PAPER 47:
REVIEW ON THE ROLE OF SULFUR IN BITUMEN PROPERTIES

Sayeda Nahar, TNO

Liz Mensink, Rijkswaterstaat

Xueyan Liu, Peng Lin, Delft University of Technology

Ministerie van Infrastructuur en Waterstaat

TU Delft

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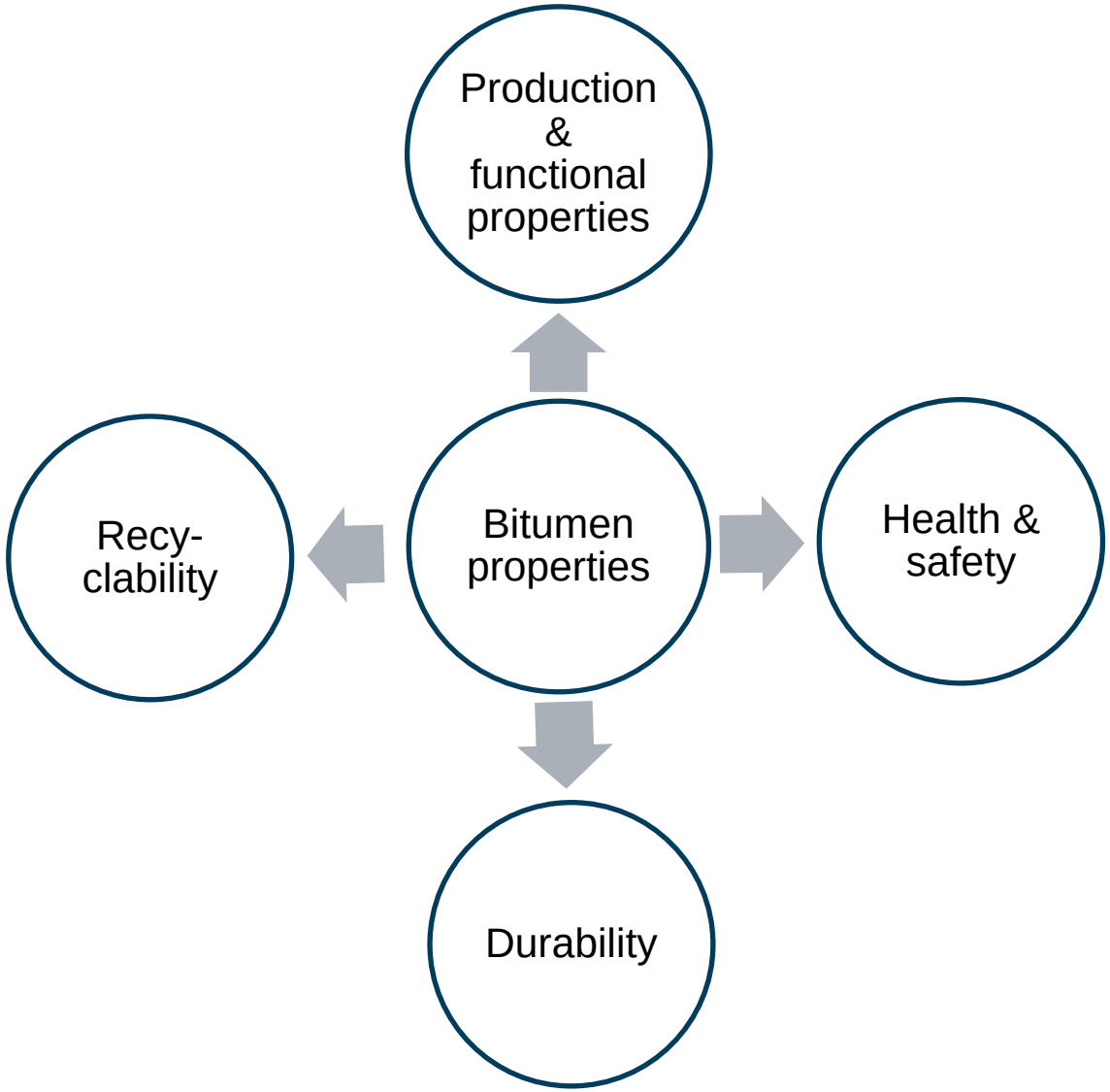
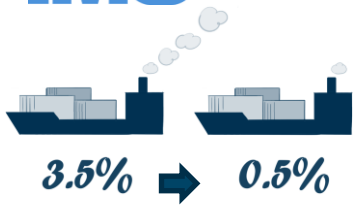
ASPECTS OF BITUMEN PROPERTIES



