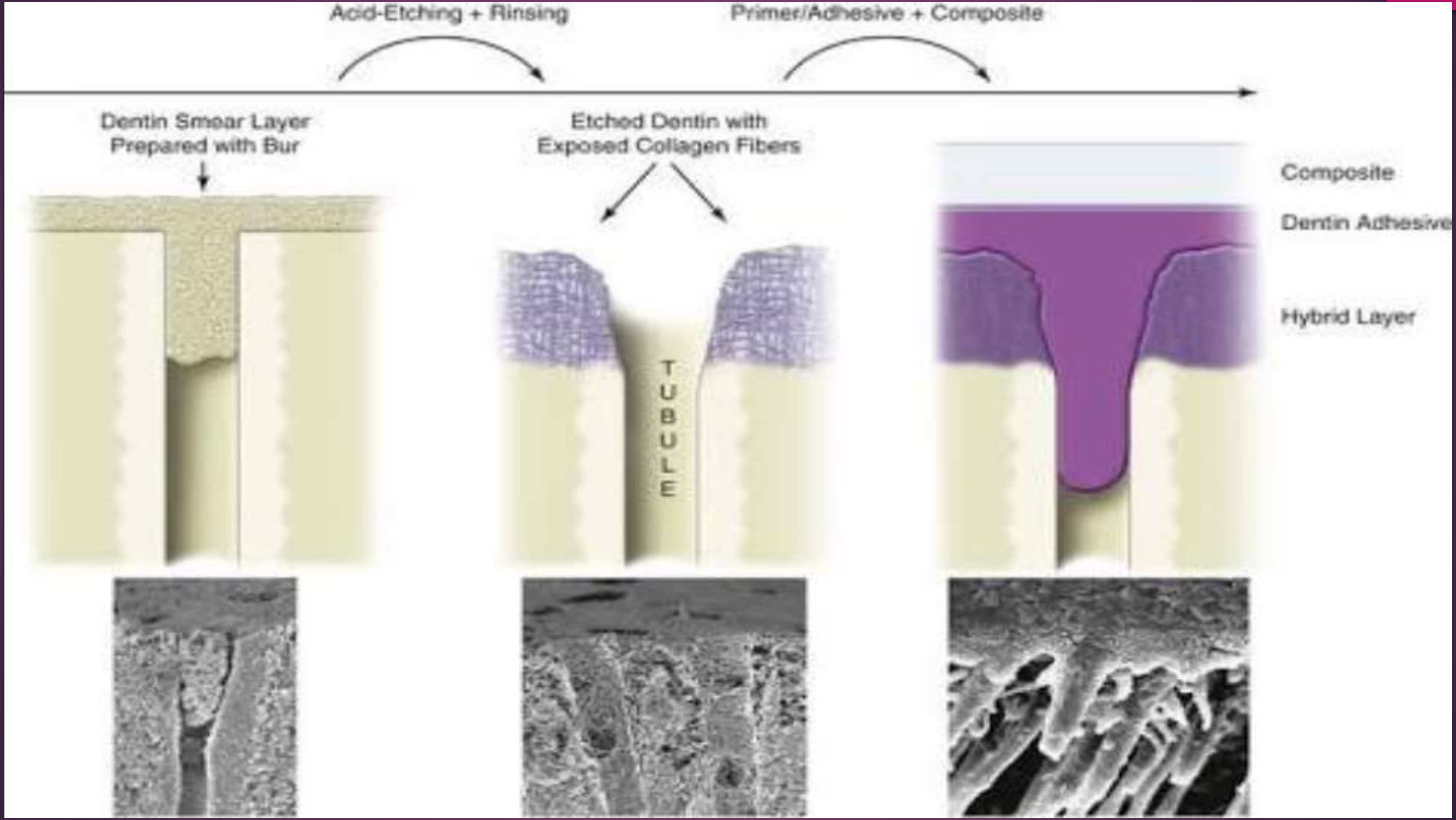
Fig. 2: Classification of contemporary adhesive into three-step total etch, two-step total-etch, two-step self-etch and the single-step self-etch systems. The two-step total-etch and the single-step self-etch adhesives may be considered as simplified adhesives in which hydrophilic resins are employed without an additional coating of comparatively more hydrophobic resins

