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Exploring Surface Texture And Distinct Wettability in the Wings of *Flying Subterranean Termite*



Presented by

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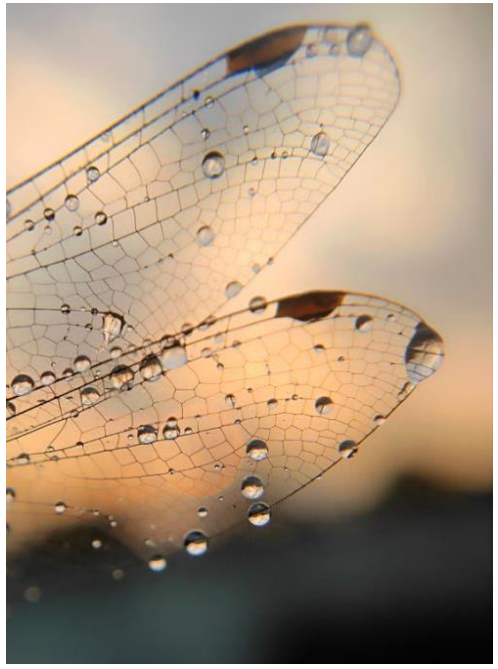
INTRODUCTION

➢Wettability in Nature: From Water Repellency to Liquid Adhesion







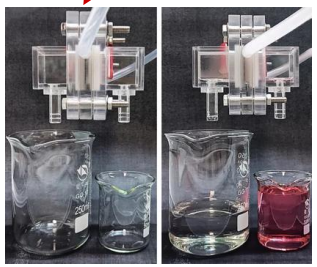
From Natural Wettability

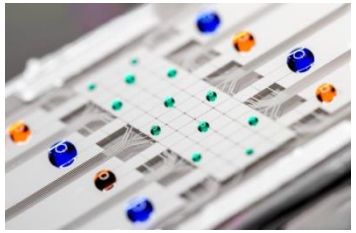
To Real-World Applications

Self-cleaning surfaces



Oil–water separation







Microfluidics

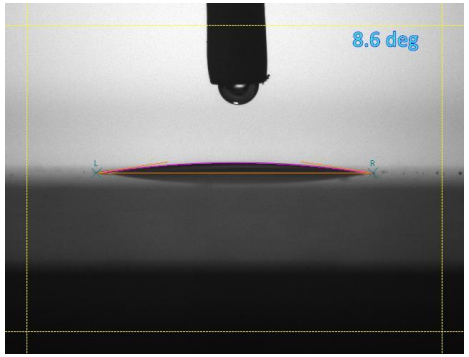
Water harvesting



Anti-fouling and corrosion protection

WETTABILITY — PROPERTY AND ORIGIN

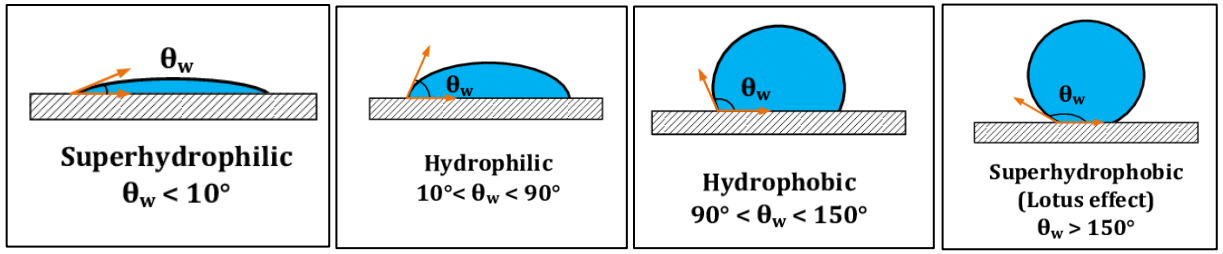
- Wettability describes how a liquid spreads on a solid surface.
- It is commonly characterized by the contact angle (θ) formed at the solid–liquid–air interface.



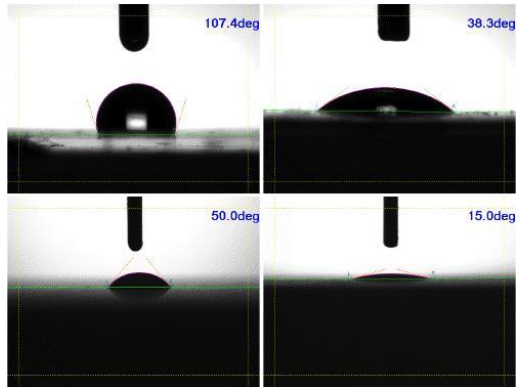
Good wetting
Small contact angle



Poor wetting
Large contact angle

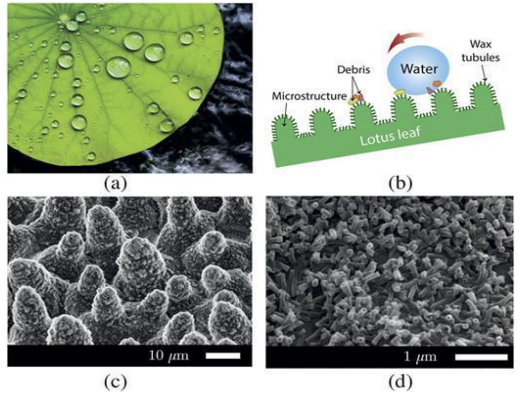


What determines wettability?



