Riding the Wave - UV wavelengths in LED Curing

Dirk Exner
Quick Overview

**FOUNDED IN 2002**
**16 YEARS EXPERIENCE**

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**NO MERCURY**

100% LED FOCUSED

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**PRODUCTION**

+12,000 UV LED Lamps per Year

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**EMLOYEES**

160 HQ in Oregon
Global Direct Sales & Technical Support Team

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**APPLICATION**

#1 with PHOSEON
Print, Coating, Adhesives

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**PROVEN LIFETIME**

70,000 HOURS
### Why UV LED?

<table>
<thead>
<tr>
<th>More Economical &amp; Productive</th>
<th>More Ecological</th>
<th>More Repeatable &amp; Reliable</th>
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<tbody>
<tr>
<td>Instant ON/OFF</td>
<td>No ozone</td>
<td>Consistent, stable, predictable, controllable curing</td>
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<tr>
<td>Virtually no maintenance</td>
<td>No mercury</td>
<td>Repeatability is essential for Low Migration printing</td>
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<tr>
<td>Less waste and scrap</td>
<td>40-80% less energy</td>
<td>40K + on time hours with minimal degradation</td>
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<td>More printer up time</td>
<td>40-80% less CO₂</td>
<td>Better through cure &amp; adhesion</td>
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<tr>
<td>40-80% less energy</td>
<td>Less noise</td>
<td>Less heat</td>
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<tr>
<td>No ozone extraction</td>
<td>No hazardous UVB/UVC</td>
<td></td>
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<tr>
<td>No spares (bulbs, shutters, reflectors)</td>
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Why UV LED? - Minamata

“New global treaty cuts mercury emissions and releases, sets up controls on products, mines and industrial plants”

Kumamoto, Japan, 10 October 2013

(...) The Minamata Convention on Mercury - a global, legally binding treaty which opened for signature today - was agreed to by governments in January and formally adopted as international law today. (...) Under the provisions of the Minamata Convention, Governments have agreed on a range of mercury-containing products whose production, import and export will be banned by 2020. These items have non-mercury alternatives that will be further phased in as these are phased out. (...)

- Convention adopted by 139 governments
- Convention signed by 128 governments

www.mercuryconvention.org
Why UV LED? - RoHS Reloaded

- Recast RoHS II 2013: “...It also requires heavy metals such as lead, mercury, cadmium, and hexavalent chromium and flame retardants such as polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) to be substituted by safer alternatives....”

- “Brussels, 20 July 2011 - The ban on heavy metals and other dangerous chemicals in electrical and electronic equipment has now been extended to a much wider range of products... ... Environment Commissioner Janez Potočnik said: "Where there are alternatives available it is not acceptable to expose people or the planet to dangerous substances. We all come into daily contact with products and these new rules increase further the level of safety we can expect. They improve consumer safety, health and environmental protection, and they also improve the way the rules will work at national level.\“...”

- Leading global inkjet printer suppliers have stopped developing printers with mercury arc lamps years ago
Understanding UV (LED) output

UV LED ≠ UV Hg arc lamps
UV Wavelengths

- LED 385 or 395 or 405nm
- LED 365nm
- Mercury Lamp

Wavelength (nm)

- UVC: 200-280nm
- UVB: 280-315nm
- UVA: 315-400nm
- VISIBLE LIGHT: 400-700nm
- INFRARED: 700-1800nm
UV Wavelengths

- Different spectra
- Pure Mercury, Iron, Gallium

Source: Dr. Hönle
LED Photo Initiators (Free Radical)

Source: Fraunhofer IPA
LED Photo Initiators (Free Radical)

- Limited Choice
- Types
  - Phosphine Oxides
  - Thioxanthenes
  - Benzophenones
- Names
  - TPO
  - TPO-L
  - BAPO
  - ITX
  - DETX
- Polymeric versions
- Always Blends!
LED Photo Initiators (Free Radical)

- Main Issues
  - Yellowing
  - Surface Cure
  - Migration
- Optimized formulations with additives etc. minimizing these issues
- Modified, improved PIs available
- New PIs, specifically developed for UV LED, are being launched currently, overcoming these issues
What LED Wavelength to pick?

- 365nm vs. 385/395nm
  - Many inks more reactive at 365nm
  - Lower efficiency/power of 365nm light sources more than offset by higher 385/395nm power

- 385nm vs. 395nm
  - Large spectrum overlap plus tolerances
  - Negligible curing performance differences, no general advantage for either wavelength

- 405nm?
  - Better throughcure for thick layers
  - Better throughcure for whites

- Wavelength combinations
  - No evidence of any benefits, UVA wavelengths too close together
LED Wavelengths
LED Wavelengths - UVC

- Phoseon Life Sciences
  - Disinfection/sterilisation/deactivation/decontamination (KeyPro™)
    - UVC (plus UVA)
  - Chromatography, fluorescence (KeyView™)
    - Full Spectrum with LED
LED Wavelengths - UVC

- 278nm for Curing
  - Limited supply
  - Higher price point
  - Low power and efficiency adapted to specific applications
  - Lifetime dependant on intensity / application
Conclusions

- LED has clear benefits over mercury arc lamps
  - No mercury (EU RoHS mercury ban)
  - Substantially reduced CO₂ emissions
  - Better process consistency
  - Improved curing
  - Higher productivity
- 385/395nm work
- Expanding application range and freedom of formulation
  - New raw materials tailored for UV LED launched
- New LED wavelengths at the distant horizon
Thank you!

Dirk Exner