Heraeus

UV-Technology

for the Decoration of Glass and Ceramics

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Heraeus Ceramic Colours is one of the leading manufacturers of materials for the decoration of ceramics and glass. Precious metal preparations, lustres, ceramic and organic colours as well as auxiliary materials such as media and covercoats are manufactured at six production sites worldwide. Representatives in more than 80 countries provide excellent service close to the customer and around the globe.

Since 1890 Heraeus has been considered a professional partner for ceramic decorations and has always been using its extensive expertise in handling modern processes and techniques to develop tailor-made and economically successful products. Since the 1990s, UV-technology has become an integral part of the Heraeus Ceramic Colours product range.

UV-Technology for the Decoration of Glass and Ceramics

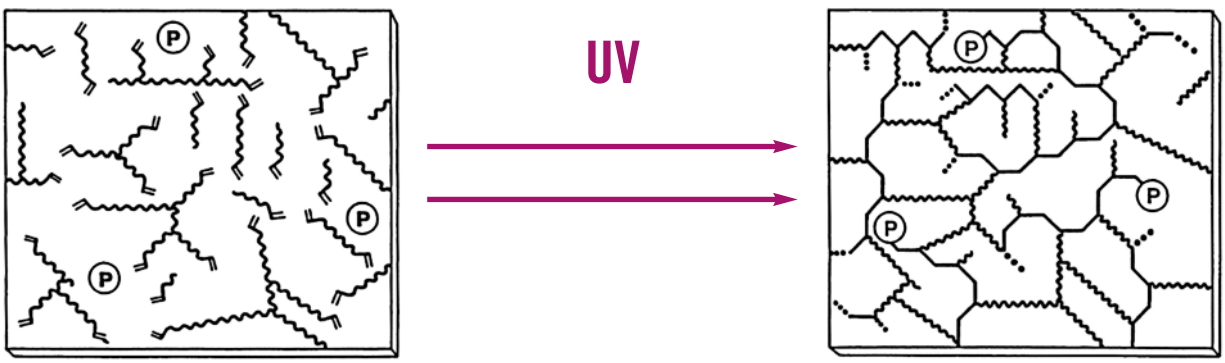
Customers benefit from technical innovations. By the use of special, UV-curing decorating materials, technically challenging and ecologically friendly decorations of glass and ceramics can be realized in an economic and innovative way. This brochure gives you a general idea of UV-technology as well as special UV-curing products for the production of ceramic decorations.

Principles of light-induced Curing

In contrast to the physical drying of colours and covercoats, in which the binder system forms a film with the colour pigments and fillers due to evaporation of the solvent, a chemical reaction takes place in the curing of reactive systems. Solvents are generally not a constituent of the formulation since the diluting monomers of such systems are bonded during the polymerisation.

Molecules which carry reactive groups are contained in a system which is to be cured with UV-light. These are polymerized by so-called initiators, which are activated by light (fig. 1). A network is formed which, depending on the intended application, must be scratchproof and free of adhesive or it must be possible to print and varnish over it. At present, radical or cationic curing are used in the graphics industry. Here, the polymerisation reactions are started with high energy UV-light. The radical mechanism is distinguished by its high reactivity and its compatibility to ceramic systems. Good adhesion on a variety of substrates is a typical feature of the cationic curing system, due to the negligible shrinkage of the film layer. Radical systems are used as media in the mixing of ceramic powders to paste for the decoration of glass and ceramic substrates. The polymer is completely removed from the colour layer by combustion during

Fig. 1: Formation of a network



the firing of the colour film on the substrate. Both, radical and cationic formulations, can be used for colours with organic pigments and covercoats, like sand-blasting protective covercoat. After curing, the colour layer remains on the substrate in the form of a decorative or functional decor.

The polymerisation in the curing of a reactive paint layer is complex. Therefore, it is necessary to coordinate carefully all components of the mixture with regard to the curing of the colour layer in order to achieve the intended results. These are fast curing, flexible layers, resistance during further processing, an excellent firing result and – if organic colours are used – immediate adhesion and resistance on the substrate.

