HOFFMANN MINERAL
Unternehmensgruppe Hoffmann

Sillitin Z 89 puriss in

100% UV-curing clear varnish

glossy topcoat, abrasion resistant

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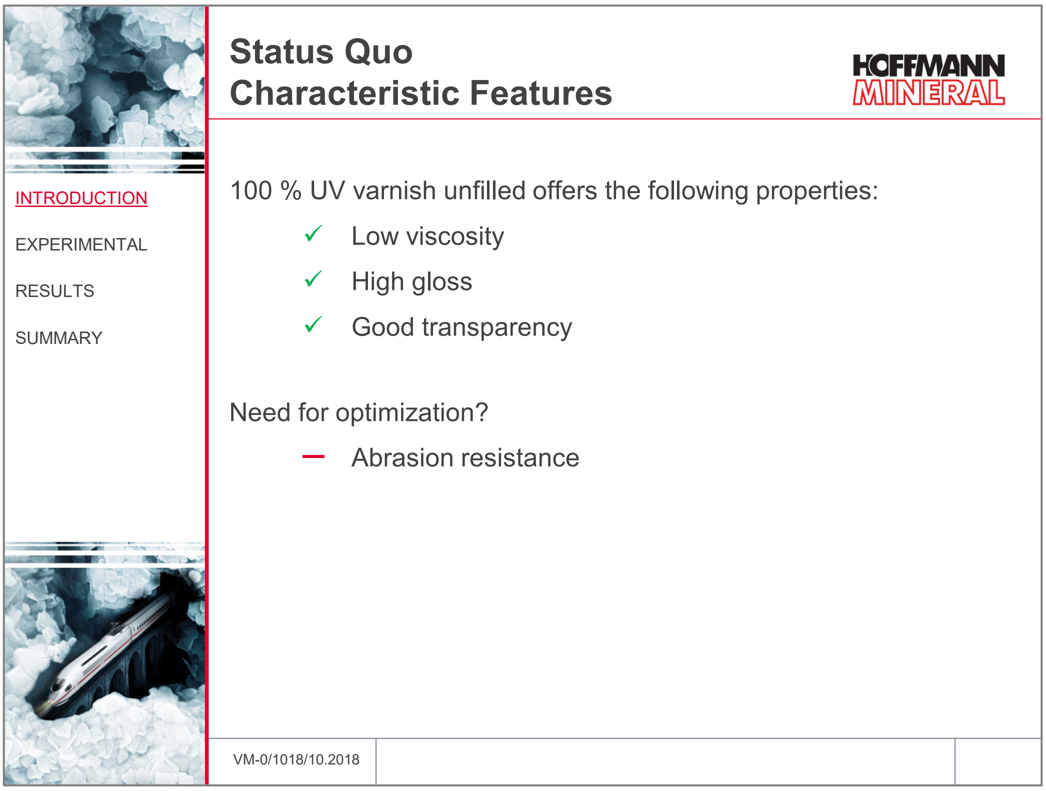
1 Introduction

Most glossy, clear varnishes are unfilled, transparent top coats that consist exclusively of binding agents, curing agents and additives. Their basic function is to make the quality of an object appear as premium as possible. Furthermore, the varnish also has to offer protection against mechanical and environmental influences for the underlying layer, whether this is the layer immediately beneath the varnish or the substrate itself. By modifying the binding agent or incorporating special additives, it is now possible to make the varnish more resilient to environmental influences. An improvement in the mechanical resistance – particularly the abrasion resistance – requires the addition of mineral particles. Ideally, this should not affect other properties, such as the viscosity, flow, gloss or transparency.

Mineral particles can, of course, be used in matt varnishes to improve their mechanical properties; however, the same does not apply directly to glossy varnishes, as the use of mineral particles in these generally has a matting effect. The ideal solution would be to find mineral particles that increase the mechanical resistance of the varnish without affecting its appearance.

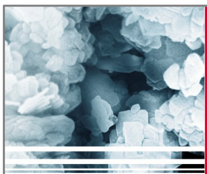
This study has the aim of presenting a special grade of Neuburg Siliceous Earth to increase abrasion resistance whilst also maintaining the visual properties as far as possible and minimizing formulation costs.



