Research and Creative Experience for Undergraduates (RCEU) Program 2023

Anisotropic Spiky Colloids for Antifouling Surfaces

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Motivation

Fouling is the accumulation of contaminants on a surface. Fouling reduces surface efficiency and can cause contamination, impacting several industries such as medical, maritime, and space.[2,3]

Our **approach** uses the assembly of anisotropic spiky colloids to fabricate antifouling surfaces to repel the broad range of shapes and sizes of fouling materials.

Objective: Characterize the assembly of anisotropic spiky colloids of differing spike size and distribution over a planar surface to repel fouling materials of different shapes and sizes.

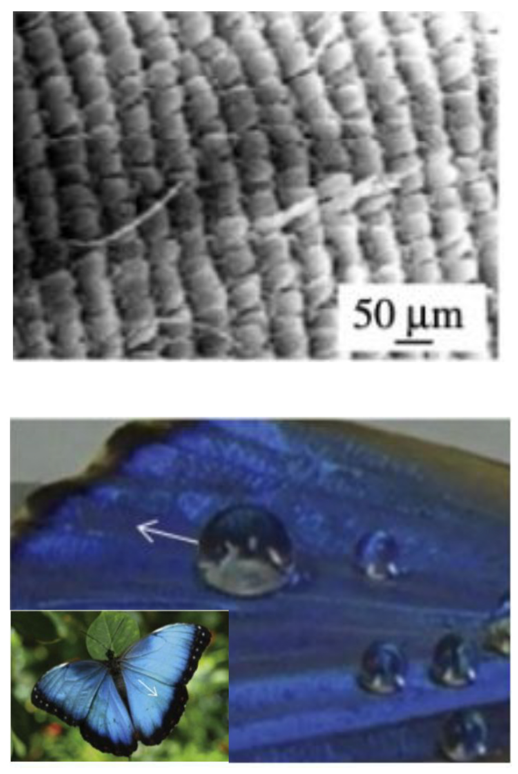


Figure 1. (a) European common blue butterfly wing (*P. Icarus*) at 50µm,[1] and (b) a giant blue morpho wing (*Blue Morpho didius*) showing superhydrophobic and anisotropic flow properties.[2]

Methodology

Particle morphology and spike distribution

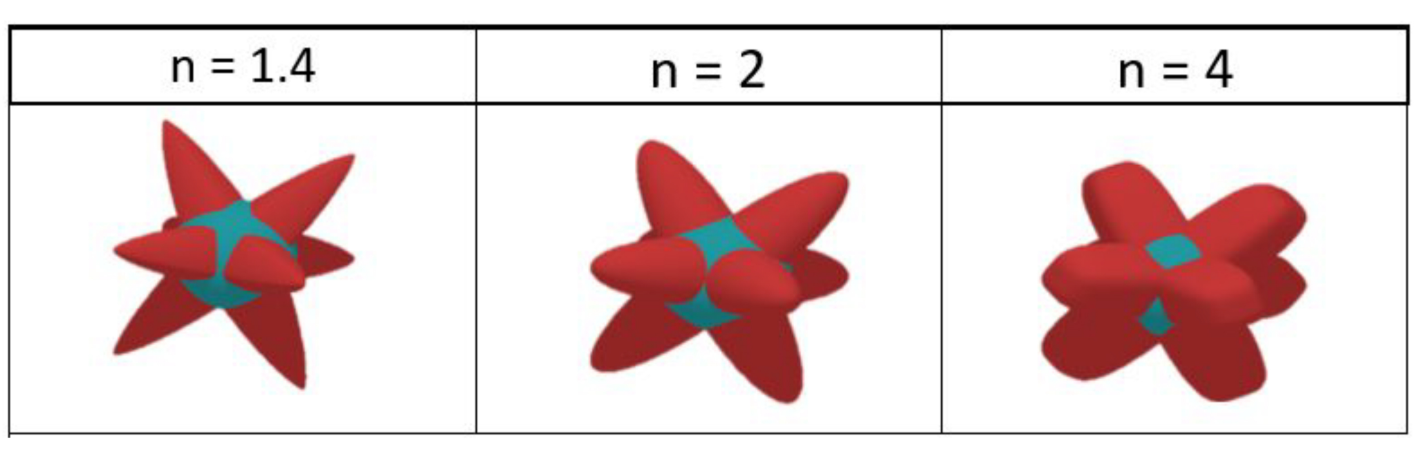


Figure 2. Particles schematics with a cube spike distribution with varying superellipsoid parameters, ranging from n= 1.4 to 4.

