

KPE-CEAB CHARACTERIZATION AND EVALUATION OF ASPHALT BINDER PROPERTIES (CEAB)



Rijkswaterstaat
Ministry of Infrastructure
and Water Management



Seminar: 'Bouwen op Kennis'

*Met KPE naar een
klimaatneutrale weg*

1 november 2021

DR. X. LIU
DR. S.N. NAHAR
DR. P. LIN

**Knowledge-based
Pavement
Engineering
2020-2024**

TNO  **TU Delft**

BACKGROUND OF CEAB

OVERVIEW OF REFINERIES TRANSITION



Bitumen production capacity closures.

New (re-)entries.



Pernis (Shell)

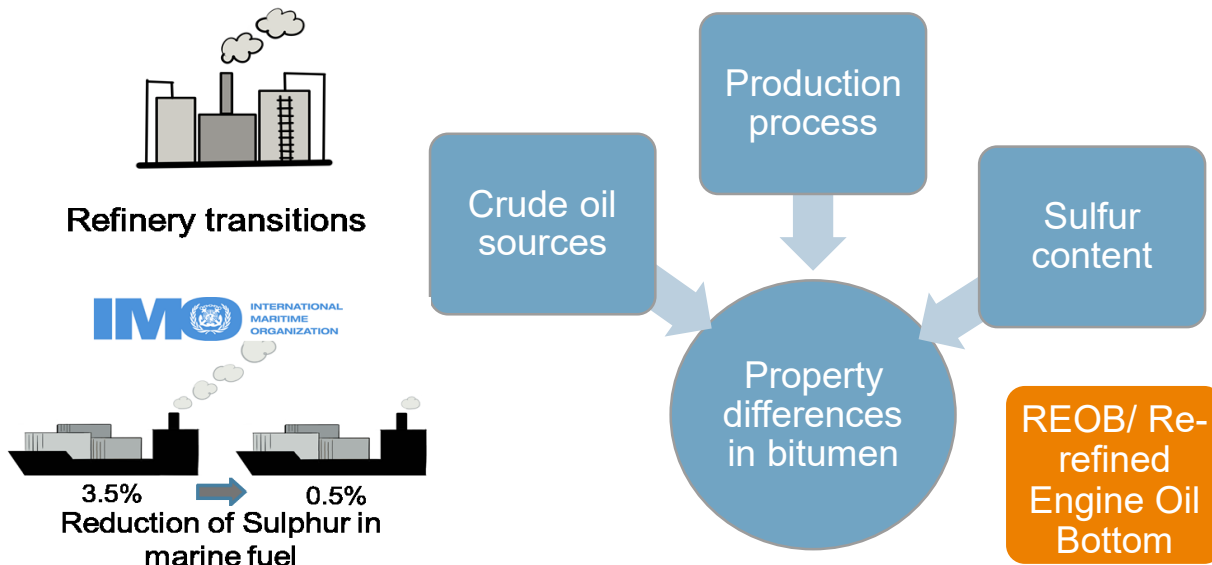
Harburg (Nynas)

BACKGROUND OF CEAB

DRIVERS OF THE CHANGE

Changes in the Bitumen Industry

- Refineries are in transition
- Changes in fuel demand
- Closure of bitumen production in refineries around this region
- Change in legislation: IMO 2020
- Variation in refinery feedstocks



Changes in the Asphalt Industry

- High RAP content in new asphalt mix
- Changing of recycling methods of RAP
- Evolution of rejuvenator types and application methods
- Use of sustainable/recycle source of raw materials