Annil Dhingra and Amteshwar Singh, 2014

8th GENERATION DENTIN ADHESIVE

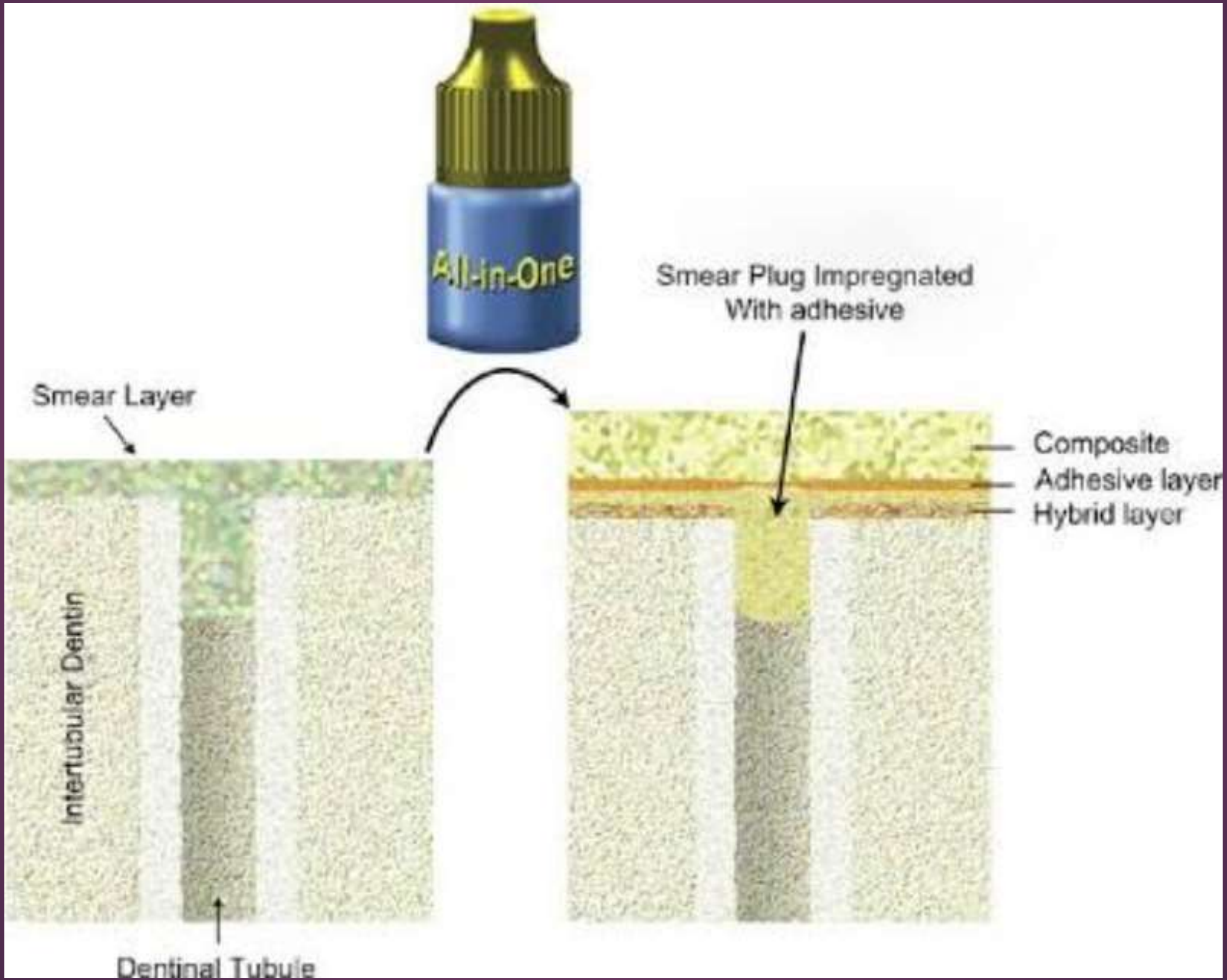


TOTAL ETCH



Jorge Perdigao et.al., 2015

SELF ETCH

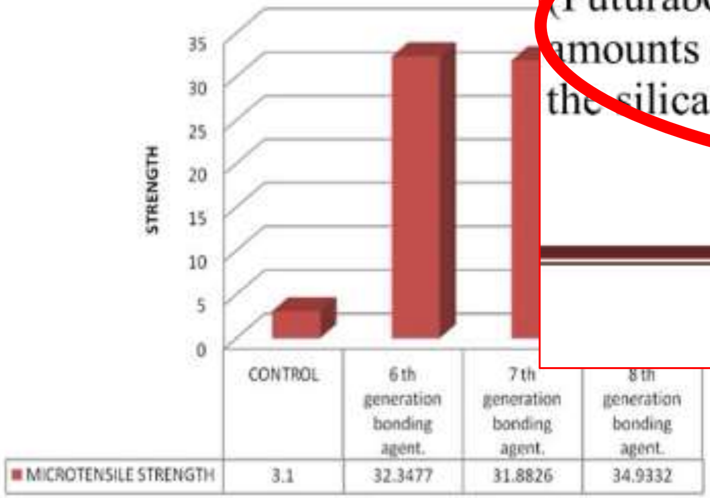


Jorge Perdigao et.al., 2015

etch adhesive, Clearfil SE Bond showed slightly higher bond strength than Adper Easy One, the one step self adhesive. This may be due to the component 10-MDP (10-methacryloxydecyl dihydrogen phosphate) in the Clearfil SE Bond, which has the potential to bond chemically with the hydroxyapatite crystal.[17] In addition the one step self-etch adhesive systems generally have less cross-linking monomers. These cross-linking monomers provide most of

Figure 3: Specimens obtained after hard tissue microtome sectioning

MICROTENSILE STRENGTH



Graph 1: Comparative evaluation of micro tensile bond strengths of sixth, seventh and eighth generation bonding agents

agent (Futurabond DC, Voco, Germany). The pH of all the adhesives used comes around the range of two and belonged to the mild self etch category. However difference in bond strengths was shown between these adhesives. The recently introduced eighth generation dentin bonding agent (Futurabond DC, Voco, Germany) contains significant amounts of highly functional nano sized cross linking agents, the silica particles and has the advantage of being dual cured.

Paul Joseph et.al.,2013

PubMed Search term

↓ Full text

Microtensile bond streng
adhesives to caries-affe

Ceballos L, et al. J De
Show full citation