Surface chemistry

- The chemical nature and surface energy of the solid influence its interaction with the liquid.



Surface morphology

- Surface roughness and micro/nanostructures can enhance water repellency or promote wetting.

OUR SAMPLE









Kingdom: Animalia
Class: Insecta
Subclass: Pterygota
Order: Blattodea
Superfamily: Blattoidea
Family: Rhinotermitidae
Scientific name: Rhinotermitidae sp.
Common name: Flying subterranean termite

Disclaimer: We didn't harm any termites for our research, and we don't encourage this sort of activity either. For the experiments, we have collected naturally died termites

MOTIVATION OF THE STUDY

- ***Nature as an inspiration***: Insect wings possess fascinating surface architectures that exhibit remarkable and often unexpected physical properties.

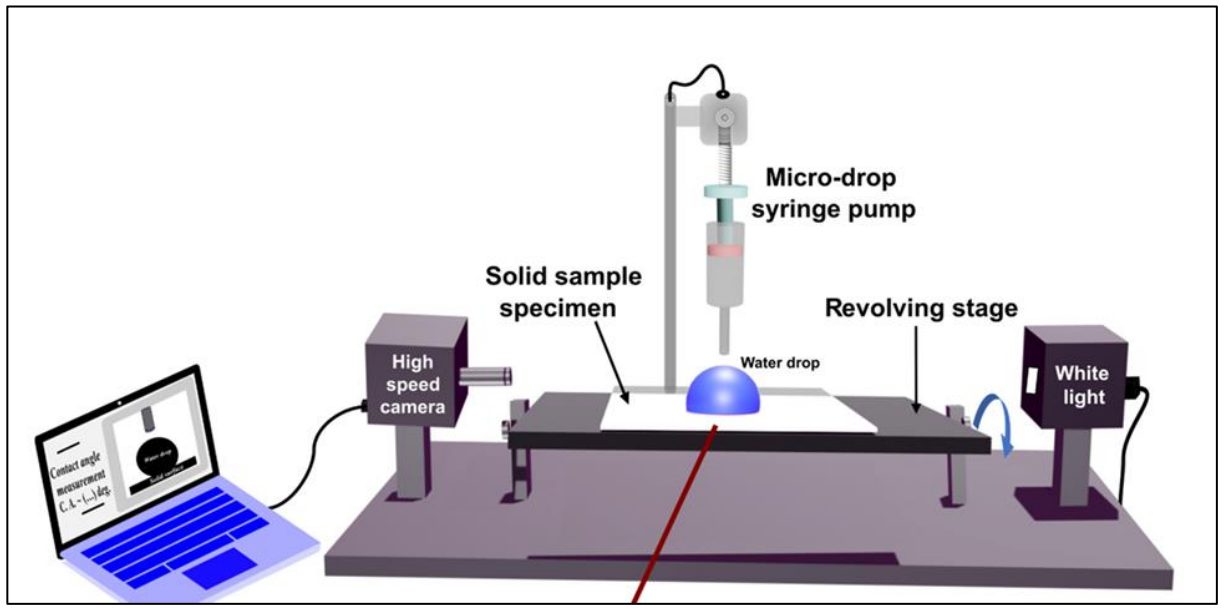
- ***Beyond water repellency***: Can a single natural surface interact differently with liquids having different surface tensions?

