LIQUID (STATE) COLOR DEVELOPMENT

OLIVER KORTEN, ORONTEC GMBH & CO. KG

Coatings Trends & Technologies SUMMIT

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The Westin Lombard, IL

coatingsconference.com

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Agenda

- (Dynamic) liquid color measurement
- 2 different processes (requiring color matching)
  - Production process
  - Color development process
- Dry to liquid spectral mapping (or vice versa)
- Technical realization
- Summary / business benefit

European Coatings Show
Conference Award-winning paper

Liquid Color Measurement (LCM)

Color measurement processes

- Usual color measurement process: sequence of 3 process steps:
  - Take sample
  - Prepare specimen
    - Ensure that a film gets built
    - Apply film
    - Dry
  - Measure specimen

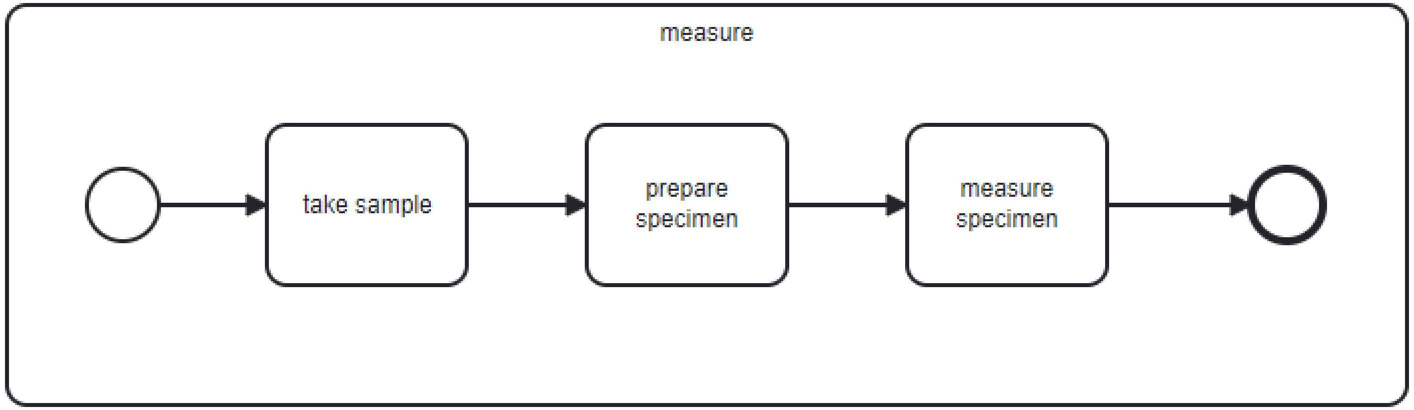
identical

less requirements

part of measurement

obsolete

- Liquid color measurement process
  - faster ← drying obsolete
    - takes approximately 3 minutes to measure (incl. cleaning of the device)
  - more reproducible ← film application automated



Advantages of
Liquid Color Measurement (LCM):

- Optimise production time: No separate application, drying and curing steps
- Measurements at any step of the production process *from the beginning to the end*
- Less error-prone: application is automated part of measurement
- Positive side-effect: Reduce energy consumption and waste

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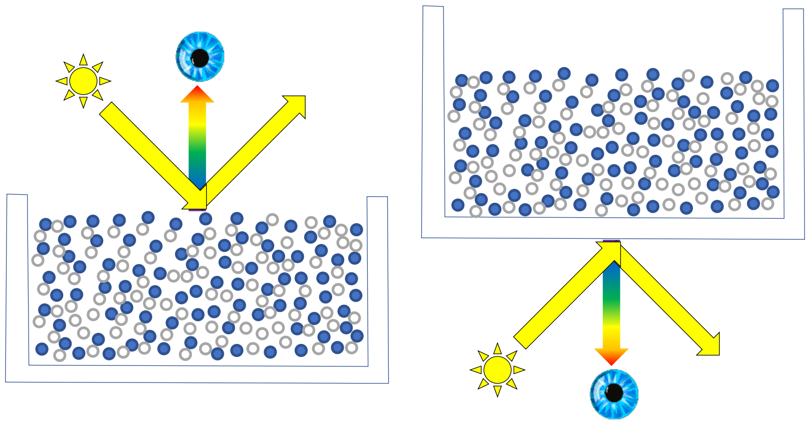
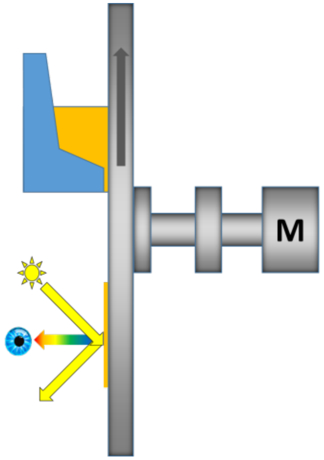
Liquid Color Measurement (LCM)

