Bio-based Additives for Asphalt Applications & Pavement Preservation

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Cargill Industrial Specialties
Cargill’s Role in Asphalt

- Cargill is a large, global provider of solutions in agricultural, food, financial and bio-industrial markets.

1. Cargill Anova™ Modifiers
2. Cargill Anova™ Rejuvenators
3. Cargill Anova™ Green Diluents
4. Cargill Anova™ Anti-strips
5. Cargill Anova™ WMA
6. Cargill Anova™ Emulsifiers
Agenda

• Background on Rejuvenation

• Application Categories:
  1. Rejuvenated High-Recycled HMA
  2. Rejuvenating Pavement Preservation
  3. Rejuvenating Cold Patch
  4. Rheology Modifiers

• Conclusions
Components in Hot-Mix Asphalt

• Aggregate
  – Load carrying component in mix

• Asphalt binder
  – Binds aggregate together
  – Waterproofs

• Air voids
  – Allows for expansion of asphalt binder
  – Allow for compaction under traffic
    • As-built 6 - 8% voids
    • After traffic 3 - 5% voids
Introduction

EFFECT OF ASPHALT AGING

• Pavements age from the surface, downwards
• Aging is affected by rate of air permeability (porosity), climate conditions, UV, etc.
• Aged bitumen is more brittle and less durable.
  • Flaws can quickly become crack initiation points, and eventually water penetration points.
• Excessive use of aged reclaimed asphalt pavement (RAP) can impart same properties to new pavements.
  • An engineered solution is needed…
What is rejuvenation?

• “Rejuvenation” is an inaccurate, but popular term.
  • Rejuvenators do not undo oxidative aging!!!
• A good rejuvenator reverses the impact of aging on asphalt, reactivating the bitumen, to restore performance, and durability.

- Reduce modulus/viscosity
- Restore balance of asphalt fractions
- Restore phase/colloidal stability
- Reduce brittleness / improve damage resistance
- Restore “healing” ability
- Equal (or better) aging behavior than original binder!
Simplified Bitumen Colloidal Model

Unaged Bitumen - Stable

Low Polarity Aromatic Oil

Asphaltene

Resins
Simplified Bitumen Colloidal Model

Aged – Loss of softer fractions

Low Polarity Aromatic Oil

Asphaltene

Resins
Simplified Bitumen Colloidal Model

Aged – Forming Rigid Structures

Low Polarity Aromatic Oil

Asphaltene

Resins
Simplified Bitumen Colloidal Model

After Ideal Rejuvenation…

Low Polarity Aromatic Oil

Asphaltene

Resins

Ideal Rejuvenator
Material Considered in this Presentation

The Rejuvenator:

<table>
<thead>
<tr>
<th>Description</th>
<th>Flash Point</th>
<th>Viscosity at 60°C</th>
</tr>
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<tbody>
<tr>
<td>Chemically Modified Veg oil-based Rejuvenator</td>
<td>&gt;290°C</td>
<td>28.5 mPa.s</td>
</tr>
<tr>
<td>TFO Mass loss</td>
<td>&lt;1%</td>
<td>TFO Visc Ratio</td>
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<tr>
<td>TFO</td>
<td>1.1</td>
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</tbody>
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The Asphalt Binders Considered:

- RAP contents ranging from 30 to 85% by weight of mixture.
- Base binders ranging from XX-34 to PG64-22, as well as pen grades 40/50, 50/70, and 70/100.
- All are dense graded surface and base course mixes.
- All DCT tests done at climatic PG+10 temperature.
- All IFIT and Overlay tests done at 25C.
Rejuvenated High-Recycled HMA
The Potential of high RAP Rejuvenation…
The allowable RAP dosage is often estimated using a blending chart in accordance to PG, R&B, or Pen Grade.

- High Temperature Rutting Resistance
- Low Temperature Cracking Resistance
- Softening Point
- FRAASS
- Penetration
- Extraction & Recovery
- 4mm DSR
- High and Low Temperature
Adjusting Performance using Rejuvenator Dosage

- Normal paving grade bitumen + rejuvenator can perform better than soft bitumen / flux.