2 Experimental

2.1 Base formulation

A base formulation free from additives and fillers was used as the basis for the study. Its binding agent system comprises an aromatic epoxy acrylate and polyether acrylate in a 1:1 ratio. It also includes Omnirad 184, an α-hydroxy ketone, as a photoinitiator.



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Base Formulation

Percent

	Description	
Laromer LR 8986	Aromatic epoxy acrylate	48.06
Laromer PO 8967	Polyether acrylate	48.06
Omnirad 184	Photo initiator α-hydroxyketone	3.88
Total		**100.0**

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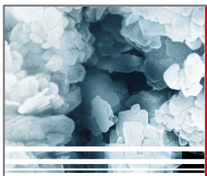
2.2 Formulation variants

The starting point was a base formulation without filler, which serves as a control. 5 and 10% Sillitin Z 89 puriss were dispersed using 0.2% Byk 088 as defoamer. The relatively low dose of defoamer already offers adequate deaeration.
The pigment volume concentration (PVC) increases with the addition of Sillitin Z 89 puriss to 2.4% and 4.9% respectively.



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Formulation Variants

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Percent

	Control	Sillitin Z 89 puriss	
Laromer LR 8986	48.06	45.57	43.16
Laromer PO 8967	48.06	45.57	43.16
Omnirad 184	3.88	3.66	3.48
Sillitin Z 89 puriss		5.00	10.00
BYK 088 (defoamer)		0.20	0.20
Total	**100.0**	**100.0**	**100.0**
PVC	0.0	2.4	4.9

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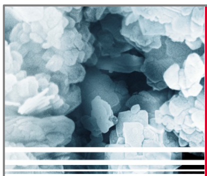
2.3 Filler characteristics

Sillitin Z 89 puriss is a very light-coloured grade without surface treatment from Hoffmann Mineral. It belongs to the fine products of the Neuburg Siliceous Earth products with an average diameter d_{50} of 1.8 µm and an upper cut d_{97} of 8 µm. It has an oil absorption value of 53 g / 100 g. The puriss quality is achieved by means of an additional physical follow-up treatment. It leaves barely any residue and offers improved dispersion properties. At 1.55, the refractive index of Neuburg Siliceous Earth (NSE) is close to that of the binding agent, meaning varnishes with NSE offer excellent transparency.



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Filler Characteristics

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	Sillitin Z 89 puriss
Color X	81.8
Color Y	86.1
Color Z	86.4
Particle size d_{50} [µm]	1.8
Particle size d_{97} [µm]	8
Oil absorption [g/100g]	53
Refractive index n	1.55
Surface Treatment	none

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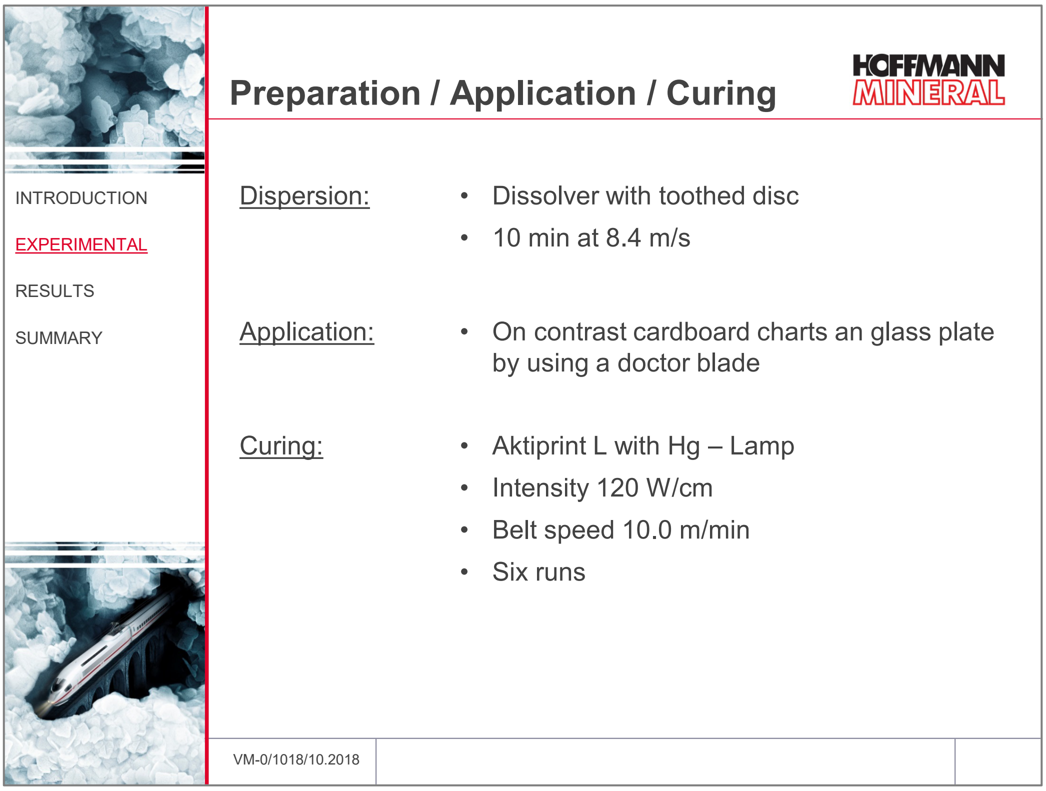
2.4 Preparation, application and curing

