Collision dynamics of liquid drops on wood: Insights into the effect of surface roughness and surface tension

Siam Hossain, Prof. Shi-Yow Lin

Department of Chemical Engineering, National Taiwan University of Science and Technology

國立臺灣科技大學
NATIONAL TAIWAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

RESEARCH MOTIVATION

- Impact of liquid drops on wood plays a vital role in several industrial, commercial and scientific applications
  - Synthesis of bio-composites
  - Application of coatings in shipbuilding industry
  - Developments in additive manufacturing techniques
- However, there is a limited literature focused on uncovering drop impact behavior on wood.
- Improper understanding of collision dynamics can cause:
  - decreased process efficiency
  - loss of material contained within impinging drop
  - indirect environmental issues

EXPERIMENTAL SETUP

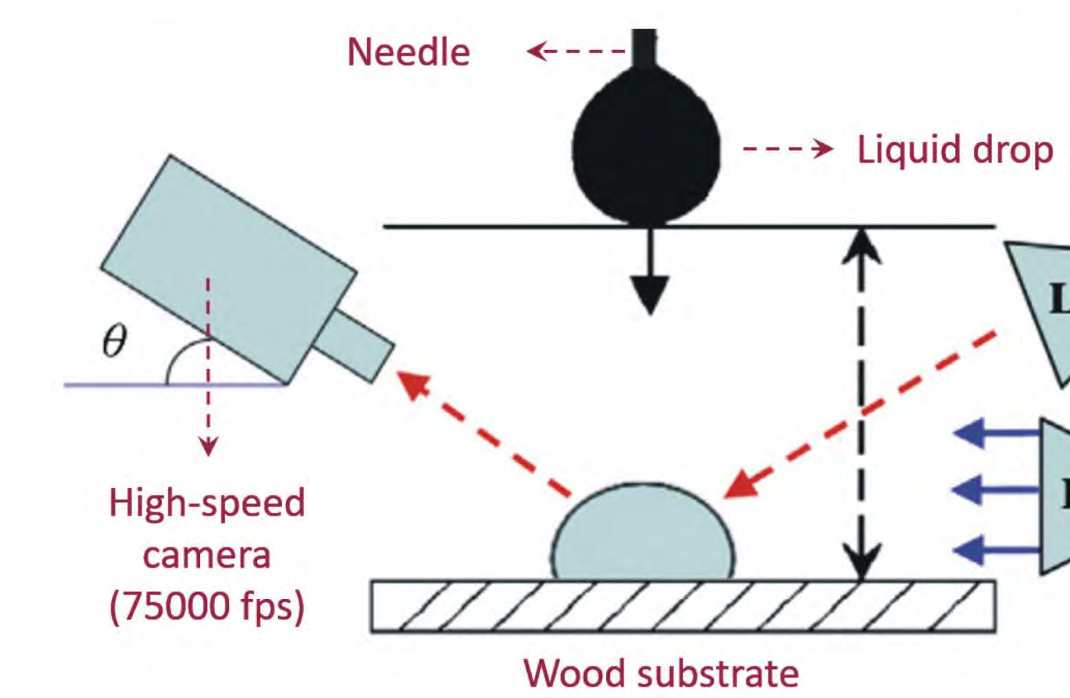
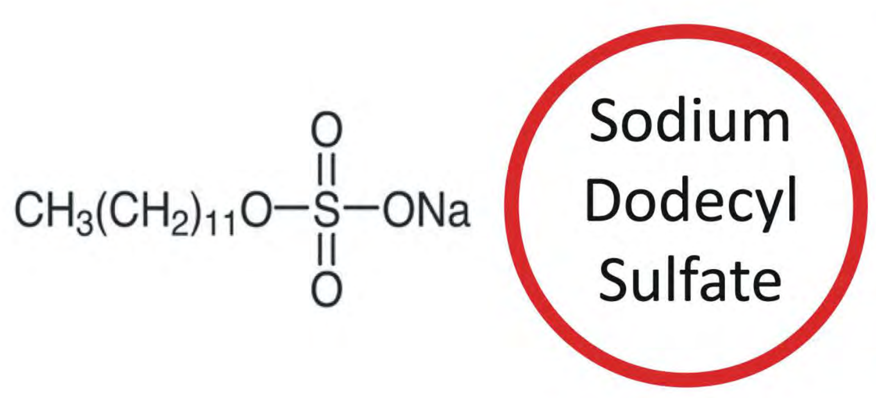


