WORKSHOP ON BITUMEN EMULSION TECHNOLOGY

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VIENNA, AUSTRIA

# Use of Bio-Binders in Cold Recycling of Existing Pavements

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# What does the word “BIO” stand for?

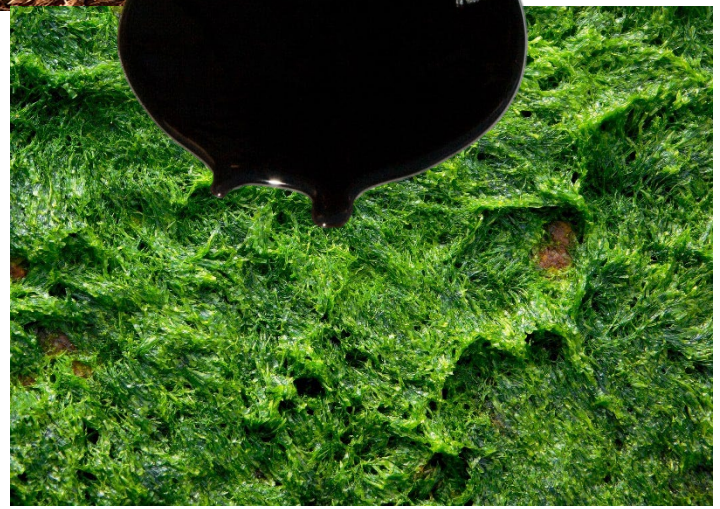
- Biological
- Biodegradable
- Biogenic
- Biomass
- Ecological agriculture
- Organic
- Renewable
- Sustainable
- Recyclable
- Green
- Environmentally friendly

βίος (*bíos*, “life”)
connected with life and living things

In general terms, **bio**products are products that are made from **bio**mass (= made of material that comes from living organisms, such as plants and animals)

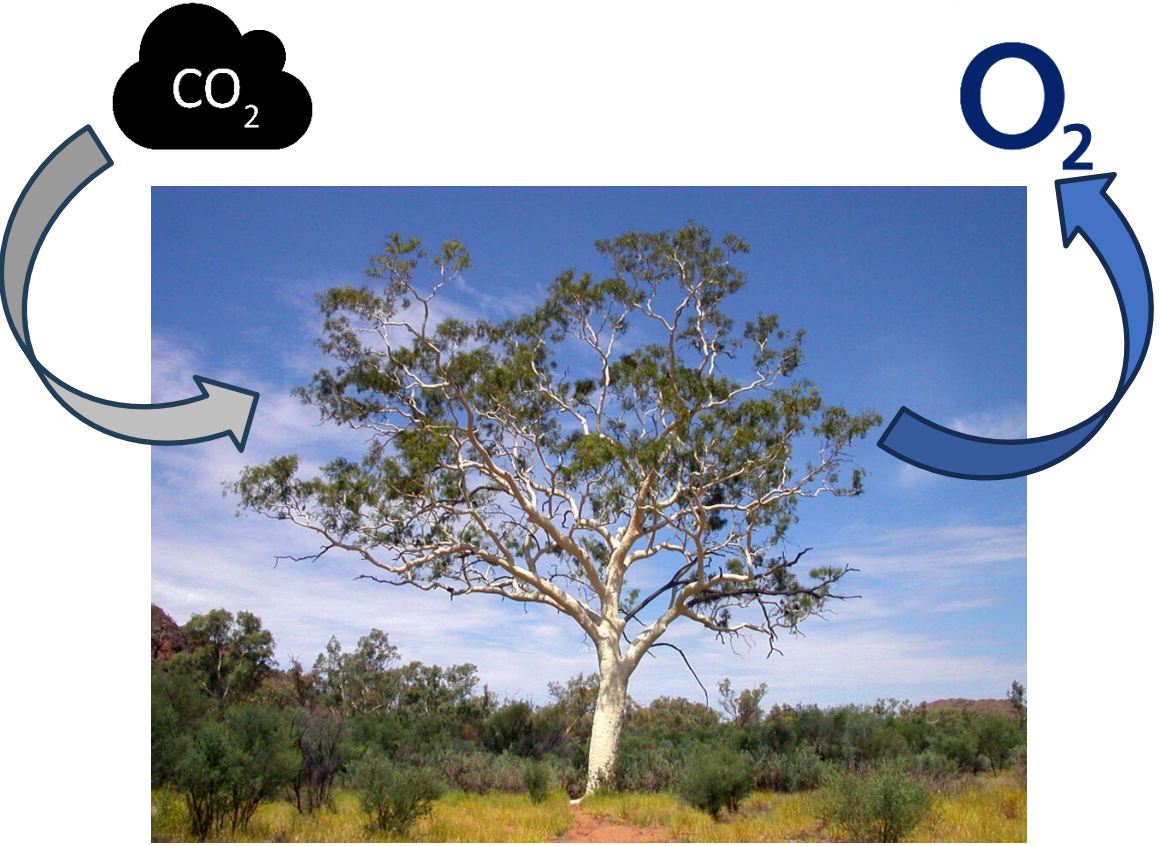
# Biomass includes:

- Woody biomass
- Herbaceous biomass
- Agricultural biomass
- Forestry biomass
- Animal waste biomass
- Industrial biomass
- Aquatic biomass
- …



# Biomass is modified to produce various products including bio-oils, bio-char, and bio-resins.

# The environmental advantages




Biogenic carbon is ‘stored’ in the tree

Carbon is produced during the manufacturing process

Usually, carbon stored > carbon produced to manufacture bio-oils

This ‘negative’ carbon can be discounted from the carbon footprint of bitumen

Bio-bitumen is a lower carbon material than conventional bitumen

*… way more complicated than it seems, several hypotheses, different calculation methods*

# SUSTAINABILITY AND TRANSPARENCY

- Official verified EPDs created for more than 33 products and registered with EPD Australasia and EPD International
- The first and only till now verified registered EPD of bitumen binders with EPD Australasia
- Available to view and download by anyone
- Benchmark for carbon accounting of pavement construction and maintenance projects
- Step toward our commitment to be transparent with industry

| | | |
|---|---|---|
| **Declaration Owner** | **SAMI Bitumen Technologies Pty Ltd (SAMI)**<br>3-5 Gibbon Road, Winston Hills NSW 2153<br>www.sami.com.au<br>+61 02 9624 0101 | |
| **EPD Program Operator (Regional programme)** | **EPD International AB**<br>Box 210 60, SE-100 31<br>Stockholm, Sweden,<br>E-mail:<br>info@environdec.com | **EPD Australasia Limited**<br>Address: 315a Hardy Street, Nelson<br>7010, New Zealand<br>Web: www.epd-australasia.com<br>Email: info@epd-australasia.com<br>Phone: +61 2 8005 8206 (AU) |
| **LCA/EPD Produced** | **start2see Pty Ltd**<br>36 Renaissance Bvd,<br>Mernda, VIC 3754, Australia<br>Web: www.start2see.com.au<br>Email: Rob.Rouwette@start2see.com.au<br>Phone: +61 403 834 470 | |

# WHAT ARE BIO-BINDERS?

They are binders produced **fully or partially** from bio-materials.

| Classification | Basis | Examples |
|---|---|---|
| Source-based | Biomass type | Lignin, tall oil, bio-oils |
| Function-based | Role in binder | Modifier, extender, replacement |
| Processing-based | Production method | Pyrolysis, esterification, fermentation |

Functions: serve as **replacement, extender, or modifier** for bitumen

- Bitumen is “replaced”
- Bitumen is “stretched” using cheaper or renewable materials
- Bitumen is “tuned” or “enhanced”, not replaced

# TOXICITY RISKS OF BIO-MATERIALS

Important:
**Bio ≠ Non-toxic**

Ricin

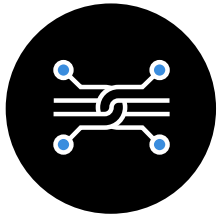
Nicotine

Algal toxins

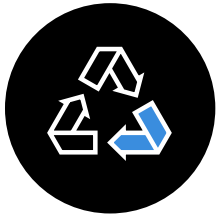
Always check the SDS!