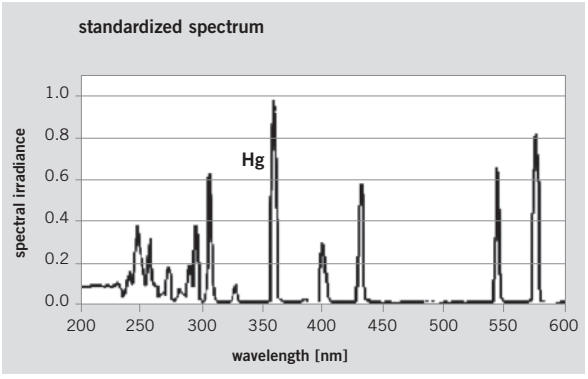
UV-Radiation as an Energy Source

UV-radiation is generated in a quartz glass tube containing a noble gas and lowest quantities of mercury. The electrical energy applied causes the mercury to evaporate as well as the generation of a plasma which emits UV-radiation (fig. 2). The use of special additives (e.g. iron) leads to a shift of the spectrum (fig. 3).

The emitted radiation excites the photo initiators in the mixture The curing of the colours or covercoats is started by their subsequent decomposition. Besides the radiation in the UV-range, the radiation sources also generate visible light and heat (fig. 4).

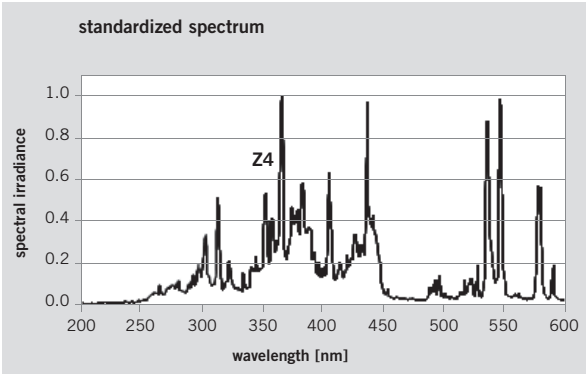
- approx. 25 % UV-radiation (see figure 2 and 3 for radiation values)
- approx. 15 % visible light
- approx. 60 % infrared radiation (heat)