- Refinery transitions
- Closure of bitumen production

IMO INTERNATIONAL MARITIME ORGANIZATION

- Reduction of sulphur in marine fuel



- Diverse additives

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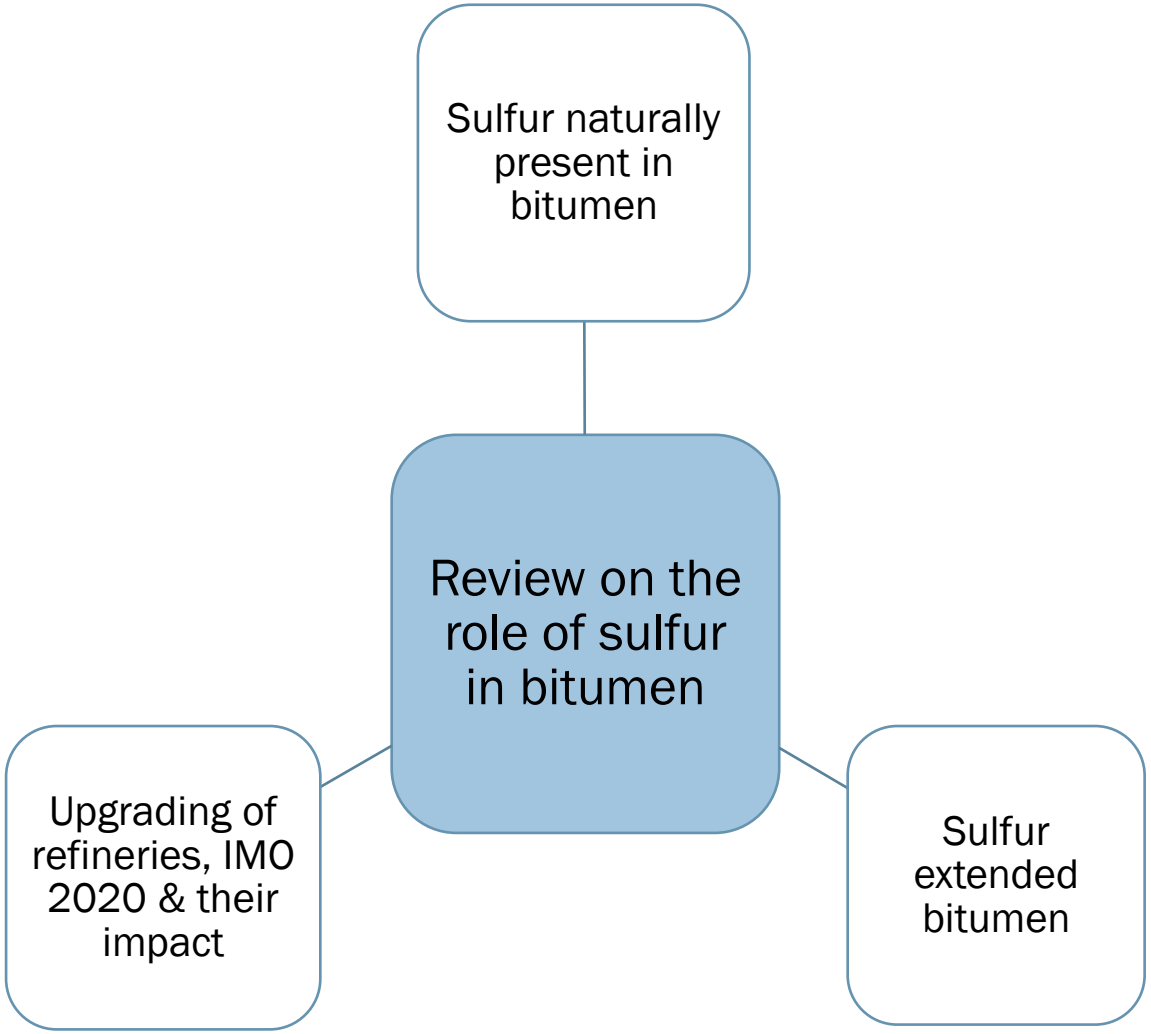
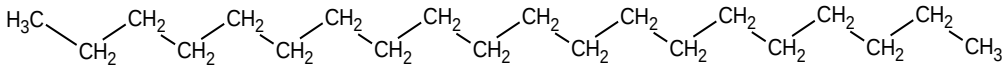
SULFUR IN BITUMEN



