3.6 Designing a toolbox for bitumen to answer the need for tomorrow's pavement

Laurent Porot

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Abstract

The asphalt industry is facing some key challenges. There is a need to move towards more sustainable and environmental friendly solutions to construct the pavements for tomorrow. This has to answer the market needs for greater performance with improved warranties, increased safety and less impact on environment, all in required budget constraints. At the same time, there is an even greater diversity in binders, petroleum based binders from different sources or processes for which bitumen quality may be affected. Up to now, specifications and characterisation for asphalt binders have been designed for known petroleum-based bitumen. With complex binders, more fundamental understanding and properties have to be considered to really capture the long-term benefits in road and airport engineering. And finally, beyond the technical requirements, sustainable aspects need to be part of the design including circularity, environmental impacts, health and safety amongst others. This is an important paradigm where new technologies are needed and adjustment of designing materials.

Thus, the need for new solutions are becoming increasingly common practice. Designing the exact solution may depend on various parameters such as the nature of the modifier, the dosage level, or the expected effects on the binder, on the asphalt mix and finally on the pavement. It can be viewed as a toolbox where different options can be selected and combined together to adjust the properties of the binders that fits the need for pavement applications.

Through some examples with the specific use of polymers and bio-based additives, an example of general framework will be discussed to be served as a toolbox to design materials to bring the frontiers of road and airport engineering a step further to the future.

About the speaker

Laurent is Market Development Manager at Kraton, based in the Netherlands, in charge of technical development for polymer and pine chemical additives in paving and roofing application. He has a master degree of civil engineering from Ecole Nationale des Ponts et Chaussees, France. With 30 years of experience, he has capitalised a worldwide expertise on pavement engineering with pavement design, materials, job works and research & development.

He is member of numerous international scientific committees and representative in industry association. He has been working with key research institutes in the field of asphalt and pavement materials within projects and inter-laboratory experiment. With a robust technical background he extended his learning on environmental impacts and Life Cycle Assessment. He is passionate about interacting with people to design more sustainable solutions.

iFRAE DELFT 2021 5th International Symposium on Frontiers of Road and Airport Engineering

Workshop: Changes in binder properties and the role of additives

Designing a toolbox for bitumen to answer the need for tomorrow's pavement

Laurent Porot, Kraton Polymers B.V. the Netherlands

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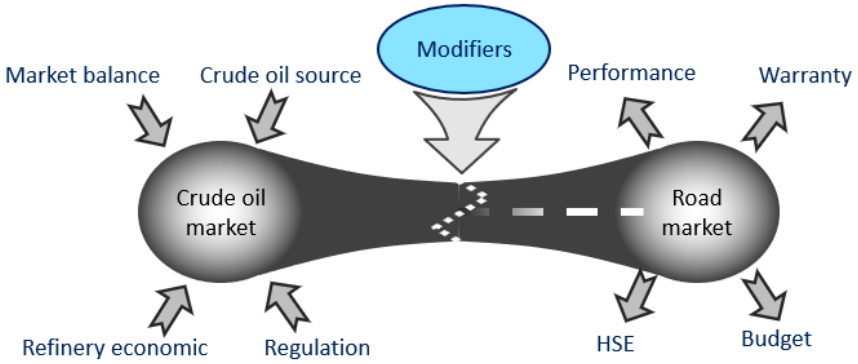
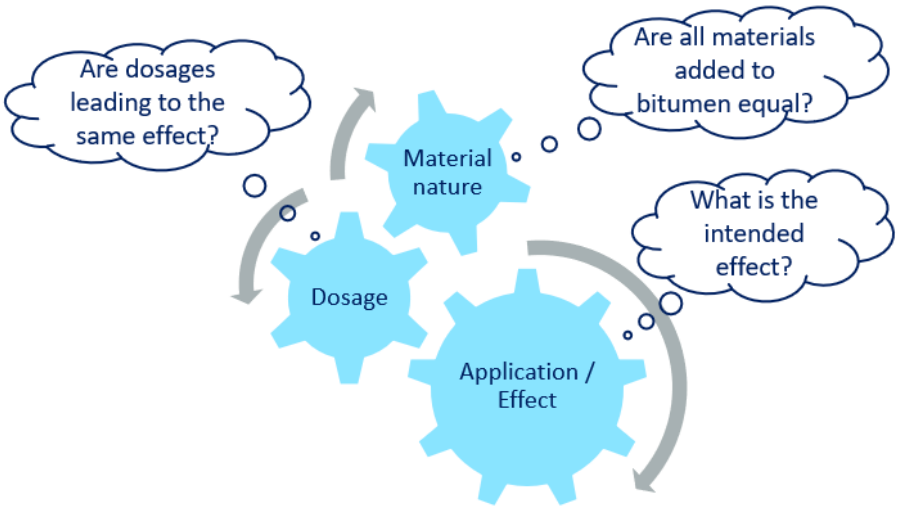
Designing a toolbox

