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What makes fillers go round – laboratory studies on the new TPH Spectra®ST

When developing a new filler material controlled laboratory studies are indispensable. Various performance parameters need to be evaluated in order to compare the innovation to materials already being integrated to the market. The following article shows examples of studies undertaken at renowned universities. Conclusions from these studies relevant to daily use in clinical practice are described at the end.

The new TPH Spectra ST is formulated with the patent applied SphereTEC™ filler technology and shows particular handling properties. SphereTEC fillers are pre-polymerized fillers (PPF) with a mean size of 15 µm. Therefore, one major research focus was to investigate whether PPFs of this size would interfere with strength or polishability of the final composite.

Mechanical strength – static and dynamic challenges

Flexural strength is in the current norm ISO 4049 the only listed parameter for testing mechanical strength of a composite. In the Research Laboratory for dental Biomaterials at Erlangen University (Germany), flexural strength was measured in a 4-point bending experiment after 2 weeks of water storage (Figure 1).

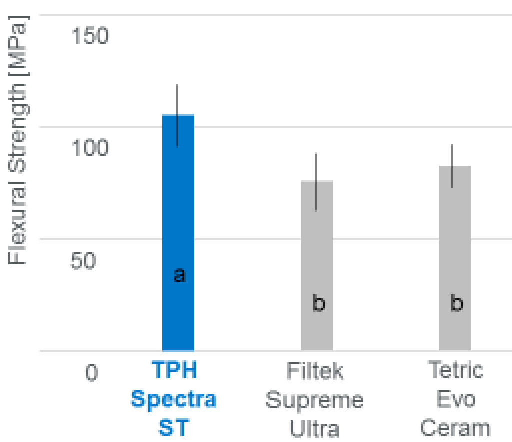

Figure 1 Flexural strength in 4-point bending after 2 weeks of water storage (Belli R and Lohbauer U, 2015)[1]

[1] Different letters indicate statistically significant differences.

Besides this 'static' approach in which specimens are loaded with increasing force until fracture, 'dynamic' loading is very helpful to better predict long-term stability. In this approach, specimens are loaded in cycles of a much lower force. This fatigues the material in a somewhat similar manner to that seen in daily chewing. To evaluate the flexural fatigue strength a specimen is loaded up to 10'000 cycles at a frequency of 0.5 Hz. If the specimen survives this challenge, force for the next specimen is increased. In contrast, the force will be decreased if the specimen broke. Altogether, 25 specimens per material need to be tested to calculate the flexural fatigue strength (Figure 2).

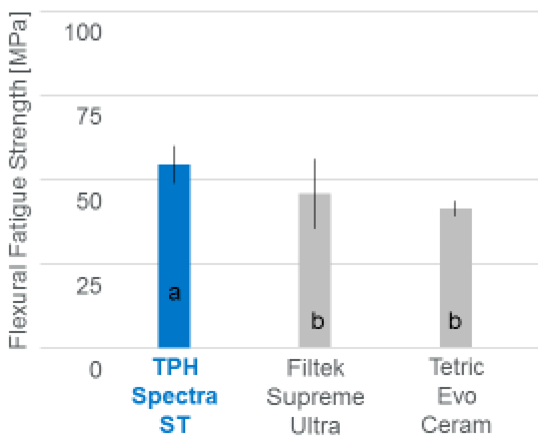

Figure 2 Flexural fatigue strength in 4-point bending (Belli R und Lohbauer U, 2015)[1]

Both measurements demonstrate TPH Spectra ST´s high mechanical strength. Therefore, it is indicated for both – direct fillings and indirect restorations (e.g. onlays) made of composite.

Wear resistance – generalized and localized

Of special interest in posterior teeth is, besides mechanical strength, whether the material can resist chewing without loss of vertical height. The clinical process of wear is a mixture of quite complex mechanisms and currently cannot be reproduced with one single simulation method. Therefore, TPH Spectra ST was tested at four different universities using different protocols (Table 1).