2 LCM types

- Static
  - Contactless measurement from above a Petri dish or container
  - Measurement through the bottom of a transparent cuvette
- Dynamic
  - Contactless measurement
  - Film application on rotating cylinder/disk

- Advantages of dynamic LCM:
  - Renewal of film building with every rotation
  - Negligible time dependency (no homogeneity issues)
  - No flocculation
  - No sedimentation
  - No leafing
  - No adhesion to container walls

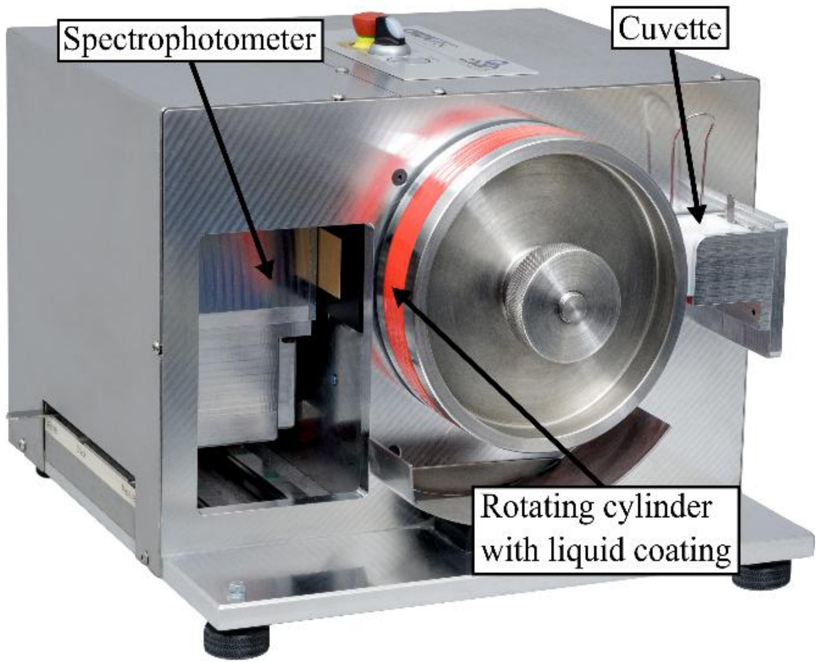


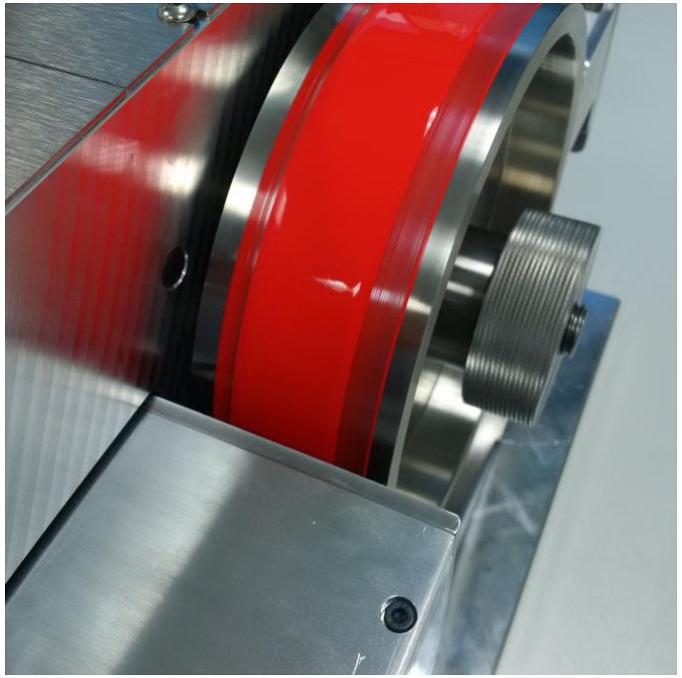


Dynamic Liquid Color Measurement Device

Example: Dynamic Liquid Color Measurement device equipped with 45°:0° spectrophotometer

