Electrically Assisted Vat Photopolymerization of Bioinspired Hierarchical Structures with Hydrophobicity Enhancement

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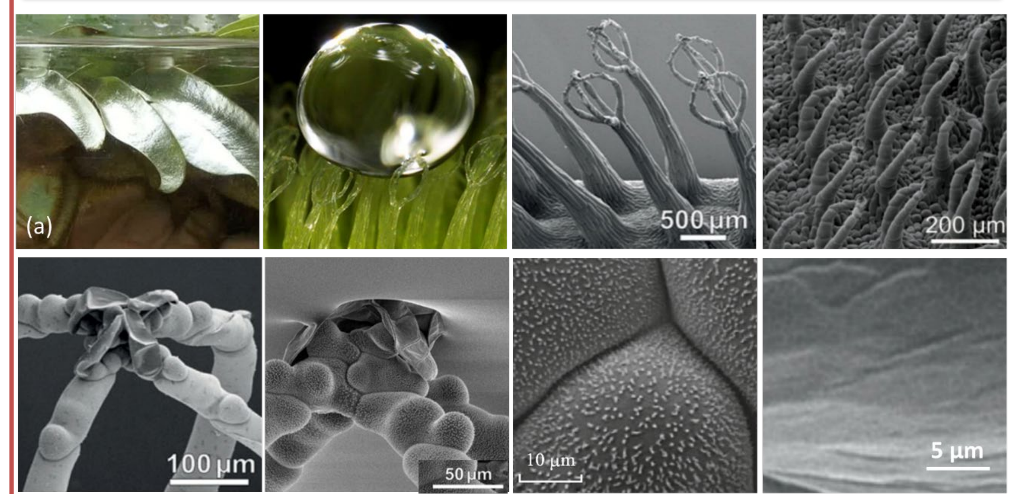
1. INTRODUCTION:

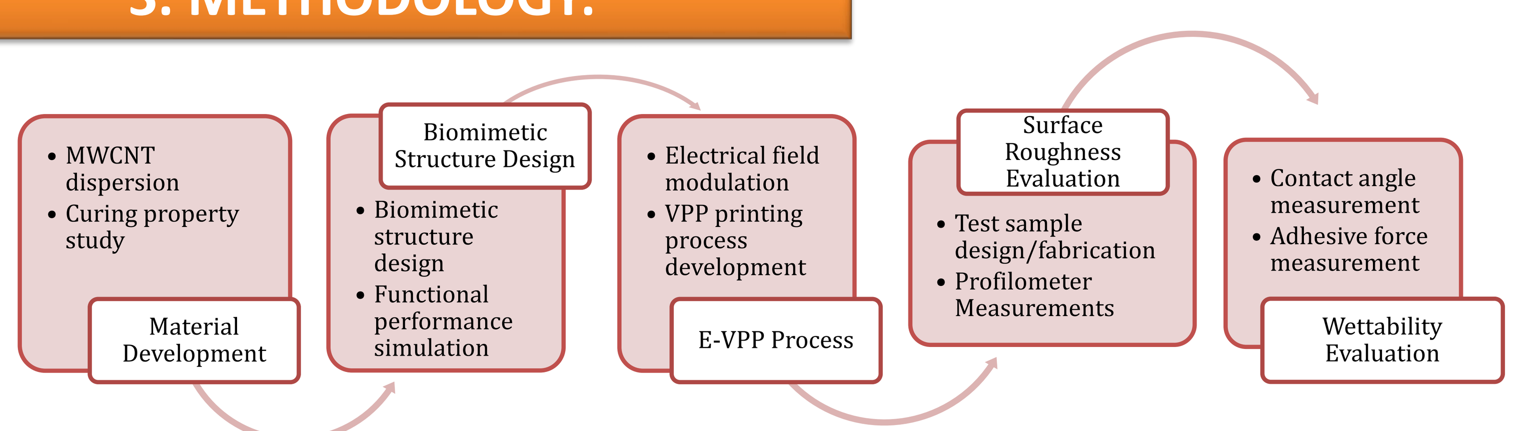


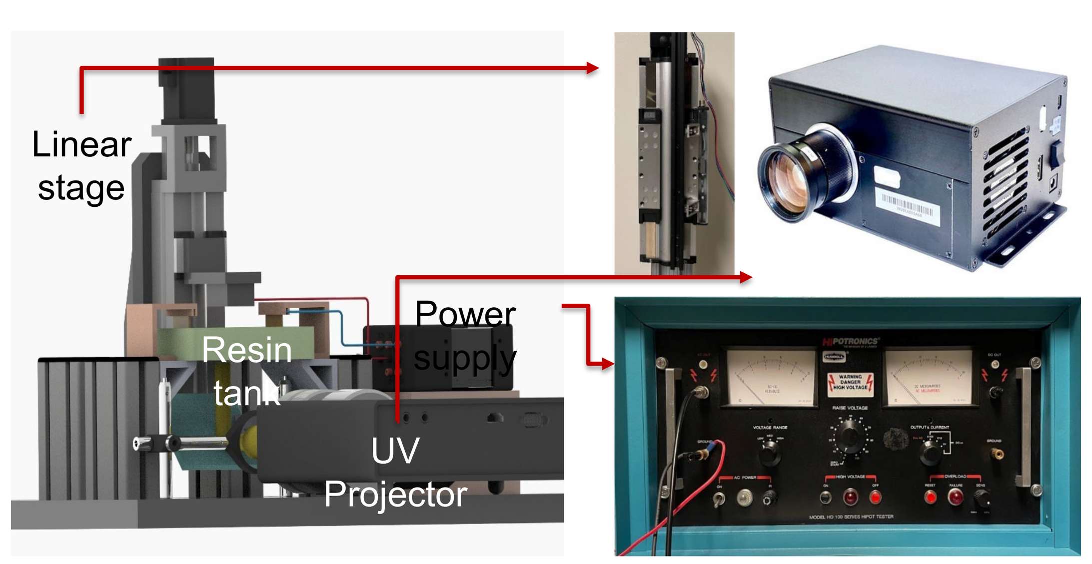
The design of next generation superhydrophobic surfaces are influenced by biological architectures, which make use of specially designed structures. For insulation, several aquatic organisms have naturally evolved sophisticated structures that can sustain stable air layer underwater for extended periods of time "Salvinia Effect". They are recognizable due to different wettabilities, such as wrinkled hydrophilic patches on top of superhydrophobic eggbeaters "Dual Scale Roughness".

2. PROBLEM STATEMENT:

- How to develop biomimetic superhydrophobic surfaces with dual-scale roughness for underwater applications?
- How to control the distribution of nanofillers to achieve desired surface roughness?
- The objective of this research is to use 3D printing process to fabricate and study the superhydrophobic eggbeater structures inspired from Salvinia Molesta with dual scale roughness

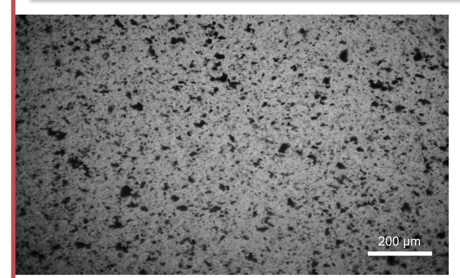
3. METHODOLOGY:



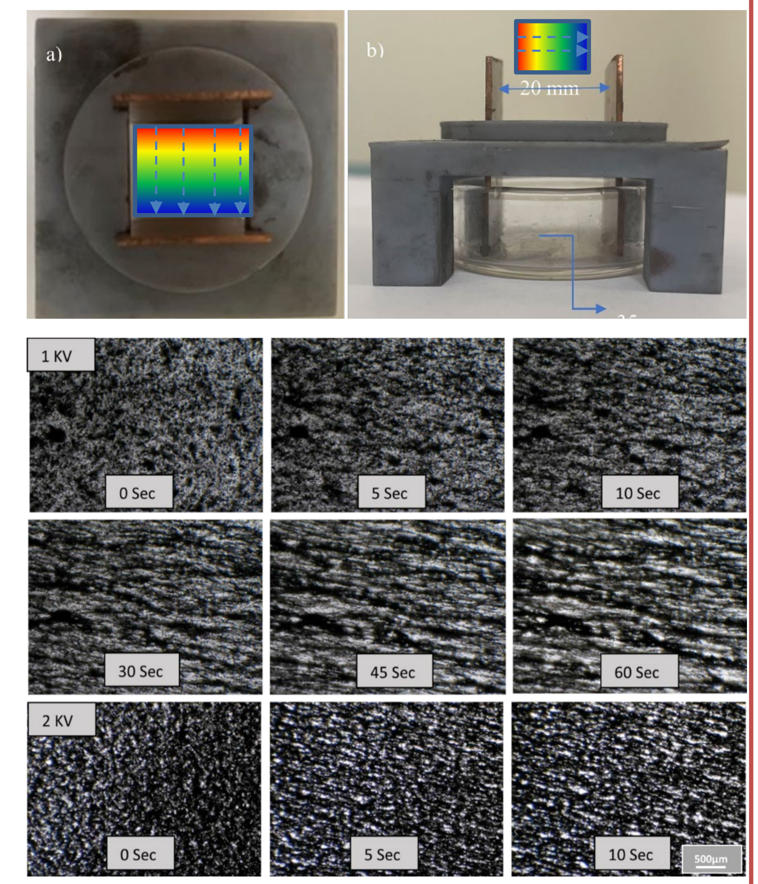


- Controllable MWCNT distribution can be modulated by dynamic control of electrical field
- The nanoscale surface roughness of printed object can be adjusted by modifying the CNT distribution

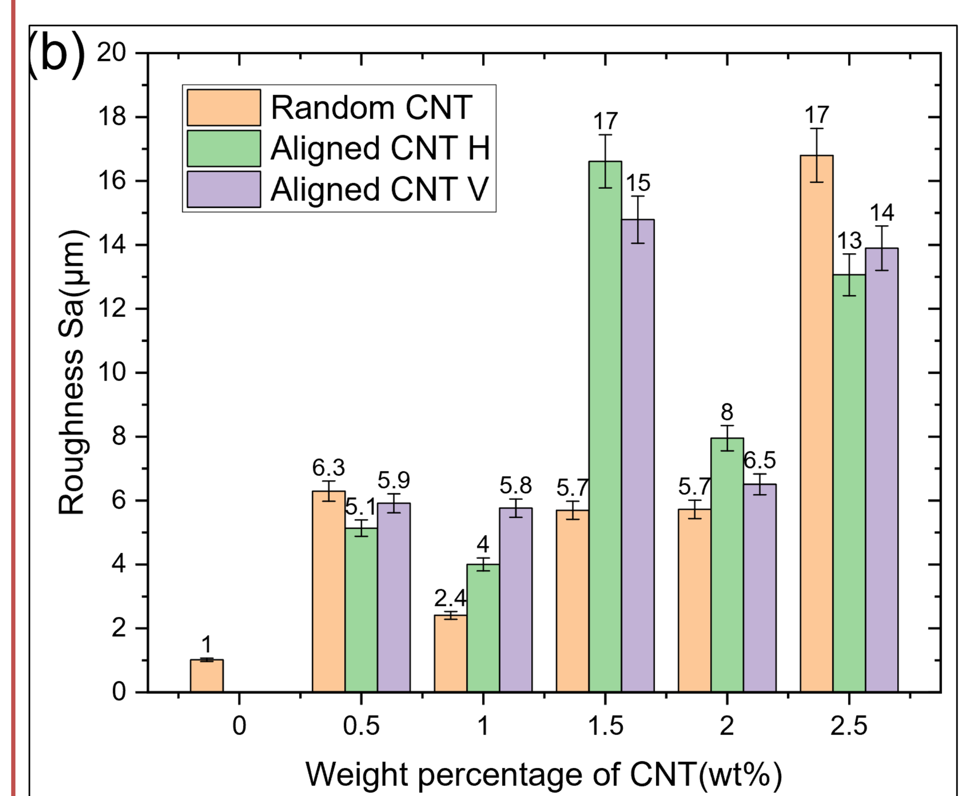
4. RESULTS:



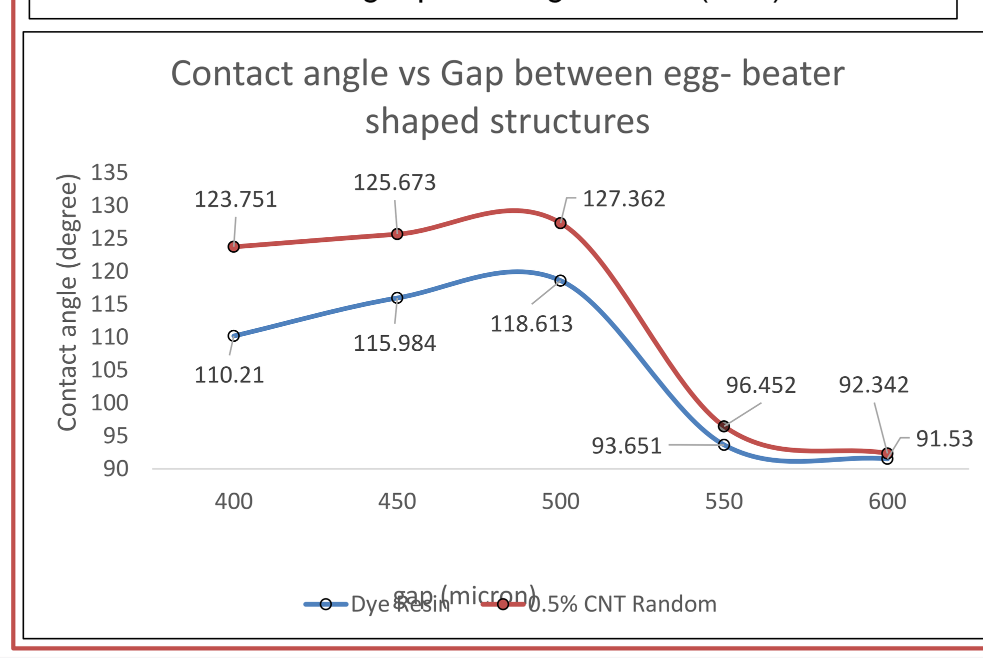
- MakerJuice Red resin with a viscosity of 220cp. Modulus of 655 MPa is used.
- MWCNT mixtures of 0.5%, 1% 1.5%, 2% and 2.5% of total weight percentages.

