3M ESPE

Rocatec

Bonding

Scientific Product Profile

Content

1 Preface

The Rocatec method has been established in German-speaking countries since 1989. It is now state of the art in dental retention-free adhesive bonding technology.

The system demonstrates its versatility in a large number of indications and applications which are described by numerous sources in the literature.

With Rocatec, metal, resin and ceramic surfaces can be coated with a silicatised adhesive layer which ensures durable retention-free bonding to resins.

Below is a detailed description of the system and evidence of the impressive clinical successes.

2 Introduction

In the new millenium the Rocatec system is no longer a product innovation, but it still sets the standard in modern dental adhesive technology.

In German-speaking countries the product is extremely popular not only because of its reliability in bonding metal to resin without marginal gaps. Elimination of the need for macroretention and the simplicity of the system generally are reasons enough to promote Rocatec internationally and establish it as state of the art there as well.

2.1 History

The system was introduced to the German market in 1989. It was thus the second method after Silicoater (Kulzer) which used silicatisation of metals to achieve a reliable bond to the resin. The advantages of the Rocatec system over the classic Silicoater process were in the heat-free generation of the silicate layer and its visual monitoring on metal.

Originally 3M ESPE offered the dental customer a 3-chamber sandblasting unit and two types of sand. The modern Rocatector delta offers several optimised features, extra reliability and simplified operation. A finer blasting sand has been supplementing the range for a number of years now.
Recently there has been another addition to the range of products, Rocatec junior, a single-chamber sandblasting module.

2.2 Background

For some time 3M ESPE has been successfully represented in the Laboratory market with the light-cured indirect composite Visio Gem and the Rocatec adhesive bonding system as an ideal complement to this microfilled composite. The 1997 introduced 3M ESPE crown and bridge veneering material Sinfony, an ultra-fine particle composite, is also optimally matched to the Rocatec system.

Other manufacturers of indirect resin materials state in their instructions for use that the Rocatec system is a suitable method for bonding their composite resin to metal.

The chemical background of the tribochemical Rocatec system is described in greater detail below.

2.3 Motivation

3M ESPE achieved the goal of creating a universal bonding system for the dental market more than ten years ago. New rival technologies have often demonstrated that the standard set by the Rocatec system remains unsurpassed.

2.4 Indications

The range of indications is as large as the desire to create a bond between two dental components irrespective of whether they are resins, metal or ceramics. Here is a sample list of potential applications:

- veneering of crowns and bridges
- veneering of secondary work (e.g. telescopic and attachment work)
- cast dentures (bond between cast and resin)
- veneering of the articulated areas of casts or brackets
- superstructures in implantology
- electroplated prosthetics
- repairs to ceramic or composite veneers
- bonding of adhesive bridges
- characterisation of preformed teeth made of resin or ceramic
- bonding of ceramic teeth to denture acrylic

- attachment base for cementing all-ceramic work, inlays and onlays, veneers and orthodontic brackets
- attachments and prosthetic aids

All metals, alloys, electroplated gold and particularly titanium are suitable as substrates (see bond strength further below).

All the ceramics available on the market can be coated, even zirconium oxide.
All hard resins (e.g. PMMA, epoxides) and composites can be provided with a silicate adhesive layer, but not waxes, elastomers (too soft) or natural teeth (their water content is too high).

3 Chemical background

3.1 General overview

Rocatec is a tribochemical method for silicatising surfaces. Tribochemistry involves creating chemical bonds by applying mechanical energy. This supply of energy may take the form of rubbing, grinding or sandblasting. There is no application of heat or light which would normally be the case with chemical reactions.

For this reason the Rocatec system may also be referred to as cold silicatisation because the mechanical energy is transferred to the substrate in the form of kinetic energy and the silicatisation takes place macroscopically without any change in temperature.

The Rocatec system consists of

a coating unit (Rocatector delta or Rocatec junior),

microblasting sand Rocatec Pre (cleaning and activating the surface),

coating sand Rocatec Plus or Rocatec Soft and

silane solution 3M ESPE Sil (resin primer).

3.2 Adhesion mechanism

First of all the surface to be coated is cleaned by blasting with 110 µm aluminium oxide sand (high-purity aluminium oxide, Rocatec Pre) and then roughened. This activates the surface and creates a uniform pattern of surface roughness which is ideal for the ensuring microretentive anchorage of the resin.