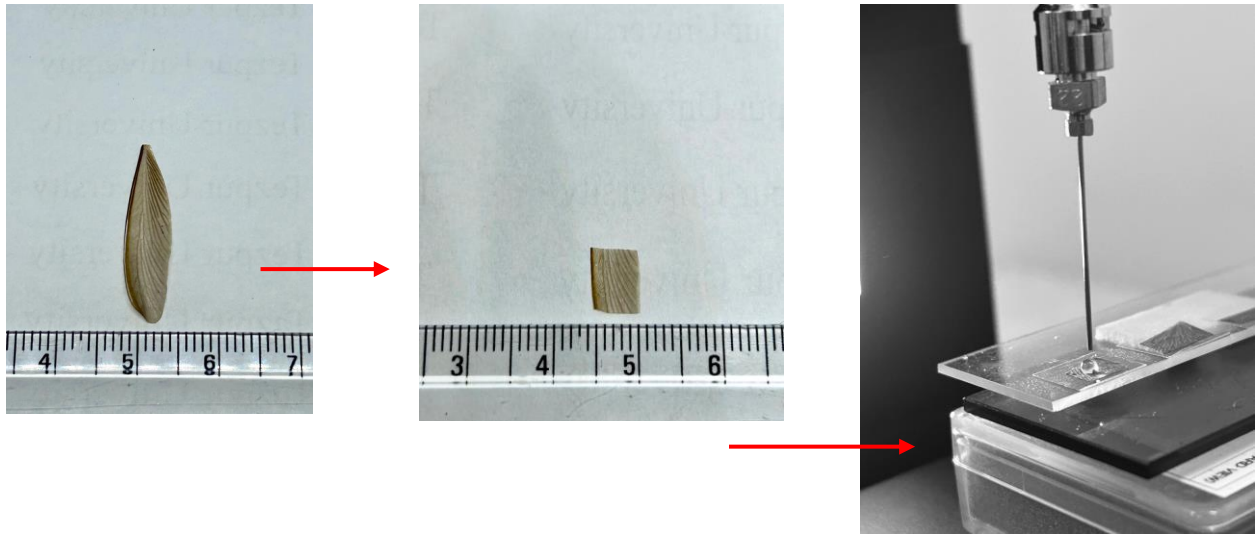
- ***An unusual architecture***: What makes termite wings interesting is their vertically aligned columnar structures separated by relatively large gaps (~14 μm).

- ***The science behind the structure***: How do surface morphology and inter-structural spacing govern the wetting behaviour of different liquids?

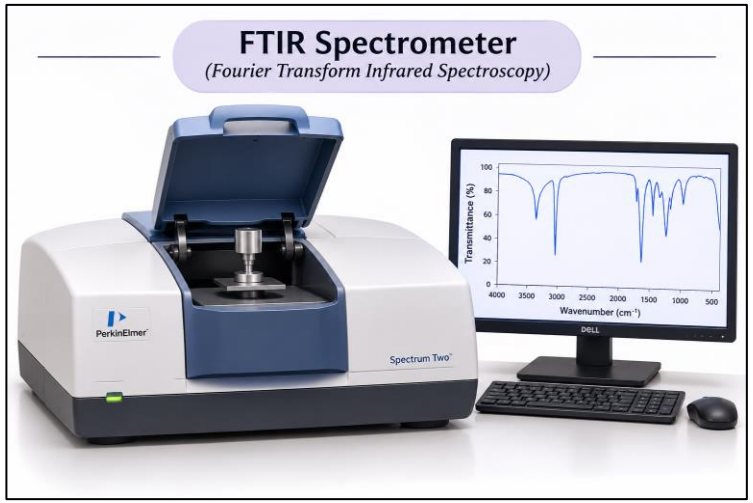
- ***From nature to technology***: Can understanding these natural surface characteristics provide new insights into designing multifunctional biomimetic materials?

EXPERIMENTAL DETAILS









- FESEM was employed to investigate the surface morphology, microstructural features, and hierarchical architecture of the sample at high resolution.
- FTIR spectroscopy was employed to identify the characteristic functional groups and chemical bonds present on the sample surface.