University	Method	Description
Amsterdam	ACTA	spring loaded antagonist wheel in rice and millet seed shell slurry
Creighton	Leinfelder	loading of samples in PMMA slurry generalized: flat stylus (non-contact) localized: stainless steel ball (contact)
Marburg	chewing simulation	loading onto marginal ridge of class II restorations in posterior teeth
Zurich	chewing simulation	loading with antagonist made of bovine enamel

Table 1 Overview of sites evaluating wear resistance

At Creighton University (Omaha NE, USA) two protocols are applied to test generalized and localized wear, respectively. Both protocols include loading the specimens for 400'000 cycles at 1 Hz with 80 N with a stylus that additionally rotates for 30°. To simulate generalized non-contact wear, a flat stylus is used that does not touch the surface of the specimen. A stainless steel bearing is mounted to this stylus so that it touches the specimen and is used to simulate localized (contact) wear. To mimic the food bolus being chewed on during mastication a slurry of about 44 µm small acrylic glass (PMMA) beads surrounds the specimen in both protocols throughout the experiment (Figure 3).

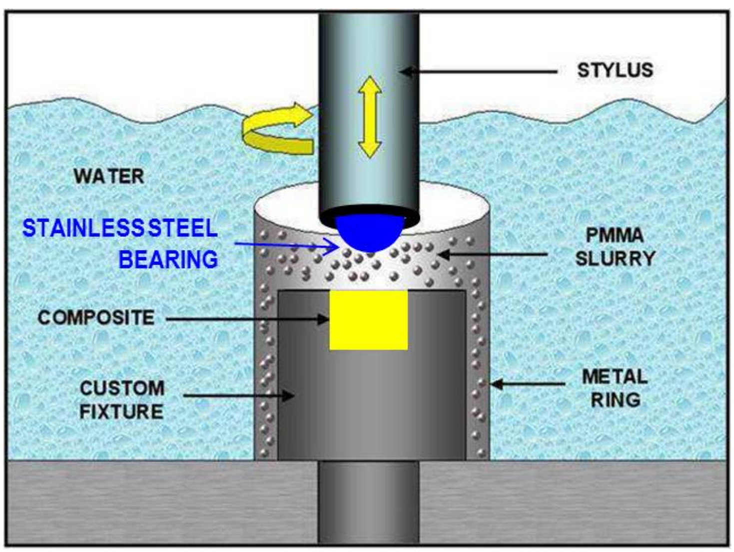

Figure 3 Localized wear in a Leinfelder wear machine (Latta MA und Barkmeier W, Omaha NE, USA)

Results from localized wear in the Leinfelder wear machine – expressed as maximum depth of the wear facet – are shown in the following diagram (Figure 4).

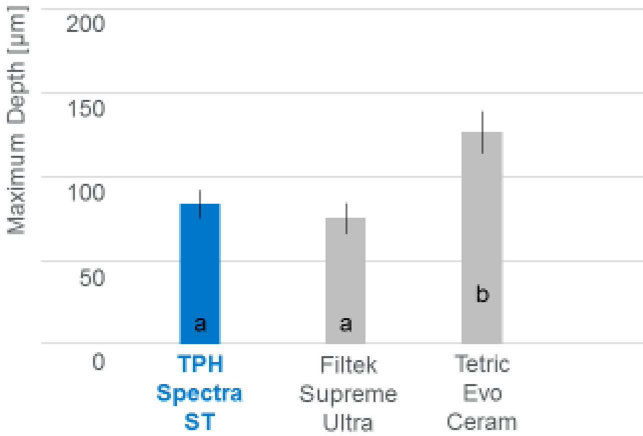

Figure 4 Maximum depth of wear facets in the Leinfelder wear machine (Latta MA, 2015)[1]

A representative scanning electron microscopy (Figure 5) taken from a specimen after generalized wear shows a uniform surface – neither SphereTEC granulates nor the particulate glass fillers, they are made of, can be differentiated from the surrounding composite formulation and its glass fillers. This is indirect proof of the excellent integration of SphereTEC fillers into the overall composition, which is essential for low wear when large pre-polymerized fillers are used.

