WHY USE REJUVENATORS

- Restoring the properties of aged binder
- Improving mix flexibility
- Reducing consumption of virgin materials
Oxidation of bitumen causes an increase in polarity through formation of carbonyls and sulfoxides primarily in the asphaltene fraction and an increase in polarizability through conversion of aromatic resins to asphaltenes.

As polarity and dispersion forces increase, asphaltene particles bind more tightly resulting in layering. This effect increases with increased oxidation.

The layering of the asphaltene particles imparts rigidity which in turn leads to cracking as viscoelastic properties are lost.

The increase in overall polarity of the bitumen increases its viscosity.
SOL-GEL MODEL OF BITUMEN STRUCTURE

**SOL type**
- Asphaltenes
- High MW, aromatic species

**GEL type**
- Low MW, aromatic species
- Naphthenic compounds

AGING

RESTORATION
REJUVENATION

“Rejuvenation” does not mean reversing the oxidation; rather it means a return of the viscoelastic properties of the binder.

The layering of the asphaltene particles must be interrupted.

A rejuvenating agent should reduce the overall viscosity through a decrease in the effective particle size of the asphaltenes by peptizing the asphaltenes.

A plasticizer will lower the viscosity of the binder by lowering the viscosity of the continuous phase through dilution (like adding water to honey).

A plasticizer will not interrupt the layering of the asphaltenes and will therefore not return the viscoelastic properties and prevent cracking.
Rejuvenators will disrupt the layering and networking of the asphaltenes and stabilize the resulting system.

Plasticizing additives only reduce the viscosity of the surrounding continuous phase.
ROLE OF A TRUE REJUVENATOR

The physical and chemical characteristics to restore aged asphalt to the requirements of current asphalt specifications

- Restoration of Maltene characteristics
- Activate aged binder and not just soften or plasticize the binder
- Eliminate/reduce cracking & maintain/improve rut-resistance.
- High flash point for use in HMA plant
- Disperse readily and maintain miscibility with asphalt binder
- Must be uniform from batch to batch
ADDITIVE PERFORMANCE

- Reproducible
  - Recovery of Viscoelastic Properties
    - Performance Additives/Rejuvenators
- Variable
  - Recovery of Viscoelastic Properties

- Reproducible
  - Reduction of Viscosity
    - Soft Binder
    - Flux Oils
    - Process Oils
- Variable
  - Reduction of Viscosity
    - Agriculturally Based Products
    - Recycled Vegetable Oils
    - REOB
REJUVENATORS SHOULD POSITIVELY IMPACT THE PERFORMANCE

RAP Master Curve $G^*$ at 10 rad/s

- Relaxation and cracking resistance
- Compaction and workability
- Rutting resistance

G* (Pa)

Temperature (°C)

- PG64-22
- RAP
- RAP + Rejuvenator
- RAP + Rejuvenator
Exudation droplet test measures miscibility as a function of exudation as visible under UV light, after storage under 60°C for 96 h.

Droplet of binder is placed in a 10 mm by 1 mm cell on a smooth marble plate.

Performance additives blended with asphalt resulted in no additional exudation.

Single phase system not bi-phase.
### IDEAL PERFORMANCE ADDITIVE PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Easy to use</strong></td>
<td>Liquid at room temperature; easy addition to the system. Easy to use at low temperatures.</td>
</tr>
<tr>
<td><strong>End Performance</strong></td>
<td>Improved Texas Overlay Test results. Improved Hamburg/APA Test results.</td>
</tr>
<tr>
<td><strong>Safe</strong></td>
<td>No risk at elevated process temperatures. Safe to use, no harm to workers.</td>
</tr>
<tr>
<td><strong>Stable</strong></td>
<td>Product does not degrade in mix plant or over time on the road; properties are maintained. No exudation.</td>
</tr>
<tr>
<td><strong>Sustainable</strong></td>
<td>No competition with food source.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low viscosity</td>
<td>Cloud point – stable over wide temperature range.</td>
</tr>
<tr>
<td>User friendly</td>
<td>Improved cracking resistance. Improved rutting resistance.</td>
</tr>
<tr>
<td>High Flash Point</td>
<td>Non-hazardous.</td>
</tr>
<tr>
<td>Excellent thermal and oxidative stability</td>
<td>Fully miscible with bitumen.</td>
</tr>
<tr>
<td>Produced from bio renewable feedstock</td>
<td></td>
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</tbody>
</table>
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QUESTIONS