RESULTS AND DISCUSSIONS

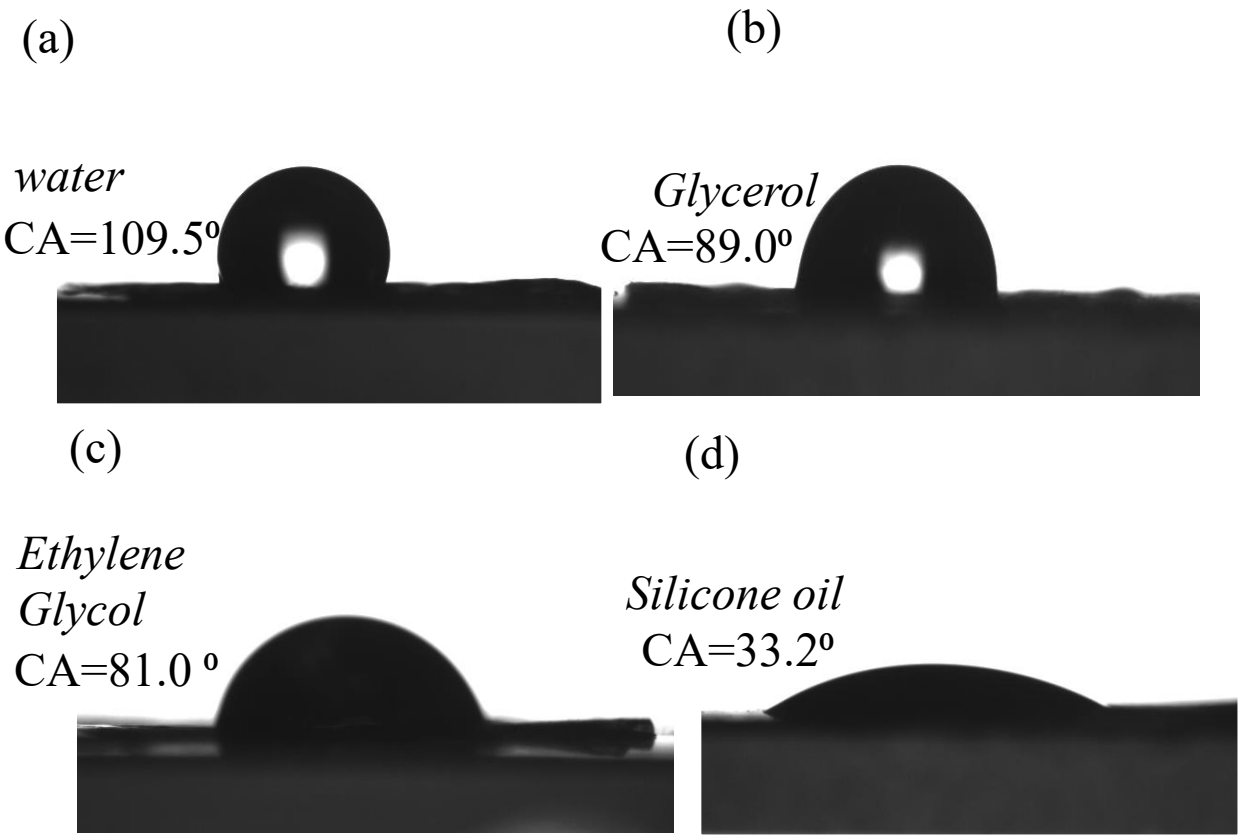


Fig : optical images of various liquids placed on the wing surface

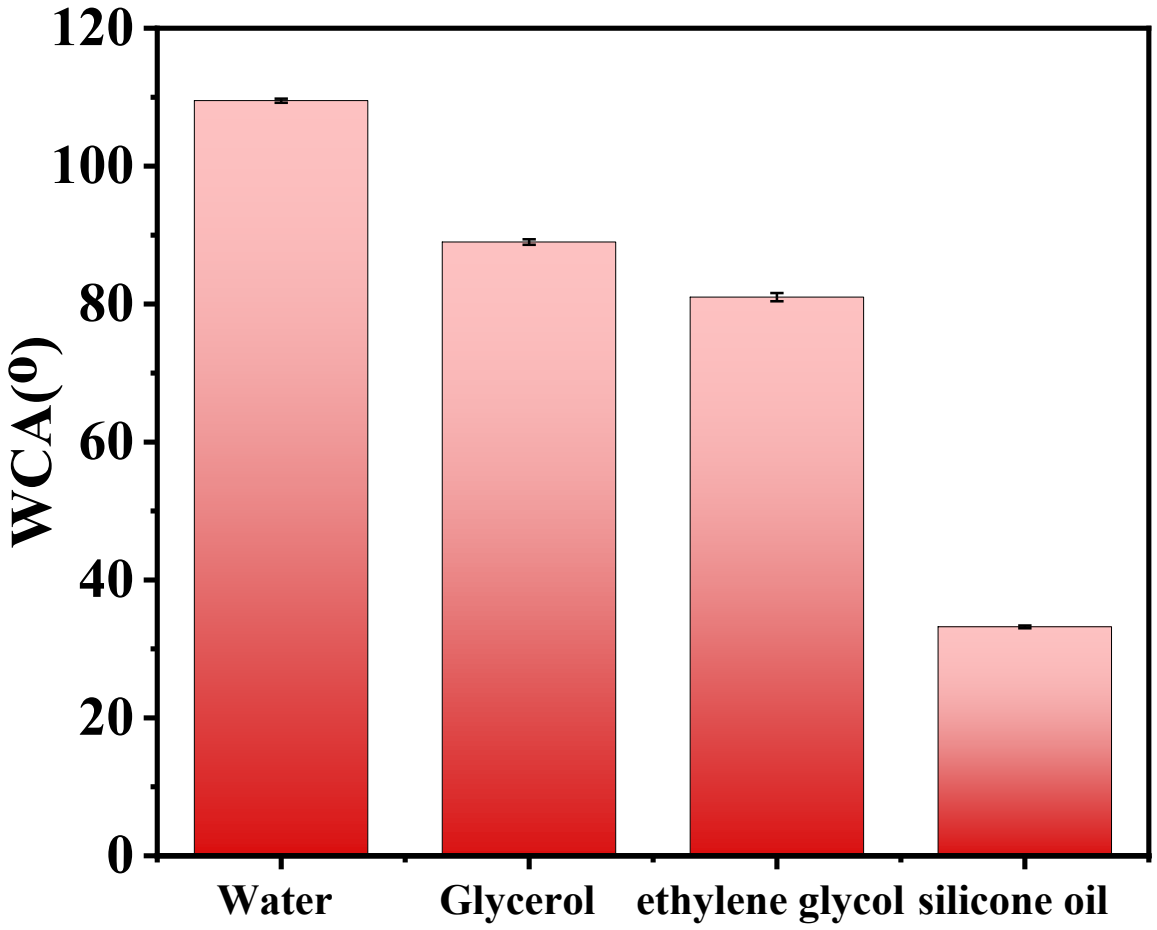


Fig: Static WCA measurments using different liquids

SURFACE ENERGY

- The **Kaelble-Uy model** was used to determine the surface free energy in order to further correlate the experimentally reported wettability with the leaf's surface properties.

$$\alpha_1 x + \beta_1 y = c_1$$