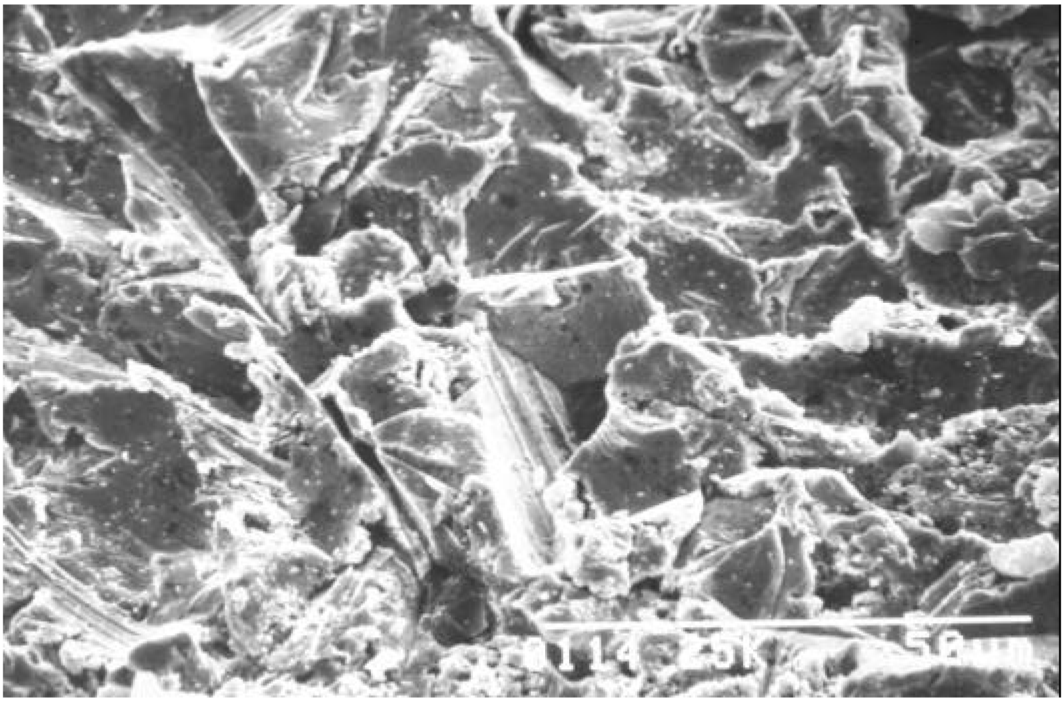
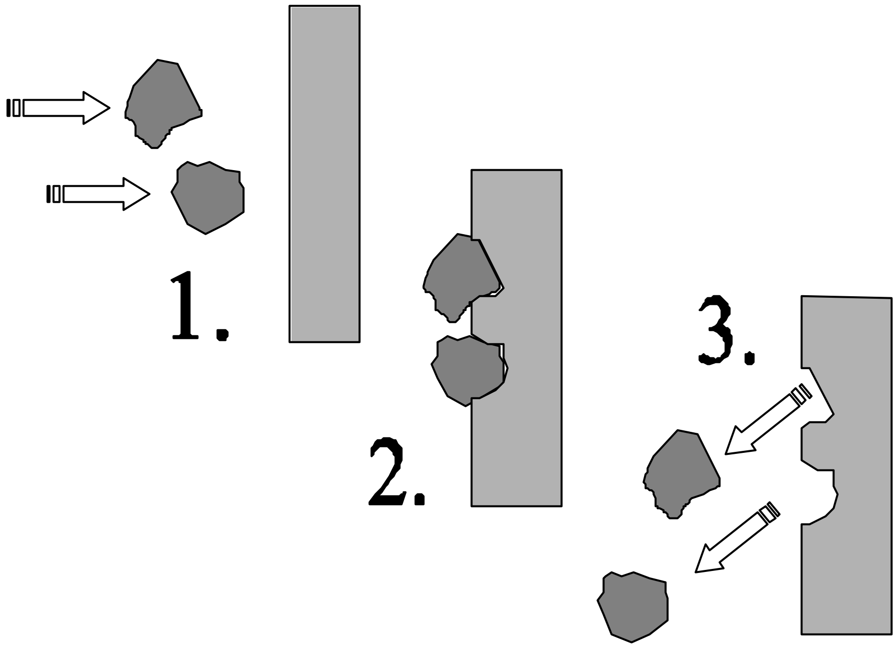


Fig. 1: SEM picture of a sandblasted gold surface (Rocatec Pre, 110 µm), magnification 1000 x.



<u>Fig. 2:</u> Microblasting with Rocatec Pre: **1.** The 110 µm aluminium oxide is blasted onto the surface to clean it. **2.** On the surface a microretentive roughness is achieved. **3.** The aluminium oxide leaves the cleaned activated surface.

This is followed by tribochemical coating of the microblasted surface with silica-modified aluminium oxide (Rocatec Plus or Rocatec Soft). The sand described above (Pre) is coated with a thin layer of SiO_2 (silica or silicon dioxide) (110 µm or 30 µm aluminium oxide + SiO_2 = Rocatec Plus or Rocatec Soft). Apart from ceramicising the surface, the impact of the particles also causes a certain amount of abrasion. With substrates which are highly susceptible to abrasion (e.g. thin electroplated metal edges) it is therefore advisable to use the 30 µm blast grit (Rocatec Soft) because it is less abrasive, but produces the same adhesive strength (Pfeiffer 1993). By contrast with the classic Rocatec Plus, with Rocatec Soft the medium grain size of the carrier aluminium oxide is reduced from 110 µm to 30 µm.

Ceramization of the blasted surface takes place when the grains hit the surface. This means that locally very high temperatures are caused by the transfer of impulses and energy (but only locally - macroscopic measurement shows no heat formation!). The affected surfaces of the substrate and grit in the atomic and molecular ranges are excited to such an extent that a so-called triboplasma forms.

The SiO_2 is impregnated into the surface up to a depth of 15 µm and at the same time fused to the surface in islands (see Figs. 4 and 6). The high level of energy which is required is created by the acceleration of the grain to a velocity of up to 1000 km/h due to the geometry of the blast nozzle and a blast pressure of at least 2.8 bar.

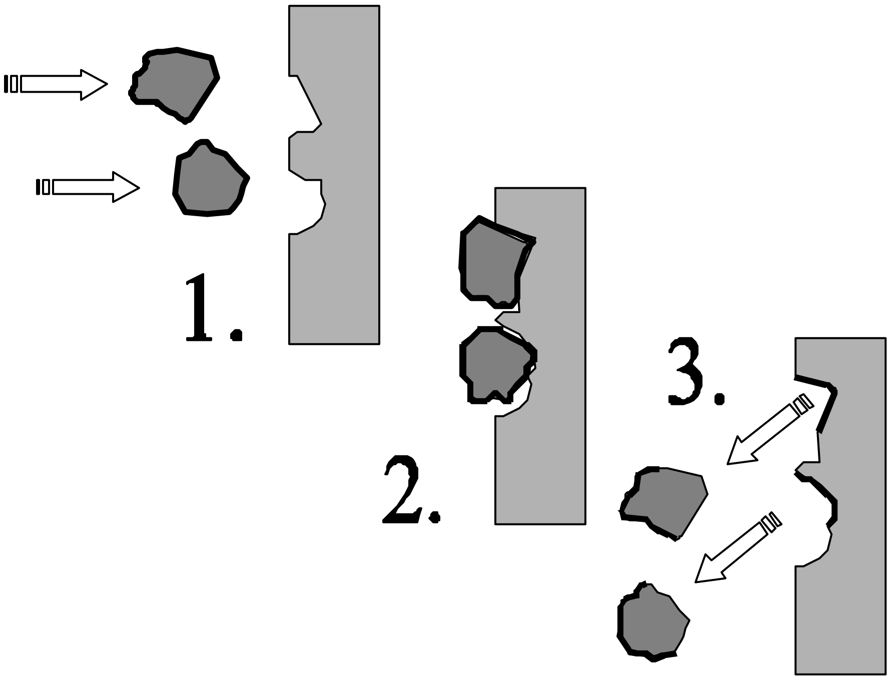


Fig. 3: Ceramization with Rocatec Plus: **1.** The 110 µm coated aluminium oxide is blasted onto the roughened surface. **2.** On the surface a triboplasma is created in microscopic ranges. **3.** The aluminum oxide, which is after the ceramization only partially coated, leaves the surface which is itself now partially coated with SiO_2.