# The implementation of low carbon binders implies meeting a complex set of requirements

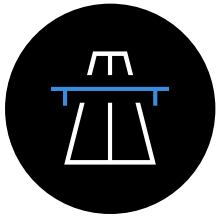
No increased impact on HSSE



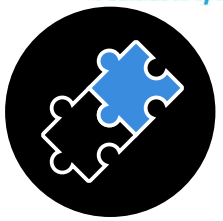
Consistent quality



Recyclable



Similar life duration



Emulsion and PMB Compatibility

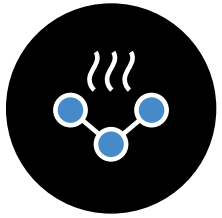
No odour issues

No Fumes

Good workability

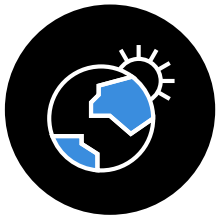
Fixed prices over tender period

High RAP content friendly

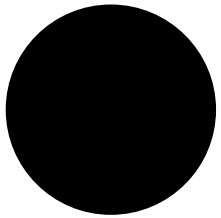


Lower emission Level (VOC)

No extra logistic investment to manage the binder



Climate change impact readiness

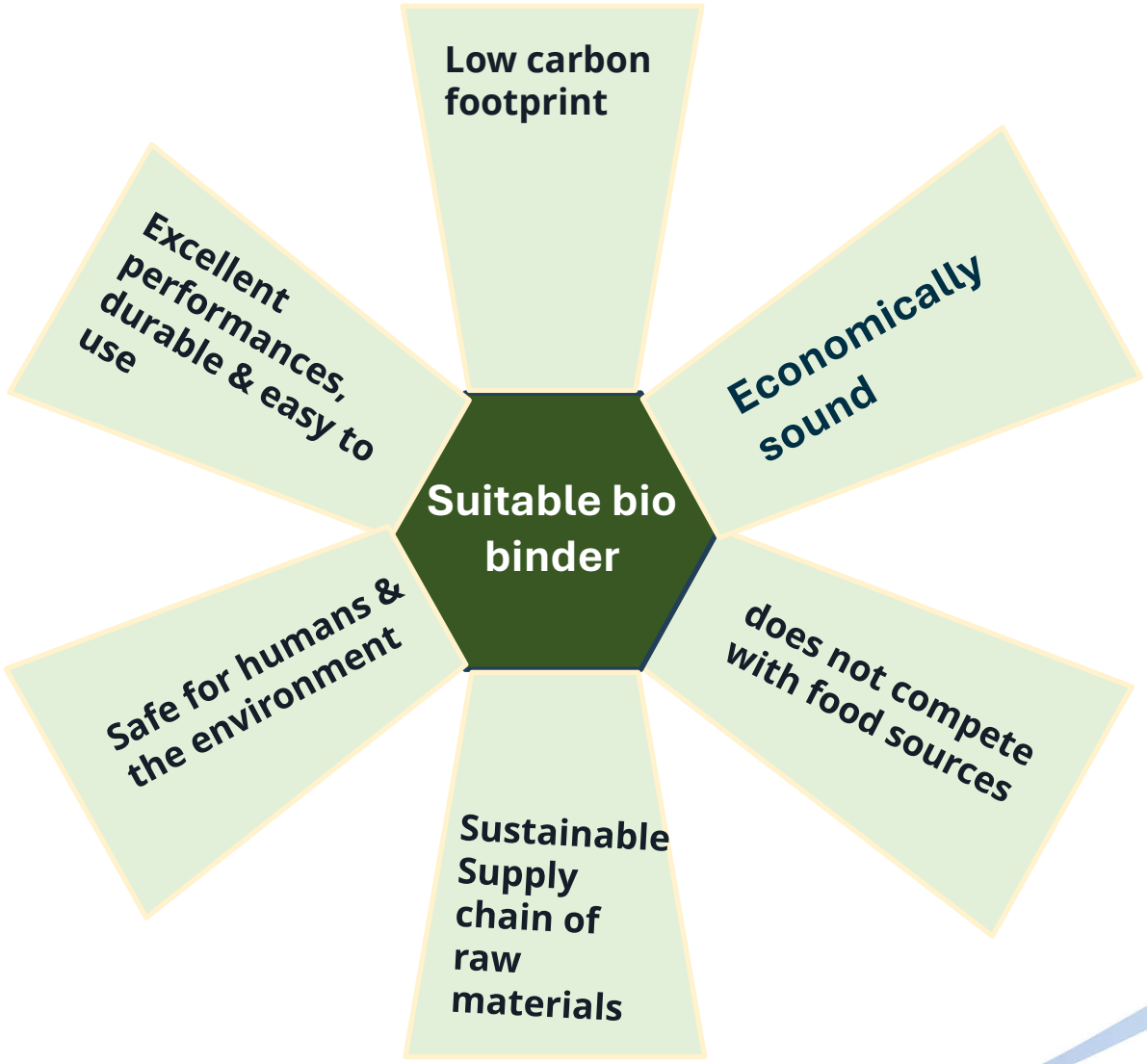


Warm Mix techniques compatible

Foaming ability

Source: Arnaud Waché, AfPA conference 2025

# Start from materials selection

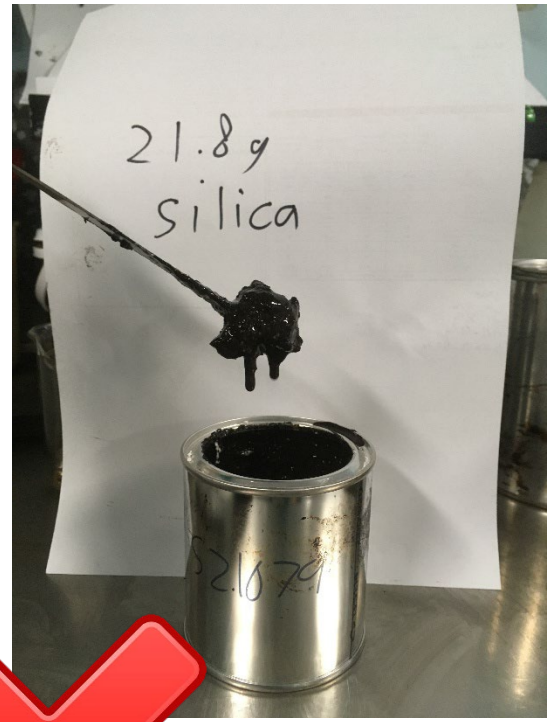




# Carbon Calculation

| Products | Carbon footprint (kg $CO_2$e per ton of product) | Carbon footprint reduction (kg $CO_2$e per ton of product) | Carbon footprint reduction (%) |
|---|---|---|---|
| **Polymer modified binder** | | | |