KNOWLEDGE BASED PAVEMENT ENGINEERING – KPE & CEAB

DEVELOPMENT OF ASSESSMENT METHODS

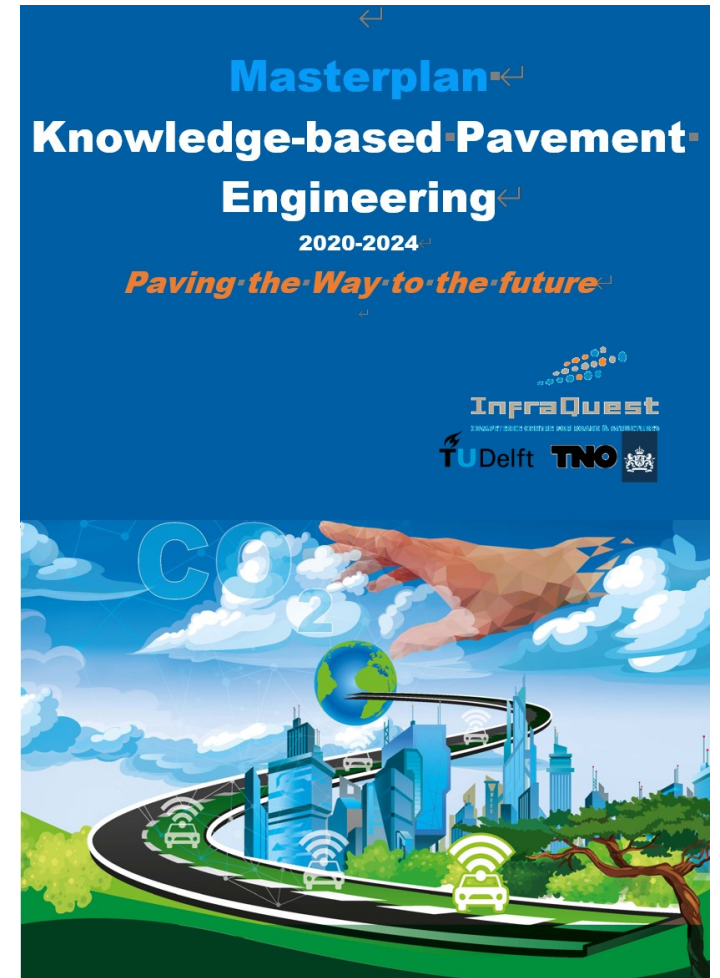
Trends & developments

Materials are changing rapidly:

- ▮ Design
- ▮ Production/construction
- ▮ Service life

Themes and process:

- ▮ Assessment methods per damage mechanism
- ▮ Effect of constituent materials/additive property on asphalt concrete performance
- ▮ Effect of material degradation on the initial properties and expected life time
- ▮ Monitoring in the field
- ▮ Life time prediction
- ▮ Connecting practice, research and regulations

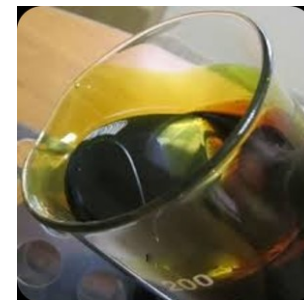


CHARACTERIZATION AND EVALUATION OF ASPHALT BINDER PROPERTIES (CEAB)

- *Task 1* Mapping changes in bitumen/rejuvenator properties
- *Task 2* Assessment of bitumen/rejuvenator properties
- *Task 3* Properties in relation to durability
- *Task 4* Impact and assessment of bitumen/rejuvenator properties in relation to asphalt mixture performance
- *Task 5 & 6* Planning & Dissemination