- Contactless dynamic measuring principles
- Single angle measurement device / rotating cylinder
- Spectrophotometer measurement range: 400 nm - 700 nm
- Set resolution of 10 nm
- Measurement duration: approx. 3 minutes (incl. cleaning)





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Production process

- All characteristics of the product are known, e.g. based on
  - An initial production batch
  - A formerly approved/accepted batch

- Above characteristics comprise
  - Reflectance (dry and/or liquid measurement)
  - Derived color positions
  - Formulation, i.e. (color) components and amounts

Color development process

1. Customer request:

   Develop a color for a given standard in a given quality as

   - A color formula
   - A given volume of liquid in a container
2. Color measurement of given standard (i.e. dry measurement)
3. Mapping of dry measurement into liquid measurement
4. Use of mapped measurement as standard for liquid color development
   - Comparison of liquid measurement of current sample vs. virtual liquid digital twin of standard
5. Converting into dry state measurement data
   - Virtually (always possible by mapping)
   - By dry measurement of prepared (i.e. applied and dried) sample

Precondition for liquid color development

- Way to come up with a liquid color standard

Idea:

- Use Artificial Intelligence (AI) to predict color for alternate state
  - For production process:
    - Prediction of color position probably sufficient because of completely known characteristics, especially color components and (roughly) corresponding amounts
  - For color development process:
    - Prediction of color position not sufficient, especially due to metamerism risk
    - Prediction of reflectance required to determine appropriate (so far unknown) color components and corresponding amounts

AI generated spectral mapping

1. Define colors for training and testing
    - Only 240 training and 24 testing colors available
    - Training colors somehow optimized only for color position mapping (former project)
2. Prepare corresponding liquid and dry samples
    - According to the usual sample preparation process
3. Measure above samples
    - Using LCM device and usual dry color measurement device
4. Train map
5. Test map, i.e. evaluate mapping performance on test data

Bonus:

- With every additional pair of dry and liquid measurement, the training dataset can be enlarged leading to a more representative mapping

Technical realization

1. Wrap spectral mapping into a web application with a REST API
   - Spectral dry to liquid and vice versa mapping
2. Parallel administration of dry and liquid color measurements
   - Allowing for conversion to virtual digital twin at any time
3. Optional: Incorporation of a formulation system
   - Identical characterization echelon of color components for dry and liquid state
     - Bonus: above measurements reusable to extend training set

➢ Hybrid color development

- Start with and stay within liquid color development until close enough to standard
- Eventually switch to dry color development, e.g. for final hit and approval

Summary and benefits

- (Dynamic) liquid color measurement
  - Automated application → *more reproducible*
  - No spraying or draw down → *less requirements, less waste, faster* → *less costs*
  - No drying → *faster, less energy consumption* → *less costs*
  - Usability from the beginning to the end → *universal possible uses*
- Dry to liquid spectral mapping
  - Dry color development process → liquid color development process → *faster, less costs*
  - Spectral → *good pigment selection control* → *less metamerism risk*
- Technical realization
  - Parallel administration of measurements → *full control, flexible usability*
  - REST API → *flexible usability*

Enabler for significant cost reduction

Acknowledgements

- Color position mapping:
  - LCM in Standardised Automation Processes.
    Oliver Korten et al., ECJ, Issue 4/2024
- Spectral mapping:
  - Enhanced Colour Forecasting - *ECS Conference Award-winning paper.*
    Gaoyuan Zhang et al., ECJ, Issue 6/2025

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https://smartpaintfactory.com