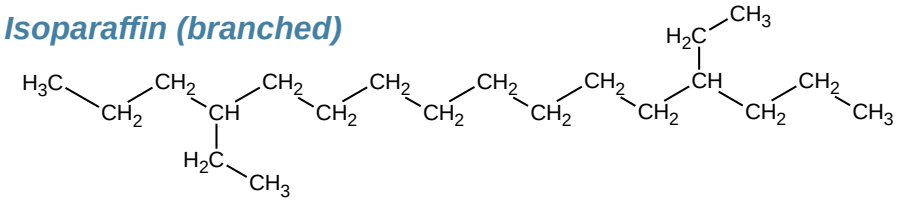
BITUMEN COMPOSITION

Saturates

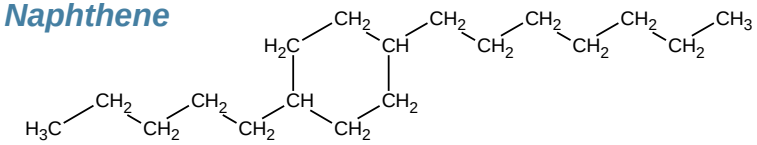
Paraffin



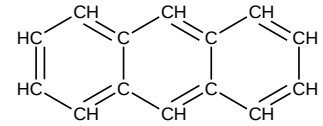
Isoparaffin (branched)