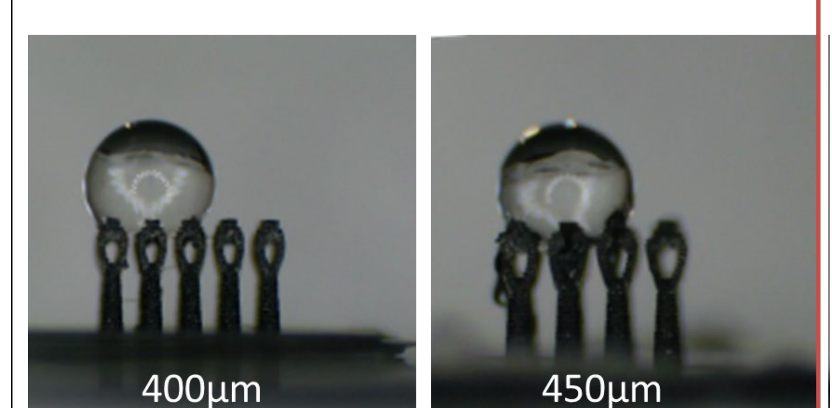


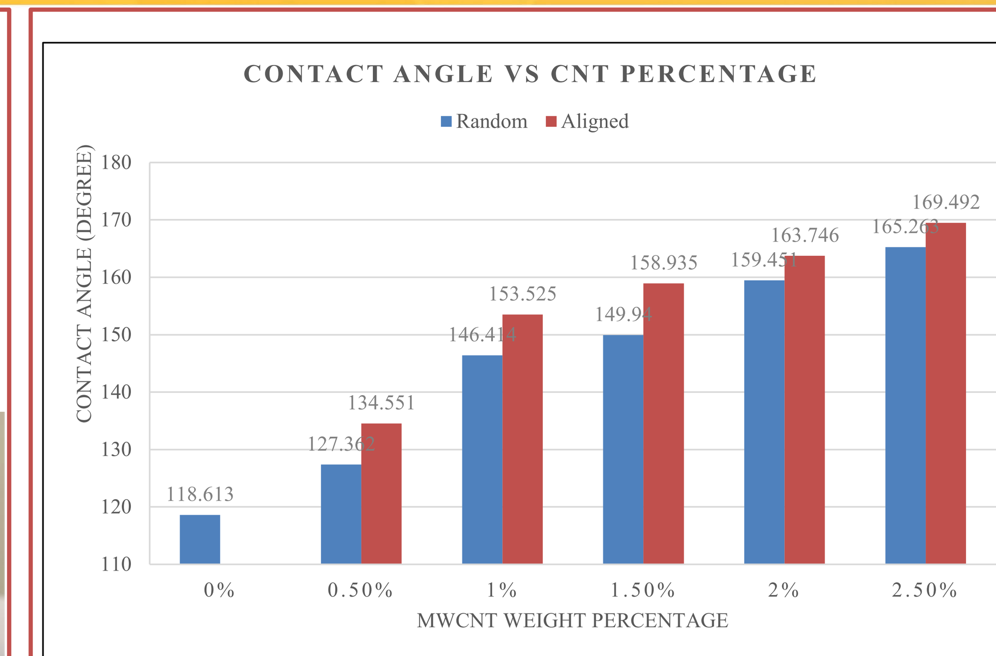
- The red resin and MWCNT mixture is stirred at 650 RPM for 2 hours.
- Two copper electrodes are placed inside the either side of the glass tank with a distance of 20 mm and are connected to Hipot Tester.
- More percentage of MWCNT present in the mixture, the more time it takes to align at low voltages, and it gradually decreases with increase in the AC voltage.



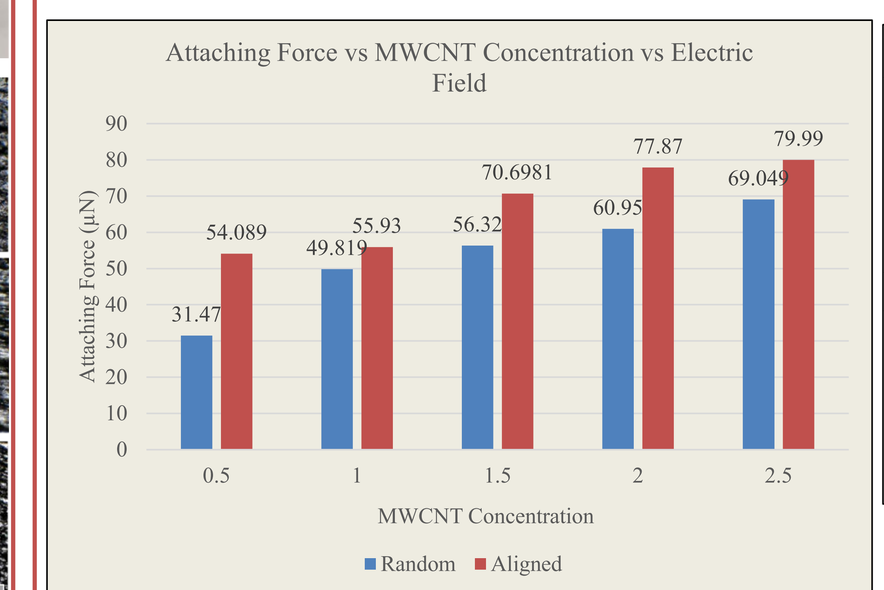
- Aligned Mixtures have better roughness than Random oriented mixtures in the direction parallel to the electric field compared to perpendicular direction.
- Higher the MWCNT % , higher the roughness for printed part.
- Contact Angles are observed for different geometric distances between individual eggbeater hairs.