The today bitumen world



More needs for modifiers



Various options

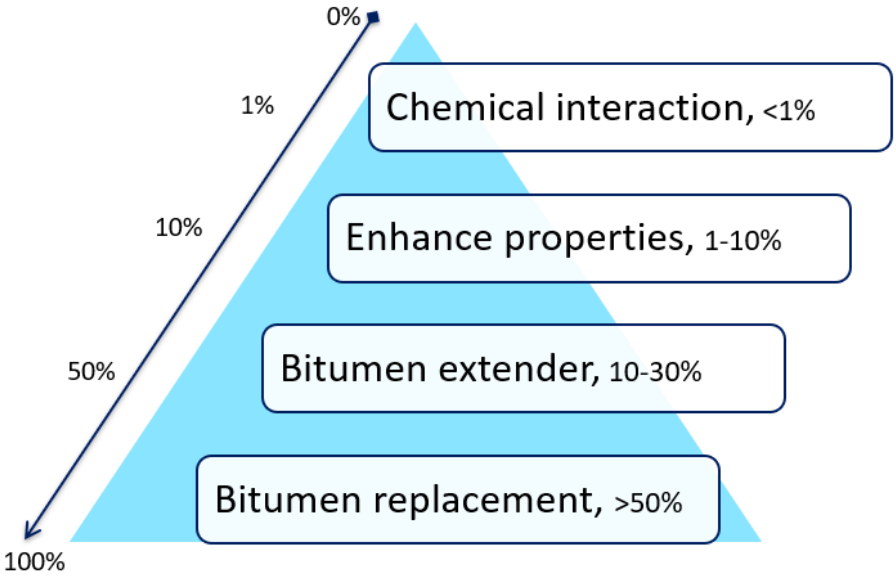
Solid particles (natural asphalt, lignin, waxes,...)

Polymers (elastomers, plastomers, PE,...)

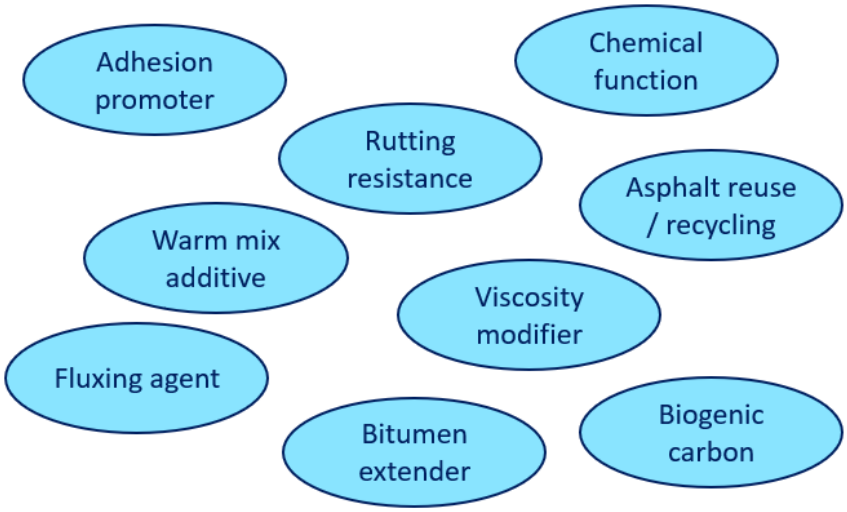
Viscous / semi-liquid (Flux, REOB,...)

Liquid additives (antistripping, warm mix additives,...)

