# Thermochromic pigment user guide.

Thermochromic pigmet is technologically advanced product and on the contrary to many of our other pigments and dyes it has quite fragile structure. Because of that, to fully enjoy this product properties and avoid damaging of pigment, few rules must be followed.

**1. Application temperature.**

Thermochromic pigment can survive 30 minutes at 140°C and up to 10 minutes at 200°C without any visible damage. Avoid using temperature above 220°C during production – it will quickly destroy pigment. It's recommended to reduce time of heating pigment above 140°C – as it was mentioned above pure pigment can survive up to 30 minutes in such conditions but other compounds of medium such as solvents become more reactive and may react with pigment. It's good to cool down finished product as soon as possible.

**2. Pigment dosage.**

0,5% up to 2% of thermochromic pigment is recommended for resin or plastics casts – or any other thick products. If product material is already coloured then up to 2,5% of thermochromic pigment should be used. Plastic fillers such as titanium dioxide, calcium carbonate, carbon black, flame retandants or other pigments may cover thermochromic pigment colour.

For printing inks and paints 8%-12% addition is suggested.

**3. Mixing and friction.**

Thermochromic pigment microcapsules are liable to mechanical damage. Hence friction must be reduced during production process when such pigment is used. Low speed agitator, hand mixing, three roll mill or other "gentle" mixing methods are recommended. Ball mill or high speed agitator will quickly destroy pigment structure. Also repeated extrusion operations should be avoided. To shorten mixing time, addition of dispersing agents should be considered.

**4. Requirements for used medium.**

Thermochromic pigment is enclosed in few micrometers size microcapsules. Wall of such microcapsule is very thin. Solvents with 3 or less carbon atoms in particle (such as methanol, ethanol or acetone) should be avoided. So small particles easily penetrate microcapsule wall and destroy pigment structure – issue is colour deformation or pigment discoloration. On the other hand solvents with 6 or more carbon atoms in particle are considered as safe for pigment.

If small particle solvents like ethanol must be used then only as much of mixture should be produced as it is needed for current usage. Solvent will quickly evaporate after painting/printing and should not damage pigment.

Below is a table describing impact of different solvents on thermochromic pigment – data shows time needed to form visible deformations in pigment performance (at 20°C). Only pure solvents were examined – usually in reality, medium contains mix of solvents, binders, emulsifiers and other compounds which may react with thermochromic pigment. Because of that this table is for reference only.

| Methanol | DMF | Ethanol | Acetone | Ethanol 40% | Isopropyl alcohol | Ethyl acetate | Ethylene glycol/diethyl ether | Butyl acetate | Butanone |
|---|---|---|---|---|---|---|---|---|---|
| Up to 5 hours | Up to 2 days | Up to 2 days | 10-60 days | 20-90 days | 1-6 months | 2-5 months | 3-10 months | 3-10 months | 3-6 months |
| - | - | - | - | - | - | - | - | - | - |
| Water (pH 2-8) | Toluene | Cyclohexanone | Benzyl alcohol | Gasoline | Mineral oil | Turpentine | Plasticizer DOP | Xylene | Cyclohexane |
| More than 36 months | More than 12 months | More than 12 months | More than 12 months | More than 12 months | More than 12 months | More than 12 months | More than 12 months | More than 12 months | More than 12 months |

Check medium composition carefully before adding thermochromic pigment – even small amounts of methanol, ethanol, acetone or other solvents with small particles may seriously damage pigment during long time exposition. Because of that when new medium is used tests are suggested – especially in case of commercial use.

**5. UV resistance.**

Thermochromic pigments are weak against UV light. Finished products coloured with thermochromic pigments should be covered by layer of lacquer with UV protection. - this is mandatory when product will be oftenly used outside buildings under direct sunlight. Pigment may be added to UV hardened resins – hardening time is short so UV light doesn't damage pigment in visible scale.

**6. Thermochromic pigment and water based mediums.**

Thermochromic pigment can be added to water based paints and inks. As it was mentioned above medium should not contain solvents with less than 4 atoms of carbon in particle. Medium pH should be in range 2-8 (optimally 2,5-5). Strong alkali medium (pH above 8) will sooner or later damage pigment. Small addition of nonionic surfactant will make thermochromic pigment more easily to disperse in medium.

**7. Inks and paints.**

- When thermochromic paint or ink is applied we expect that above exact temperature it will become transparent and reveal pattern hidden under it. Thermochromic pigment microcapsules had refrection index 1,5-1,54 – if binder used in paint/ink has significant refraction difference then we will behold "fog" effect instead of translucent layer after reaching color changing temperature. Generally alkyd and acrylic resins cooperates well with thermochromic pigment and on the other hand polyamide resins and cellulose nitrate works poorly.

- Differences in refraction index have also some impact in case of choosen solvent. Solvents like toluene, xylene and benzene methanol (refraction indexes are: 1,496, 1,493 i 1,54) has similar refraction as thermochromic pigment and works well with it. But if we use for example isobutyl alcohol (refraction 1,377) with significantly different refraction then we will observe smaller colour concentration than in reality. This effect is however temporary and when solvent evaporate observed colour concentration will become normal.

- Pigment microcapsules acts like clear glass. Regular thin glass is transparent, but thick 100mm glass has green colour. So if we want to get fully transparent thermochromic surface then only thin layer of thermochromic paint/ink should be used – just enough to cover oryginal surface pattern when pigment is in coloured state (below temperature of color

changing).

- Used medium should be free of phosphates, bromides and chlorides. Such compounds, even in small amounts may permanently damage pigment and disturb its transparency.

**8. Possible effects.**

After reaching defined temperature thermochromic pigment become transparent. Below this temperature pigments undergo color mixing rules. Because of that four effects are possible:

- Thin layer of pigment (as paint or ink) will become transparent after reaching defined temperature – revealing pattern on surface under pigment layer.

- When used in thick objects (e.g. resin casts) pigment will become white after reaching defined temperature – refraction of thousands microcapsules gives the same effect as dense fog.

- Medium can be also coloured with other dye or pigment. It's important to make it properly – this second colouring agent should not cover thermochromic pigment effect. For example we will use resin dyed with green transparent dye and add red thermochromic pigment with colour changing temperature 30°C. According to color mixing rules under 26,5°C (at this temperature red pigment starts to fade) resin will be yellow. When heated from 26,5°C to 30°C resin color will start changing from yellow to green – when temperature reach 30°C resin will become green as it originally was.

- Using few different thermochromic pigments (various colours and color changing temperatures) will give product which will have few different colours depending on temperature.

**9. Storage of pigment and thermochromic products.**

Thermochromic pigment is not resistant to UV. Hence it should be keeped away from direct sunlight, in dark place if possible. Finished thermochromic products should be covered with lacquer protecting from UV – especially if those products will be oftenly exposed to direct sunlight.

Thermochromic pigment can change colour defined amount of times without significant change of performance (check TDS for exact data). Therefore pigment and products containing it should be stored in temperature few °C degrees below colour changing temperature (eg. pigment which change colour at 30°C starts fading at 26,5°C – so it's safe to store it at 24°C or below).

Freezing thermochromic pigment may also damage it – so minimum storage temperature is 4°C.