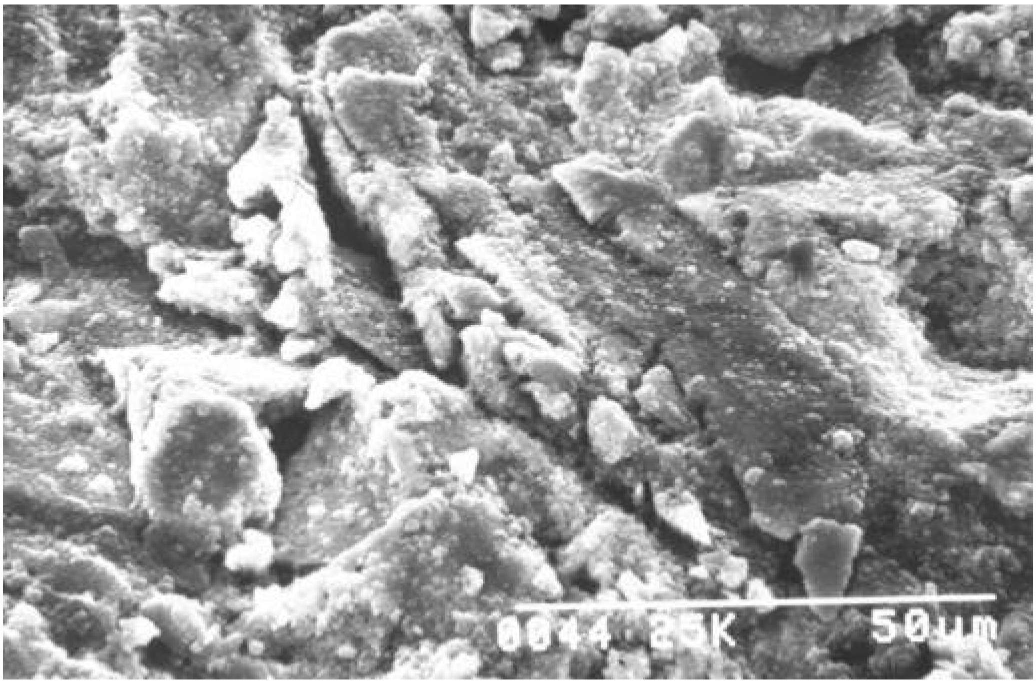
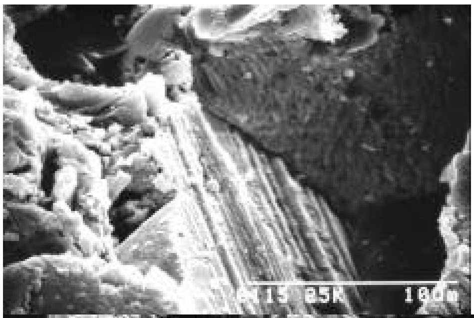
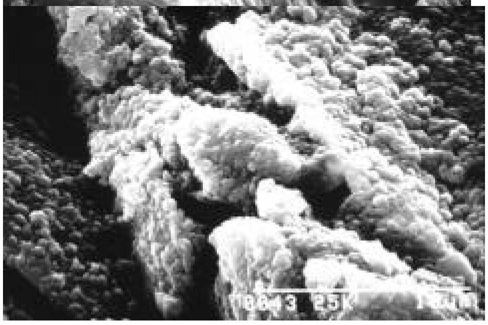
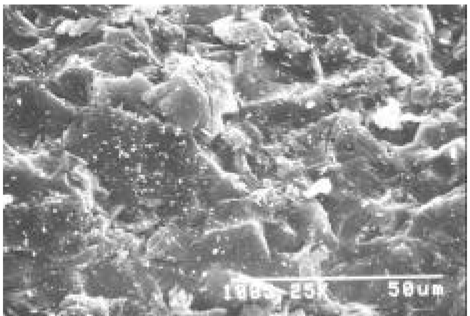


Fig. 4: SEM picture of a sand-blasted gold surface (Rocatec Pre, 110 µm), magnified 1000x, after coating with Rocatec Plus (110 µm).





<u>Figs. 5 and 6:</u> SEM pictures of a sand-blasted gold surface (Rocatec Pre, 110 µm), magnified 1000x, before and after coating with Rocatec Plus (110 µm).



<u>Figs. 7 and 8</u>: SEM pictures of a sand-blasted ceramic surface (Vita VMK) after microblasting (Rocatec Pre, 110 µm) [Fig. 7] and after coating (Rocatec Plus) [Fig. 8], magnified 1000x.

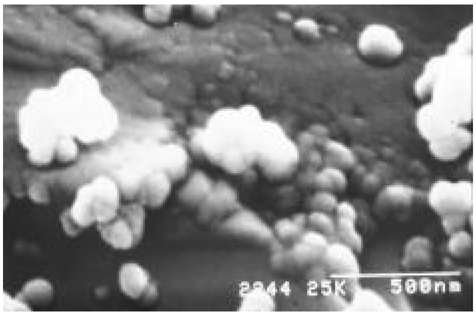
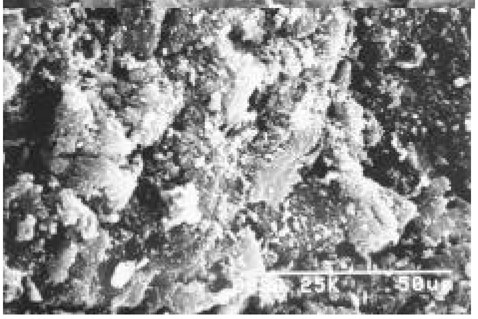


__Fig. 9:__ SEM picture of a ceramic surface (Vita VMK), magnified 60000x, **after** coating with Rocatec Plus (110 µm). The insular deposits of SiO_2 can be seen clearly.



