Advances in modern toner technology: Chemical and bio-based Toners
Agenda

Colour Toner
  – Why was Chemical Toner developed?
  – Chemical Toner Manufacturing
  – Advantages of Chemical Toner

Bio-based Toner: True innovation
  – Why are bio-based toners being developed?
  – Bio-based Toner Manufacturing
  – Advantages of bio-based Toner
Why colour printing?
Because people love colours

Everything else is in Colour
(Computer, Internet, Newspaper, TV, Magazines, the “real world” etc.)

It is available and affordable

Colour makes things easier to understand
Our brain likes to process information in pictures

More colour capturing and reproduction devices are available

Colour makes a good and professional expression

plus many other reasons

Colour printing is a natural desire
How many Black and White TVs do you think are still around?
Ink Jet or Laser?

- The customer has to have the right expectations.
- If the customer thinks that he can print Photos using a Colour laser in the same quality than he can print them using ink, then he has the wrong expectations.
- Laser has constructional constraints to picture quality (4 colours against up to 6 and pico liters against dpi).
Why are the OEMs turning to Chemical Toner?

- In order to print at 600 DPI, the toner size must be about 6-8 microns. To print at 1200 DPI (e.g. HP CP4525), control of particle size and shape is critical – this is virtually impossible with conventional toner. Chemical Toner is more consistent → consistent particle size and shape equals consistent charging properties.
- The higher yield of Chemical Toner allows for smaller cartridges resulting in smaller footprint printers → which are demanded by the market.
- Encapsulation permits good fusing at low energy levels (allows for Energy Star® qualification)
- Less V.O.C.s and CO₂

Which OEMs use Chemical toner?

- All major LBP OEMs! Canon, HP, Samsung (CLP320/325 is their first), Xerox, Ricoh, Konica Minolta, brother, etc.

Why the Aftermarket is clinging to Conventional Toner?

- Cost of Technology (e.g. R&D, Water Treatment and the cost of failure!)
- Intellectual Property
**Spheridized Toner**

- **Resin**
  - Toner matrix

- **Second additive (lubricant)**

- **Charge control agent**

- **Wax**
  - Fusing

- **Silica**
  - Flow aid
  - Tribo-charging
  - Storage stability

- **~ 10 μm**

**Conventional Toner**

- **Mixing of Raw Materials**
- **Extrusion** (melting together)
- **Cooling**
- **Crushing** (e.g. jet- or Hammer mills)
- **Classification**
- **Additive Blending**

**Heat Treatment**

- Only real difference to the normal conventional toner process.
Emulsion Aggregation Toner

Encapsulation: Wax and colorant on the inside- shell and additives on the outside

Resin
- Wax
  - Toner matrix
- Silica
  - Flow aid
  - Tribo-charging
  - Storage stability
- Pigment
  - Colorant (only in the inside)
- Charge control material

~ 8 μm

Chemical Toner
- Controlled Reaction e.g. Emulsion Aggregation
- Washing & Drying
- Additive Blending
Conventional Toner

- **Spheridising**
  - Conventional toner is produced and then smoothed by heat and mechanical process.

- **Strong Points**
  - Less expensive than chemical

- **Weak Points**
  - Wide particle size distribution
  - Higher pile heights
  - Interaction with OEM
  - Poorer fusing
  - Non-uniform shape
  - Wax on surface – poor flow
Chemical Manufacturing Methods (1)

- **Chemical Milling**
  
  - Components are mixed with a plasticiser, melted, and processed through high shear mixing.
  
  - **Strong Points:**
    - Enables easy use of all conventional resins, including polyesters
    - Simple process – low investment
    - Good colour gamut
    - Surface roughness can be controlled
    - Can use either dye or pigments for colorant
  
  - **Weak Points:**
    - Solvent based process
    - Potential for solvent fumes during fusing
    - Poor image permanence with dye colorants
Chemical Manufacturing Methods (2)

• Emulsion Aggregation

  – Coagulation

  – Strong Points:
    • It’s a smooth potato shaped
    • Cleans easier
    • Tight particle size distribution
    • Good fusing
    • Wider colour gamut
    • Better control of particle shape
    • Glossy or matte finish

  – Weak Points:
    • Complex process
    • Difficult to use polyesters
Chemical Manufacturing Methods (3)

