
THE IJC.COM 2016, 3RD ANNUAL INK JET CONFERENCE 2016, DÜSSELDORF, 5-6 OCTOBER 2016
Outline

- Who is Clariant?
- Introduction to Organic Colorants for Digital Printing
  - How to describe colorants?
  - Which colorants are in use as of today?
  - Which are the key performance indicators?
  - Selected examples
- Conclusion
Clariant at a glance

A GLOBALLY LEADING COMPANY IN SPECIALTY CHEMICALS

5807
Sales 2015 (CHF m)
from continuing operations

227
Net result 2015 (CHF m)
from continuing operations

4
Business Areas

853
EBITDA 2015 (CHF m)
before exceptionals

14.7%
EBITDA margin 2015
before exceptionals

110
in 53
companies
countries

17213
Employees 2015
Four Business Areas – the right portfolio for future growth

<table>
<thead>
<tr>
<th>Business Area</th>
<th>Sales (CHF m)</th>
<th>EBITDA (CHF m)</th>
<th>EBITDA Margin</th>
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</thead>
<tbody>
<tr>
<td>Care Chemicals</td>
<td>1,445</td>
<td>272</td>
<td>18.8%</td>
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<tr>
<td>Catalysis</td>
<td>704</td>
<td>177</td>
<td>25.1%</td>
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<tr>
<td>Natural Resources</td>
<td>1,217</td>
<td>206</td>
<td>16.9%</td>
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<tr>
<td>Plastics &amp; Coatings</td>
<td>2,441</td>
<td>313</td>
<td>12.8%</td>
</tr>
</tbody>
</table>
How to generate a full color print:
Trend: expanded Color Gamut by additional colors

Classical CMYK-Trichromatic Color System:

Expanded Color Gamut:
E.g. with Hexachrome System and additional Color Shades besides CMY

- Yellow
- Orange
- Magenta
- Cyan
- Black
The Color Space or Color Gamut
CIE x,y-chromaticity diagram (CIE 1931)
Selected Criteria & Requirements for Ink Jet Inks

| Color                  | - Target shade or color system: CMY or others
|                       | - **Colorant chemistry selection: dyes or pigments or both**
|                       | - Coloristic features: transparency, chroma, strength
|                       | - Pigment fastness
| Image quality         | - Print quality (High OD, edge acuity)
|                       | - Permanence: lightfast-and solvent/water fastness
|                       | - Abrasion resistant, substrate compatible
|                       | - Media compatibility: quick fixation on various media
| Jettability           | - Viscosity (purity, particle size of pigments)
|                       | - Surface tension (surface properties)
|                       | - Conductivity (< 10 mS); high conductivity → salt content can corrode head (purity of pigment)
| Reliability           | - Non-clogging, no cogation (print head, formulation)
|                       | - Hardware-material compatibility (corrosion-print head)
|                       | - Storage stability (viscosity-pigment size, surface properties)
| Coloration Costs      | - Price/kg
|                       | - Color strength
|                       | - Dispersion quality (close to 100 % primary particles)
| Safety                | - Environmental safe (e.g.) non-toxic, critical by products
|                       | - Safety handling: non-flammable, no odor
|                       | - Ames negative
The international designation system for colorants is the: Colour Index (C.I):

Example: Pigment Yellow 155 (P.Y 155 - Color Index Generic Name)

- The colors are defined by the basic color shade like Pigment Yellow, Violet; or for dyes: Acid Yellow A.Y. etc.
- There are approx. 11,000 generic names
- The numbers are assigned in sequential order starting with 1 …open end
- For one Colour Index pigment structure more than 200 individual sales products can exist: e. g. P.Y 74
- These individual sales products can have significant performance differences (acc. aimed application fields)
# Selected Criteria & Requirements for Ink Jet Inks

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Coloristic features: how are they linked to particle-size and chemical structure?

- **Pigments are insoluble**
  - Color influenced by chemical + crystal structure

- **Dyes are soluble**
  - Color only influenced by the chemical structure

The World of Pigments overlaps with Dyes at the lower end of the Nanometer Scale

- **Color of Dyes are driven by Chemistry**
- **Color of Pigments are driven by Chemistry and Solid-State Physics**
Pigment Morphology: Crystal Structure defines shade
Example: Pigment Violet 19

Chemical constitution: Molecular structure
Orientation of molecules

Crystal structure

Solid-state properties:
- Density
- Hardness
- Heat stability
- Fastness
- Color Shade

Tailored optimization of the solid-state

α-phase
β-Phase
γ-Phase
Typical Colorants in Use for Inkjet Inks

**Organic Color Pigments**

**Yellow:**
- Pigment Yellow 74
- Pigment Yellow 120
- Pigment Yellow 150
- Pigment Yellow 151
- Pigment Yellow 155
- Pigment Yellow 180

**Magenta:**
- Pigment Violet 19
- Pigment Red 122
- Pigment Red 146
- Pigment Red 176
- Pigment Red 185
- Pigment Red 264