__Figs. 10 and 11:__ SEM picture of a sand-blasted resin surface (Bioplus-Zahn, Detrey) after microblasting (Rocatec Pre, 110 µm) [Fig. 10] and after coating (Rocatec Plus) [Fig. 11], magnified 1000x.

The coated surfaces still have to be conditioned in order to be able to create a bond with the resin. This next step is silanisation with 3M ESPE Sil. A chemical bond between the inorganic silicatised surface and the organic resin can only be made in this way.

This resin may be a veneering resin, an opaquer or any other methacrylated monomer system (MMA, Bis-GMA, etc.).

The resulting anchorage roughly corresponds to the chemical bonding of silanised fillers in composite.

Such bridging of a chemical bond between inorganic and organic constituents can only by achieved by a special molecule, namely a dual molecule which can react with silicatised surface at one end and with methacrylate groups (double bond) at the other.

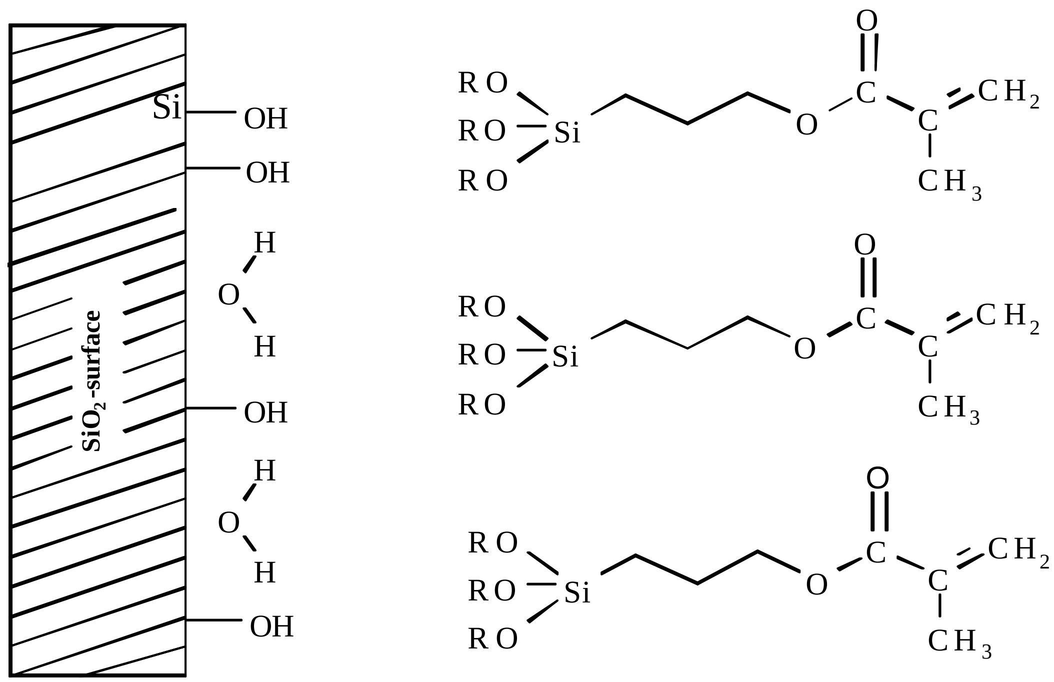


Fig. 12: The silane molecules (on the right) approach the inorganic surface which is covered with hydroxide groups and water molecules.

The silane used in 3M ESPE Sil is characterised by two molecule ends of different polarity. The alkoxy groups of the silanol unit (left end of the silane molecule Fig. 12: $(RO)_3Si$-) make a chemical bond with the silicatised surface.

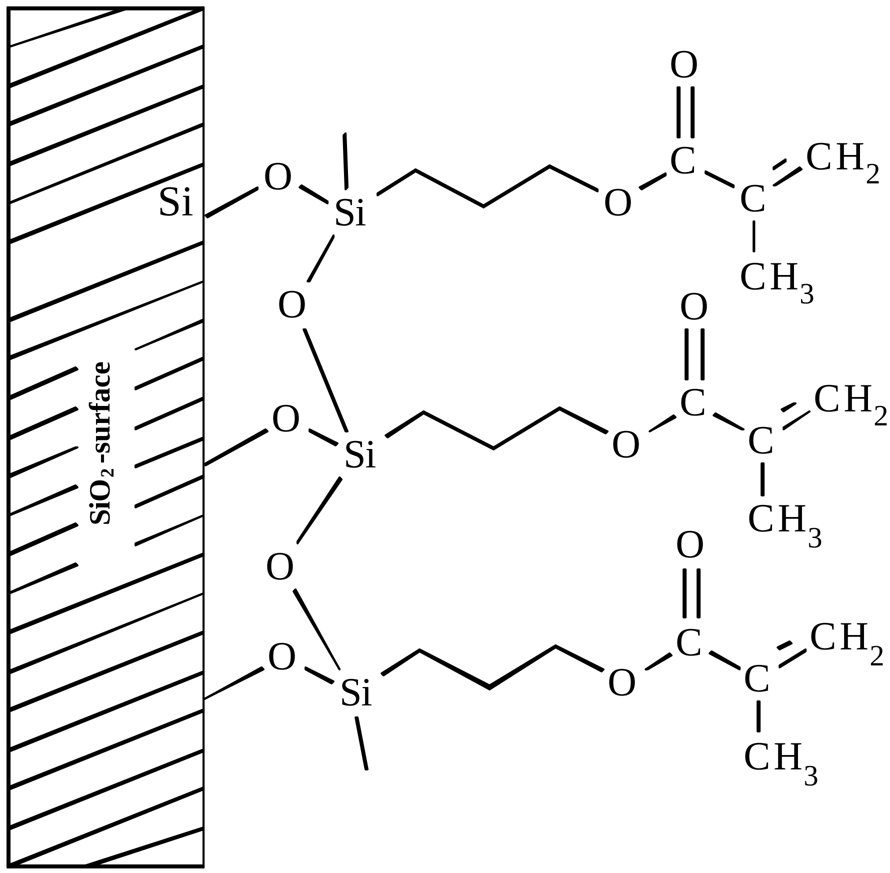


Fig. 13: The silane molecules have made a chemical bond with the SiO_2 component of the coated surface (splitting alcohol; not illustrated here).