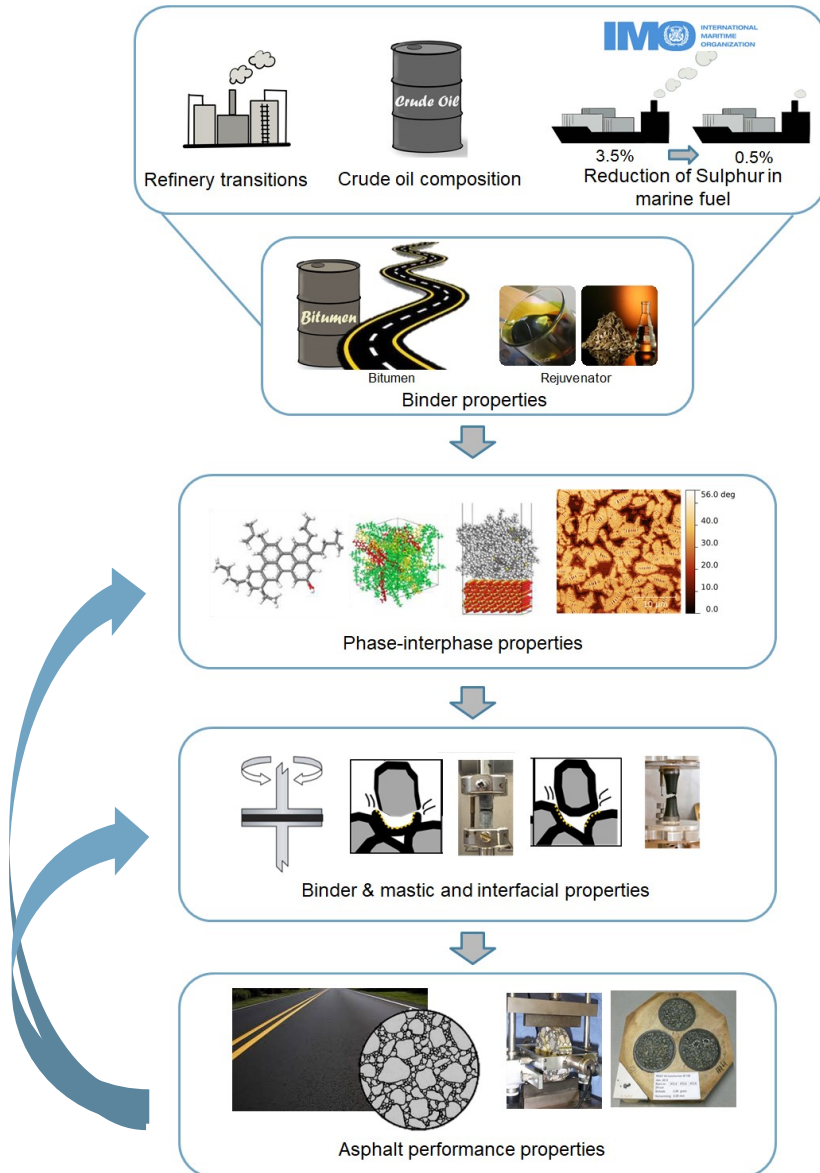


Bitumen



Rejuvenator

APPROACH



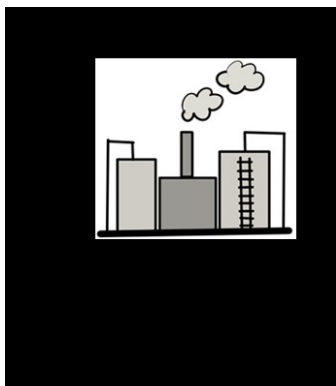
- ❑ Mapping changes in bitumen/rejuvenator properties
 - Changes in property aspects in the bitumen market
 - Rejuvenation market and its current trends
- ❑ Micro Scale: Characterizing bitumen/rejuvenator quality
 - Property assessment of neat bitumen
 - Property assessment of rejuvenators and rejuvenated bitumen
- ❑ Meso Scale: Link bitumen/rejuvenator quality to durability
 - Assessment of bitumen quality to its durability
 - Influence of rejuvenator on durability of aged binder
- ❑ Macro Scale: Impact and assessment of bitumen/rejuvenator properties in relation to asphalt performance

DESCRIPTION OF THE TASKS

TASK 1 MAPPING CHANGES IN BINDER PROPERTIES

SUB TASK 1.1 CHANGES IN THE BITUMEN MARKET

- Nature and origin of the bitumen
- Transition in refineries and its impact on the production process
 - Upgrading of refineries
 - IMO 2020
- Health and safety aspects in the value chain
- Production of range of bitumen grades by blending process, e.g. Re-refined Engine Oil Bottom (REOB).
- Evaluation method available for property assessment: state of the art



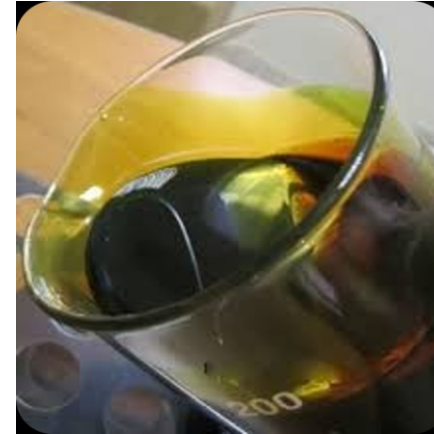
A review on current insights and understanding of the influence of IMO policy, refining methods, crude oil sources has been drafted.



TASK 1 MAPPING CHANGES IN BINDER PROPERTIES

SUB TASK 1.2. REJUVENATION MARKET AND ITS CURRENT TRENDS

- Origin, production process, and chemical nature of the rejuvenators
 - Aromatic extracts and naphthenic oils
 - Bio-oils from agro/forest/ specially engineered
 - Waste oils
 - Recycled oils
 - LVO rejuvenator
- Functions of rejuvenators.
 - Decrease viscosity and improve workability
 - Improve fatigue and low temperature cracking resistance
 - Improve adhesion to aggregate (recycled asphalt)
 - Compatibility between fresh and recycled bitumen
- Evaluation method available for quality assessment-state of the art
- Availability and practical experience