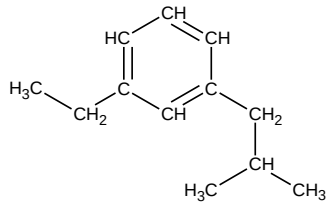


Naphthene

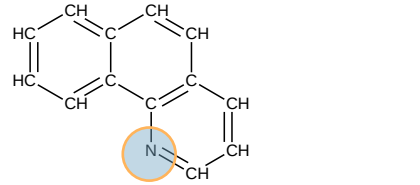


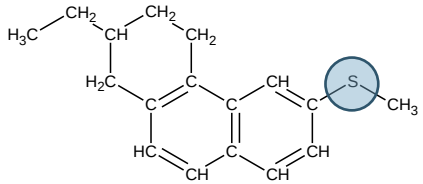
Aromatics



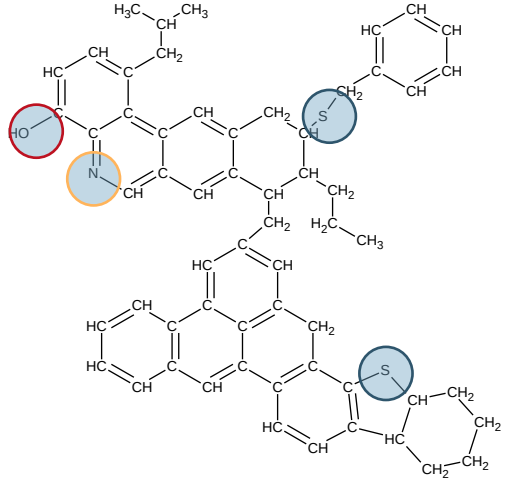


Resins





Asphaltenes



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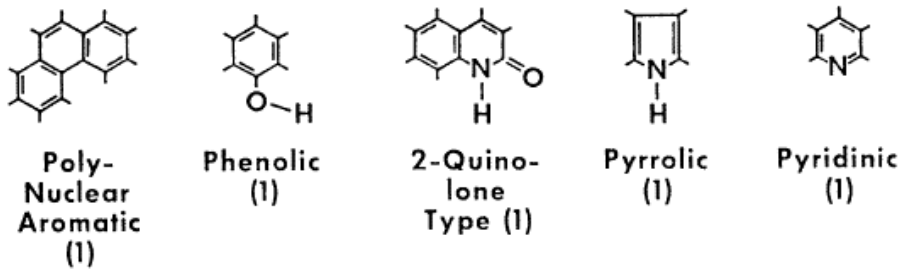
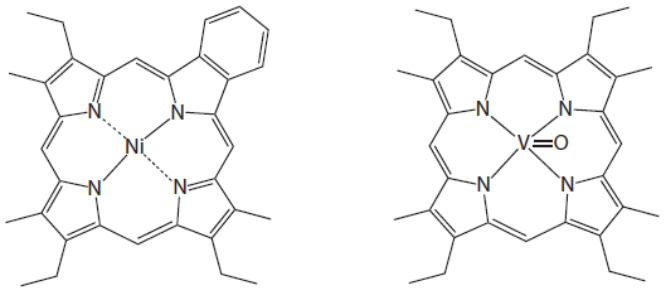
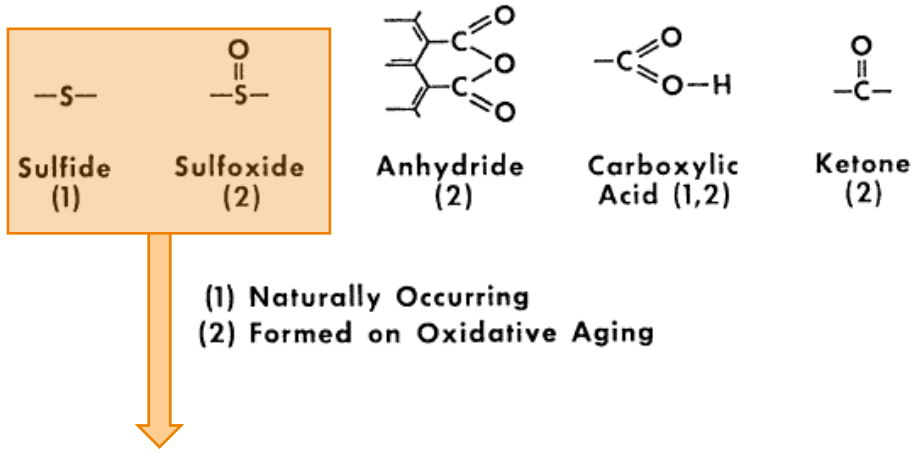
FUNCTIONAL GROUPS IN NEAT AND AGED BITUMEN

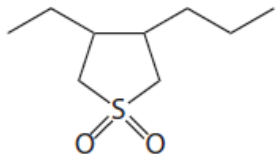




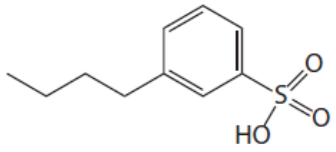
Nickel and Vanadium porphyrin structures in bitumen



