Evaluation of bio-based products in architectural paints

M. Wenkin, C. de Lame, M. H. Delvaux, A. Lourtie, A. Pimez, A. Richel, G. Olive
Coatings Research Institute

Created by the Industry

CoRI is a Belgian non-profit organization funded in 1957 in order to stimulate innovation and research in the paint, varnish and coatings industry by scientific and technological developments.

For the Industry

Close collaboration with IVP (the professional federation of industries active in varnishes, paints, sealants, printing inks and artists’ colors). IVP represents around 70 companies in these sectors, approximately 3,500 employees.
Our mission

to provide assistance, support and services by offering

- problem-solving
- ad hoc analysis
- contract research
- technical assistance
- training

...to paint manufacturers, raw materials suppliers, professional applicators and industrial users...
ACTIVITIES

- Research
  - Collective research
  - Contractual research
  - Pre-normative

- Testing and Analysis

- Technical assistance and Expertise

- Training - Congress
Research area

Improving ecological footprint

- Biomaterials, VOC, LCA, ...

Multi Functionalization

- Reduction of building energy consumption, anti corrosion, anti icing, color effects, protection, conductivity, odors/VOC reduction

Link between performance and formulation

- Durability, resistance, substrates (wood = Eco buildings)

Regulation Market

29 collective research programs between 2007 & 2015
Evaluation of bio-based products in architectural paint formulations

Bio-based products:

- Products wholly or partly derived from biomass, such as plants, trees or animals (the biomass can have undergone physical, chemical or biological treatment) (CEN 16575)
Considered bio-based products (I)

- The first part focuses on the use of sugar esters, of commercial alkyl-polyglucosides and alkyl-polypentosides and of a commercial sugar base polymer as dispersing agents.

- APG (alkyl polyglucosides), APP (alkyl polypentosides) and sugar esters
  - a class of non-ionic surfactants.
  - synthesized from renewable materials.
  - non-toxic, biodegradable, odourless and non-irritating.
  - APG and APP are widely used in a variety of household and industrial applications.
Considered bio-based products (II):

- The second part is dedicated to the use of wheat gluten as binder or co-binder in architectural paints.

- Wheat gluten is a by-products of the wheat starch industry. It’s widely available and at low price.

- It can be distinguished from other industrial proteins by some of its particular properties like:
  - its insolubility in water,
  - its viscoelastic behaviour,
  - its potential film-forming ability,
  - its RH-dependent gas barrier properties and its rather high water vapour permeability.
Bio-based additives
## Selected commercial biobased additives

<table>
<thead>
<tr>
<th>Name</th>
<th>Chemical nature</th>
<th>Active matter (%)</th>
<th>Dry matter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disp 1</td>
<td>non-ionic, modified fatty acid derivative</td>
<td>100</td>
<td></td>
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<tr>
<td>Disp 2</td>
<td>polymer</td>
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</table>

<table>
<thead>
<tr>
<th>Sugar based</th>
<th>Chain-length</th>
<th>Active matter (%)</th>
<th>Dry matter (%)</th>
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<tbody>
<tr>
<td>Disp 3</td>
<td>APG*</td>
<td>C4</td>
<td>49-51</td>
</tr>
<tr>
<td>Disp 11</td>
<td>APG*</td>
<td>C8</td>
<td>65-70</td>
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<tr>
<td>Disp 4</td>
<td>APG*</td>
<td>C8</td>
<td>68-72</td>
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<tr>
<td>Disp 5</td>
<td>APG*</td>
<td>C8-C10</td>
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<tr>
<td>Disp 6</td>
<td>APG*</td>
<td>C8-C10</td>
<td>60</td>
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<tr>
<td>Disp 7</td>
<td>APG*</td>
<td>C10</td>
<td>50</td>
</tr>
<tr>
<td>Disp 8</td>
<td>APP**</td>
<td>C5</td>
<td>60</td>
</tr>
<tr>
<td>Disp 9</td>
<td>APP**</td>
<td>C5 and C10-C12</td>
<td>60</td>
</tr>
<tr>
<td>Disp 10</td>
<td>Sugar-based polymer</td>
<td></td>
<td>51</td>
</tr>
</tbody>
</table>
Selected bio-based additives

- Synthesized sugar esters

  Disp 12: Fructose palmitate (C10),
  Disp 13: Fructose laurate (C12)
  Disp 14: Fructose caprate (C16)

  synthesised by the University of Liège according to an enzymatic process (Olive, G.; Pompeu Torezan, G.A.; Blecker, C.; C. R. Chimie 15 (2012) 1037)

- Selected commercial petrochemical additive

  Polyacrylic ammonium salt
Paints preparation

- **Dispersant demand curves** measurements to determine the amount of additives required to fully wet and disperse the pigments and fillers.

![Graph](image)

- **Conc. additive/pigments and fillers (%)**
- **Viscosity (Pa.s)**

50%wt pigments and fillers
Replacement of the **petrochemical** dispersing and wetting agent of a reference architectural paint by the **bio-based** additives with the optimized concentration.

The sugar ester were added with a fixed amount of 3.8% (ratio dry sugar ester/pigments and fillers).

Architectural paint:

- The binder: anionic aqueous dispersion of acrylic ester and styrene copolymer (Axilat UG DS2800 from Momentive).
- Pigment volume concentration 38.5%
- Dry matter 64.3%.
Liquid paints characterization

- **Storage stability**

Viscosity measurements

- at the initial stage,
- after a storage of 1 month at room temperature and at 50°C.