Aromatic Extracts



Paraffinic Oil



Bio-based Oil



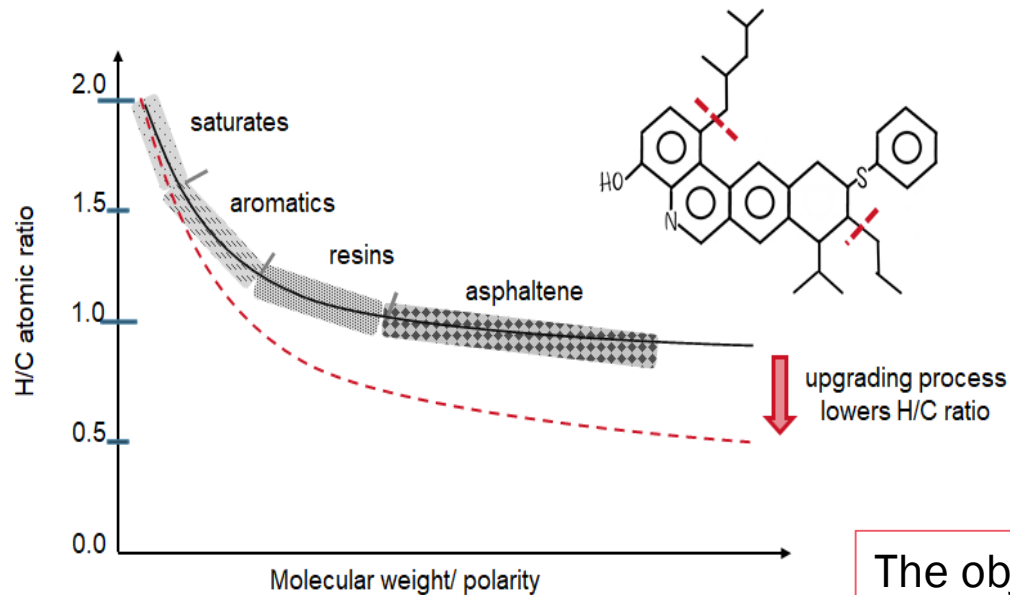
Naphthenic Oil

a review on the understanding the state of art of rejuvenator market and the impact of rejuvenator properties on the performance of pavement structure has been drafted.

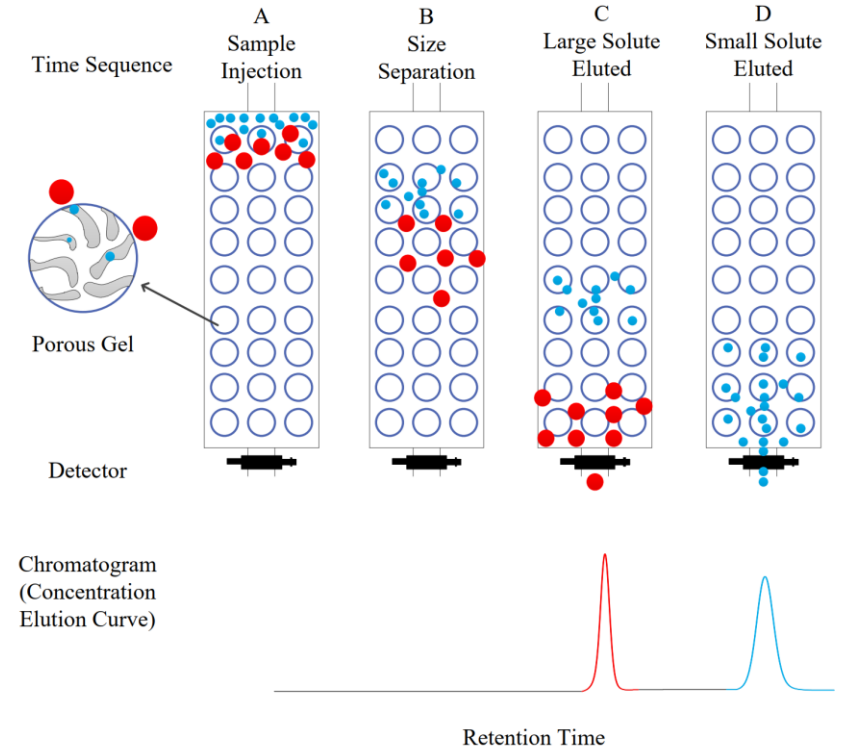
TASK 2 ASSESSMENT OF BINDER PROPERTIES

SUB TASK 2.1. ASSESSMENT OF PROPERTIES OF THE NEAT BITUMEN

- Selection of bitumen from different processes and origins
 - Assessment of chemical composition
 - Assessment of mutual compatibility
 - Assessment of temperature susceptibility with a focus on low temperature