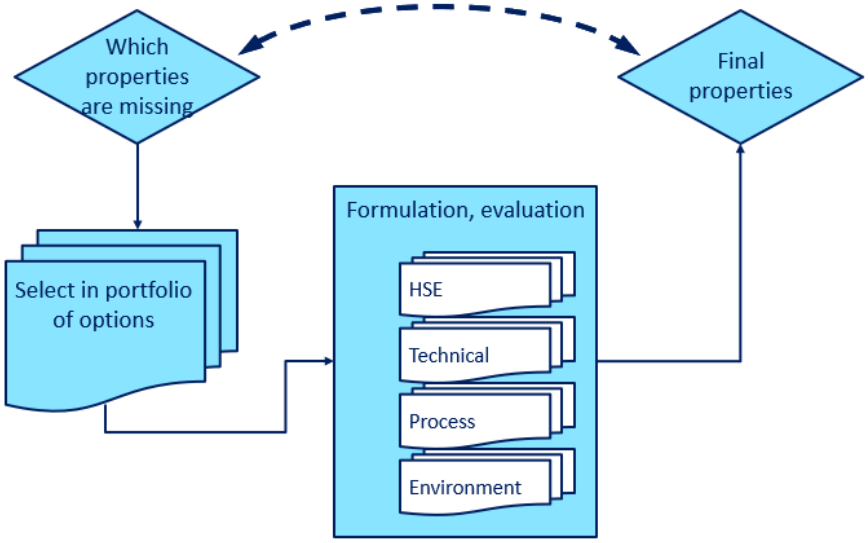
Dosage level



Application types



Need for a toolbox

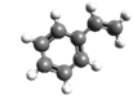


Designing a toolbox

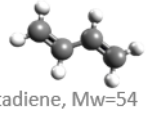
Example with SBS polymer

What is SBS

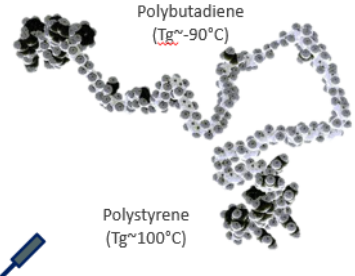
- **S**tyrene-**B**utadiene-**S**tyrene polymers
  - Thermoplastic elastomer block copolymers
  - From monomers, Styrene and Butadiene



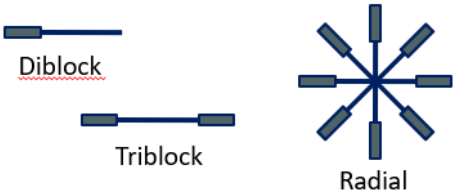
Styrene, Mw=104



Butadiene, Mw=54

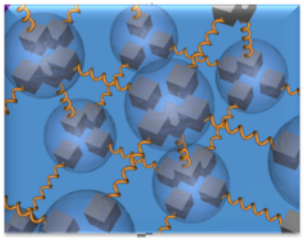


  - Different structures



SBS polymer in bitumen

- SBS dissolves in bitumen to form an elastic network
  - Leading technology for bitumen modification
- Key features in bitumen
  - Greater resistance to rutting
  - Improve durability
  - Extended life time by 20-30% as compared to non modified*
  - Recyclable

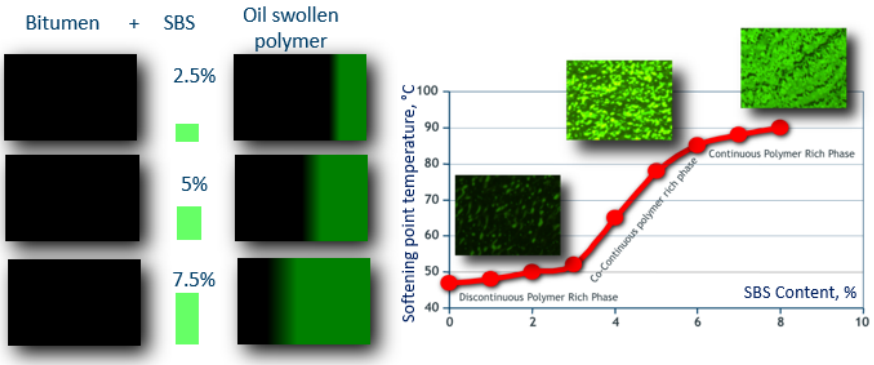


Elasticity is key

* Asphalt Institute, ER-215 Engineer's Report: Quantification of the effects of PMA for Reducing Pavement Distress, 2005

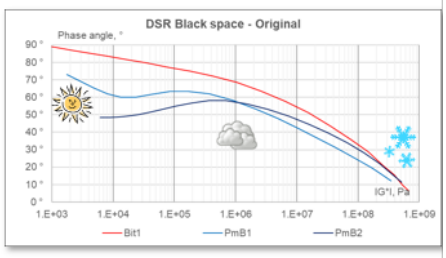
How SBS behaves in bitumen

- SBS swells in oil phase, increasing volume by 7-10 times
  - Balance between bitumen / polymer rich phase
  - Direct influence in elastic behaviour