The results show a strong increase of the viscosity after 1 month storage at 50°C for paints prepared with

- Disp 7 (APG C10) at the highest concentration,
- Disp 5 (APG C8-10),
- Disp 6 (APG C8-C10),
- Disp 13 (fructose ester C12) and
- Disp 14 (fructose ester C10)

meaning that these paints have a limited storage stability.
Liquid paints characterization

- **Drying time** ASTM D5895 - “Standard test methods for evaluating drying and curing during film formation of organic coatings using mechanical recorders”.

- Stage I — Set-to-Touch Time
- Stage II — Tack-Free Time
- Stage III — Dry-Hard Time
- Stage IV — Dry-Through Time
Liquid paints characterization

- Open time ASTM D7488 - "Test method for open time of latex"
Liquid paints characterization

Open time

Open time (22°C/50%HR)

- Ref 7,4%
- Disp 1 - 4%
- Disp 2 - 8%
- Disp 2 - 10%
- Disp 3 (APG C4) - 7,5%
- Disp 11 (APG C8) - 1,5%
- Disp 5 (APG C8-C10) - 7,5%
- Disp 6 (APG C8-C10) - 6%
- Disp 7 (APG C10) - 7,5%
- Disp 7 (APG C10) - 11%
- Disp 8 (APP C5) - 3%
- Disp 9 (APP C5 et C10-12) - 7,5%
- Disp 10 - 3%
- Disp 12 - Palmitate 3,8%
- Disp 13 - Laurate 3,8%
- Disp 14 - Caprate 3,8%

ASTM D5895
Liquid paints characterization

- Dynamic surface tension

Krüss tensiometer at room temperature (platinum ring – vessel diameter: 44.5 mm - paint volume 20ml – immersion depth: 3 mm - rate: 3 mm/min – Harkins Jordan method).
Dry paints characterization

- **Spreading rate at a hiding power of 98 % ASTM D2805-11 – “Standard Test Method for Hiding Power of Paints by Reflectometry”**.

![Graph showing spreading rate](image-url)
**Dry paints characterization**

- **Wet scrub resistance** ISO 11998 – « *Paints and varnishes -- Determination of wet-scrub resistance and cleanability of coatings* ».

![Graph showing thickness loss after 200 cycles](image)
## Biobased additives: conclusions

<table>
<thead>
<tr>
<th>Name</th>
<th>Chemical nature</th>
<th>Additive/fillers and pigments (%)</th>
<th>Storage stability</th>
<th>Open time</th>
<th>Spreading rate</th>
<th>Wet scrub resistance</th>
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<td>Disp 5</td>
<td>APG*</td>
<td>C8-C10</td>
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<td>APG*</td>
<td>C8-C10</td>
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</tbody>
</table>
Gluten
Paints preparation

- Dispersion of wheat gluten (from Aldrich) in an aqueous solution
- Adjustment of the pH of the gluten dispersion to 8
- Mixing of the gluten dispersion with a styrene-acrylic dispersion (Axilat DS2100 or Axilat DS2800 from Momentive)

<table>
<thead>
<tr>
<th>Paint</th>
<th>Binder</th>
<th>Dry ratio Gluten/Axilat</th>
<th>Dry content</th>
<th>PVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Gluten/Axilat DS2100</td>
<td>1/6</td>
<td>33,8</td>
<td>41</td>
</tr>
<tr>
<td>B</td>
<td>Gluten/Axilat DS2800</td>
<td>1/6</td>
<td>33,8</td>
<td>41</td>
</tr>
<tr>
<td>C</td>
<td>Gluten/Axilat DS2100</td>
<td>1/1</td>
<td>36</td>
<td>12</td>
</tr>
<tr>
<td>D</td>
<td>Gluten/Axilat DS2800</td>
<td>1/1</td>
<td>36</td>
<td>12</td>
</tr>
</tbody>
</table>
Paints characterization

- **Storage stability**
  - Measurement of the viscosity at the initial stage, after a storage of one month at RT and at 50°C
  - Paint B (Gluten/Axilat DS2800 1/6) is stable
## Paints characterization

### Dry paints characterization

<table>
<thead>
<tr>
<th></th>
<th>Persoz (s)(^{(1)}) ISO1522</th>
<th>Liquid water permeability (ml)(^{(2)}) after 24H</th>
<th>Vapour water transmission coefficient (g/m²/24h) (dry thickness) (^{(3)}) ASTM D1653</th>
<th>Wet scrub resistance – thickness loss after 200 cycles (µm)(^{(4)}) ISO11998</th>
</tr>
</thead>
<tbody>
<tr>
<td>A : Glut 2100 1/6</td>
<td>90</td>
<td>5</td>
<td>406 ± 29 (88 ± 8 µm)</td>
<td>12,9</td>
</tr>
<tr>
<td>B : Glut 2800 1/6</td>
<td>28</td>
<td>1</td>
<td>165 ± 11 (75 ± 3 µm)</td>
<td>4,7</td>
</tr>
<tr>
<td>C : Glut 2100 1/1</td>
<td>85</td>
<td>6,5</td>
<td>545 ± 17 (60 ± 2 µm)</td>
<td>26,2</td>
</tr>
<tr>
<td>D : Glut 2800 1/1</td>
<td>64</td>
<td>7</td>
<td>542 ± 17 (67 ± 2 µm)</td>
<td>24,6</td>
</tr>
</tbody>
</table>

\(^{(1)}\)Application on tinned iron panels (200 µm wet)  \(^{(2)}\)Application on porous substrate (two layers)  \(^{(3)}\)Free films composed of two layers  \(^{(4)}\)Free films composed of two layers
In the tested architectural paint, some sugar-based additives gave results at least similar to the petrochemical one.

The most promising ones are APG-C8 and APP-C5. Only small amount of dispersant is required.

Paints were successfully prepared from gluten and styrene-acrylic dispersion. One of them has good storage stability, high wet scrub resistance, high water vapour permeability and low liquid water permeability.
...thank you for your attention