Schematic of H/C atomic ratio of SARA fractions



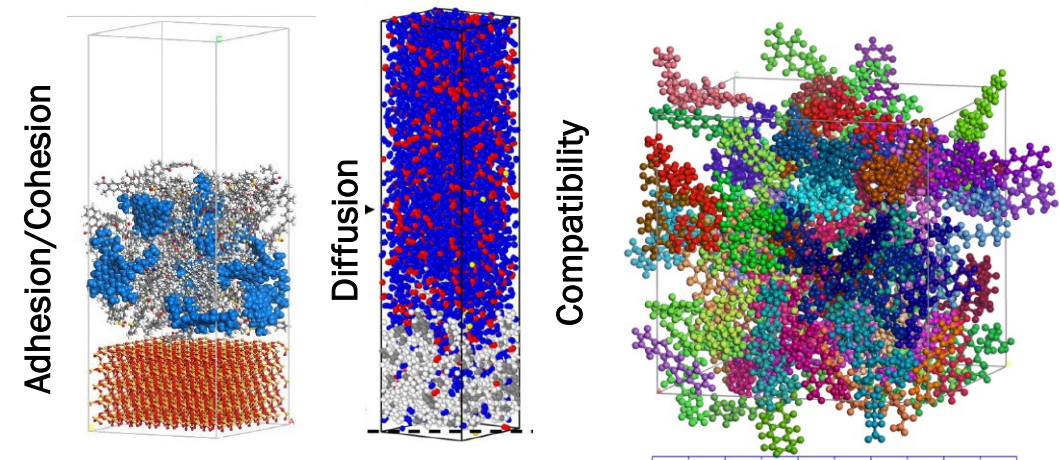
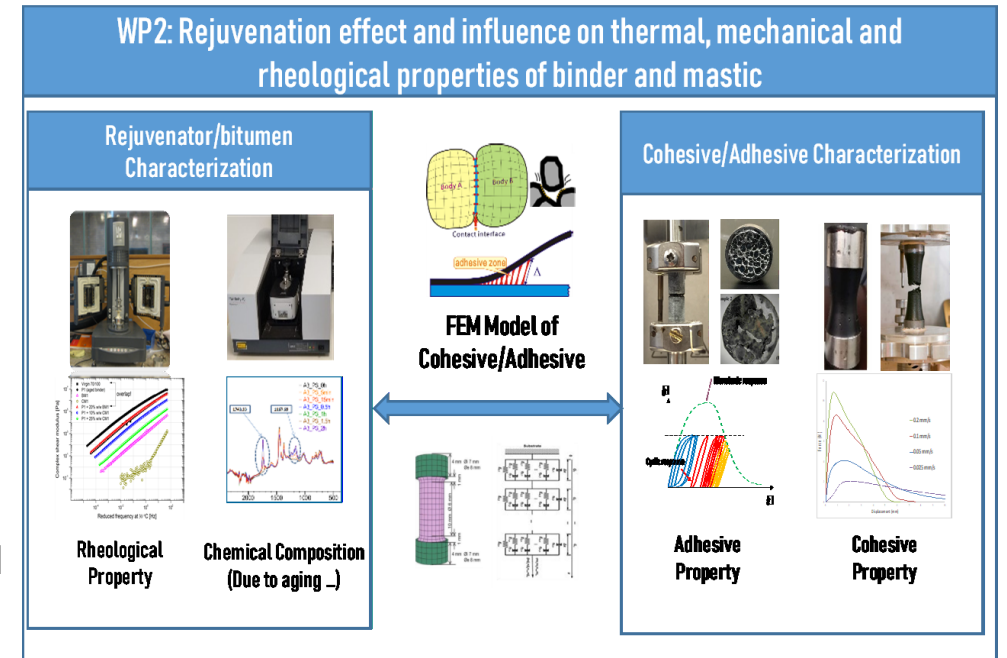
Schematic of GPC analysis

The objective is to fingerprint different type of bitumen and find the link between bitumen's chemical composition and properties.

TASK 2 ASSESSMENT OF BINDER PROPERTIES

SUBTASK 2.2. ASSESSMENT OF PROPERTIES OF REJUVENATORS AND REJUVENATED BITUMEN

- Selection of typical represented rejuvenator ingredients
- Fundamental mechanism of rejuvenation (Molecular Level)
 - ▮ Experimental
 - ▮ Assessment of **chemical** composition
 - ▮ Assessment of **rheological** properties
- **Molecular dynamics** simulation
 - ▮ Viscosity-lowering or softening potential
 - ▮ Chemical composition compensation and compatibilization potential
 - ▮ Re-dispersing potential
 - ▮ Adhesive/cohesive property improving potential
- **Effect of rejuvenator** in the base bitumen (Binder Level)
 - ▮ Viscosity-lowering or softening potential
 - ▮ Chemical composition compensation and compatibilization potential
 - ▮ Re-dispersing potential
 - ▮ **Rejuvenation mechanism**