Then the methacrylate groups (right-hand silane side) can copolymerise with the monomers of the resin. In this way the chemical bond is finally achieved between the substrate (e.g. metal) and the resin.

3.3 Material properties

One major benefit is the visual monitoring of the coating process. The coat of silicate applied causes the metal surfaces to darken. The technician immediately sees the success of ceramization. With ceramic or resin surfaces, of course, this is not possible.

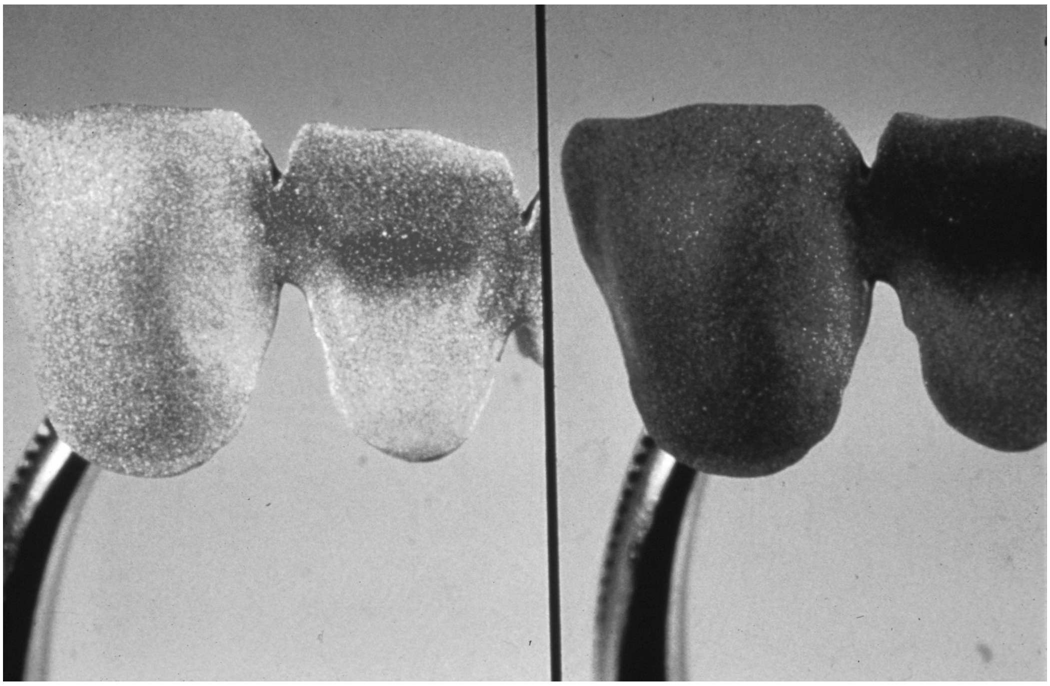


Fig. 14: Metal surface after microblasting with Rocatec Pre (left) and after silicatising with Rocatec Plus (right). The dark discolouration of the metal after application of the ceramic layer can be seen clearly.

Another major advantage is the cold silicatisation, thus avoiding thermal stressing within the metal framework and thus the risk of distortion. With thermal silicatisation methods such distortion can occur even with constructions which have been cast without stress.

As with composite filler technology, retention-free adhesive bonding technology has been used successfully for many years, due to a silicatised intermediate layer which can chemically bond with resin. During this time it has proved to be absolutely durable in the long term and insusceptible to hydrolysis.

4 Composition of product

4.1 Presentation

The Rocatec system consists of the coating unit Rocatector delta or Rocatec junior and the blasting mediums Rocatec Pre, Rocatec Plus and Rocatec Soft as well as silane solution 3M ESPE Sil.

Figs. 15 + 16: The Rocatector delta (left) and Rocatec junior (right) each with blasting medium.

4.2 Constituents

Rocatec Pre:	High-purity aluminium oxide 110 µm
Rocatec Plus:	High-purity aluminium oxide 110 µm, modified with silica (SiO_2)
Rocatec Soft:	High-purity aluminium oxide 30 µm, modified with silica (SiO_2)
3M ESPE Sil:	Silane in ethanol

5 Test results

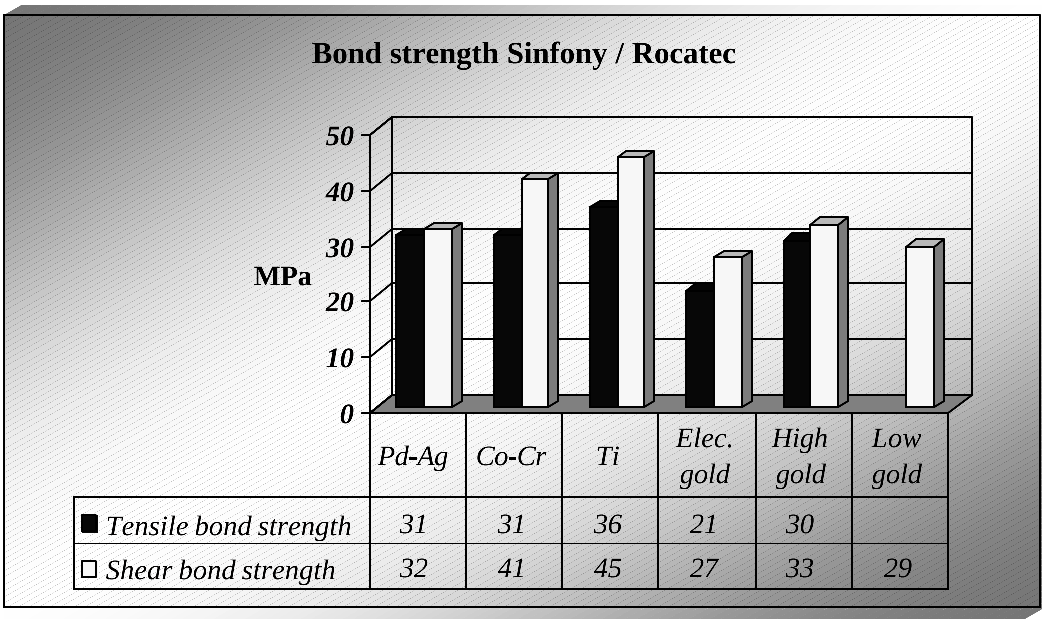
Here is an overview featuring a selection of the large number of internal and external data which prove the universality, reliability and durability of the Rocatec system.