| Highly modified binder | 868 | -544 | 62% |
| Bio - highly modified binder | 324 | | |
| **Pure bitumen** | | | |
| 60/70 | 425 | -87 | 20% |
| Bio - 60/70 | 338 | | |
| **Polymer modified emulsion** | | | |
| CSS emulsion | 304 | -54 | 17% |
| Bio based CSS emulsion | 250 | | |

# Emulsification of bio binders

## Bio binder type A




Bio binder type A before and after shear testing (left and right image respectively)

## Bio binder type B

- It was possible to make smooth and stable emulsion with bio binder type B

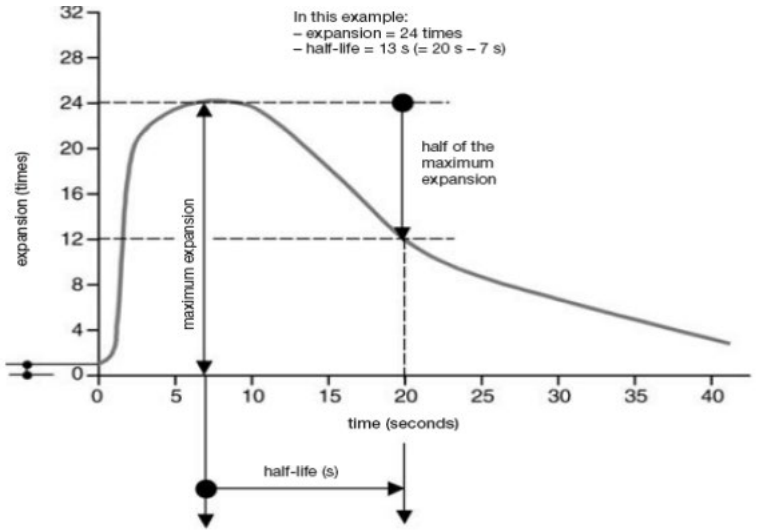
# Emulsion Properties

| | | Results | | Specifications |
|---|---|---|---|---|
| **Test name** | **Test method** | Conventional ETB emulsion | Bio based ETB emulsion | CSS – AS1160-26 |
| **%Binder content** | AS2341.23 | 62.7 | 62.6 | > 60 % |
| **pH** | As manufacturer | 2.97 | 2.63 | 1.5 – 4.0 |
| **Visc 25°C, mPa.s** | AS 2341.4 | 34 | 62 | 25 -75 |
| **Sieve residue 150µm, %** | AS 2341.26 | 0.10 | 0.06 | 0.15 % max |
| **Residue after shear mixing** | SAMI-LCAM-P02 | 0.03 | 0.00 | |
| **Silica stability test** | SAMI-LCAM-P02 | 102.5 | 89.9 | |