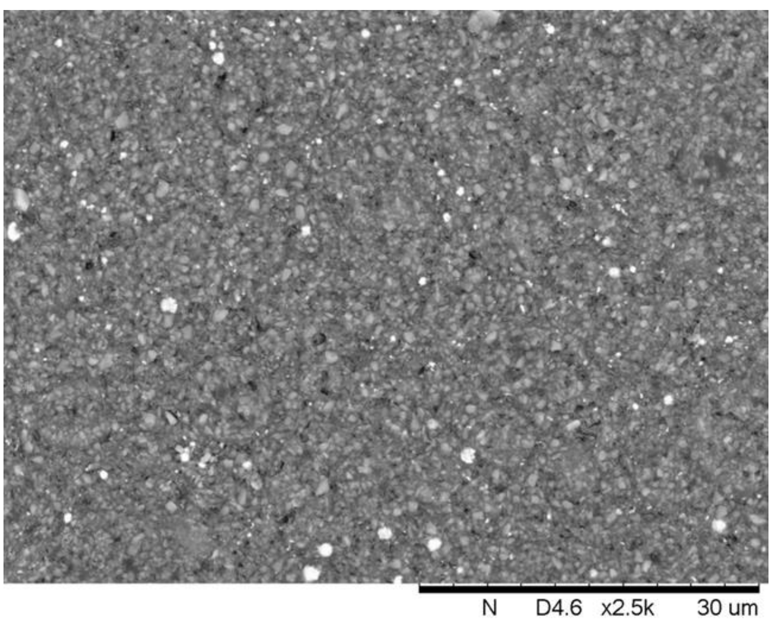

Figure 5 Scanning electron microscopy of TPH Spectra ST after generalized wear in the Leinfelder wear machine (Latta MA, 2015)

Polishability – time and gloss

High wear resistance in occlusal load bearing areas and easy polishability resulting in high gloss are quite often understood as contradiction. Furthermore, polishing to high luster is another good test to verify how the larger SphereTEC fillers compare to the surrounding composite formulation with its glass fillers having a mean size of 0.6 µm. All components need to be abraded equally in order to achieve high luster in a fast and easy way. Therefore, polishability of TPH Spectra ST was tested following an established protocol at the Oregon Health&Science University (Portland OR, USA).

Specimens of 5 x 12 mm size were firstly roughened in a standardized manner and then finished and polished by one experienced dentist (da Costa J) using two popular systems. Gloss was measured repeatedly after 20 seconds until no further significant change was observed to evaluate progress over time. According to a publication of the American Dental Association (ADA)[2], 40 gloss units (dotted line in Figure 6) are considered to represent a clinically accepted gloss.

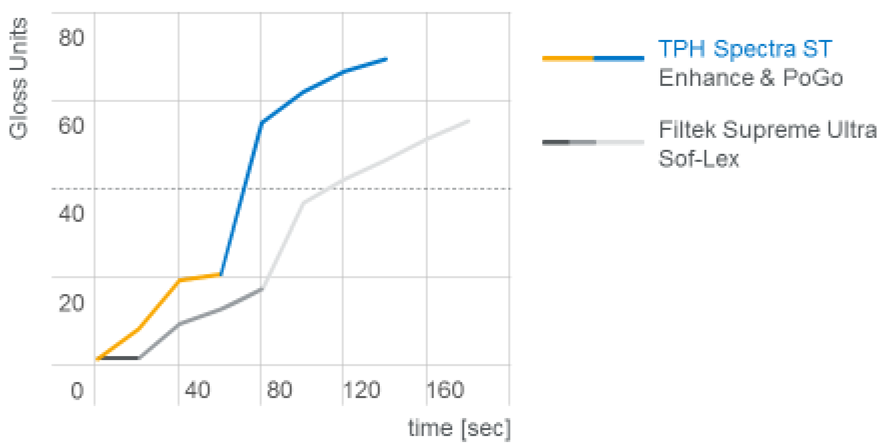

Figure 6 **Gloss over time while finishing (yellow and dark gray lines) and polishing (blue and light gray lines) composites with different finishing and polishing system (da Costa J and Ferracane J, 2017)**

This study revealed that using Enhance and PoGo for finishing and polishing TPH Spectra ST lead to higher gloss in viewer steps compared to the control.

[2] ADA professional product review (2010). Polishing systems. 5(1) 2-16.

Conclusion – laboratory studies and clinical practice

Whether and to which extent laboratory studies are relevant to evaluate the potential in daily practice is a continuously discussed question among practitioners and scientists. However, fact is that clinical success of any filling therapy is significantly influenced by the quality of the procedure while restoring. In laboratory studies it is easy to establish ideal conditions. Despite numerous other challenges in daily practice, it is worthwhile investing in optimizing the procedures needed for adhesive dentistry in order to guarantee long-term clinical success.

Results from the above described laboratory studies with the new TPH Spectra ST revealed very high mechanical strength and low wear in load bearing areas in combination with an easy and fast polish to high gloss. Hereby, verifying that the innovative filler technology SphereTEC promotes the formulation of a highly performing composite. The implementation of this potential into daily practice is facilitated by its pleasant handling properties.

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