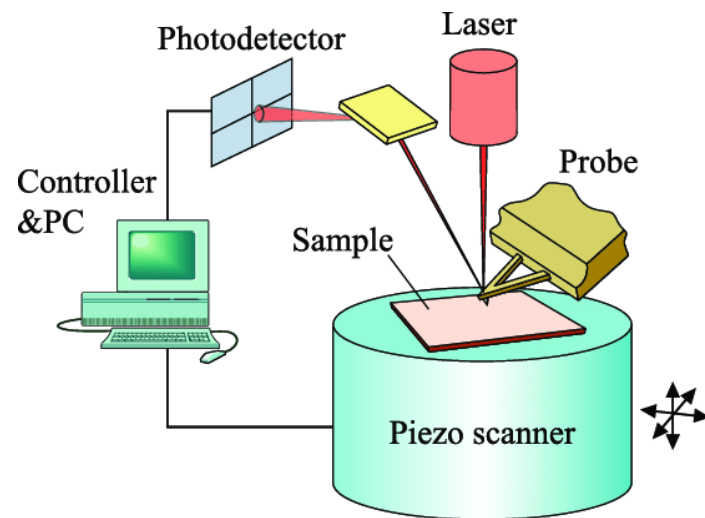


04 DESCRIPTION OF THE TASKS

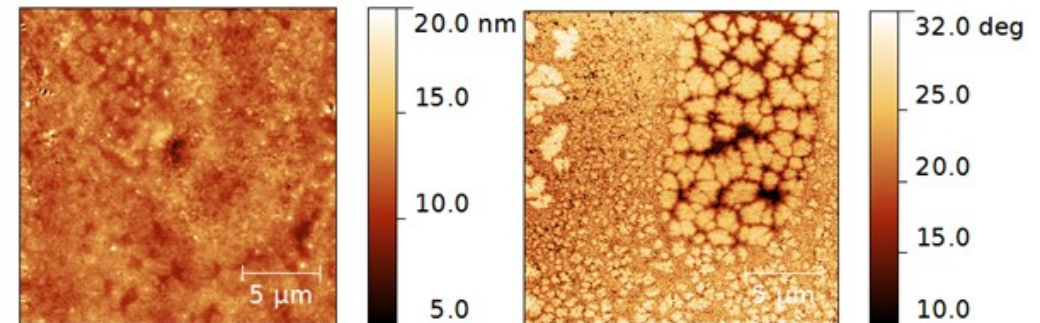
TASK 3 PROPERTIES IN RELATION TO DURABILITY

SUB TASK 3.1. ASSESSMENT OF DURABILITY OF BITUMEN FROM DIFFERENT SOURCES

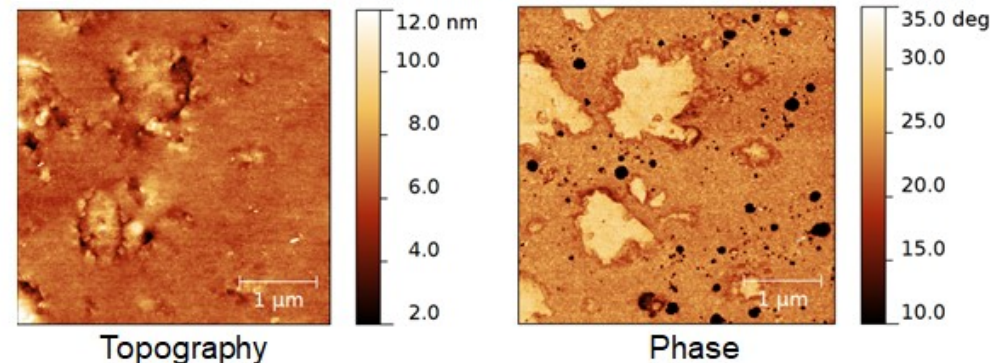
- Resistance to oxidation and physical hardening
- Resistance to moisture damage
- Potential for recyclability