METHODS: Extracted carious human molars were ground to expose flat surfaces where the caries lesion was surrounded by normal dentine. Surfaces were bonded with either Prime & Bond NT, Scotchbo
Bond or Prompt L-Pop, acc
manufacturers' recommend
built up using resin compos
After storage in water (37 d

CONCLUSIONS: The total-etch adhesives evaluated produced higher bond strengths to normal and caries-affected dentine than self-etching systems. Laser fluorescence measurements discriminated caries-affected dentine from normal dentine, and were strongly correlated with KH. However, laser fluorescence and KH did not permit high correlations with resin-dentine bond strengths in caries-affected

Ceballos et.al., 2003

Composite

- Material with two or more distinct substances
  - Silica, glass, polymers
- Dental resin composite
  - soft organic-resin matrix
    - polymer
  - hard, inorganic-filler particles
    - Glass, silica
- Most frequently used
  - esthetic-restorative material

Leinfelder 1993

COMPOSITION OF COMPOSITE RESIN

RESIN MATRIX (ORGANIC MATERIAL)

1. Protect filler
2. Transferring load to strong fiber
3. Hold filler together

Responsible for: Physicall properties

FILLER (ANORGANIC MATERIAL)

1. Strength
2. Hardness
3. Abrasion resistance

Responsible for: Mechanicall properties

COUPLING AGENT

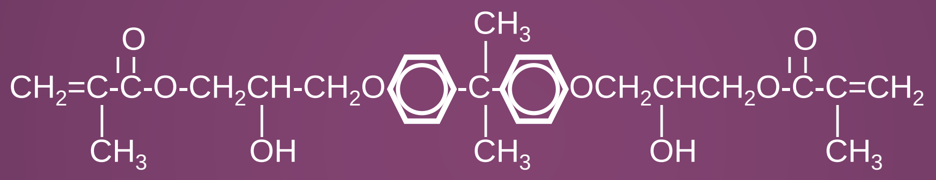
Bond to resin amatrix and filler

Responsible for: filler to matrix bond

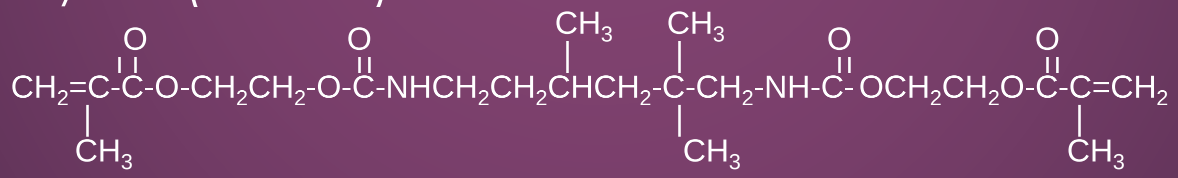
Annusavice, 2003

RESIN MATRIX (MONOMER)