All UV varnishes were prepared by using a toothed disc equipped dissolver with a peripheral speed of 8.4 m/s. After 10 minutes, the grain fineness was below 15 µm.

The application of the films was carried out with a doctor blade on contrast cardboard for measuring gloss, color and transparency, in addition by the same process on glass plate to assess the visual impression. Gloss and color measurement, the latter for assessing the transparency, was done on the black sections of the contrast cardboard. The dry film thickness of the paint was 30 µm on both substrates. All tests were carried out under standard conditions of 23 ° C and 50% relative humidity.

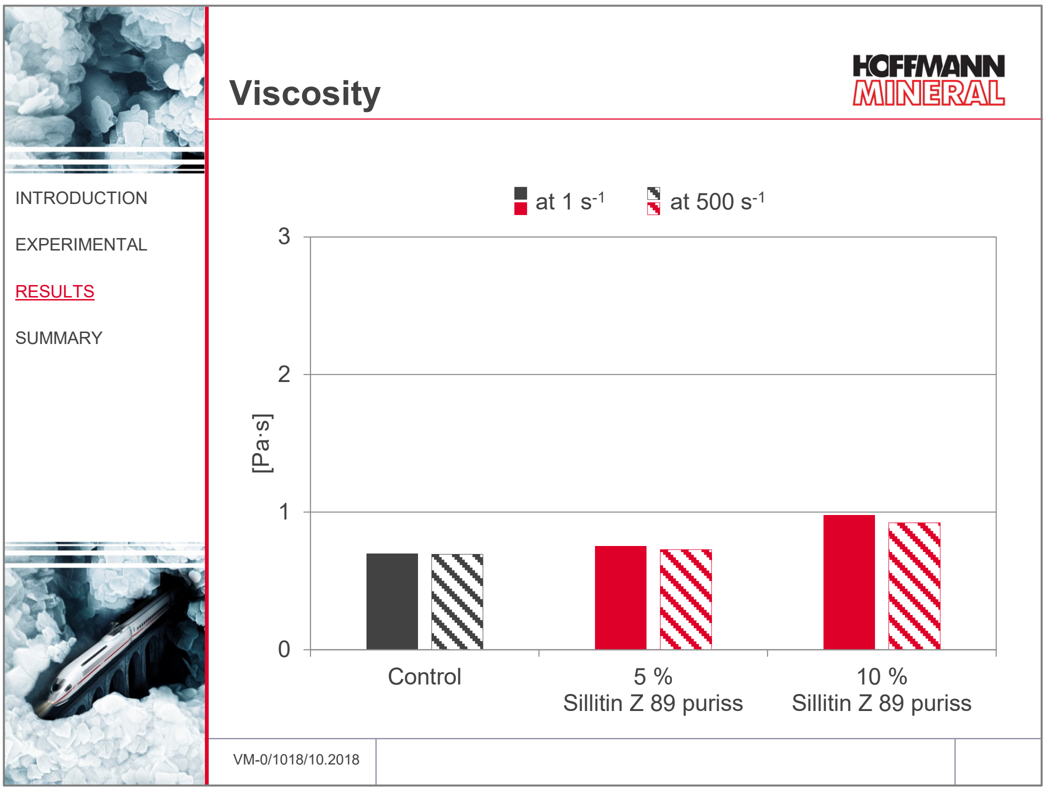
The films were cured with the Aktiprint L UV-curing machine using a mercury lamp with an intensity of 120 W/cm and a belt speed of 10 m/min. It took six cycles through the UV-curing machine to achieve a fully cured layer of the varnish. The required number of cycles was determined using a potassium permanganate test.
For the test, an aqueous 1% potassium permanganate solution was prepared. The solution was applied to the varnish films one day after curing on the white section of the contrast cardboard. After waiting for one minute, the solution was first soaked up with a cloth before being wiped away with a damp cloth. The resulting discoloration of the film, representing residual double bonds, was measured with a spectrophotometer one hour later. The delta E of the discoloration was calculated from the colour values of the affected and unaffected film. A graph was drawn up to show the dose plotted against the delta E according to the number of cycles. After six cycles, the delta E remained largely constant, so that maximum conversion and thus complete hardening can be assumed.