Cyclic sulfone

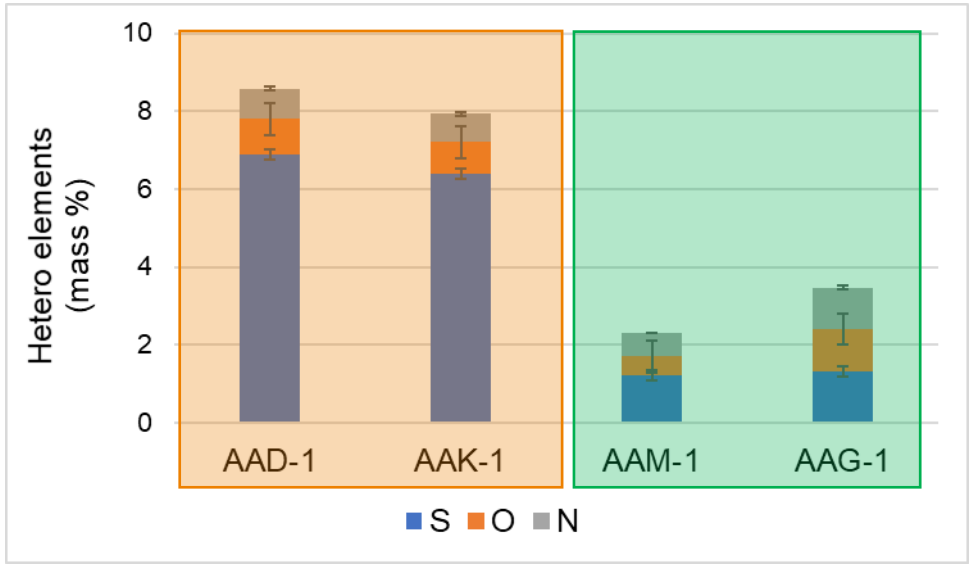


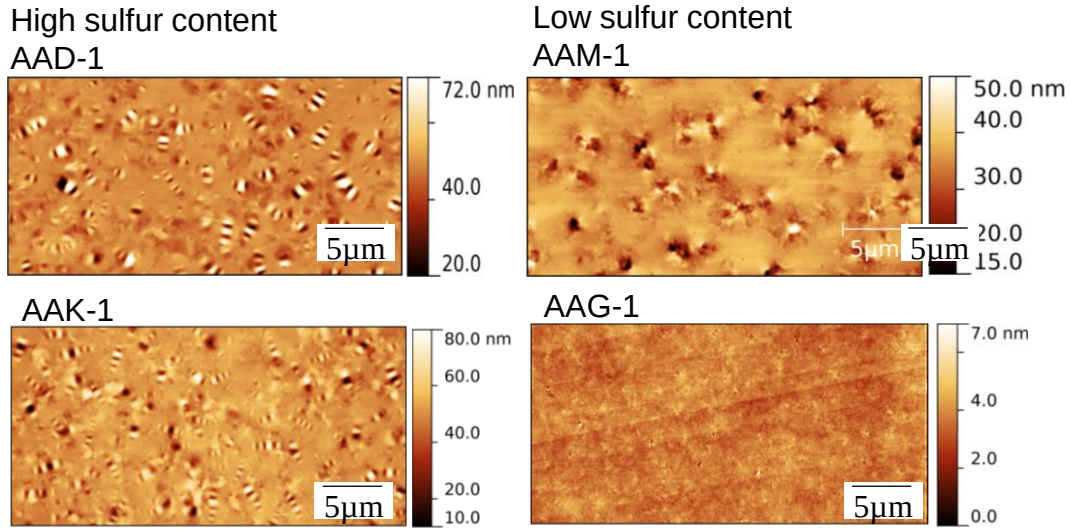
Sulfonic acid

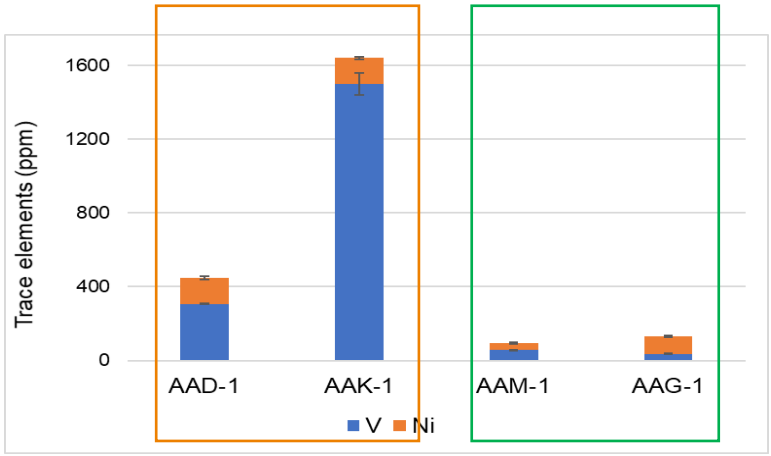


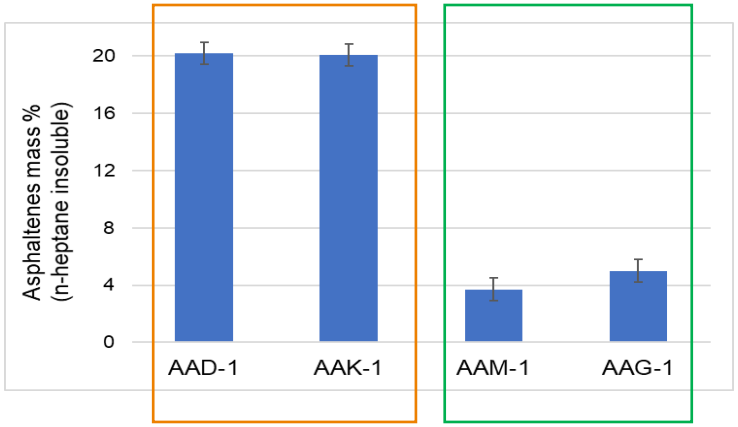
- aliphatic sulfides into sulfoxides,

STRATEGIC HIGHWAY RESEARCH PROGRAM (SHRP) BITUMEN