Fig 1. Illustration of the experimental setup

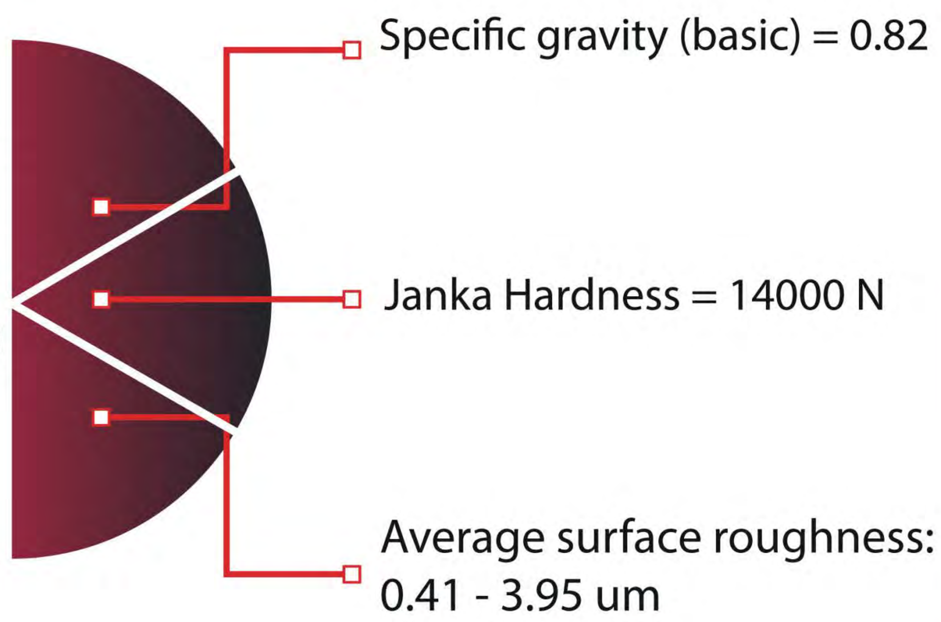
SURFACTANT



- CMC = 8.0 (mol/cm³)
- Concentration: 0.8 - 20 (mol/cm³)
- Surface tension: 72 - 40 mN/m

WOOD SUBSTRATE

Diospyros crassiflora (Gabon ebony)