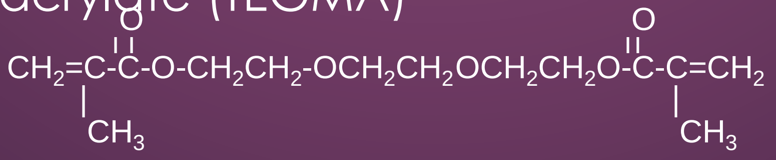
- Binds filler particles together
- Provides "workability"
- Typical monomers
  - Bisphenol A glycidyl methacrylate (Bis-GMA)



  - Urethane dimethacrylate (UEDMA)

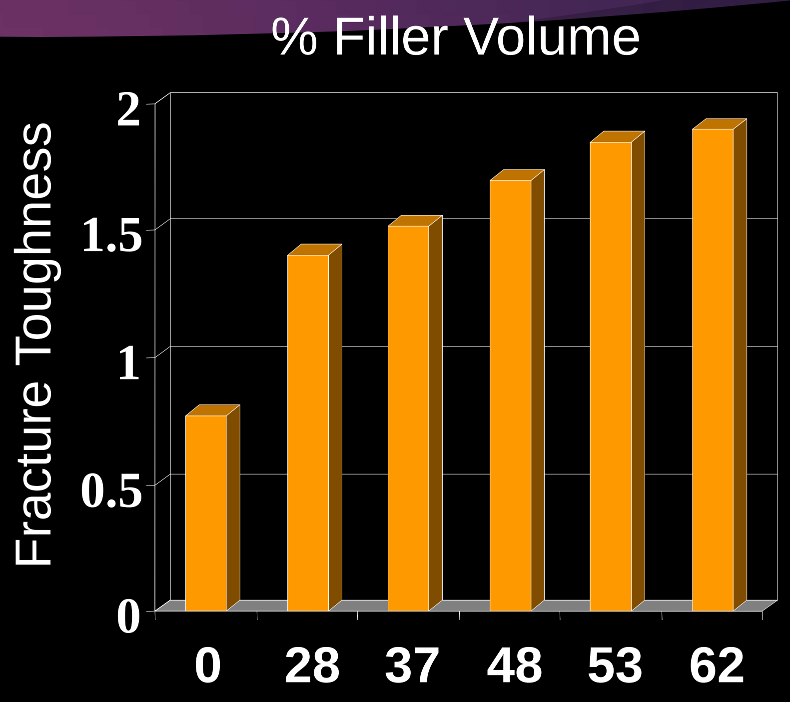


  - Triethylene glycol dimethacrylate (TEGMA)



Filler Particles

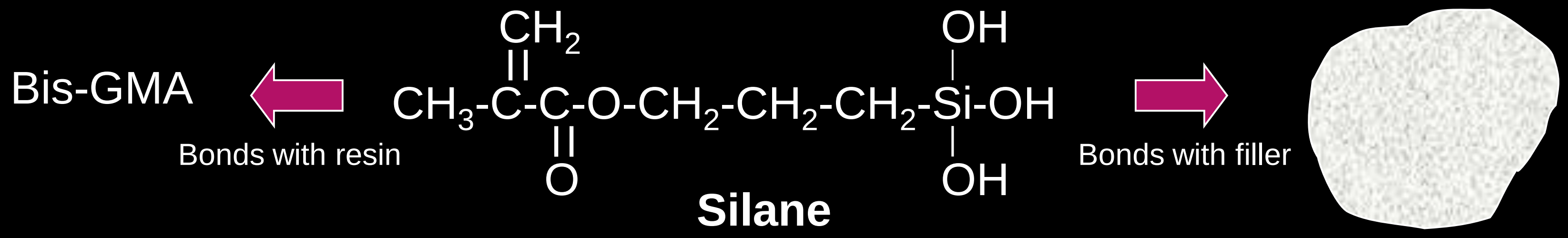
- Increase fillers, increase mechanical properties
  - strength
  - abrasion resistance
  - esthetics
  - handling
- 50 to 86 % by weight
- 35 to 71% by volume