- **Suspension Polymerisation**
  - **High-speed Dispersion**
  - **Strong Points:**
    - Round
    - Good Charge Control, Flow and Transfer
    - Perfect match with the OEM
  - **Weak Points:**
    - Difficult Cleaning
    - Heavily Patented
    - Limited to Spherical Shapes

Canon/HP Process

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Chemical Colour Toner offers real advantages in print quality

<table>
<thead>
<tr>
<th>Conventional Toner</th>
<th>Spheridised Toner</th>
<th>Chemical Toner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits compared to conventional toner</td>
<td>Apply to spheridised Toner</td>
<td>Apply to Chemical toner</td>
</tr>
<tr>
<td>Uniform particle size</td>
<td>😊</td>
<td>😊 😊</td>
</tr>
<tr>
<td>Uniform particle shape</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>High transfer efficiency</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>High flow</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Uniform charging</td>
<td>😞</td>
<td>😊</td>
</tr>
<tr>
<td>Low pile height</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Good Fusing</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Wide colour gamut</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Sharp half tones</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Minimal batch to batch variations</td>
<td>😊</td>
<td>😊</td>
</tr>
</tbody>
</table>

Consequence: Chemical Toner offers better yield, better fusing, crisp colours, more consistency and less stress
Chemical Toner offers better colours, better fusing and better halftones
Chemical Toner produces well defined letters

Chemical Color Toner

4-point Font in a HP 3600

Conventional Color Toner

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Typical issues with non chemical toner in a modern Colour Cartridge

- Waste bin overfill
- High torque
- High torque and toner build up
## Canon/HP OEM Chemical Toner Evolution

### S-Toner™

<table>
<thead>
<tr>
<th>Toner</th>
<th>Model</th>
<th>Release Year</th>
<th>Speed (C/B)</th>
<th>W.U. Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP4500</td>
<td>1998</td>
<td>4/16 ppm (4-cycle)</td>
<td>250 sec (Halogen)</td>
<td></td>
</tr>
</tbody>
</table>

**Toner Analysis**
- D50 vol.: 7.3µm
- <5 pop.: 13%
- Circularity: 0.975
- Sp.: 137 deg-C

**Fuser exposure time pp C*:** <15 sec.

### New S-Toner™

<table>
<thead>
<tr>
<th>Toner</th>
<th>Model</th>
<th>Release Year</th>
<th>Speed (C/B)</th>
<th>W.U. Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP4600</td>
<td>2002</td>
<td>17/17 ppm (Tandem)</td>
<td>29 sec (IH)</td>
<td></td>
</tr>
</tbody>
</table>

**Toner Analysis**
- D50 vol.: 6.6µm
- <5 pop.: 22%
- Circularity: 0.974
- Sp.: 123 deg-C

**Fuser exposure time pp C*:** <3.5 sec.

### Color Sphere™

<table>
<thead>
<tr>
<th>Toner</th>
<th>Model</th>
<th>Release Year</th>
<th>Speed (C/B)</th>
<th>W.U. Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP4700</td>
<td>2005</td>
<td>31/31 ppm (Tandem)</td>
<td>0 sec (Ceramic)</td>
<td></td>
</tr>
</tbody>
</table>

**Toner Analysis**
- D50 vol.: 6.9µm
- <5 pop.: 22%
- Circularity: 0.978
- Sp.: 119 deg-C

**Fuser exposure time pp C*:** <1.9 sec.

### New Color Sphere™

<table>
<thead>
<tr>
<th>Toner</th>
<th>Model</th>
<th>Release Year</th>
<th>Speed (C/B)</th>
<th>W.U. Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP CP3525</td>
<td>2008</td>
<td>30/30 ppm (Tandem)</td>
<td>0 sec (Ceramic)</td>
<td></td>
</tr>
</tbody>
</table>

**Toner Analysis**
- D50 vol.: 6.9µm
- <5 pop.: 10%
- Circularity: 0.978
- Sp.: 123 deg-C

**Fuser exposure time pp C*:** <2 sec.

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*minus time in between pages*
Advances in Fuser technology

Old Style Fuser (HP 4500)

Upper Roller
Halogen Heater
Toner
Paper
Lower Roller

Warm up speed 250sec.
Fuser exposure time pp C*: <15sec.