3 Results

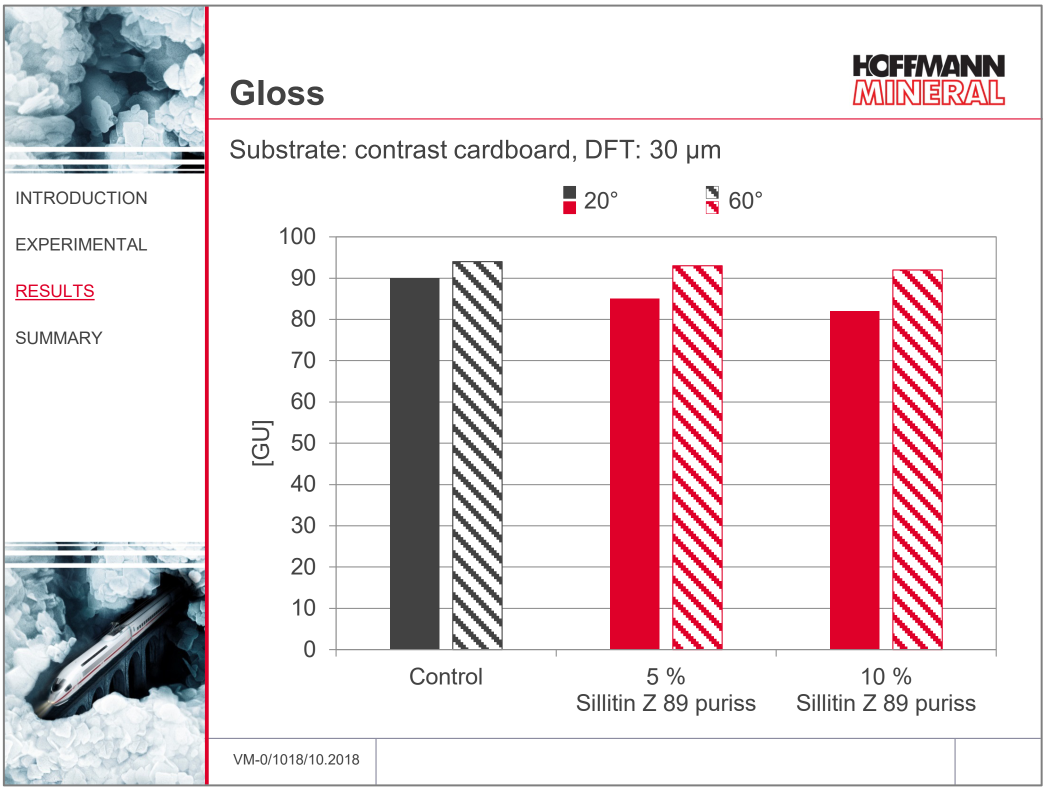
3.1 Rheology

The viscosity was determined in a plate-plate rheometer via a logarithmic ramp for shear rate. A measuring system with a diameter of 50 mm was used, the gap distance was 0.5 mm.
The viscosity of the control is relatively low at 0.7 Pas. The value is independent of the shear rate and demonstrates Newtonian flow behaviour. If the UV varnish contains 5% Sillitin Z 89 puriss, no changes can be identified in comparison to the control. A minimal increase in viscosity can only be detected with the addition of 10% filler; however, this remains below 1 Pas and the Newtonian characteristic stays the same. The processing behaviour of the filled UV varnish should be comparable.