Fracture Energy of 61% Recycled HMA using Anova™ Rejuvenator

Anova™ Rejuvenator Dosage (%)
Example #2:

- Rejuvenation resulted in a **high improvement** in durability, with minimal impact on rutting.

Number of Cycles to Cracking Failure
[Overlay Tester Cycles - Field Cores]

APA Rut Depth (mm)
Field Cores
Example #3: 100% RAP HMA

• HMA solely consisted of RAP and Rejuvenator
• Rejuvenator sufficiently activated RAP to achieve +500 J/m² fracture energy.
• No rutting issues observed.
Improved Compaction with Proper Rejuvenation

- Use of the **rejuvenator** significantly improved the Compactability, even after a 20% increase in RAP content.
  - A 25°C improvement in compaction temperatures achieved
  - No over-compaction at hot mix temperatures.
Bio-based Rejuvenating Pavement Preservation
Pavement Preservation

It's all about timing!
Rejuvenating Fog Seals

• A truck mounted spray system is used to apply product at predetermined treat-rate:
  – Often in range of 0.005-0.05 GAL/yd² depending on product type

“Sanding” can be used for rich application points and to boost friction.
Examples of asphalt preserver photos

Untreated control surface
The photo clearly shows accelerated weathering, further defined and development of longitudinal cracking and alligator cracking.

Surface treated
The photo clearly shows lighter weathering, longitudinal cracking and alligator cracking.
Rejuvenating Scrub Seals

Functions of a Rejuvenating Scrub Seal

- Fill existing cracks with a tough polymer-modified emulsion.
- Provide a durable wearing surface.
- Surface rejuvenation over time
Bio-based Rejuvenating Scrub Seal

Sweep dirt and debris

Cover manhole

Rejuvenating emulsion spraying and scrubbing
Bio-based Rejuvenating Scrub Seal

Chip application and rolling

Scrub Seal
Bio-based Rejuvenating Cold Patch Additive
What is Cold Patch?

• Cold mix asphalt mixture for use in patching and leveling applications.
• Sold in bulk, or in bags and buckets
• Used for temporary or permanent patching jobs.
• Temporary patch is used in large cities to cover construction jobs during the day.

• A good cold patch will have these properties:
  – Good storage and stockpile life
  – Good stripping resistance.
  – Good workability and compaction without need for heating
  – Resistant to pull out or rutting
Added Value at up to 100% RAP:

Anova Cutback Bitumen

Potentially up to 100% RAP

3 months later
How is it incorporated?

• **If no bitumen is to be used** in the cold patch, method will depend on necessity of drying the RAP:

  - **Extended chamber for rejuvenator blending**
  - **RAP Dryer with indirect hot oil heating**
  - **Rejuvenator sprayed at entry to mixing chamber**

Rotterdam, Netherlands
Bio-based Rheology Modification
Bio-based Rheology Modifier

RHEOLOGY MODIFIER FOR ASPHALT BINDER

0.5-5% wt.

Bio-based Modifier → Blend → PG 64-22 → PG 58-28

Needs to have following properties:

• High bitumen compatibility
• Good miscibility and simple blending
• Good aging and thermal stability
• Good polymer compatibility
• Produce stable emulsion
Performance Grade and Rheology Modifiers

ENHANCING LOW QUALITY BITUMEN: IMPROVED CRACKING RESISTANCE

- Increases UTI of bitumen through higher softening at lower temperatures without sacrificing the high-end temperature
- High impact at low dosage rate (2-3% by weight of binder)
Improve Workability of PMB

- Significant improvement of PMB workability, without significant loss of elastic recovery, when additive added to finished PMB

![Graph showing improvement in workability and viscosity](image-url)
Conclusions

• Bio-based material, such as from modified vegetable oil sources, can be used to produce compatible and high-performing rejuvenation and rheology modification additive for asphalt and pavements.

• Bio-based rejuvenator dosage can be used as the design property in Performance-based design methodology.

• Proper bio-based rejuvenation can be used as a preventive measure to preserve pavement functionality.

• Bi-based cold patch formulations can utilize up to 100% recycled asphalt content to produce cold mixes and patch material.
REFERENCES:


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