A New Paper Coating Nano-technology with Unique Characteristics to Improve Print Density

Dr. M. Patricia Wild – Eka Chemicals Inc, USA
Ylva Wildlock – Eka Chemicals AB, Sweden
Kjell Andersson – Eka Chemicals AB, Sweden
Erik Lindgren – Eka Chemicals AB, Sweden
Existing silica based coatings:

- Conventional technology for high quality inkjet printing papers
- Three main ingredients
  - Silica pigments (such as fumed, gel, colloidal)
  - Binder (PVOH, PVA)
  - Cationic polymer (PolyDADMAC)
Silica Particles

- Silica is porous and hydrophilic.
- Capable of taking up large volumes of ink liquid.
- Inter and intra particle pores make silica very absorbent.
- High internal porosity makes silica require large amounts of binders.

Silica Gel (micro scale range)
Binders

- Hold together small silica particles
- Binder level and type is a compromise because:
  - High volumes plasticize coating layer, but reduce the ink receptivity
  - Low levels give good pigmented ink compatibility, but poor physical properties (rub-off, chalking, debris)
Limitations of Existing Silica Coatings:

- Low Solids (maximum 25%)
- Requires intense drying
- Needs slow coating speed, therefore, limits commercial application
Existing Limitations (cont.)

- High binder requirements (>40 wt.%)
- Swellable vs. Capillary system
  - Slows down rate of ink absorption
    - Limits ink load
    - Decreases print density and gamut
Existing Limitations (cont.)

Cost

- High raw material costs:
  - Fumed silica (if used)
  - Addition of high amount of binders
- Cost in time
  - Slow drying due to low solids
  - On site preparation of formulations
In contrast to existing silica coatings, the new silica nanoparticle coating technology (NPC) has the following attributes:

- High Solids (up to 50%)
- No organic binder
- Good runnability
- Ready to use
Nano silica particles contain a high number of surface active silanol groups due to large surface area. Binding is by condensation of silanol groups bridging between the silica particles. Strong covalent bonds formed between the silica particles. Colloidal silica is a binder (used in the ceramic industry). Colloidal Silica (nano scale range from 2 to 100 nm).
NPC Formulation

NPC is a nanostructured porous pigment.

- Porous silica network capable to absorb ink vehicle rapidly.
- 2 μm average secondary particle size.
- Pigment is slightly cationic.
- Charge optimized for aqueous inkjet inks compatibility.
- Rheology optimized for excellent runnability.
NPC Coating Properties

- Brookfield viscosity: 300 to 500 cps
- Water retention value: <80 g/m2
- pH slightly acidic
- **Left**: uncoated base sheet
- **Right**: same base sheet coated with NPC
  - NPC follows the contour of the paper
  - Does not penetrate into the base sheet
NPC Micrographs (cont.)

- Left: pre-coated with GCC and starch
  - Fills the voids on the surface of the paper
- Right: pre-coated & top coated with NPC
  - Creates smooth surface to receive ink
Results: Gloss

Higher gloss obtained with fewer calender nips when using pre-coated paper
NPC tested on mill trials

Two mill trials:
- Rod metering
- Puddle size press

NPC Pilot and Mill Trials
Silica’s cationic groups fix ink dye to surface

Ink solvent absorbs within the NPC nano structure
Versatility in Application:

- Coating Equipment
  - From size press to coaters
- Coat Weight Range: 1.5 to 20 g/m²
- Multiple Aqueous Printers:
  - SOHO or Industrial applications
  - Narrow or wide format
  - HP, Epson, Canon
- Base Sheet Grammage: 65 to 230 g/m²
<table>
<thead>
<tr>
<th>Case Study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coating A</strong></td>
</tr>
<tr>
<td>- Silica gel based</td>
</tr>
<tr>
<td>- Primary particle size: 20 ηm</td>
</tr>
<tr>
<td>- Secondary particle size: 9 μm</td>
</tr>
<tr>
<td>- Solids content: 25%</td>
</tr>
<tr>
<td>- 100 pph PVOH binder</td>
</tr>
</tbody>
</table>

| **NPC** |
| - Nano silica based |
| - Primary particle size: 35 ηm |
| - Secondary particle size: 2 μm |
| - Solids content: 48% |
| - No organic binder added |
Case Study: Gamut Results

Gamut Volume Comparison

Similar Gamut between Coatings A and NPC
Case Study: Ink Absorption

Coating NPC: Inkjet ink stayed on the surface of the paper

Stereoscope image of Epson ink on the surface of paper single coated with NPC (RIT)
## Results: Kodak Versamark Data

<table>
<thead>
<tr>
<th>Paper Name</th>
<th>Grammage (g/m²)</th>
<th>Optical Density (High is Better)</th>
<th>Cockle 1-10 (Low is Better)</th>
<th>%Water Fast Test (High is Better)</th>
<th>%Bleed (Low is Better)</th>
<th>%Wet Rub (Low is Better)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Targets</td>
<td></td>
<td>1.20</td>
<td>3</td>
<td>99</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>NPC (WMU11)</td>
<td>78</td>
<td>1.23</td>
<td>3</td>
<td>104</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Image Grip VIP 20#</td>
<td>76</td>
<td>1.17</td>
<td>6</td>
<td>104</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>Dataspread Inkjet Pro</td>
<td>92</td>
<td>1.16</td>
<td>5</td>
<td>97</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Z-Plot 650</td>
<td>90</td>
<td>1.15</td>
<td>5</td>
<td>103</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HSIJ 24#</td>
<td>93</td>
<td>1.17</td>
<td>5</td>
<td>101</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Pixelle Bond VM</td>
<td>91</td>
<td>1.03</td>
<td>7</td>
<td>107</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>Ultra White Ink Jet</td>
<td>88</td>
<td>1.09</td>
<td>7</td>
<td>102</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: Kodak Versamark Transactional Data posted on Kodak webpage and NPC Test Results Provided by Kodak
NPC coated papers printed at Kodak on the Versamark printer showed significant optical density increase as NPC coat weight increased.
NPC coated papers were sent to RIT for printing, testing, and comparison to the OEM benchmark.

NPC paper performed better than the matte photo paper and similar to brochure paper.
Results Summary

Lab studies, pilot, and mill trials show that NPC has good:

- Runnability
- Print quality
- Color gamut
- Water permanence
- Color performance
- Dimensional stability
Future Work

- Work will be performed to determine metrics for:
  - Image Permanence
  - Visual Appearance
Conclusions

Nano Particle Coating (NPC) Technology:

- Ready to use
- Good runnability in spite of having:
  - No organic binder
  - High solids
- Suitable for mills or coating facilities
- Similar or better inkjet printing properties than the benchmark (print density, gamut)
- Suitable for matte and semi gloss paper grades
Thank you!

Are there any questions?