**Cyan:**
- Pigment Blue 15:3 /15:4

**Orange Pigments:** P.O. 34, P.O. 43, P.O. 64,

**Green Pigments:** P.G.7, P.G.36

**Violet Pigments:** P.V.23,

**Color Dyes**

**Yellow:**
- D.Y. 132
- A.Y. 23
- S.Y. 83
- Many Others

**Magenta/Red:**
- R.R. 23, 180, 241
- S.R. 91, 127
- Many Others

**Cyan:**
- A.B.9
- D.B.199
- S.B.44
- Many Others
Example: How to optimize a pigment: Transparency, Color Strength

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|       | - Ames negative  

**Improved P.Y. 151 for Ink Jet Application:**
(Ink Jet Yellow H4G)

Target: Improved Transparency and higher Color Strength by modified synthesis

**Ink Jet Grade:**
Ink Jet Yellow H4G VP3853
Length to Width ratio: **1,87 : 1**
D50: **154 nm**

**Coating Grade:**
Hostaperm Yellow H4G
Length to Width ratio: **2,58 : 1**
D50: **272 nm**
Organic Colorants for Digital Printing

Ink Jet Yellow H4G vs. Hostaperm Yellow H4G

**Hostaperm Yellow H4G vs. Ink Jet Yellow H4G**

Ink Jet Yellow H4G offers significant smaller primary particles and improved coloristic properties.

**Particle Size Comparison: P.Y 151**

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**Ink Jet Yellow H4G**

D50 = 154 nm

**Hostaperm Yellow H4G**

D50 = 272 nm
Color Comparison
Hostaperm Yellow H4G vs. Ink Jet Yellow H4G

Draw Down film:
Ink Jet grade vs. Coating Grade shows:

> higher color strength (20 %)
> higher transparency
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| **Safety** | - Environmental safe (e.g.)non-toxic, critical by products  
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- Ames negative |
Example: Improved P. R. 122 (Ink Jet Magenta E02)

Hostaperm grade vs. Ink jet grade: Purity + Particle Size improved

**purified Ink Jet pigment in aqueous dispersion:**
- lower particle size, higher transparency
- lower viscosity, Newtonian behavior

**P. R. 122 standard grade: Hostaperm**
\( d_{50} = 175 \text{ nm} \)

**P. R. 122 purified (Ink Jet grade)**
\( d_{50} = 110 \text{ nm} \)

**pseudoplastic behaviour (shear thinning)**

**Newtonian behaviour**
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<td></td>
<td>- Ames negative</td>
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</tbody>
</table>
Coloration Costs vs. Fastness Properties:
Magenta is most complex; decision is needed: Ink Costs or Ink Performance?

### Coloration Costs: CMY Color Shades of Process Colors according to relative Quality/Price level segments:

<table>
<thead>
<tr>
<th>Magenta</th>
<th>Yellow</th>
<th>Cyan</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.R. 122</td>
<td>P.Y 120</td>
<td>P.Blue 15:3</td>
</tr>
<tr>
<td>P.R. 185</td>
<td>P.Y. 151</td>
<td></td>
</tr>
<tr>
<td>P.V. 19</td>
<td>P.Y. 155</td>
<td></td>
</tr>
<tr>
<td>P.R. 146</td>
<td>P.Y. 180</td>
<td></td>
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<tr>
<td>P.R. 147</td>
<td>P.Y. 74</td>
<td></td>
</tr>
<tr>
<td>P.R. 184</td>
<td>P.Y. 12,13</td>
<td></td>
</tr>
<tr>
<td>P.R. 57:1</td>
<td></td>
<td>P.Blue 15:4</td>
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<tr>
<td>P.R. 48</td>
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</tr>
</tbody>
</table>

### Coloration Costs vs Light Fastness: Example Magenta pigments:
Costs/C.I. to color 1 kg bulk material vs. C.I. Light Fastness (1-8: acc. to blue wool scale)

<table>
<thead>
<tr>
<th>Light Fastness</th>
<th>Pigment C.I. No.</th>
<th>Cost Performance</th>
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</thead>
<tbody>
<tr>
<td>High</td>
<td>P.R. 122</td>
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</tr>
<tr>
<td>Medium</td>
<td>P.R. 184</td>
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</tr>
<tr>
<td>Low</td>
<td>P.R. 146</td>
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</tr>
<tr>
<td></td>
<td>P.R. 57:1</td>
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</tbody>
</table>

Coloration Costs [US$/kg]
Conclusion and Trends

1. Colorants are one of the key components in Ink Jet Color printing and influence the print quality and costs significantly

2. Pigment-based Ink Jet Inks are increasingly used due to higher fastness properties of pigments

3. More and more ink systems use additional colors like Orange, Violet, Green, etc. to expand the color gamut and final print quality

4. A trend from high performance pigments to mid performing ones is seen because Digital Print costs getting more and more in competition to conventional printing.

5. However, the print process & IJ inks performance still require specific pigment qualities compared to conventional printing systems.

6. Environmental regulations gain more and more importance in Ink Jet printing concerning colorants.
Thank you!

Dr. Ruediger Baur
Clariant Plastics and Coatings
Technical Marketing Non Impact Printing
06.10.2016

what is precious to you?