$$\alpha_2 x + \beta_2 y = c_2 \text{ ; here } x \text{ and } y \geq 0$$

$x = \sqrt{\gamma_s^d}$ and $y = \sqrt{\gamma_s^p}$, $\alpha_1 = \sqrt{\gamma_{L1A}^d}$, $\alpha_2 = \sqrt{\gamma_{L2A}^d}$

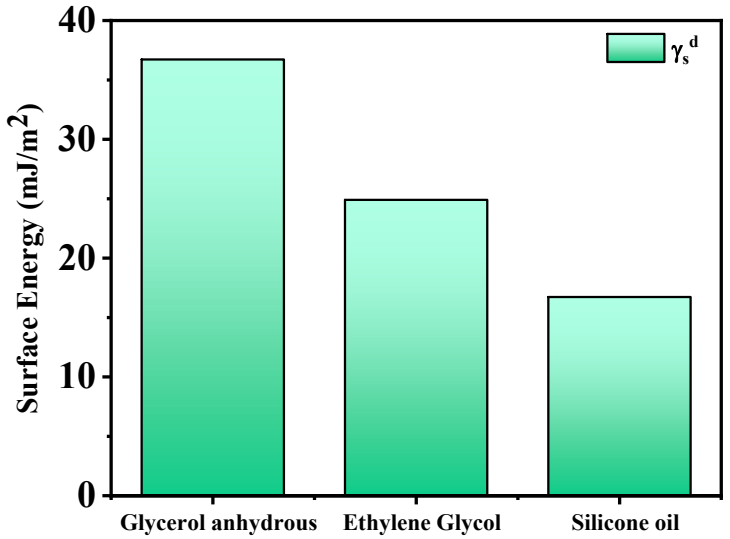
$\beta_1 = \sqrt{\gamma_{L1A}^p}$ and $\beta_2 = \sqrt{\gamma_{L2A}^p}$

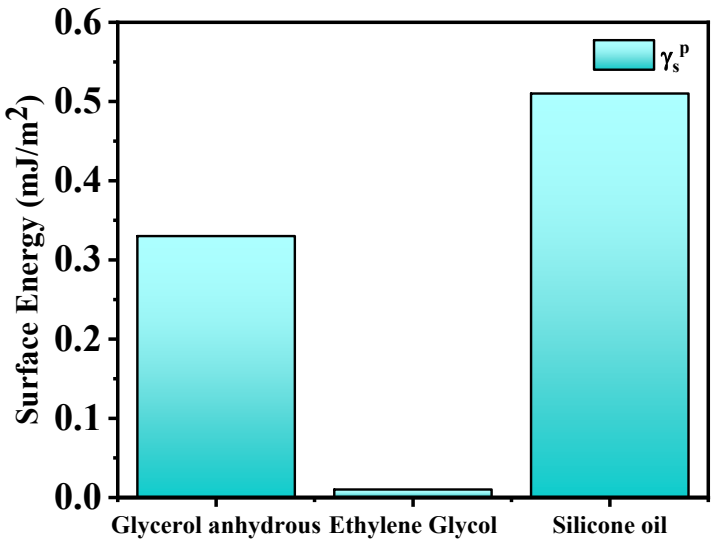
$c_1 = \frac{\gamma_{L1}^{total}}{2}(1 + cos\theta_{L1})$ and $c_2 = \frac{\gamma_{L2}^{total}}{2}(1 + cos\theta_{L2})$ respectively .

