Superhydrophobicity and Oleophobicity on Paper Using Plasma Treatments

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Superhydrophobic Paper via Plasma Processing

- Superhydrophobicity defined as having a CA > 150°
- Requirements for superhydrophobicity
  - Surface roughness
  - Low Surface Energy
- Plasma process
  - Selective etch of amorphous cellulose

Untreated $\rightarrow$ O₂ plasma etch $\rightarrow$ deposition (~100 nm layer)
(create nano-roughness) (low surface energy)

Balu et al., Langmuir, 24, 4785 (2008)
Tunability of Droplet Adhesion

- All substrates are superhydrophobic
- Ability to tune adhesion/hysteresis

Selective Adhesion on SH Paper

- Wax dots printed onto SH paper
  - Preferential adherence to wax dot

- Difference in hydrophobicity enables sampling from bulk droplets

Balu et al., *Lab Chip* 9, 3066–3071 (2009)
Sampled Volume Control

- Sampled volume is dependent on the hysteresis of the printed dot.

**Increasing Hysteresis**

**Hysteresis can be controlled...**

- Chemically
  - Different wax types
- Physically
  - Surface roughness from sandpaper

Li et al., JAST (In Press)
Droplet Splitting

• Print designs with multiple islands
  ○ Bulk droplets can be split into several smaller droplets
• Biomedical testing

• Proof of concept with glucose colorimetric agent

Li et al., JAST (In Press)
Other Superhydrophobic Surfaces

• Same fundamental idea
  - Surface roughness
  - Low Surface Energy

• Superhydrophobic stainless steel
  - Etched in HF acid and nitric acid passivation
  - Fluoropolymer deposition

304 Stainless Steel

Li et al., *Langmuir* (Submitted)
Other Superhydrophobic Surfaces

316 Stainless Steel

Li et al., Langmuir (Submitted)
Other Superhydrophobic Surfaces

- Superhydrophobic Teflon (PTFE)
  - Oxygen plasma etch
  - No further deposition

Etched (155°)  Unetched (90°)

2 μm
Current Work: Oleophobic Paper

• Oleophobic paper made using same process
  o Oxygen plasma etch
  o Fluoropolymer deposition

• Current work focused on fabricating robust superhydrophobic and superoleophobic paper substrates

Hexadecane (> 120°)  Water (> 150°)
Summary

• Superhydrophobic paper
  o Plasma process
  o Oxygen etch and fluoropolymer deposition

• Droplet sampling
  o Controllably sample volumes from a bulk droplet
  o Biomedical applications

• Other superhydrophobic surfaces
  o 304 and 316 Stainless Steels
    • HF acid etch and nitric acid passivation
  o Teflon

• Extension of same fundamental parameters to oleophobic paper