

Online Observation of Heterogeneous Nucleation on a Bitumen Surface under Turbulent Hydrodynamic Conditions

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Previous studies suggest that the formation of micron-sized bubbles on a bitumen surface under hydrodynamic conditions might enhance bitumen recovery in oil sands extraction. However, there is no direct observation of heterogeneous nucleation process on a bitumen surface. In this study, an on line visualization system is designed specifically to study the heterogeneous nucleation and coalescence of gas bubbles on a bitumen surface under hydrodynamic conditions with a maximum average linear fluid velocity of 17 m/s. The silicon wafer covered bitumen surface is mounted on the bottom surface of a venturi-based fluid flow cell.

The continuous growth and coalescence of highly deformed bubbles on bitumen surfaces are observed. With continuous grow of the bubbles, the drag force exerting on the bubbles increases correspondingly to exceeds the adhesion force of the bubble on bitumen, leading to slip of the bubble on the bitumen surface and carrying the bitumen around the bubble towards the downstream. When the fluid flow stops, spherical micron-sized bubbles are observed on the bitumen surface as shown in Figure 1 (a). In contrast, such bubbles are not observed when the tests are conducted with hydrophilic silica surfaces, as shown in Figure 1 (b). These micron-sized bubbles are anticipated to enhance bitumen liberation and attachment of micron size bubble-activated bitumen with flotation bubbles. Gas diffusion from flowing fluid to nucleation cites on the bitumen surface is believed to be the key of heterogeneous gas nucleation under hydrodynamic conditions. The results obtained provide the foundation for the designing of novel oil sands extraction devices.

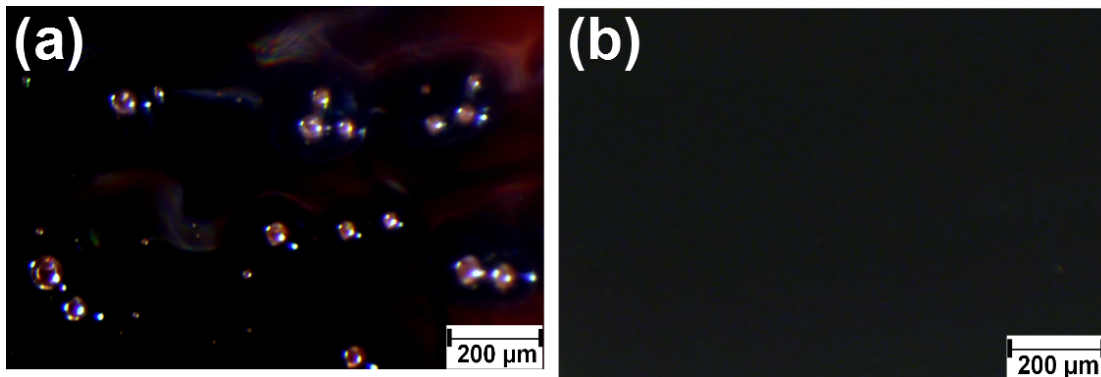


Figure 1. Comparison between bitumen surface (a) and hydrophilic silicon wafer (b) exposed to fluid flow of an average fluid velocity 17 m/s, showing a large number of bubbles formed and remained on the bitumen surface in contrast to the absence of visible bubbles on hydrophilic silica surface.