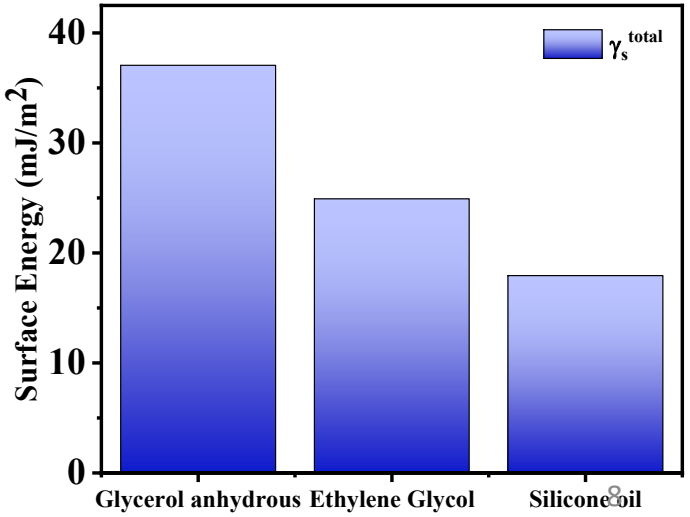
The γ_{Li}^{total} is given by $\gamma_{Li}^{total} = \gamma_{LiA}^d + \gamma_{LiA}^p$, i=1 and 2

Different liquids	Surface energy			
	γ_s^d (mJ/m^2)	γ_s^p (mJ/m^2)	γ_s^{total} (mJ/m^2)	Average Static contact angle
Glycerol anhydrous	36.72	0.33	37.05	(89.0 ± 0.4)º
Ethylene glycol	24.90	0.01	24.91	(81.0 ± 0.6)º
Silicone oil	16.72	0.51	17.93	(33.2 ± 0.2)º

The surface energy calculations were done taking water as the reference liquid, WCA was found to be (109.5 ± 0.3)ºand surface tension of water = 72.8mJ/m^2







