# SILRES® MK POWDER

## Silicone Resins

SILRES® MK POWDER is a condensation curing methyl silicone resin with good solubility in various organic solvents. The product can be used as a binder or as an impregnation agent for porous materials. Besides SILRES® MK POWDER is the ideal product for making tack-free prepregs with excellent storage stability.

Compared to other WACKER silicone resins SILRES® MK POWDER gells relatively fast at elevated temperature. It is therefore particularly suitable for fully automated production lines.

Fully cured SILRES® MK POWDER has the lowest carbon content of all WACKER silicone resins and thus yields a very high ash content when pyrolized.

Composites made of SILRES® MK POWDER show long-term stability against weathering, moisture and UV light; they can therefore be exposed continuously to constantly changing climatic conditions, UV radiation and temperatures significantly higher than 300 °C (572 °F). SILRES® MK POWDER further provides water repellency and excellent electrical insulation properties to the respective composite materials.

## Properties

Uncured:

- Silicone resin with methyl groups only
- Solid
- Delivery form: powder (when needed as flakes, please ask for our product SILRES® MK FLAKES)
- Good solubility in organic solvents
- Fast heat curing when catalyzed

Cured:

- Lowest carbon content of all WACKER silicone resins
- Very high binding strength
- Excellent heat stability
- Marginal smoke emission on pyrolysis

### Specific features

- Condensation-curing
- Electrically insulating
- Filler and pigment compatibility
- Heat resistant
- Hydrophobic
- Solvent-free
- UV & weathering-resistant

## Technical data

### General Characteristics

| Property | Condition | Value | Method |
|---|---|---|---|
| Ash content (after pyrolysis at 1000 °C) | - | approx. 82 wt. % | - |
| Bulk density | - | 500 kg/m$^3$ | - |
| Carbon content (cured resin) | - | approx. 18 wt. % | - |
| Colour | - | white | - |
| Melting point | - | 35 - 55 °C | - |
| Supply form | - | powder | - |

These figures are only intended as a guide and should not be used in preparing specifications.

All the information provided is in accordance with the present state of our knowledge. Nonetheless, we disclaim any warranty or liability whatsoever and reserve the right, at any time, to effect technical alterations. The information provided, as well as the product's fitness for an intended application, should be checked by the buyer in preliminary trials. Contractual terms and conditions always take precedence. This disclaimer of warranty and liability also applies particularly in foreign countries with respect to third parties' rights.

## Applications

- Heating Elements
- Laminates & Composites
- Resistors & Capacitors

## Application details

- Impregnation agent for porous materials
- Binder for composites made of inorganic mineral fillers
- Binder for laminates made of fibrous fillers, cloths, woven or non-woven reinforcing materials
- Typical fields of industrial applications: household appliances, mechanical engineering, automotive, electrical industry.

# Processing

## Handling and Curing

SILRES® MK POWDER can be processed in powder form, as an aqueous suspension and in solution. The silicone resin powder is readily soluble in toluene, xylene and THF. For solutions with a solids content below 50 wt.% acetone, ethyl acetate and methyl isobutyl ketone (MIBK) can be used. With ethanol (technical quality, water content < 2 wt.%), propanol or butanol the preperation of low concentrated solutions is possible, while SILRES® MK POWDER is barely soluble in methanol and aliphatic hydrocarbons.

The curing of SILRES® MK POWDER is accelerated by a number of catalysts. The curing speed depends on the type of curing agent, the catalyst amount and the curing temperature. Please note: curing acceleration is most efficient with liquid catalysts or when the resin is processed in solvent. Adjacent table lists some typical catalysts and the resulting gelling times at 150°C as a function of the catalyst quantity (solution of 50 wt.% SILRES® MK POWDER in toluene; catalyst quantities given in % by weight, based on solid silicone resin).

| Gelling time at 150 °C, minutes<br>Added catalyst quantity: | 0.5 wt.% | 1.0 wt.% | 2.5 wt.% |
|---|---|---|---|
| WACKER® Catalyst F, 100% | 5 | 5 | 4 |
| WACKER® Catalyst K83 | 135 | 45 | 7 |
| GENIOSIL® GF 91 | 6 | 5 | 4 |
| Triethanolamine | 6 | 5 | 7 |
| Tetrabutylammonium acetate* | 3 | 3 | 3 |
| Butyltitanate | 120 | 30 | 9 |

* applied as a 10 wt.% solution in ethanol

**IMPORTANT:** the pot life of catalyzed resin solutions usually is limited, even at room temperature. We therefore recommend to add the catalyst immediately before use and to process the catalyzed mixture within the next few hours. To increase the life time of concentrated, catalyzed SILRES® MK POWDER solutions it is beneficial to add some 5 wt. % of alcohol, such as ethanol or butanol.