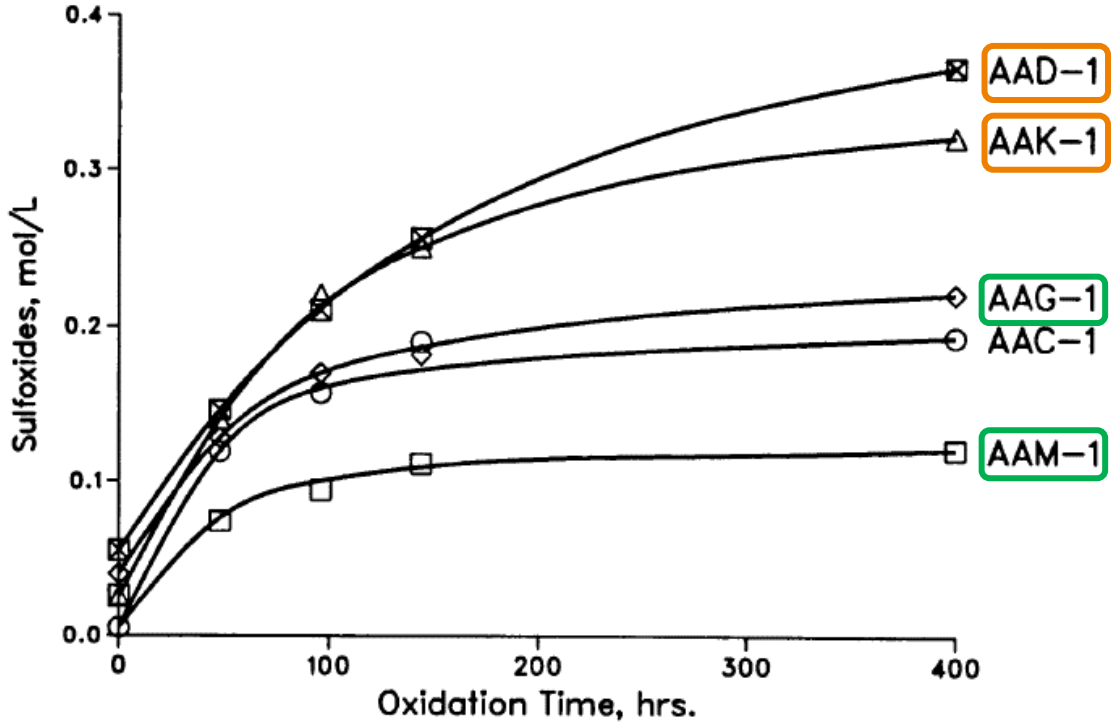


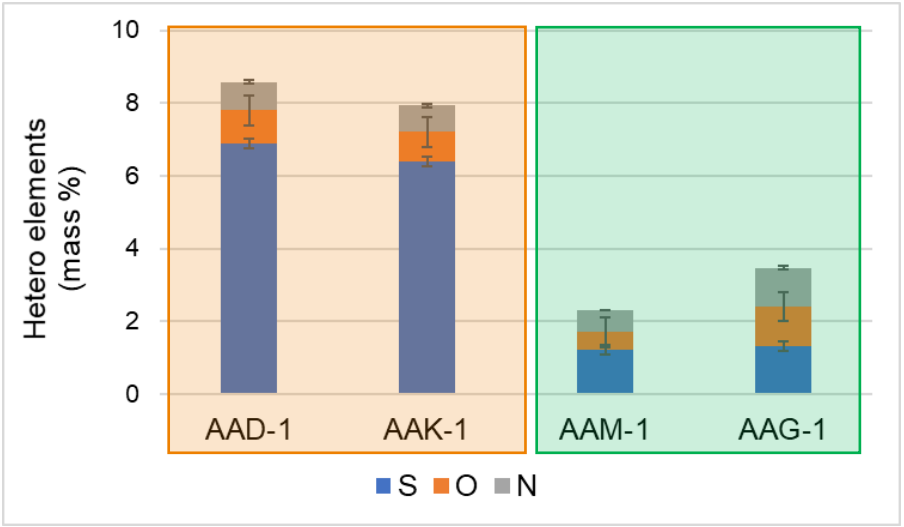




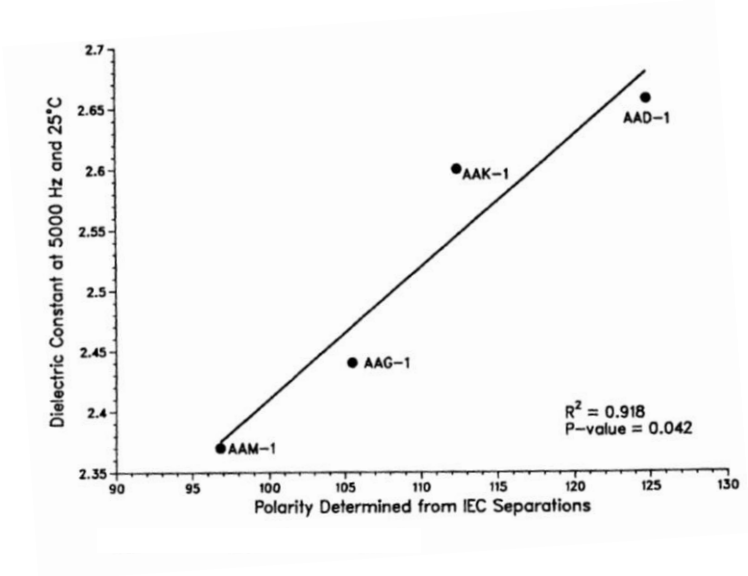
- asphaltene fraction hosts most of the trace metals: influence the size and agglomeration
- The influence of sulfur alone to facilitate agglomeration is limited