Fig. 2: Mercury lamp



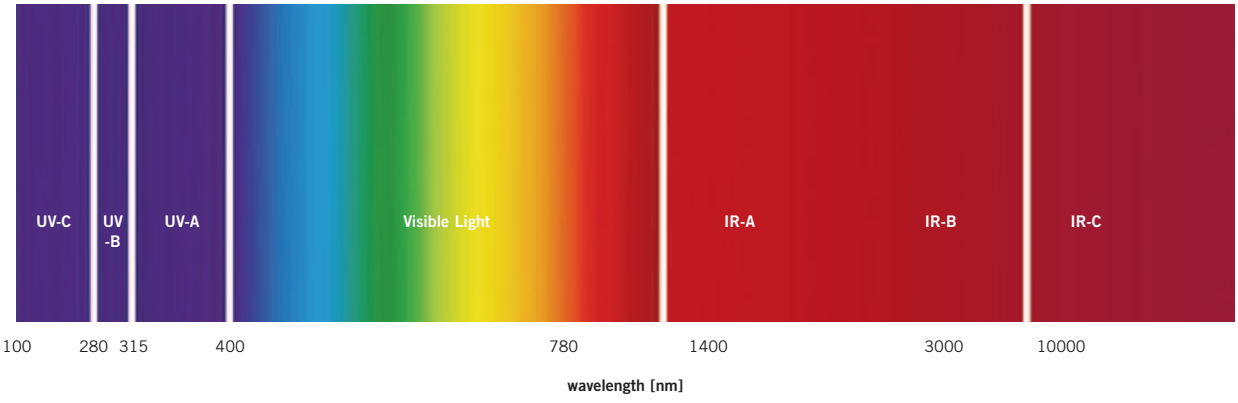
10 % UV-C, 8 % UV-B, 7 % UV-A

Fig. 3: Iron doped lamp



5 % UV-C, 5 % UV-B, 17 % UV-A

Fig. 4: Electromagnetic spectrum

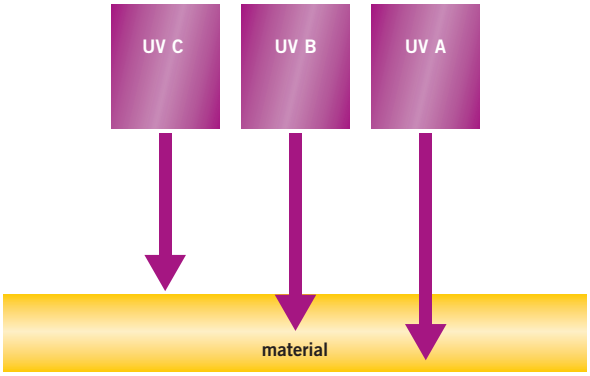


For detailed information on UV- and IR-lamps please refer to www.heraeus-noblelight.com.

Influence of the Colour Pigments and Fillers on the Curing

The chromophoric components, such as inorganic colour pigments, organic pigments as well as dissolved and undissolved precious metal compounds, titanium dioxide and frits with a proportion of 5-70 % in the colour paste have a decisive influence on the reactive behaviour on the whole system. The absorption behaviour of these materials leads to a partial loss of the incident energy. As figure 5 shows, mainly UV-A radiation is capable of penetrating the coloured layer. Therefore, iron and gallium doped sources are suitable for the curing of colour layers applied by screen printing (fig. 3).

Fig. 5: Penetration of the material by UV-radiation



Applications in Ceramic Screen Printing

Decorations on ceramic substrates can be achieved both by direct and indirect printing. UV-curing precious metal preparations are delivered ready to use. UV-media represent an aid in rendering the ceramic colour or frit suitable for application. A typical composition is shown in figure 6. Organic colours are generally pasted (fig. 7) as well. However, they can be adjusted to the substrate by the means of adhesive agent. Thermal re-curing at 160°C (320°F) is advisable in case of difficult substrates and high demands with regard to resistance. In the manufacture of decals, the three dimensional network formed (fig. 1) must be maintained flexible by softeners or suitable reactive monomers in order to ensure problem-free application as a decal.

Fig. 6: Composition of a ceramic screen printing colour

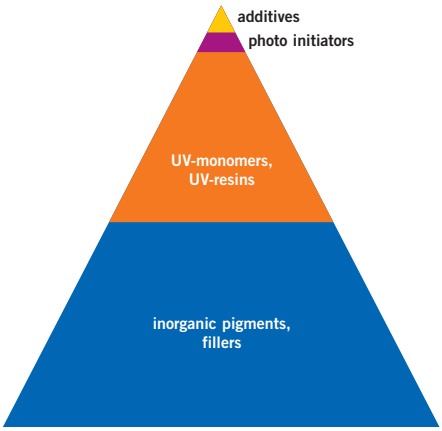
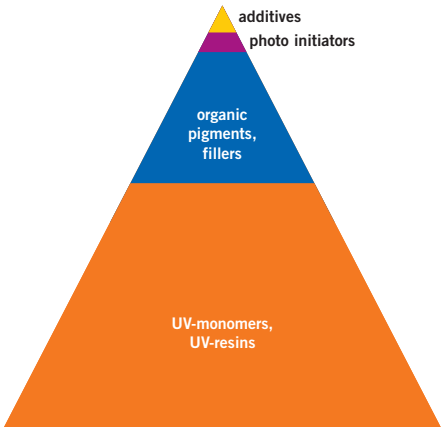


Fig. 7: Composition of an organic screen printing colour (Series OGG 92/UV)