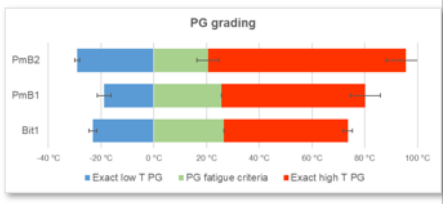


Overall effect on properties

- Effect on rheology
  - Higher elasticity with rubber plateau at high Temperature



- Effect on specification
  - Increase high T
  - Maintain low T
  - Reduce temperature susceptibility

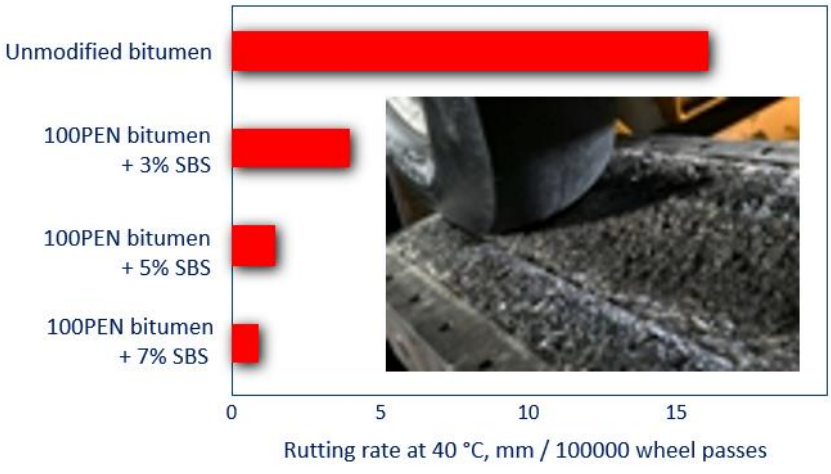


Bit1 is 35/50 pen bitumen, PmB1 is standard PmB, PmB2 is highly modified PmB

From "Characterisation of complex polymer modified bitumen with rheological parameter", L. Porot et al, EATA 2021, doi.org/10.1080/14680629.2021.1910070

Effect on asphalt mix

- Wheel tracking test – rutting resistance

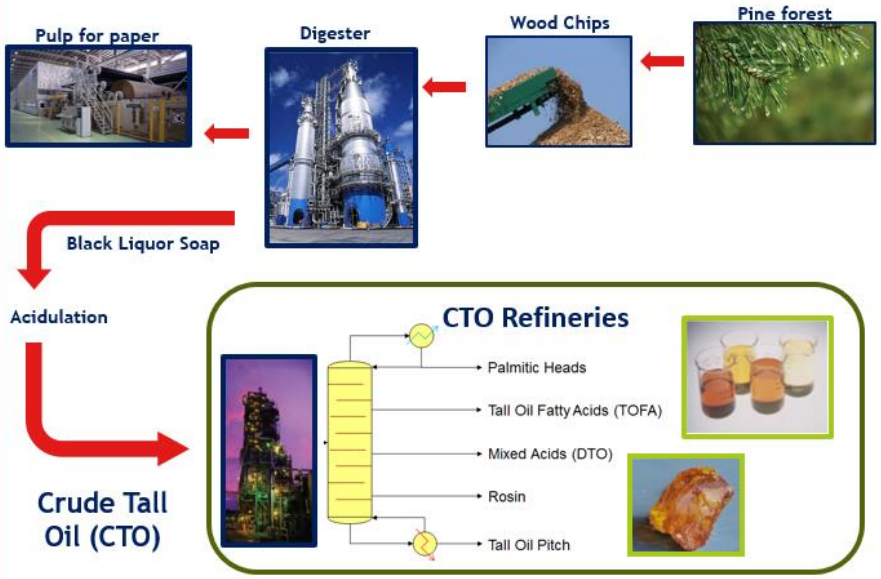


Designing a toolbox

Example with SBS polymer

Examples with pine chemistry additives

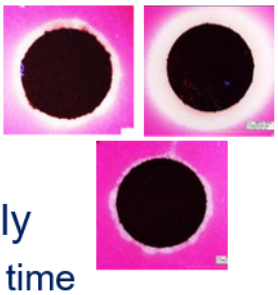
What is Pine chemistry?