Ferracane J Dent Res 1995

Coupling Agent

- Chemical bond
  - filler particle - resin matrix
    - transfers stresses
- Organosilane (bifunctional molecule)
  - siloxane end bonds to hydroxyl groups on filler
  - methacrylate end polymerizes with resin



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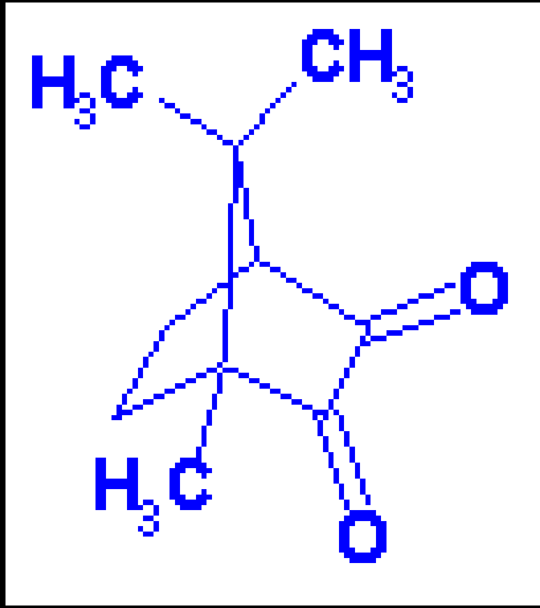
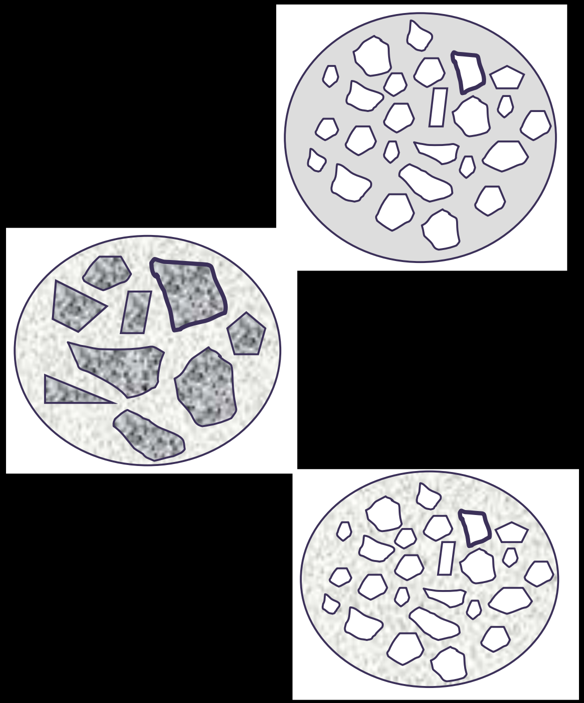
Visible-Light Activation

- Camphorquinone
  - most common photoinitiator
    - absorbs blue light
      - 400 - 500 nm range
- Initiator reacts with amine activator
- Forms free radicals
- Initiates addition polymerization



Classification System

- Historical
- Chronological
- Based on particle size
  - traditional
  - microfilled
  - small particle
  - hybrid



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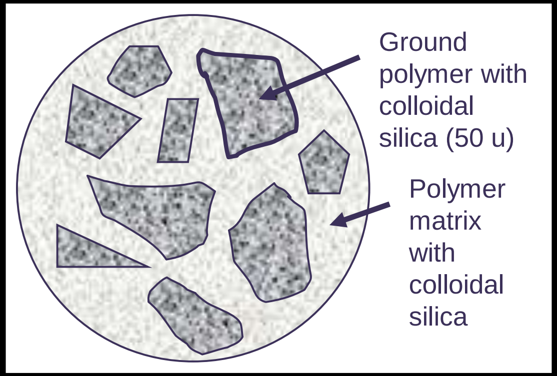
Traditional (Macrofilled)