Many results and parameters cannot be compared between the different test institutes due to the different test setups used. However the rankings within a tested group are always representative and usually correspond to the rankings of other studies.

5.1 Adhesion to metal

The graph below shows the bond strength of Sinfony to various alloys after Rocatec pretreatment from a tensile bond test and the shear bond test (according to ISO 10477), each after exposure to water and thermocycling.

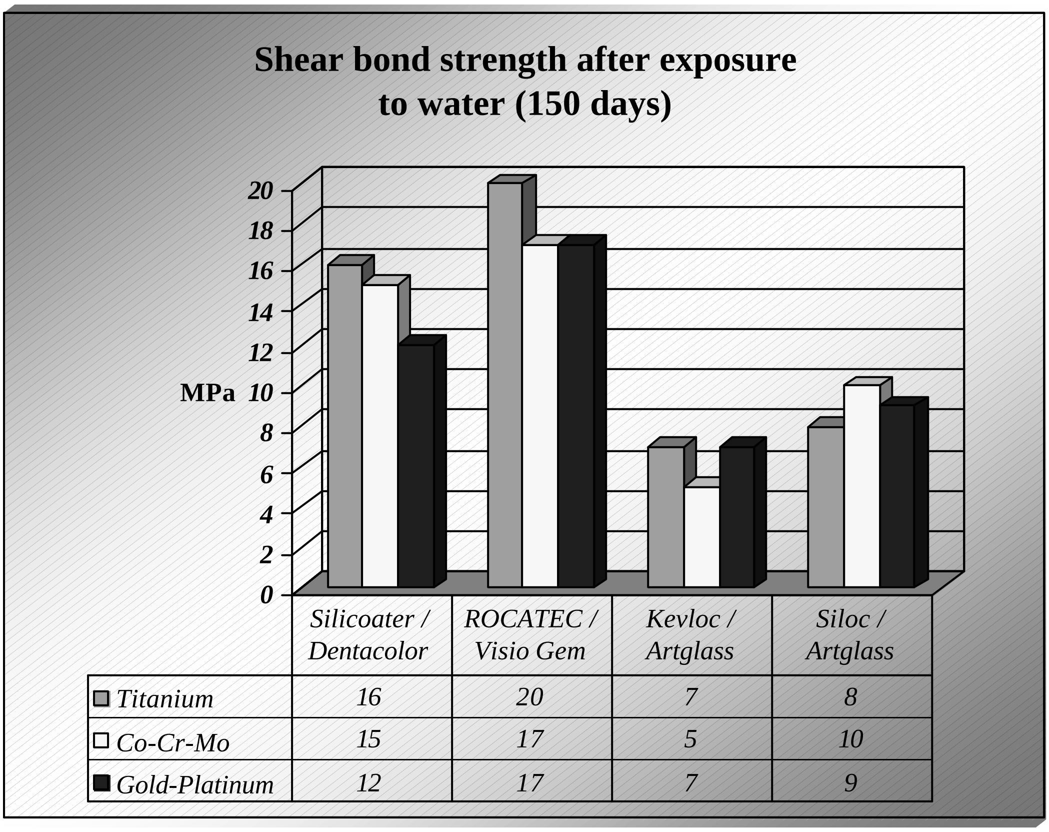
By contrast with all the other measurements using Rocatec Plus, electroplating gold was coated instead with Rocatec Soft.



	Pd-Ag	Co-Cr	Ti	Elec. gold	High gold	Low gold
■ Tensile bond strength	31	31	36	21	30	
□ Shear bond strength	32	41	45	27	33	29

Fig. 17: Bond strength of Sinfony to different alloys after Rocatec - coating

In 1998 the Regensburg team lead by Behr and Rosentritt demonstrated the hydrolysis resistance and long-term bond of the Rocatec system. The investigations were performed with the predecessor to Sinfony, Visio Gem.



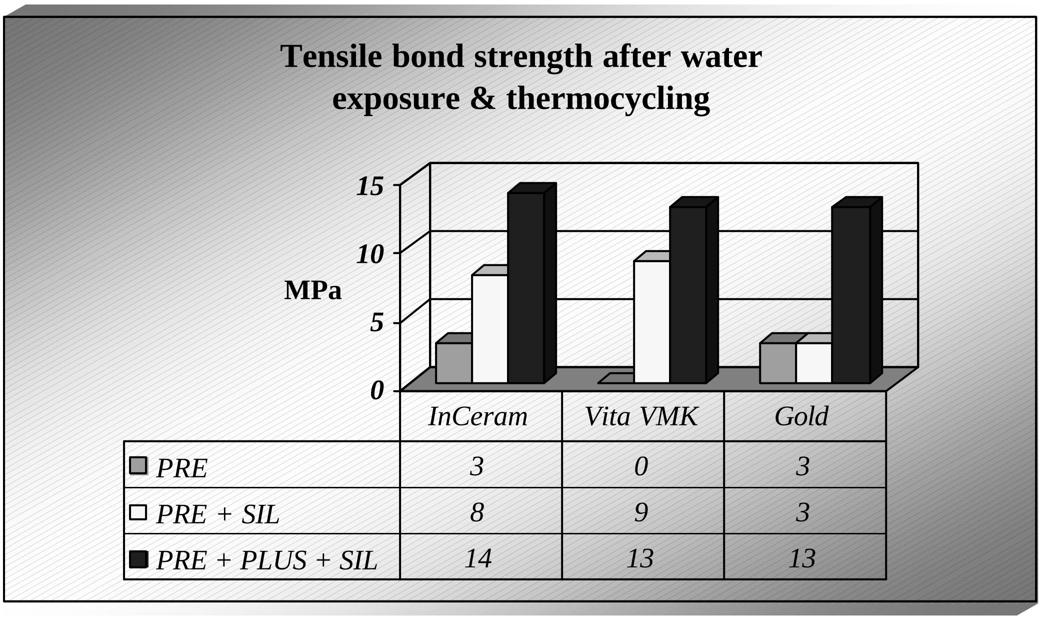
	Silicoater / Dentacolor	ROCATEC / Visio Gem	Kevloc / Artglass	Siloc / Artglass
Titanium	16	20	7	8
Co-Cr-Mo	15	17	5	10
Gold-Platinum	12	17	7	9

Fig. 18: Bond strength of indirect resins to various alloys after 150 days of exposure to water (Hindelang, et al., 1998).