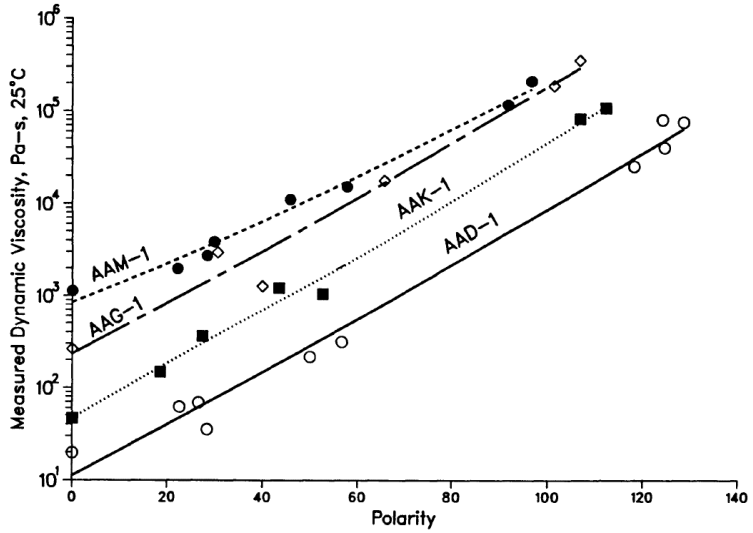
SULFOXIDE FORMATION AS A FUNCTION OF (PAV) AGEING @ 60°C





PROPERTIES

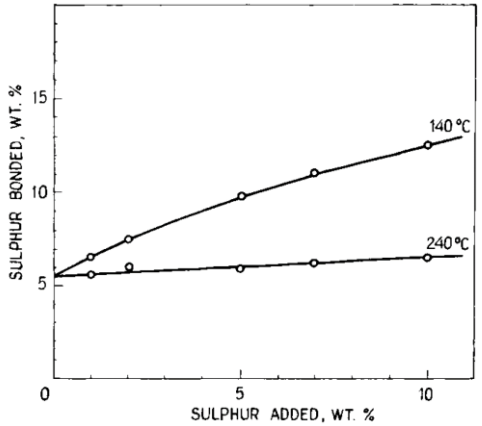




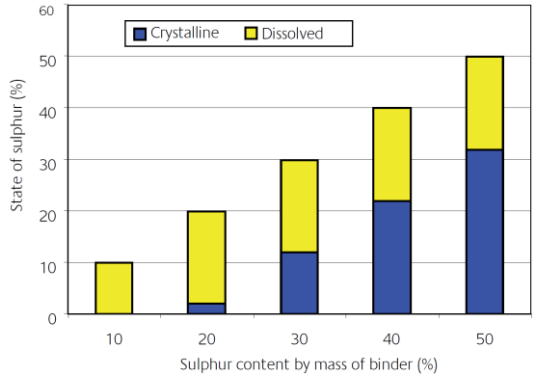
- Higher sulfur-containing bitumen shows higher polarity
- Viscosity as a function of polarity: linear relationships
- High sulfur-containing bitumen is more susceptible to moisture damage and low temperature cracking.

SULFUR-EXTENDED BITUMEN (SEB)

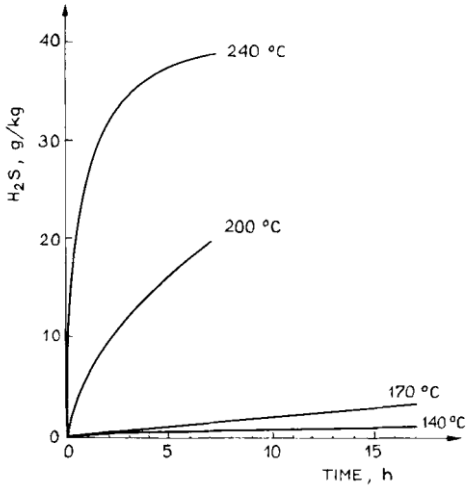
- Treating bitumen with sulfur
- The concept is available since 1930s and reported improved properties (i.e. stiffness, rutting resistance) over conventional bitumen
- Sulfur in SEB can be found in three different forms: (1) chemically bonded, (2) 'dissolved' in bitumen, and (3) crystalline sulfur
- low modification, sulfur incorporates well and extends the binder rheological properties;
- higher modification, acts as a filler
- Viscosity and softening point of SEB increase with the processing time
- Emission: Below 140 °C the formation of hydrogen sulphide and sulfur dioxide is negligible



