Contribution ID: **289** Type: **Contributed**

Distinctive Microstructures in Bitumen Evolve with Time and Composition

Tuesday 19 June 2018 10:50 (20 minutes)

The diverse microstructures that are observed by atomic force microscopy (AFM) in bitumen suggests complicated intermolecular associations. These microstructures largely contribute to bitumens'bulk mechanical properties; therefore, it is essential to understand the chemical–microstructural–mechanical relationships for optimal design of bitumen-related applications. However, the complex nature of bitumen and the various influencing factors often lead to practical challenges in investigation of bitumens'microstructures and their chemical origins. This study addressed some of the main concerns related to AFM characterization of bitumens'microstructures, namely the dependence of bitumens'microstructures on such factors as sample preparation methods, annealing conditions and durations, and chemical composition.

Microstructures of bitumen films of a few micrometers or thicker were comparable, regardless of their sample preparation methods. Additionally, bitumens annealed at room temperature for over 2 months showed time-dependent microstructures, which correlate well with bitumens'room-temperature steric hardening behavior as verified by other researchers using modulated differential scanning calorimetry. Microstructures of the bitumen films stabilized after different annealing durations depending on the dimensions of the molecular structures and the complexity of the molecular interactions among the multiple phases in each bitumen. Distinctive microstructures were observed for remixed bitumens with increasing asphaltene concentrations. Consistency between our observations and other literature suggests that microstructures observed by AFM are probably not just a surface phenomenon. The above findings provide deeper insights into the establishment of the complicated chemical–mechanical relationships for bitumen that pave the path toward tuned bitumen performance.

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Session Classification: Nanometer Structures and Nanotechnology

Track Classification: Nanometer Structures & Nanotechnology