SELECTED RESULTS

Effect of surface tension - splash phenomenon

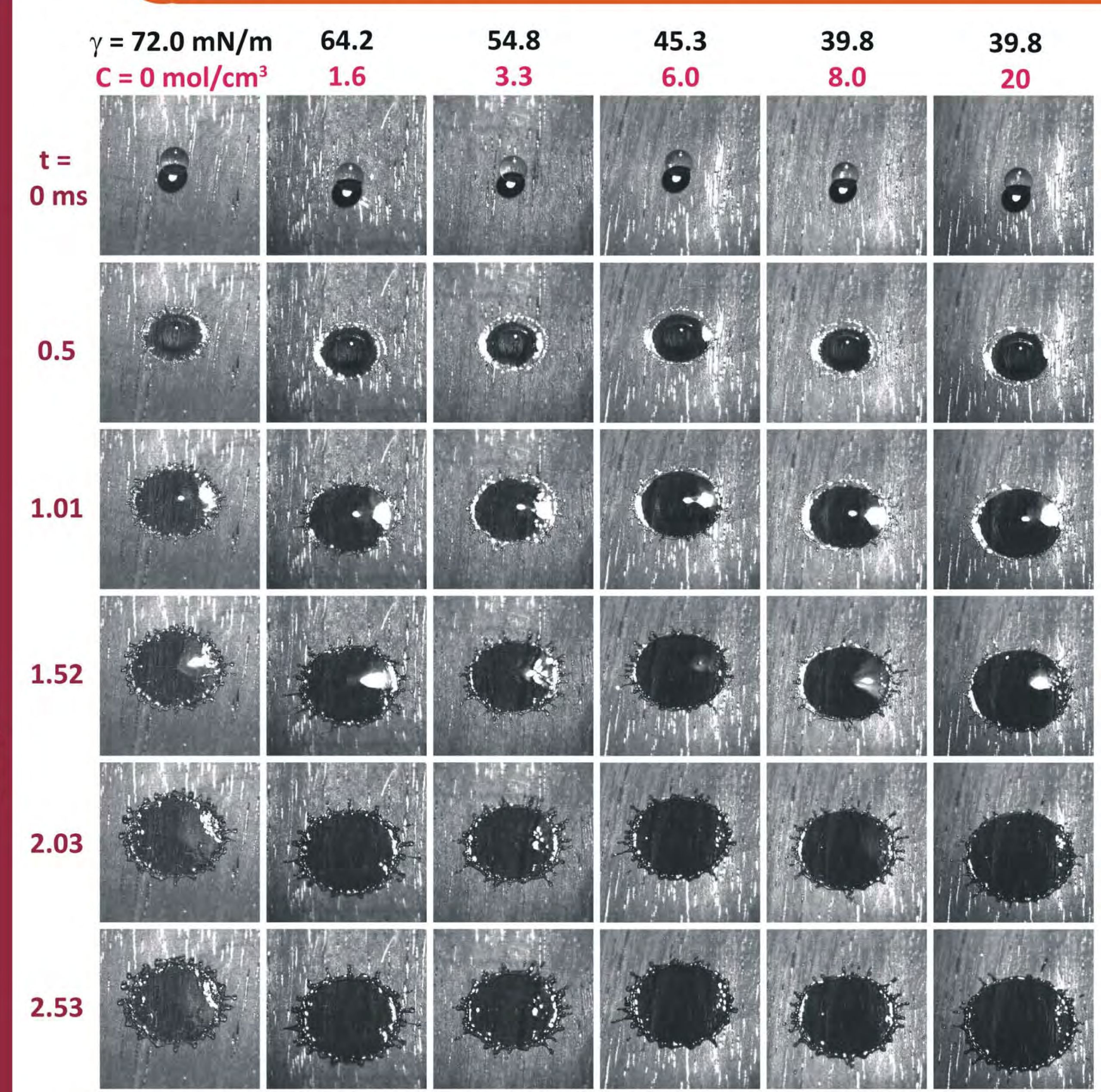


Fig 2. Sequence images illustrating the behavior of an SDS solution drops impinging on Gabon ebony (R_q = 0.60 um) at H = 40 cm.

- Decrease in surface tension corresponds to (i) increased splashing, (ii) greater instability during impingement, and (iii) pronounced splashing phenomenon.
- Lowering the surface tension from 72 to 40 mN/m increased the critical Weber number (the value at which an impinging drop exhibits splashing) from 180 to 250.
- However, lowerring the surface tension enhanced the wettability - the drop spread to a greater extent over wood.
- The increased splashing, formation of a greater number of emitted droplets is attributable to more pronounced formation of Rayleigh-Taylor instabilities during the impact.