Influence of temperature on chemically bonded sulfur



State of sulfur



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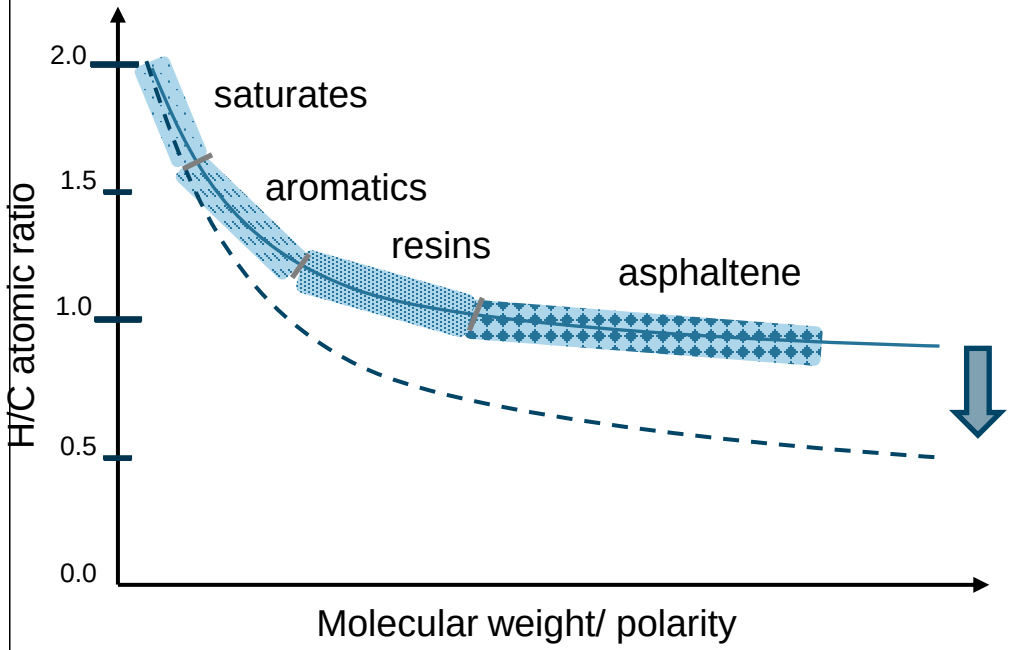
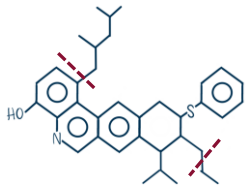
BITUMEN COMPOSITION IN RELATION TO PRODUCTION PROCESS



upgrading process lowers H/C ratio



Upgrading of vacuum residue:

- Deasphalting: Solubility based separation
- Oxidation: Passing air through bitumen at elevated temperature→ Oxidized/Blown bitumen
- Thermal cracking
  - Breaks the long paraffinic side chains attached to aromatic rings to form shorter molecules (above 420 °C to break C–C bonds)
  - C–S bond is weaker than other aliphatic bonds.
  - Thermal processing results in hydrogen sulfide (H_2S), even at temperatures below 250 °C
- Hydrotreating/desulfurization
  - hydrogen is introduced into this specific process usually resulting in desulfurization

CONCLUSIONS

- Discussed the presence of sulfur in bitumen, and its relation to other bitumen components, most prominently the asphaltenes and trace metals.
- Most sulfur groups tend to oxidize more allowing for even more polar interactions.
- Sulfur in bitumen molecules induces polar interactions, promoting agglomeration of asphaltenes.
- Increased polarity, shows an increase in viscosity.
- By adding sulfur into bitumen (SEB), at low concentrations influences the rheological properties, and at high concentrations partly act as a filler, also changing the mechanical properties.
- Discussed changes in refining process, upgrading trends where increasingly harder grades bitumen are being available.

ACKNOWLEDGEMENT

KPE- program: Characterization and Evaluation of Asphalt Binder Properties (CEAB)