In the early 1990s, the first dental adhesives with adhesion ability to dentine appeared on the market. Those adhesives are now called the 4th generation and became the “gold standard” because of their good bonding ability and long-term proven clinical experience. But, their application method is quite complicated, time-consuming and not error-proof. That led to subsequent development and resulted in the 5th generation of dental adhesives, which merged the primer and bond into one bottle. The 6th generation eliminated the step of separate etching with phosphoric acid and the 7th generation finally united all the work steps into one. Each generation has certain limitations and the newer the generation, the less clinical experience and worse long-term predictability.

At first sight, adhesives of the 7th generation offer the easiest application. But, some problems still remain. For example, some adhesives contain hydrophilic (aqueous) and hydrophobic (oily) components in one bottle, which tend to separate so the bottle has to be shaken well before use. Perfect mixing and constant quality over time is questionable. The same problem appears when two components have to be mixed before use. Another difficulty is caused by the presence of a solvent that has to be evaporated before curing. Remnants of solvent or excessive drying weaken the bond strength and can cause post-op sensitivity.

Specifically, hydrophilic is needed to etch and penetrate hard dental tissues, as well as a substance that is hydrophobic to copolymerise with methacrylates. 4-META (4-methacryloxyethyltrimellitic acid anhydride) seems to be a very promising substance.

First synthesised in Japan during 1979 and used as a component of the base resin for partial removable dentures, it significantly increased the bond strength to metal alloys. In the late eighties, 4-META started to be used in amalgam-bonding agents and veneering resins. Further research has proven the adhesion ability on dental ceramics, and finally 4-META as a component of dental adhesive was found to have the ability to penetrate hard dental tissues and form a hybrid layer on dentine, with excellent sealing ability after polymerisation. So, here we have a substance that is able to adhere to most materials commonly used in dentistry.

There are two carboxylic groups on the aromatic core (coupled together as anhydride). They ensure the acidic and of course hydrophilic behaviour of 4-META. These groups react with the mineral part of hard dental tissues – calcium, thus becoming neutralised. The opposing end of the molecule contains a methacrylic group that is hydrophobic and reacts with other methacrylates. The reaction started by a curing light forms a co-polymer of the 4-MET-Ca complex and TEGMA, UDMA and other resin components.
Bond-1™ SF and 4-META – A new hope for dental adhesives
MUDr. Jan Prouza, Dvůr Králové

Dentin Bonding TEM Study
By: Leuven Biomat. Research Cluster
Katholieke Universiteit Leuven, Belgium

No smear layer was detected

Clear resin tags formed in dentin tubules

4-MET

\[ \text{Ca}_{10}\{(PO_4)_6(OH)_2 \} \]
HYDROXYAPATITE (HAP)

4-META-HAP stable salt formation

Adhesive Monomer 4-META adhesion to tooth mechanism

www.pentron.eu
4-META is the keystone of a new adhesive system from Pentron. Bond-1®SF is a single component self-etching light-cured bonding agent without solvents. To penetrate dentine, 4-META does not need any solvent, which gives Bond-1 SF some unique properties. Solvents (acetone, alcohol, water, etc.) are used in most dental adhesives. Insufficient evaporation of the solvent can weaken the bond strength or cause post-op sensitivity. Absence of the solvent eliminates the step of “drying the adhesive”, saves time and reduces the risk of error. A hybrid layer formed without solvent does not attract humidity from dentine (water treeing) and improves the quality and durability of the adhesive connection. Bond-1 SF has pH=3–4, which is why it has a high bond strength to enamel (22.6 MPa) when compared to other self-etching adhesives. The bond strength to dentine is 27.7 MPa.

The filler content is 40.5%. That gives Bond-1 SF a high – not slumping – viscosity and good visibility on the cavity surface. A thick layer of adhesive forms an elastic layer – a stress breaker – which increases the stability of the adhesive connection.

Application of Bond-1 SF is the easiest imaginable. Just brush it on the surface of the cavity for 20 seconds then light cure for 10 seconds. A single layer is sufficient. Bond-1 SF is delivered in a unique application form – a syringe with flocked needle tips. That allows precise and economic application into the cavity.

There are some very new adhesive materials on the market (Vertise, Fusio). Their qualities are so unique that it forced us to determine a new generation – the 8th generation of dental adhesives. Bond-1 SF is a member of that new generation.

In-vitro studies show good quality and high strength of adhesive connections using 4-META in the material. Long-term clinical experience will prove whether the idea was correct and the results sustainable.