- Developed in the 1970s
- Filler: Crystalline quartz
  - produced by grinding or milling
  - large - 8 to 12 micron
- Difficult to polish
  - large particles prone to pluck
- Poor wear resistance
- Easy Fracture
- Examples: Adaptic, Concise
- Suitable for Class 1, 2

Annusavice, 2003

Microfilled

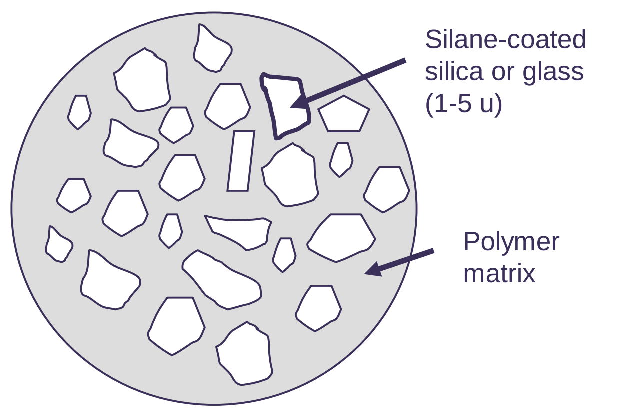
- Better esthetics and polishability than macrofilled
- Tiny particles
  - 0.04 micron colloidal silica
  - increases viscosity
- Lower filler content
  - inferior properties
    - lacks coupling agent
    - lacks radiopacity
- Linear clinical wear pattern
- Suitable for Class 1,2



Annusavice, 2003

Small Particle

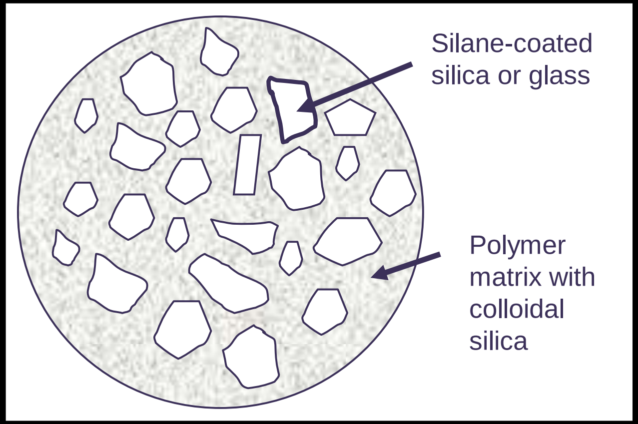
- 1 - 5 micron heavy-metal glasses
- Fracture resistant
- Polishable to semi-gloss
- Suitable for Class 1 to 5
- Example: Prisma-Fil



Annusavice, 2003

Hybrids

- Popular as “all-purpose”
  - microhybrids, microfilled hybrids
- 0.6 to 1 micron average particle size
  - distribution of particle sizes
    - maximizes filler loading
  - microfills added
    - improve handling
    - reduce stickiness



Annusavice, 2003

Hybrids

- Strong
- Good esthetics
  - polishable
- Suitable
  - Class 1 to 5
- Multiple available

Table of Properties

Property	Traditional	Microfilled	Small Particle	Hybrid
Compressive strength (MPa)	250-300	250-300	350-400	300-350
Tensile strength (MPa)	50-65	30-50	75-90	70-90
Elastic Modulus (GPa)	8-15	3-6	15-20	7-12
Coefficient of Thermal Expansion (10^{-6}/ºC)	25-35	50-60	19-26	30-40
Knoop Hardness	55	5-30	50-60	50-60

Annusavice, 2003

Newer Classification System

- Based on particle size
  - megafill
    - 0.5 - 2 millimeters
  - macrofill
    - 10 - 100 microns
  - midifill
    - 1 - 10 microns
  - minifill
    - 0.1 - 1 microns
  - microfill
    - 0.01 - 0.1 microns
  - nanofill
    - 0.005-0.01 microns

- Most new systems
  - minifillers
- Newest trend
  - nanofillers

Bayne JADA 1994

Nanofill vs. Nanohybrid

- Nanofills
  - nanometer-sized particles throughout matrix
- Nanohybrids
  - nanometer-sized particles combined with more conventional filler technology

Swift J Esthet Restor Dent 2005

Polymerization Shrinkage

- Significant role in restoration failure
  - gap formation
    - secondary caries formation
    - marginal leakage
    - post-operative sensitivity
- Counteract
  - lower shrinkage composites
  - incremental placement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