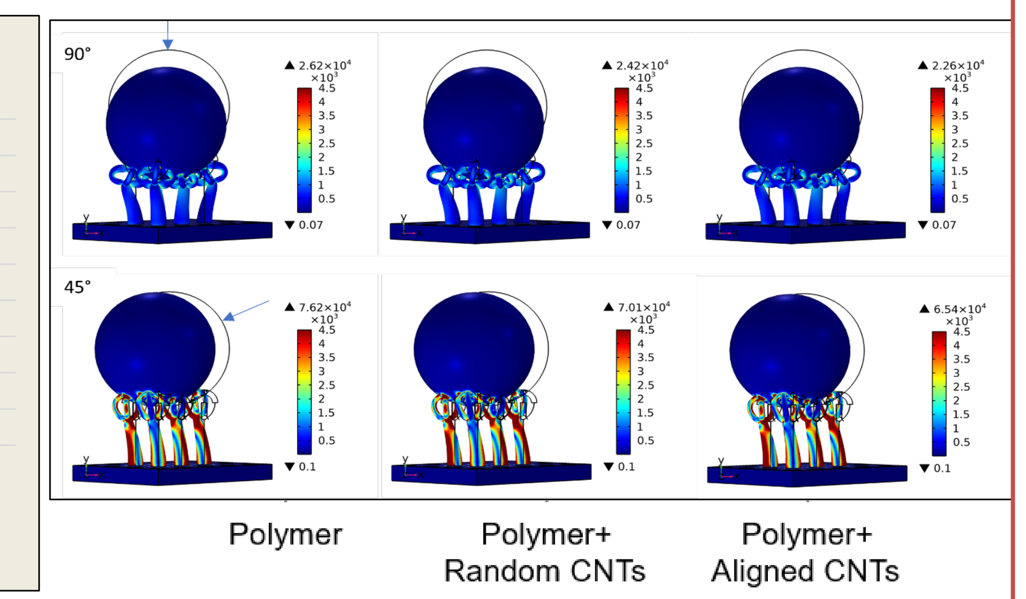






- Contact angles are observed for random and aligned MWCNT structures for different MWCNT mixtures.
- Highest CA is observed at 2.5% mixture at 169.492°.
- Aligned structures have higher CAs compared to random oriented structures.





- The results demonstrated that the adhesive force increased from low (31 N) to high (80 N) with an increase in the percentage of MWCNT added to the resin.
- COMSOL Simulation of Stresses induced for Polymer resin, 1% MWCNT random and aligned mixtures when water droplet is dropped from 90° and 45°. The results suggest that under a load applied in the 90° direction, the stress is centered on the tips of the eggbeater arrays whereas the 45° direction, they are involving most of the body which is brittle in nature.

5.CONCLUSION:

- The wetting properties of the printed structured surface samples were tested in this study, and they were compared with aligned mixtures of MWCNT surface samples printed with the same process parameters but made of different material compositions.
- The contact angles for aligned structures are higher than random MWCNT orientation and provides superhydrophobic properties.
- The superhydrophobicity of these surfaces and their wetting behaviors are primarily controlled by their chemical composition, micro and nanoscale roughness, and surface geometry