Incompatibility due to different chemical nature of the components



Emergence of new phase after oxidation

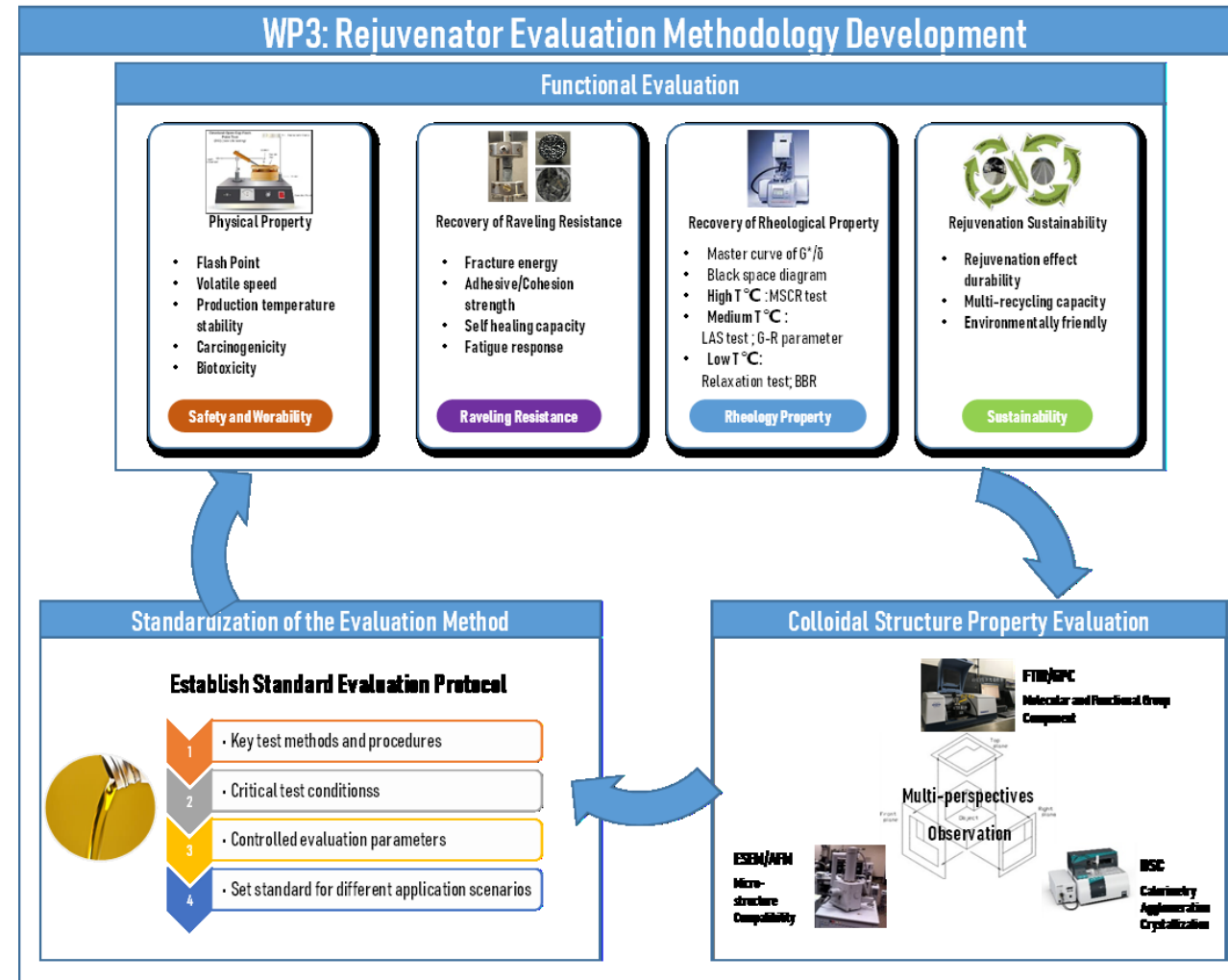


The goal is evaluation of the susceptibility of the binder to oxidation and physical hardening and how these influence the resistance to the raveling-damage mechanism;

TASK 3 PROPERTIES IN RELATION TO DURABILITY

SUB TASK 3.2. ASSESSMENT OF DURABILITY OF REJUVENATED BITUMEN

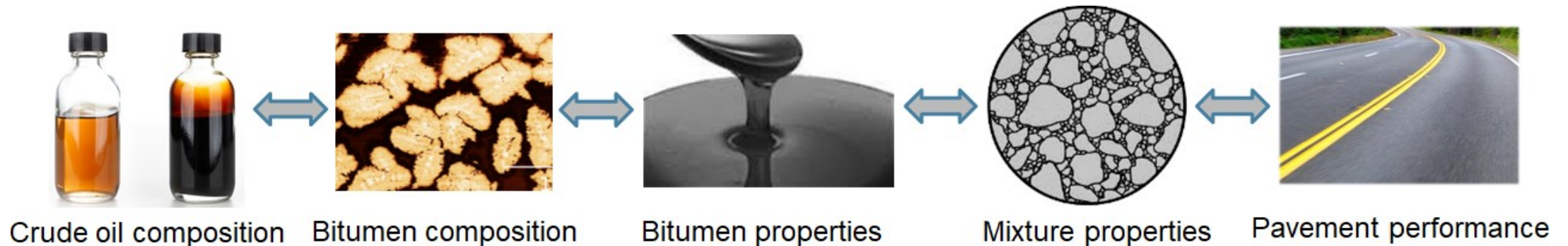
- Establish the connection among bitumen quality, rejuvenator types and raveling resistance
 - ▮ Resistance to oxidation
 - ▮ Resistance to moisture damage
 - ▮ Potential of re-recyclability
- Evaluation of adhesive/cohesive capacity of rejuvenated bitumen
 - ▮ Binder level
 - ▮ Mastic level
- Establish advanced evaluation method for rejuvenator and rejuvenated bitumen
 - ▮ Functional Evaluation
 - ▮ Colloidal Structure-Property Evaluation



TASK 4 IMPACT AND ASSESSMENT OF BINDER PROPERTIES IN ASPHALT PERFORMANCE

SUB TASK 4.1. EVALUATION OF BITUMEN PROPERTIES IN RELATION TO ASPHALT PERFORMANCE

- Evaluation in severe thermal cycles
 - Freeze/thaw cycle
 - TSRST (*Thermal Stress Restrained Specimen Test*)
- Evaluation of raveling resistance



The goal is bridging the knowledge of chemical composition, rheological parameters at the binder scale to the performance of asphalt mixture.