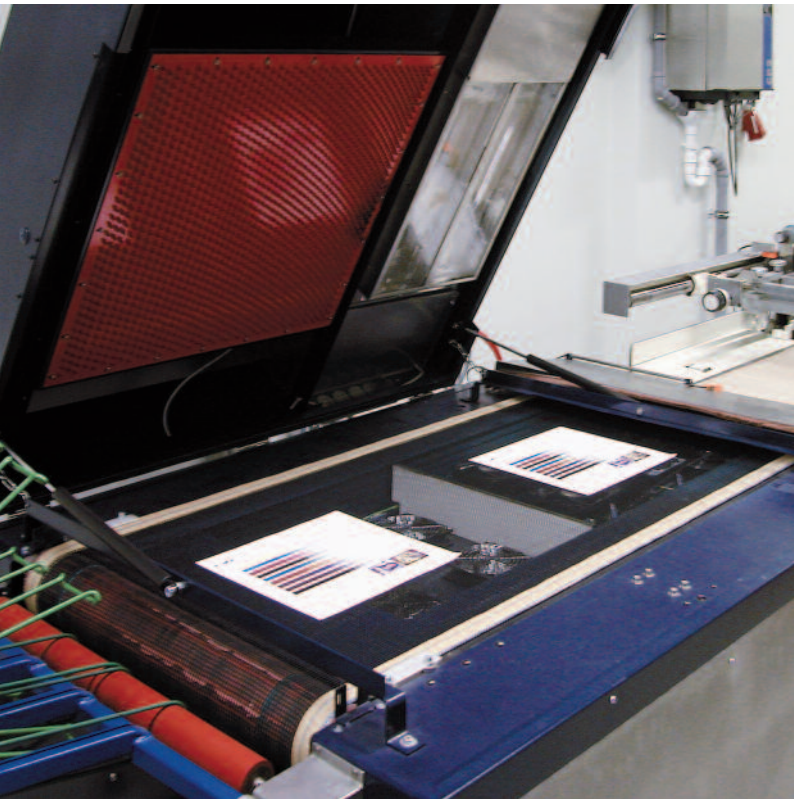


Recommendations for Ceramic Printing

UV-systems for direct screen printing are easy to manage because the substrates are insensitive to heat. Printing on decal paper requires a certain degree of technical effort in order to guarantee precise positioning of multiple colour prints. The following optimizations are recommended for the drying unit:

- UV-source
  - Iron doped medium pressure source, at least 160 W/cm
  - Irradiation power in the wave length range 315-400 nm approx. 100-400 mJ/cm²
  - Reduction of IR radiation by optimized reflectors and air-cooled lamp housing with quartz glass as heat shield

Suitable equipment with UV-lamps and cooling device.



- Cooling device (decal printing)
  - To avoid the influence of heat from the UV-source in order to prevent the maximum surface temperature on the sheet under the lamp rising above 35°C (95°F)
  - Supply of cold air directly onto the transfer sheet in order to remove heat immediately
  - After leaving the drying unit, the sheet should have reached room temperature (optimum 23°C/73°F; 60 % relative humidity).

Advantages of UV-Technology

The wide range of application possibilities for UV-technology gives the user the following advantages:

- Immediate curing and suitability for overprinting after irradiation
- No solvent emissions and thus improved working safety and no disposal costs for solvent residues
- Colours do not dry up in the screen and thus a constant printing process is possible
- Precisely reproduced drawing because fine screen structure remains open
- Printed sheets can be stacked up immediately, thus requiring less space
- Increase in productivity and quality.

UV-curing Decorating Materials

Precious Metal Preparations

Direct Screen Printing on Glass
(Firing Range 580-620°C / 1076-1148°F)

Bright Gold Paste	GGP 2151/UV-12%
Bright Platinum Paste	GPP 4531/UV

Direct Screen Printing on Glass (Fast Firing)

Bright Gold Paste	GGP 2152/UV-12 %
Bright Platinum Paste	GPP 4532/UV

Direct Screen Printing and Decals on Porcelain
(Firing Range 1180-1230°C / 2126-2246°F)

High Temperature Gold	SG 41/UV-32%
High Temperature Platinum	SG 42/UV

Direct Screen Printing on Tiles
(Firing Range 780-820°C / 1436-1508°F)

Bright Gold Paste	GGP 2344/UV-9%
	GGP 2343/UV-7%
Bright Platinum Paste	GPP 4329/UV

Lustres

Various colours are available on request.

Organic Colours

Direct Screen Printing on Glass
Series OGG 92/UV

Auxiliary Materials

Nr. 254/UV (medium for decals)
Nr. 255/UV (medium for decals)
Nr. 244/UV (medium only for direct printing)

The listed media can be applied with all ceramic colours and are available in various reactivities and thixotropic grades.

L 419/UV (UV-sandblasting covercoat)

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