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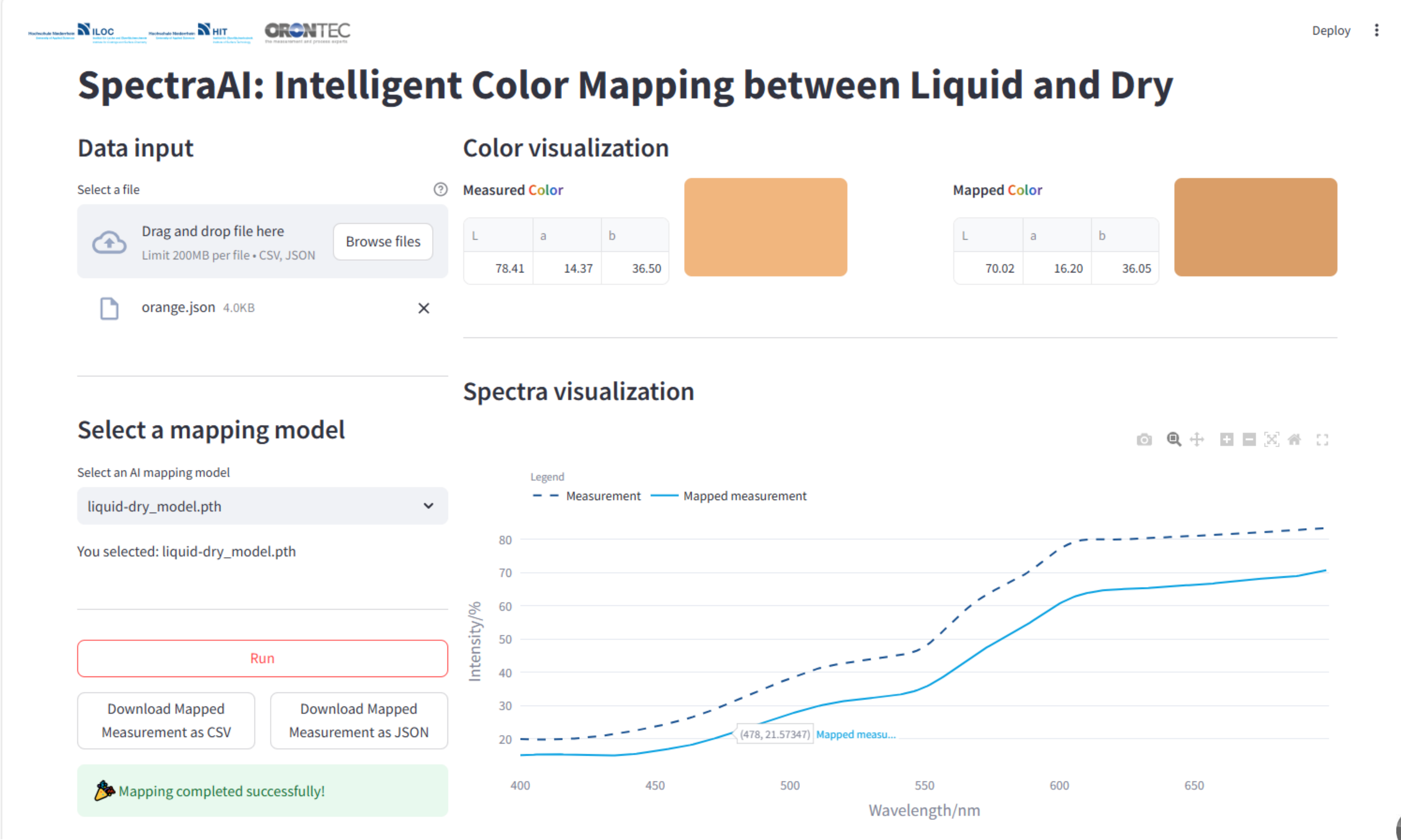
Appndix: Web Application *Spectra AI*



Appndix: REST API *Spectral AI Mapping*

Q-Chain® Spectral AI Mapping API 1.0.0.0 OAS 3.1

/openapi.json

REST API for spectra mapping using artificial intelligence machine learning models.

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default

GET `/version` Get Version

GET `/state` Get State

GET `/models` Get Models

PUT `/measurements` Map Measurement