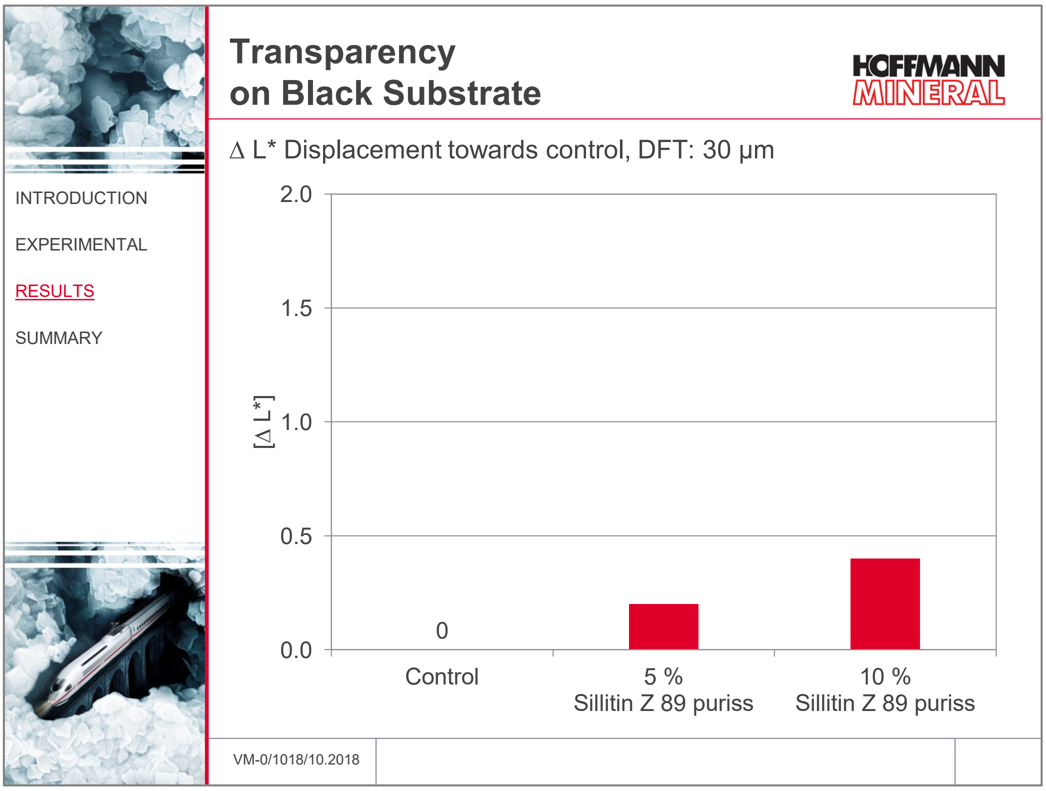
3.2 Gloss

The gloss was measured with a micro-TRI-gloss measuring instrument from Byk Gardner. The results were evaluated at a measuring angle of 20° and 60°, whereby the former represents the high-gloss area and the latter represents the medium-gloss area.
Looking at the 20° gloss, the result for the control is a value of 90 gloss units (GU), so high gloss. The addition of Sillitin Z 89 puriss causes slightly lower gloss values, but the highest concentration of 10% remains above 80 GU and is therefore also very shiny. In the 60° gloss, no difference was found between the control and the UV varnish with Sillitin Z 89 puriss. All are here over 90 GU.