FTIR ANALYSIS

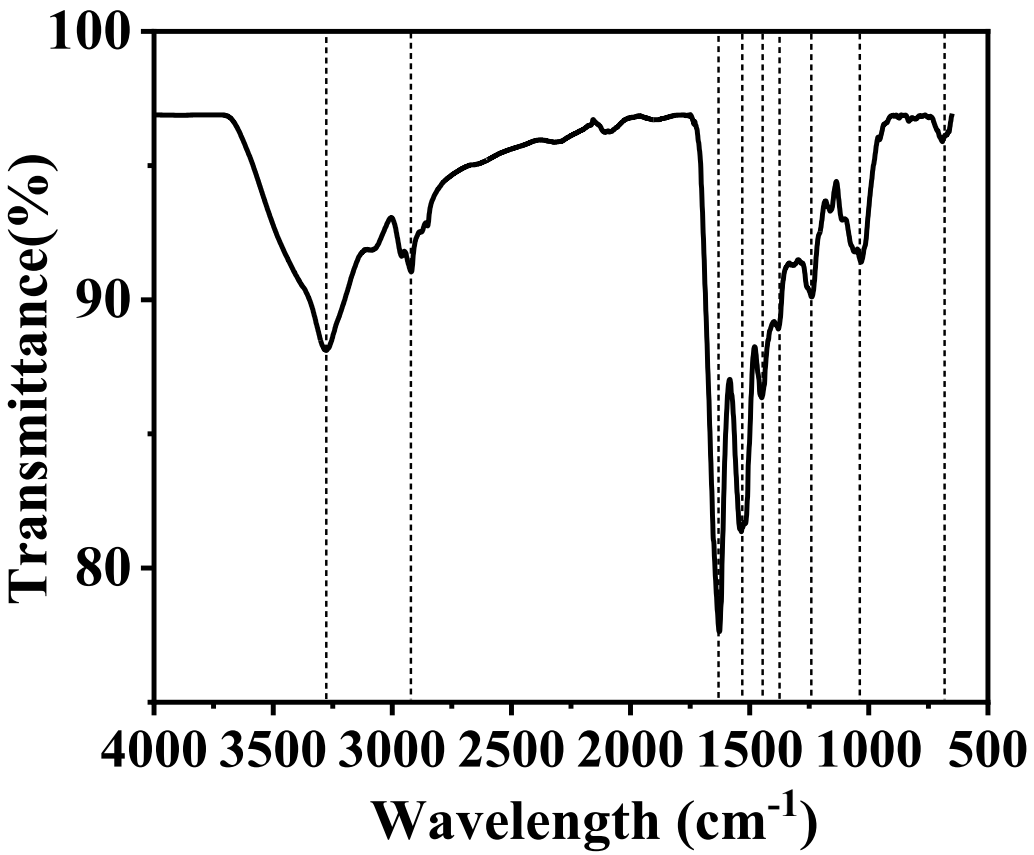
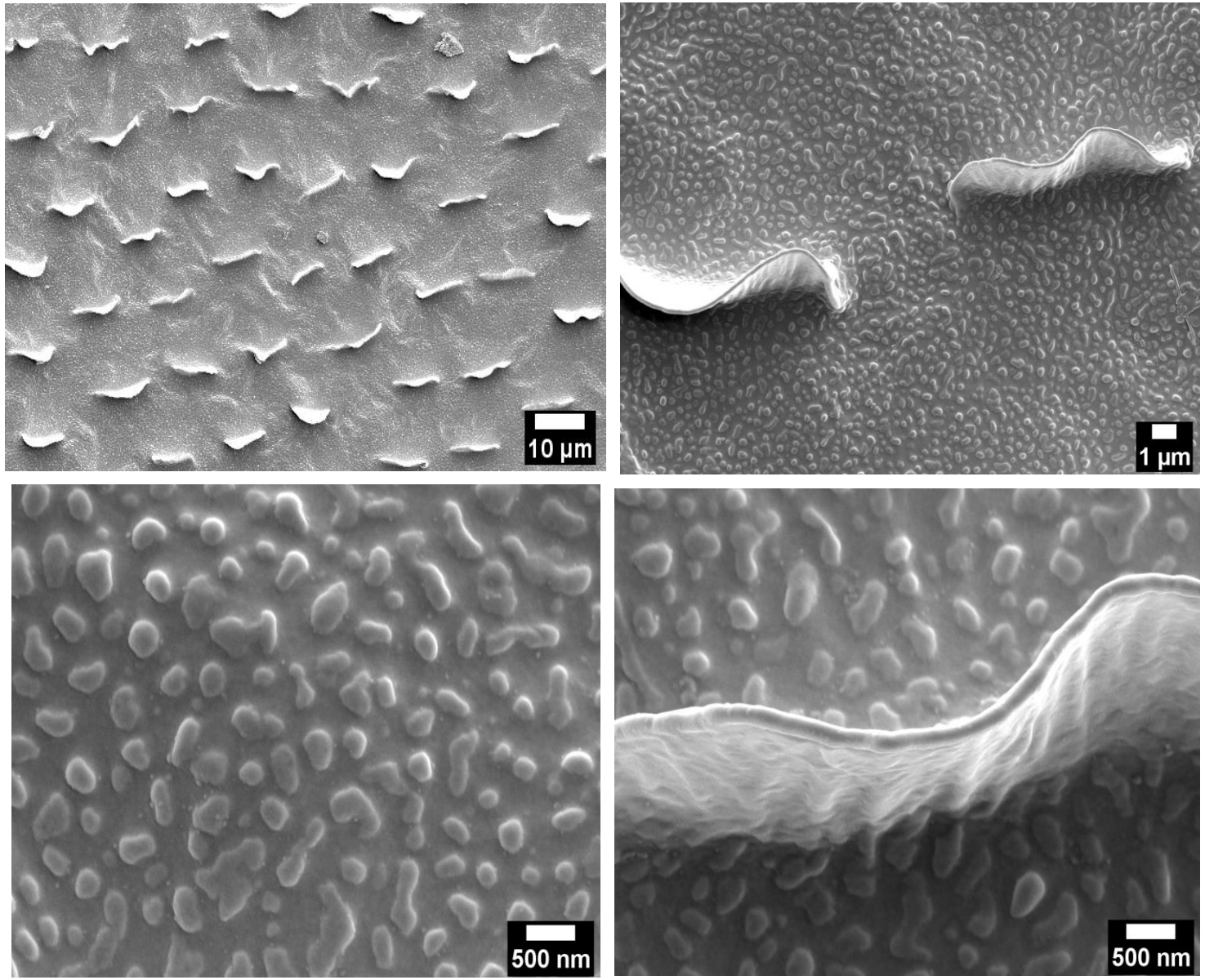


Fig: The FTIR spectra obtained in the ATR mode from the wavelength range (4000-650) cm^{-1} in percentage value transmission

Peak positions (cm^{-1})	Bonds	Possible constituents
3287	0-H stretching	Hydrogen bonded groups
2927	C-H stretching	Aliphatic chains in surface lipids and waxes
1635	C=C stretching	Chitin-protein matrix
1536	N-H stretching	Cuticular proteins
1452	C-O stretching	Aliphatic chains in surface lipids and waxes
1382	C–H stretching	Cuticular organic constituents
1243	C-O stretching	Chitin and cuticular proteins
1039	C-O stretching	Chitin carbohydrate ring

SURFACE MORPHOLOGY



Distance between the columnar structures	(14.29 ± 0.32) um
Length of the columnar structures	(1.21 ± 0.19) um
Width of the columnar structures	(189.61 ± 9.82) nm

Fig : FESEM images of the wing sample at an increasing magnification of 500x,5000x,10kx and 20kx