# Foaming characteristics

| Bitumen Source | Bitumen Temperature DegC | 1.5% Water | | 2.5% Water | | 3.5% Water | |
|---|---|---|---|---|---|---|---|
| | | Expansion Ratio | Half Life (s) | Expansion Ratio | Half Life (s) | Expansion Ratio | Half Life (s) |
| **Bio-60/70** | 180 | 5 | 17 | 6 | 15 | 5 | 13 |
| **60/70** | 180 | 6 | 13 | 7 | 10 | 10 | 8 |

- **Expansion ratio of bio version is as good as conventional bitumen (without foaming agent)**
- **Half life of bio version is higher than conventional bitumen**
  - **Better workability and compaction**
  - **Ability to coat better**




**<u>2.5% water for foaming was chosen</u>**

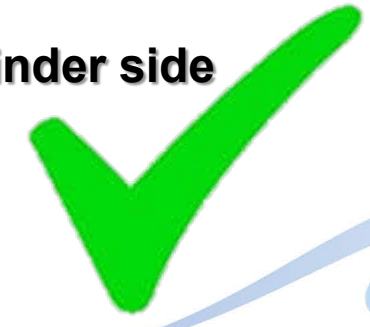
# Foam treated base (FTB) modulus

- Mix was made according to AGPT/T302.
- Binder was added after 1 hour curing of dry test portion + water + 1% lime.
- Water content calculated to reach 0.85*OMC (5.1%).
- Briquettes were compacted straight after making mix at  50 blows on each side of the briquettes.
- Conditioned 3 briquettes at 25C in conditioning chamber for 3 hours as stated in AGPT/T305.
- Conducted intial RM test on each conditioned briquettes at 25C & as stated in AS 2891.13.1
- Briquettes were conditioned at 40C for 72 hours.
- Briquettes were conditioned at  25C for 2 hours before tested.
- Conducted Three-day cured modulus at 25C as stated in AS 2891.13.1.
- Put them in 25C water bath for 24 hours.
- Conducted Soaked modulus test.


# Foam treated base (FTB) modulus

| | Bio – 60/70 | | | 60/70 | | |
|---|---|---|---|---|---|---|
| **Binder content** | **2%** | **3%** | **4%** | **2%** | **3%** | **4%** |
| **Initial modulus (Ei)** | 410.2 | 384.9 | 307.8 | 455.4 | 365.6 | 382 |
| **Three-day cured modulus (E3d)** | 1450.7 | 1400.1 | 1678.6 | 1539.4 | 1463.3 | 1799 |
| **24h soaked modulus (E3s)** | 1170 | 1174.4 | 1322.2 | 777.5 | 1021.2 | 1060.3 |
| **Ratio** | 0.80 | 0.84 | 0.78 | 0.5 | 0.69 | 0.58 |

**Same technical performance but 20% less carbon emission in binder side**



# Conclusion

- Bio-binders can provide a practical pathway to reduce carbon emissions in the pavement industry.
- Several factors must be considered before biogenic materials can be regarded as reliable and suitable for widespread industry use.
- Two key aspects for base treatment applications are the ***emulsibility*** and ***foamability*** of bio-binders.
- This research evaluated the use of bitumen emulsion and foamed bitumen for base treatment using two common biogenic materials currently used in the industry.
- One of the biogenic materials could not be successfully emulsified, while the other produced a stable and high-quality emulsion.
- Foaming was successfully achieved with one of the bio-based binders, with promising foaming characteristics.
- Foam-treated base samples were prepared and tested for resilient modulus under different conditions, then compared with conventional foam-treated base materials.
- The results showed that bio-based foam-treated base can achieve comparable technical performance to conventional FTB while reducing carbon emissions by approximately 20%.

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