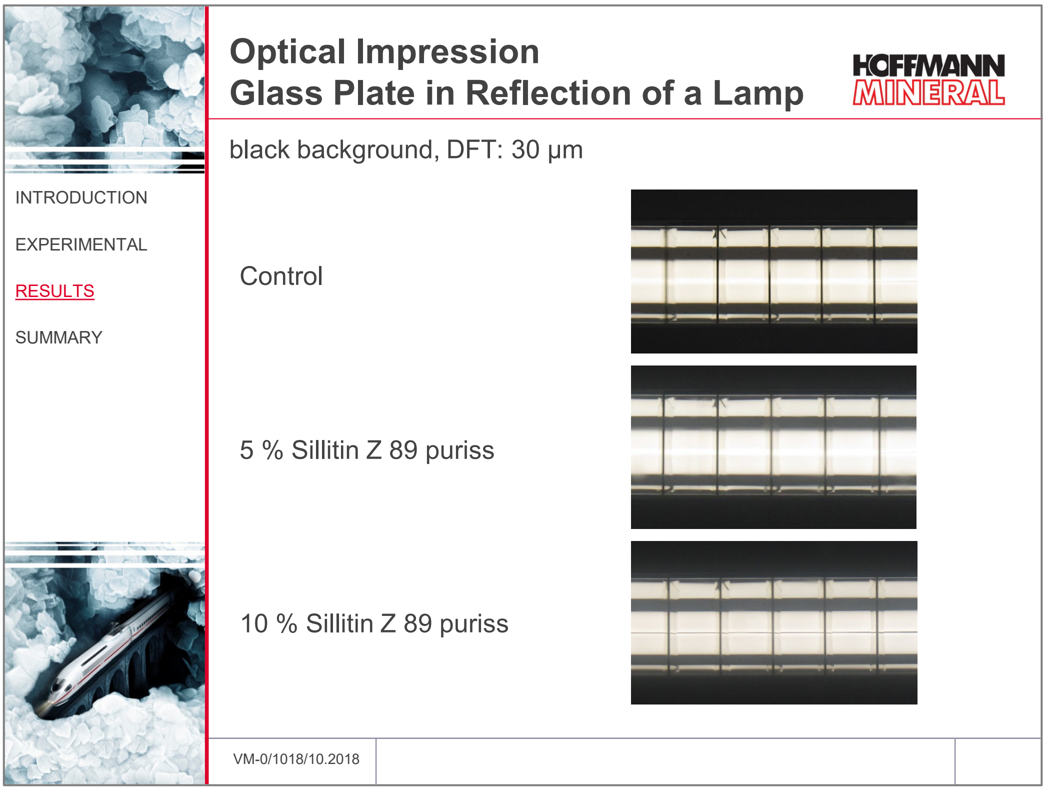
3.3 Transparency

In order to evaluate the influence of Sillitin Z 89 puriss on transparency, the color value CIE L* was determined on the black areas of the contrast cardboard using a spectrophotometer with a measuring geometry of d/8° and D 65 illuminant. The reference was the control whose brightness value L * was used as reference and from this the delta L * was calculated for the two filler containing formulations. Values below 0.5 are to be rated as very good, since optically no difference can be detected by eye. Both formulations with Sillitin Z 89 puriss have a delta L * of less than 0.5, thus maintaining the good transparency of the control formulation.