Pine chemistry in bitumen

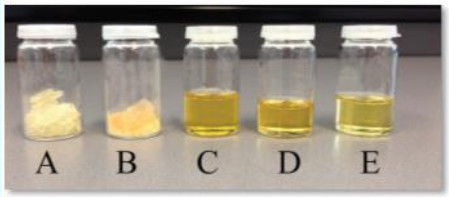
- HSE benefits
  - Products from bio-renewable feedstock
  - No known harmful additional emission (PAH, VOC)
- Compatibility with bitumen
  - "Young" bitumen like
  - Molecule structure similar to bitumen ones
- Consistent quality and supply
  - Pine trees have long growing time
  - Processed products to meet specification

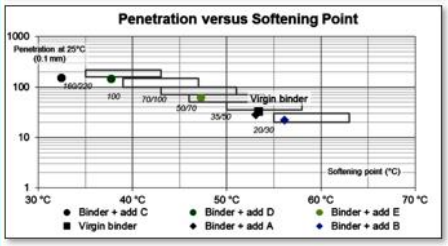
Example from exudation droplet test



Effect on physical properties

- Enable to control independently the properties of bitumen





From "Effect of bio-baed additives on bitumen properties" A. Grilli et al, RMPD Vol20-8 2019, doi.org/10.1080/14680629.2018.1474790

Dope for bitumen emulsion

- Chemical dope for bitumen in emulsion
  - Mimic the functionality of naphthenic bitumen
  - Low effective dosage <1%
- Effect on bitumen emulsion
  - Maintain good storage stability
  - Enable better control of breaking index
  - No impact on physical properties

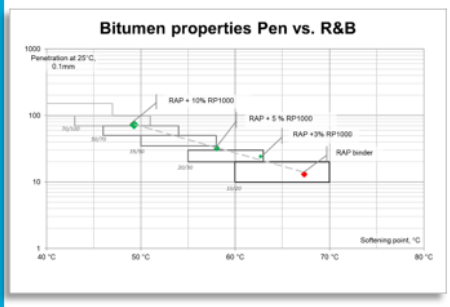
Bitumen emulsion properties EN 13808

	Unit	no additive	1% additive
Eflux time	s	47	46
Breaking index	s	160	135
Settlement tendency	%	43.9	26.4

Breaking index

Storage stability

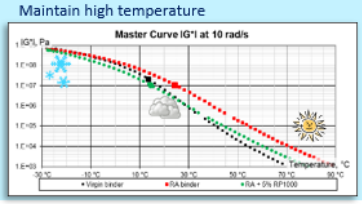
Asphalt Reuse Additive for RA



5% dosage improves aged binder by 2 grades

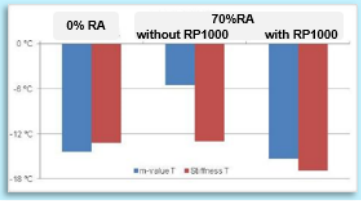
Properties in wide conditions

- Improve low temperature
- Restore intermediate temperature
- Maintain high temperature



Restore long-term flexibility

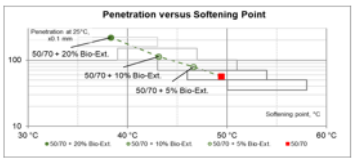
- Low temperature after long-term aging (BBR after PAV)

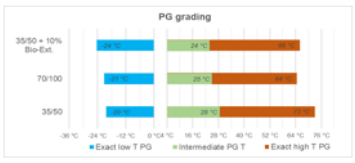


From "Asphalt and binder evaluation of asphalt mix with 70% reclaimed asphalt" L. Porot EATA 2017, doi.org/10.1080/14680629.2017.1304259

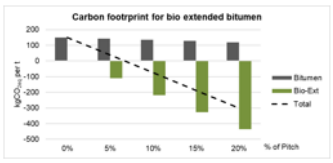
Bio-bitumen extender

- Effect on physical properties
  - A dosage of 5% reduces by 1 grade softer
  - Various applications as visco-grade, extender





- Environmental effect
  - Comes with carbon credit



Carbon offset between 5% and 10%

From "Pitch in bitumen application", L. Porot et al, August 2020 doi:10.13140/RG.2.2.21500.36487

Designing a toolbox

Example with SBS polymer

Examples with pine chemistry additives

Key takeaways

The need for toolbox

- Constant changes
  - In material properties: bitumen, mix design
  - In specifications: regulation
  - In demand: future mobility, circularity
- A path for advanced technologies
  - Existing solutions
  - New developments
- Evaluation framework
  - Going beyond standard specifications

Examples of possible technologies

- Polymer modified Bitumen to enhance high traffic road performances
- Bitumen rheology modifiers
- Chemical dopes to address chemical functions
- Asphalt recycling additive to take recycling to the next level
- Bio-bitumen extender to improve the carbon footprint
- …

Evaluation framework

Disclaimer

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Thank you!

Laurent Porot, Kraton Polymers B.V. the Netherlands

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