Intermediate“ Style Fuser (HP 4600)

Fuser Sleeve
Induction heating element
Toner
Paper
Pressure Roller

Warm up speed 29sec.
Fuser exposure time pp C*: <1,9sec.

New Style Fuser (HP 4700)

Fuser Sleeve
Ceramic heating
Non Chemical toners can produce build up on the fuser sleeve
Pressure Roller

Warm up speed 0sec.
Fuser exposure time pp C*: <2sec

*minus time in between pages

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The new fuser technologies lower the Power Consumption

- Chemical Toner allow for lower energy consumption per page in colour printing and in standby mode.
  - Helps to reduce precious resources by saving energy.
  - Enables the OEM to be Energy Star® qualified.

![Graph of power consumption for smaller footprint and group level colour printers.](image)
Chemical Toner offers better fusing

Tape Test in a HP 3600

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CHEMICAL TONER IS MORE GREEN!

Comparison of the energy & emissions of EA toner & conventional toner

- More than 35% less solid waste
- ~32% Less VOC’s!
- Some estimates as much as 35% lower CO$_2$ emissions

Per metric ton of toner produced and used.

Source: Ahamadi, A, et al, Life-cycle inventory of toner produced for xerographic processes, J Cleaner Production, 2001

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Bio-based Toner: True innovation
- Why are bio-based toners being developed?
- Bio-based Toner Manufacturing
- Advantages of bio-based Toner

08/02/2011
DELCAMP your global Partner
Sad, but true. . .

* 552,670,120 liters per year!
That is about as much as the BP drill hole would have spilled into the gulf in one and a half year.
Sustainability should be important to everybody

- In December 2006 the EU Competitiveness Council agreed to launch an initiative as a new policy approach aiming at supporting the development of markets with high economic and social value, in which European companies could develop a globally leading role.

- In May 2007 the Competitiveness Council invited the Commission to propose further steps for the creation of lead markets and other measures to enhance market demand for eco-efficient bio-based products, in order to exploit the positive environmental impact of bio-based products.

- Some of the major factors driving the future markets and demand for bio-based products are:
  - Limited availability and increased cost of fossil resources vs. renewable bio-based resources;
  - Policy development, in particular climate change mitigation, sustainable production and consumption, Lisbon agenda, industrial policy and employment growth;
  - A changing consumer demand based on the awareness of the need to ensure sustainable production and consumption.

What is bio-based Toner?

- A Toner in which petroleum-based raw materials are substituted to a certain degree (> 20%) with renewable raw materials.

- Bio-based Toner is in an ecological competition with the OEM and not with conventional aftermarket cartridges.

- BioBlack™ is a Toner made using a bio-based resin with a proprietary patent-pending toner formulation using various agriculturally derived materials, which may include corn, cottonseed and soy.

- BioBlack™ Toner are tested according to STMC on print performance.

* While the ASTM-D6866 method cites a precision of +/-3%, these results indicate that the amount of bio-derived carbon in BioBlack™ toner is far greater than a competitive toner (and infinitely greater than the OEM) for the same amount of carbon in toner.

** The ASTM-D6866 method is similar to the radiocarbon dating method, which measures the amount of carbon-14, which exists in bio-based materials, but is non-existent in fossil-based materials such as petroleum.
Resin can consist of up to 70% of crude oil. With BioBlack™ up to 34% of the crude oil can be substituted by bio-based materials.

**Resin**
- **Toner matrix**: 50-90%
- **Second additive (polishing agent)**
- **Pigment Colorant**: Magnetic property 5-50%
- **Third additive (lubricant)**

**Conventional Toner**
- **Mixing of Raw Materials**
- **Extrusion** (melting together)
- **Cooling**
- **Crushing** (e.g. jet- or Hammer mills)
- **Classification**
- **Additive Blending**

- **Charge control agent**: <2%
- **Wax**: Fusing <10%
- **Silica**: Flow aid Tribo-charging Storage stability
- **Resin**: Toner matrix 50-90%
- **Colorant**: Pigment
- **Magnetic property**: 5-50%
- **Wax**: Fusing <10%
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- **Resin**: Toner matrix 50-90%
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- **Magnetic property**: 5-50%

~ 10 μm
• BioBlack™ Toner are LGA tested for contaminants.

• BioBlack™ is the first officially bio-based certified toner in the world.
Thank you