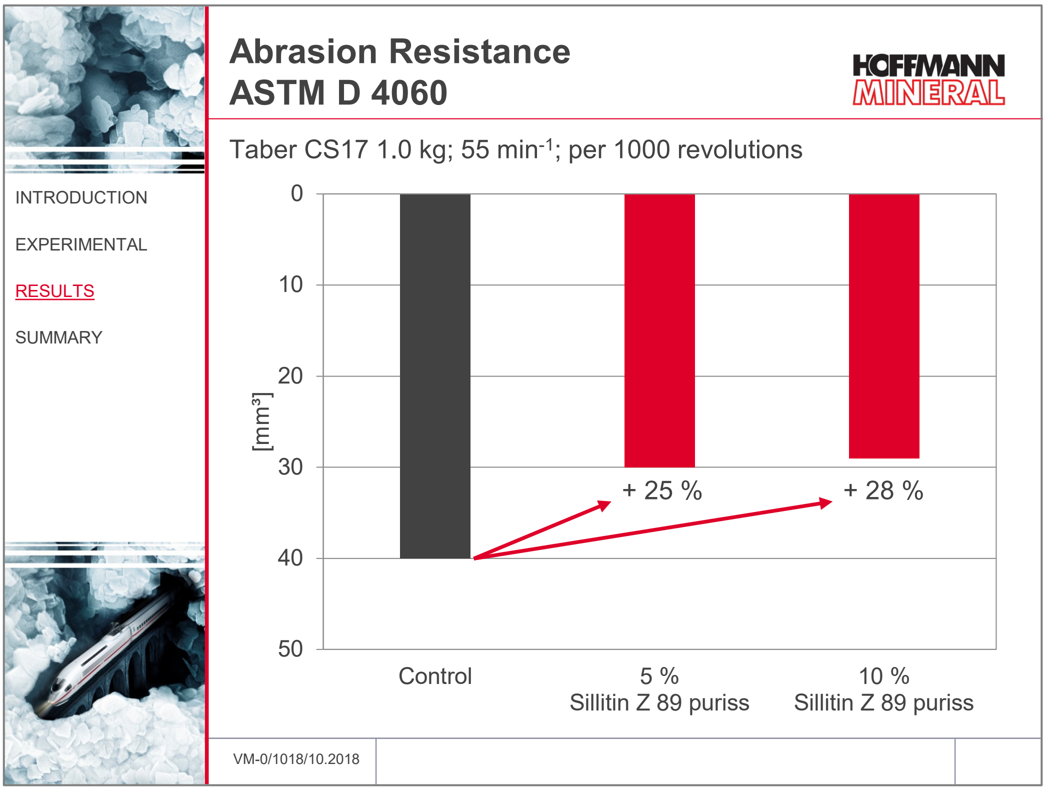
3.4 Optical impression

The visual impression as a combination of gloss and transparency of the UV varnish is shown below. For this purpose, photos were taken showing coated glass plates with black leneta foil (PVC foil) as background. The images were created in such a way that the reflected mirror image of a ceiling lamp can be seen in the center, thus ensuring a detailed representation.
All pictures show excellent surfaces with perfect leveling and high image sharpness of the ceiling lamp geometry. An influence of Sillitin Z 89 puriss is difficult to recognize.