CONCLUSIONS

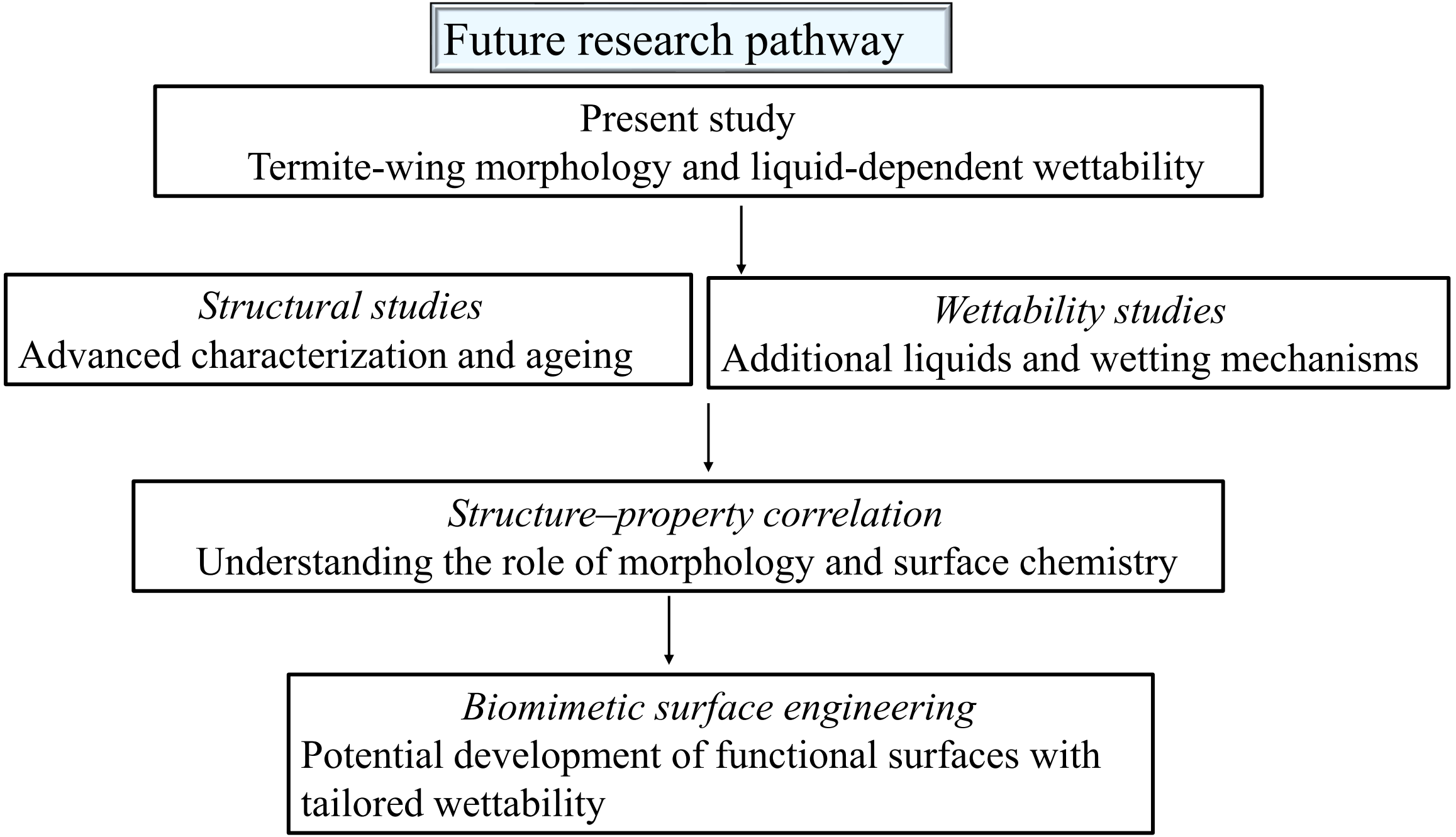
- ***Distinctive surface architecture***: The termite wing exhibits vertically oriented columnar structures separated by relatively large inter-structural gaps of approximately 14–15 µm.

- ***Liquid-dependent wettability***: The contact angle varies with the probe liquid, decreasing from ~110° for water to ~34° for silicone oil, demonstrating selective interactions with liquids of different surface tensions

- ***Role of surface chemistry***: Predominantly dispersive interactions suggest a relatively non-polar surface character, influencing the liquid–solid interactions and wettability of the termite wing.

- ***Role of surface morphology***: The observed wetting behaviour highlights the importance of surface architecture in influencing liquid–solid interactions.

- ***Biomimetic potential***: Understanding these natural surface characteristics may guide the development of engineered surfaces with tailored wettability for functional applications.


Future research pathway
Present study
Termite-wing morphology and liquid-dependent wettability
Structural studies
Advanced characterization and ageing
Wettability studies
Additional liquids and wetting mechanisms
Structure–property correlation
Understanding the role of morphology and surface chemistry
Biomimetic surface engineering
Potential development of functional surfaces with tailored wettability

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THANK YOU

"Nature is not merely a source of inspiration; it is a laboratory of intricate designs, where even the smallest structures hold the potential for remarkable discoveries."