5.2 Adhesion to ceramics

The adhesion of resin to ceramics without silanisation, but after preblasting (with aluminum oxide) is inadequate. Subsequent silanisation achieves the bond of silane to the silicone dioxide molecules of the surface. The bond obtained can, however, be almost doubled with a ceramicising coating of Rocatec Plus.

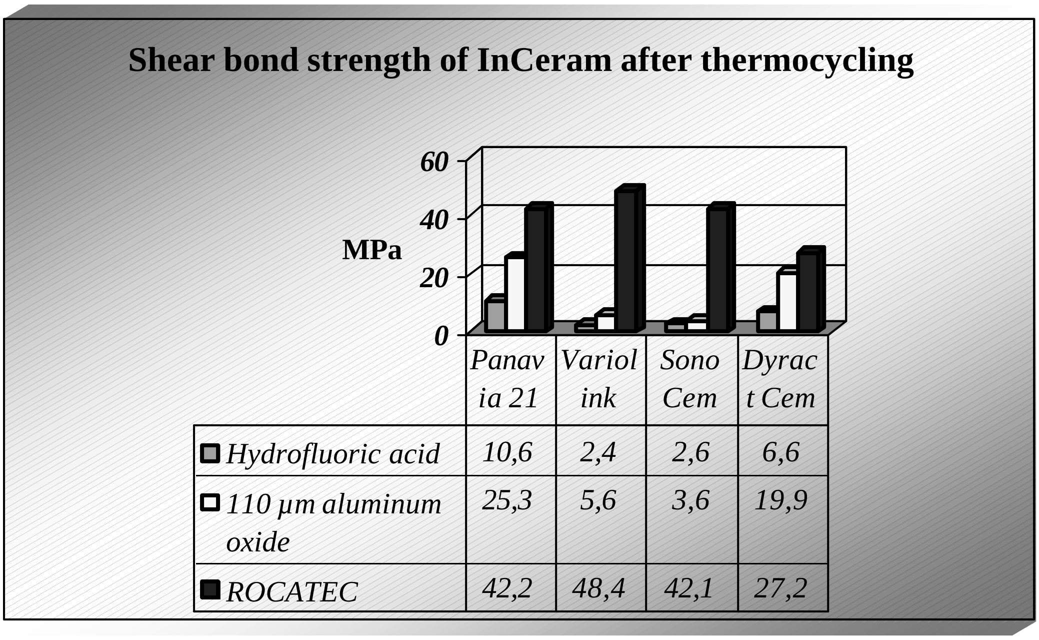
The diagram below demonstrates the suitability of Rocatec in pretreating ceramics for bonding resins and compares adhesion with the corresponding figures for gold.



	InCeram	Vita VMK	Gold
PRE	3	0	3
PRE + SIL	8	9	3
PRE + PLUS + SIL	14	13	13

Fig. 19: Adhesion of Sinfony to ceramics, compared with gold, after various Rocatec pretreatments.

Similar results were obtained by a team from Cologne/Marmara. They investigated what influence various pretreatments of InCeram had on the bonding of various cements. Here too Rocatec demonstrated the major advantage of tribochemical coating because with all the cements a significantly higher bond strength was achieved.

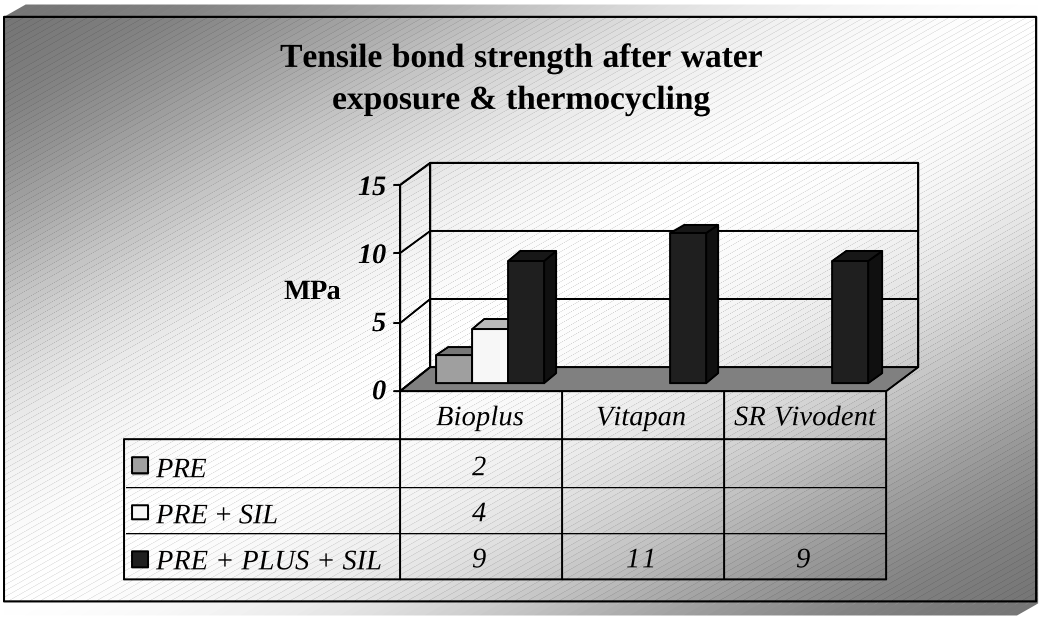


	Panavia 21	Variolink	Sono Cem	Dyract Cem
Hydrofluoric acid	10,6	2,4	2,6	6,6
110 µm aluminum oxide	25,3	5,6	3,6	19,9
ROCATEC	42,2	48,4	42,1	27,2

Fig. 20: Adhesion of luting cements to ceramics after various pretreatments.