As curing speed may considerably vary within certain limits, these figures are intended as a guideline only. We recommend running preliminary tests to optimize conditions for the particular application.

## Typical Applications

**1. Glass Fibre Laminates**
Please note: manufacturing prepregs and laminates is a complex process that needs a thorough control of various process parameters, such as temperature, catalyst quantity, nature of catalyst, solvent type, machine specific conditions, etc. Therefore, the following indications are inteded as a guide only, and we recommend running preliminary tests to optimize the conditions of the particular process.

Since fully cured SILRES® MK POWDER provides water repellency, excellent electrical insulation properties, outstanding heat resistance and long term stability against weathering, moisture and UV light, this silicone resin is often used as a binder for laminates made of fibrous fillers, cloths, woven or non-woven reinforcing materials. The following process illustrates a typical production sequence for the manufacture of glass cloth laminates.

SILRES® MK POWDER is dissolved in toluene, or any other suitable organic solvent, to form a resin solution with a solids content of about 10-20 % by weight. The curing catalyst is added right prior processing; for the purpose of storage-stable prepregs WACKER® Catalyst F,100%, WACKER® Catalyst K83, zinc acetylacetonate or related metal salts of acetylacetonate and of long-chained carboxylic acids proved most useful as catalysts.

The glass cloth is then impregnated by the catalyzed silicone resin solution either by spraying, or by running the fabric through an impregnation bath. The solvent subsequently is evaporated in a drying oven at moderate temperature (130 to 150 °C). Please note: the drying temperature must not be too high in order to avoid premature curing of the B-stage resin and of the prepreg web, respectively. Also a very long drying cycle can impair the storage stability of the prepregs made.

Depending on the target shape of the laminate product the prepreg web either is rolled-up in layers on a stainless steel mandrel, or it is cut up into smaller pieces which in turn are sandwiched to a layered stack. By applying heat (e.g. 200 °C) and high pressure (for the layered stack assembly: >10 bar) the B-stage resin converts into the C-stage to form a durable and flexurally very rigid composite with very high heat resistance.

Please note: inserting a PTFE coated glass fabric between the pressing plates and the layered prepreg stack can help to prevent the composite from sticking to the plates. Besides it has proven useful to first cool the composite down to 80 °C (or lower) before the laminating press is opened, as this minimizes the delamination risk during the decompression phase.

**2. Mica Laminates**
Please note: manufacturing prepregs and laminates is a complex process that needs a thorough control of various process parameters, such as temperature, catalyst quantity, nature of catalyst, solvent type, machine spedific conditions, etc. Therefore, the following indications are inteded as a guide only, and we recommend running preliminary tests to optimize the conditions for the particular process.

The process of making mica laminates is similar to the production of glass fibre laminates. Important: the quality of the final product strongly depends on the type of mica, its particle size distribution and the uniformity of the mica paper used.

Similar to the process described for glass fibre laminates, the binder-free mica paper is first impregntated by a catalyzed solution of SILRES® MK POWDER in toluene or any other suitable organic solvent (solids content of about 10-20 % by weight). After a short residence time the solvent is evaporated in a drying oven at moderate temperature (130 to 150 °C) to yield a physically dry, prepreg web that can be rolled-up in layers for storage.

For producing mica laminates, the prepreg web is cut up into smaller pieces, sandwiched to a layered stack of desired thickness and pressed for approximately 1 hour at 200 °C under high pressure (>10 bar).

Please note: inserting a PTFE coated glass fabric between the pressing plates and the layered prepreg stack can help to prevent the composite from sticking to the plates. Besides it has proven useful to first cool the composite down to 80 °C (or lower) before the laminating press is opened, as this minimizes the delamination risk during the decompression phase. Pressureless post-curing at 250 °C can further improve the lmainate's properties in terms of hardness and cohesive strength.