TASK 4 IMPACT AND ASSESSMENT OF BINDER PROPERTIES IN ASPHALT PERFORMANCE

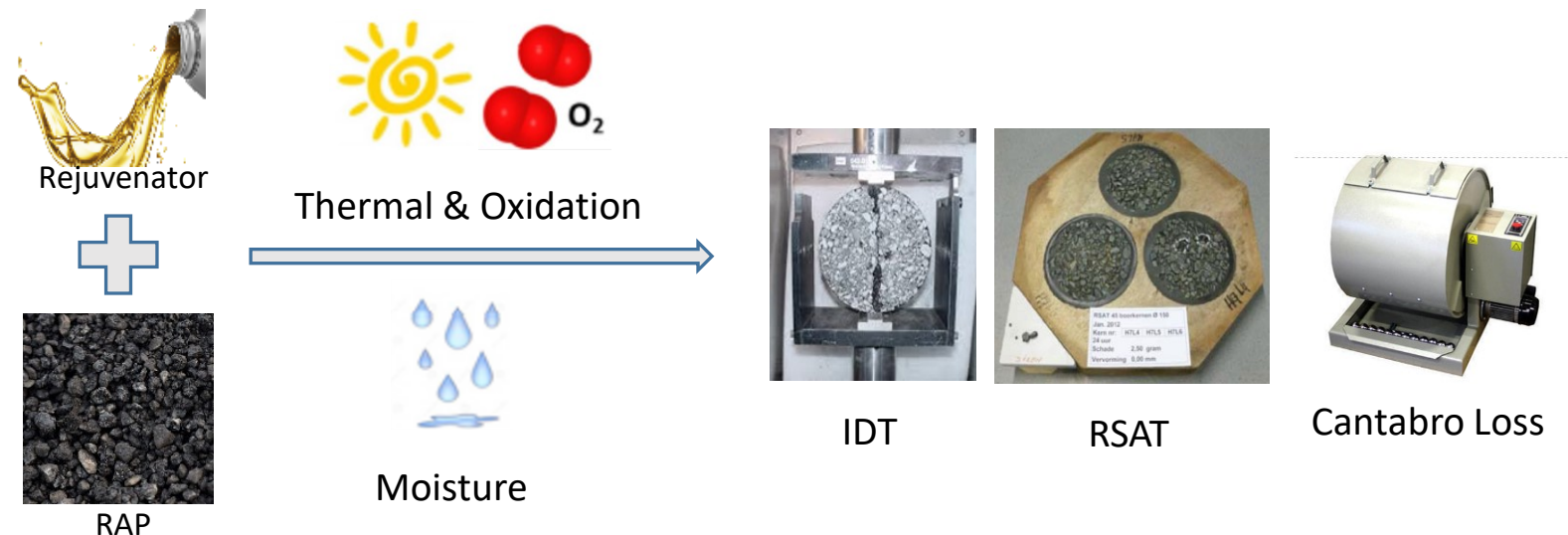
SUB TASK 4.2. EVALUATION OF REJUVENATORS IN RELATION TO ASPHALT PERFORMANCE

Evaluation of raveling resistance in extreme test conditions

- Moisture
- Aging
- Freeze/thaw cycle

Evaluation methods

- RSAT (Rotating Surface Abrasion Test)
- Indirect tensile strength ratio (ITSR)



The goal is to validate the evaluation methods established in previous Tasks, and find the link between rejuvenated binder and asphalt mixture and also the predictions of actual pavement performance.

TASK 5 & 6 PLANNING AND DISSEMINATION

- Yearly review on planning will be performed in the 4th quarter every year.
- Dissemination-Progress report
 - Provide a yearly progress report to the technical advisor from RWS.
 - The results will be discussed in CROW Infradagen in **the Netherlands**
 - Present and discuss the results in **European** events like Eurobitume and Euroasphalt (**E&E**) conference and European Asphalt Technology Association (**EATA**) bi-annual conference
 - Participate and show-case the research in international platforms like the annual meeting of 'Transportation Research Board' (**TRB**) in the **USA**
 - Workshops or web-based seminars (i.e. webinars) will be arranged **twice** in the 4 years period





**THANK YOU FOR
YOUR TIME**

DR. X. LIU

DR. S.N. NAHAR

DR. PENG LIN