5.3 Adhesion to resins and composites

Here too, as described above for ceramics, a purely microretentive anchorage of resin to resin (or composite) cannot produce adequate adhesion after sandblasting. Here as well, silanisation brings about a considerable increase in adhesion, but its optimum is only achieved after tribochemical coating.

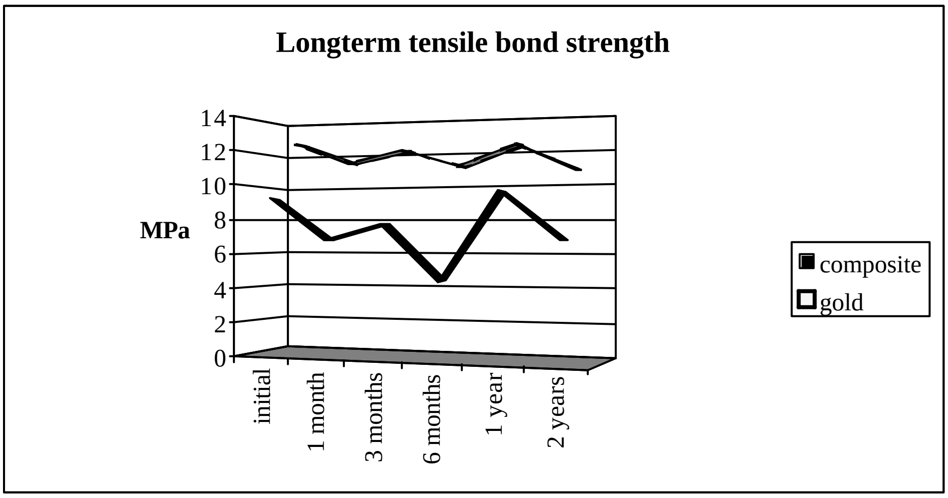


	Bioplus	Vitapan	SR Vivodent
PRE	2		
PRE + SIL	4		
PRE + PLUS + SIL	9	11	9

Fig. 21: Adhesion of Sinfony to acrylic teeth, in one case after various Rocatec pretreatments.

5.4 Other test results

Special mention must be made of the clinical success and long-term behaviour of the Rocatec bond. First of all the surface and time-independent bond strength of the tribochemical coating is impressive. On an average the figures indicated below are nearly identical to the initial values even after two years.



<u>Fig. 22:</u> Adhesion of Visio Gem / Rocatec to gold, nickel-chromium, ceramic and acrylic teeth after thermocycling and exposure to water.

In a clinical study published in 1994, Mayer reported 3-year data for 120 veneers using Visio Gem. He found no marginal gap and no discoloration of Visio Gem. Only in 6% of the cases did he find slight abrasion and in only 10% of cases was there minor flaking at the cervical margin. In no case was this cause for complaint and quite often the patient had not even noticed it. In no case was it necessary to make the veneer again.

Kern and Strub demonstrated in an in vivo study (1998) that the adhesive bond of glass-infiltrated aluminium oxide bridges to natural teeth using Rocatec is still stable even after 5 years.

A good overview of the literature concerning studies on metal and ceramic resin bonding systems is to be found in Quintessence International (Özcan, 1998).

6 Summary

The retention-free adhesive bonding system, Rocatec, with visual monitoring of surface conditioning provides high-stability, long-term bonding with no marginal gaps irrespective of the substrate.

Here once again are the **main features** of the Rocatec system:

- Visual monitoring of surface conditioning
- Rapid, easy and accurate coating
- Easy repair
- No mechanical retentions required
- High, consistent bond strength
- No thermal stress on the metal framework
- Proven bonding system with no marginal gaps
- Reliable adhesion to metal, ceramics and resin

7 Instructions for use

7.1 General

All the surfaces to be treated must be clean and dry. Moisture and residues of oil cause inadequate bonding. This point is particularly important with regard to "hidden" oil and water sources, e.g. from the compressed-air supply of the sandblasting unit.

7.2 Sandblasting

The **blast pressure** must be 2.8 bar to guarantee an adequately high level of energy for creating the triboplasma.

Blast direction: the surface must be sandblasted at right angles from a distance of 1 cm.

Sandblasting time: for each veneer unit (approx. 1 cm^2) coating takes approx. 15 seconds.

Sandblasting material: for thin work (e.g. fine gold margins) which might bend or abrade too severely on account of the 110 µm sand (Rocatec Plus), the 30 µm sand Rocatec Soft is to be preferred. The only disadvantage is that the finer sand creates much more dust.

7.3 Silanisation

The silane solution must dry out adequately after application or else solvent molecules are incorporated in the resin bonding layer and weaken it. Ideally one should wait 5 minutes. In that time no impurity must be allowed to access the silanised surface – again moisture is particularly critical.

8 Packaging types

ROCATEC -system

Typesof packaging	*item number*
Rocatector Delta 3-chamber unit	**77000**
Rocatector Delta 2-chamber unit	**77010**
Accessory Pack Rocatec Pre 3000 g, Rocatec Plus 3000 g 2 bottles ESPE Sil each 8 ml, 3 brushes	**68370**
Shipping unit	
Rocatec Pre 3 x 3000 g	**68360**
Rocatec Plus 3 x 3000 g	**68350**
Rocatec Soft 3 x 3000 g	**68340**
Single Packs	
bottle ESPE Sil 8 ml	**68300**
5 Rocatec brushes	**71320**
Accessory Parts	
1 extractor unit	**68280**
1 sandblasting module	**68270**
5 glass panels	**68260**

Rocatec junior

Type of packaging	*item number*
Rocatec junior Set Rocatec junior coating unit Rocatec Plus shipping unit 3 x 3000 g	**77030**

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