Effect of surface roughness - energy balance during impact

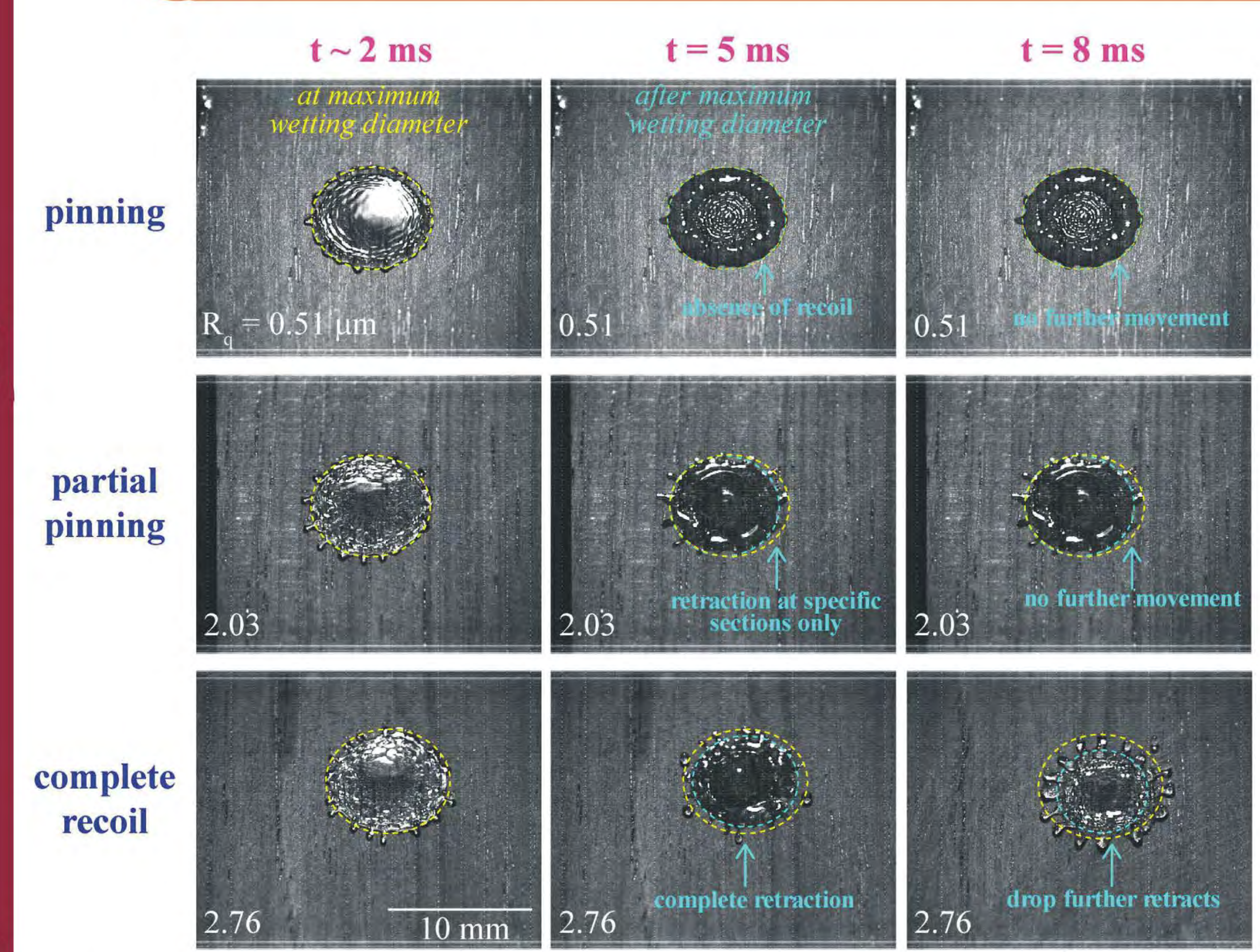


Fig 3. An illustration depicting the occurence of pinning, partial pinning and complete recoil amongst water drops impacting wood at H = 20 cm

- Increased roughness caused (i) the greater unevenness of the rapidly spreading lamella, (ii) the formation of highly prominent finger-like projections, and (iii) violent splashing.
- Recoil after reaching maximum diameter at at higher roughness - minimal energy dissipation during the drop impact process.

CONCLUSIONS

- Lowering the surface tension of an impinging liquid drop corresponded to a more pronounced growth of Rayleigh-Taylor and Kelvin-Helmholtz instabilities during the drop impact process.
- The surface roughness controlled (i) the mobility of the liquid film, (ii) the integrity of the impinging drop, and (iii) the energy balance during the drop impact process.