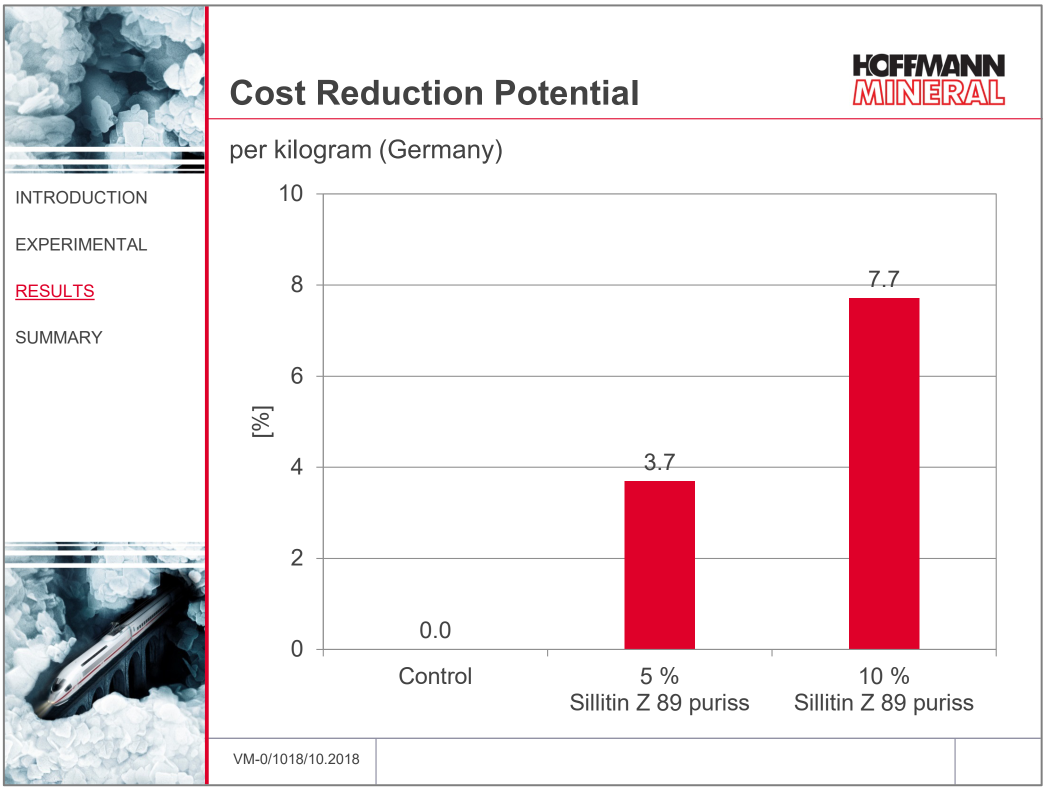
3.5 Abrasion resistance

As the final layer of the coating, the topcoat should not only look attractive, but also have high mechanical resistance. UV-curable coatings generally achieve relatively good abrasion resistance, however any enhancement is highly appreciated. The abrasion resistance was measured according to ASTM D 4060 using CS17 friction wheels, 1 kg load and a rotational speed of 55 rpm. The evaluation took place after 1000 revolutions, whereby the gravimetric loss was determined. As the coatings each differ in terms of density, the gravimetric loss was converted into the volume loss by means of the density. The control is at a value of 40 mm³. With Sillitin Z 89 puriss, losses of 30 mm³ and less can be achieved, which corresponds to an improvement in abrasion resistance of 25% or more.

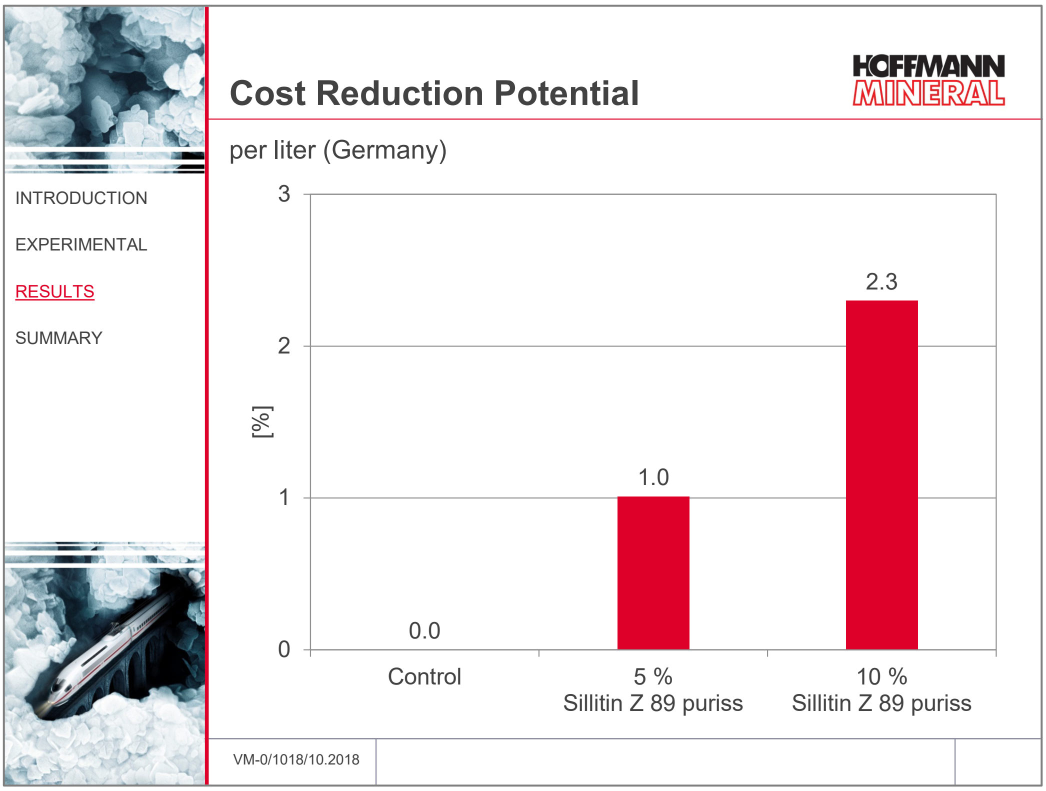


3.6 Formulation cost reduction potential

The formulation costs were calculated based on the raw material prices in Germany in 2018.
The savings potential is stated based on the control. With Sillitin Z 89 puriss, this results in savings of 3.7% to 7.7% based on weight relative to the control.



If the formulation costs are calculated based on volume, the savings potential with Sillitin Z 89 puriss is between 1% and 2.3%.



4 Summary

In 100% UV varnishes, the addition of the easily dispersible Sillitin Z 89 puriss results in:

- significant increase in abrasion resistance
- reduction in formulation costs at the same time

The high-quality property profile of the varnish remains largely unchanged in terms of:

- rheological characteristics
- high gloss level
- good transparency