**3. Hydrophobation of Magnesium Oxide Filler for Tubular Heating Elements**

Fully cured SILRES® MK POWDER provides high water repellency, excellent electrical insulation properties and outstanding heat resistance. It is therefore often used to impregnate magnesium oxide powder which in tubular heating elements acts as heat transfer medium and as dielectric packing material for the heating wire.

To improve the magnesium oxide's moisture repellency the milled powder is mixed with up to 2 weight % of SILRES® MK POWDER; a curing agent is not necessary. The powder mixture is then filled into the heater tube with inserted heating wire, followed by the compacting and shaping steps. During the first heating the silicone resin powder liquifies and impregnates the filler particles to make them hydrohobic. By this water-repellent packing the heating wire is safely protected against moisture and corrosion for the entire life cycle of the tubular heating element.

**4. Binder for Resistor Packings and for Resistor/Capacitor Coatings**
As SILRES® MK POWDER can be highly filled with mineral fillers, it often is used as binder for resistor packing compounds or in coatings for resistors and capacitors. The respective silicone resin based blends are highly fire-retardant, and they safely protect the electrical parts from moisture or any other environmental impact. Besides the thermal management is improved, which extends the lifecycle of the particular electrical element - even when continuously run at high temperature levels.

A - Production of packing compounds for cement resistors:
In a mixing kneader solid SILRES® MK POWDER is blended with finely ground inorganic fillers and pigments to give a dry powder mixture with a silicone resin content of about 10 to 20 % by weight; if applicable, glass fibres and additive powders can be used additionally. Then solid catalyst powder, e.g. WACKER® Catalyst F 100% or metal salts of acetylacetonate or of long-chained carboxylic acids, is admixed in a quantity of 1.5 to 3 wt.%, based on the amount of solid silicone resin used. Please note: due to the low softening point of SILRES® MK POWDER it is recommended to cool the mixing device in order to prevent premature agglomeration of the powder blend.

By elevating the mixing temperature above the softening point of the silicone resin, the dry powder mix can be compacted and pelletized for storage. When heated above 100 °C the pellets can be used to pack the resistor body by transfer-molding. Baking the green body at high temperature (150 °C, 90 min.) finally gives a hard, durable cement composite that safely protects the resistor body from external impacts.

B - Production of resistor and capacitor coatings:
SILRES® MK POWDER is dissolved in toluene, xylene or any other suitable organic solvent, to form a resin solution with a solids content of about 25 to 35 % by weight. Then the finely ground fillers and pigments, which in total account for up to 75 % of the final coating formulation, are added and thoroughly mixed in a kneader. Finally, a curing catalyst (e.g. WACKER® Catalyst F 100%, WACKER® Catalyst K 83 or GENIOSIL® GF 91) is admixed in a quantity of some 1.5 to 3 wt.%, based on the amount of solid silicone resin used. If necessary, more solvent can be added to adjust the consistency of the coating slurry to the particular needs.

For coating the respective electrical part is dipped into the slurry; alternatively, resistors can be coated by rolling them over the surface of the slurry. The solvent subsequently is evaporated at moderate temperature, e.g. in a drying oven. Finally the green body is cured at high temperature (150 °C, 90 min.) to give a hard, durable coating of 0.5 to 1 mm thickness. Note: to increase the coating thickness multiple dip-coating is possible.

## Packaging and storage

### Storage

Store in a dry and cool place.

The 'Best use before end' date of each batch is shown on the product label.

Storage beyond the date specified on the label does not necessarily mean that the product is no longer usable. In this case however, the properties required for the intended use must be checked for quality assurance reasons.

## Safety notes

While heat curing SILRES® MK POWDER can release a total of approx. 5 wt.% alcohol. To avoid accumulation of this chemical byproduct ventilation of the work place is recommended.

Comprehensive instructions are given in the corresponding Material Safety Data Sheets. They are available on request from WACKER subsidiaries or may be printed via WACKER web site http://www.wacker.com.

## QR Code SILRES® MK POWDER

### For technical, quality or product safety questions, please contact:

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