$$\left|\frac{x}{r_x}\right|^n+\left|\frac{y}{r_y}\right|^n+\left|\frac{z}{r_z}\right|^n=1.$$

Random Sequential Adsorption, or RSA is a process in which particles are randomly introduced to a system. If a particle is placed on the surface where there is not already a particle, it adsorbs and remains fixed for the duration of the simulation.

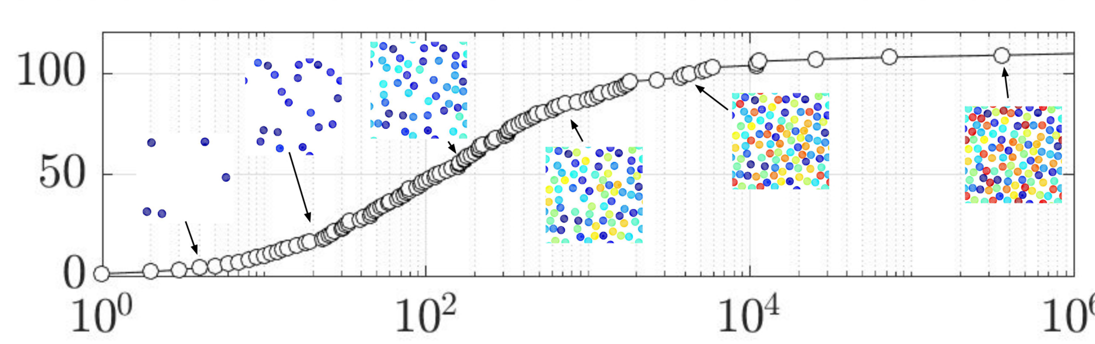
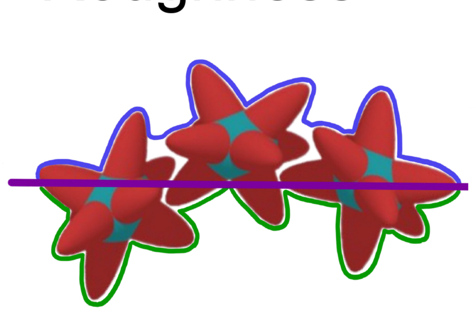


Figure 3. Representative plot of random adsorption of particles at different steps, represented in the insets.

Roughness



$$\tilde{\sigma}=\frac{1}{n_y}\sum_{j=1}^{n_y}\left(\frac{1}{n_x}\sum_{i=1}^{n_x} z(x,y)\right)$$

Figure 4. A set of particles with the peaks, valleys, and midline outlined alongside the equation used to find average roughness.

Pair correlation function

The pair correlation function characterizes the particle configuration/structure by measuring the probability of finding the center of a particle at a distance from another particle, which is defined by

$$g(r)=\frac{V}{4\pi r^2 N^2}\langle\sum_i\sum_{j\neq i}\delta(r_i-r)\rangle$$

References

1. Gregory D. Bixler and Bharat Bhushan. *Phil. Trans. R. Soc. A.*, ***370**, 2381-2417*. (2012).
2. G. D. Bixler, A. Theiss, B. Bhushan, and S. C. Lee. *J. Colloid Interface Sci.*, ***419***, 114–133. (2013).
3. S. Erramilli and J. Genzer. *Soft Matter*, **15**, 4045-4067 (2019).

Results

Adsorption variation with aspect ratio and shape

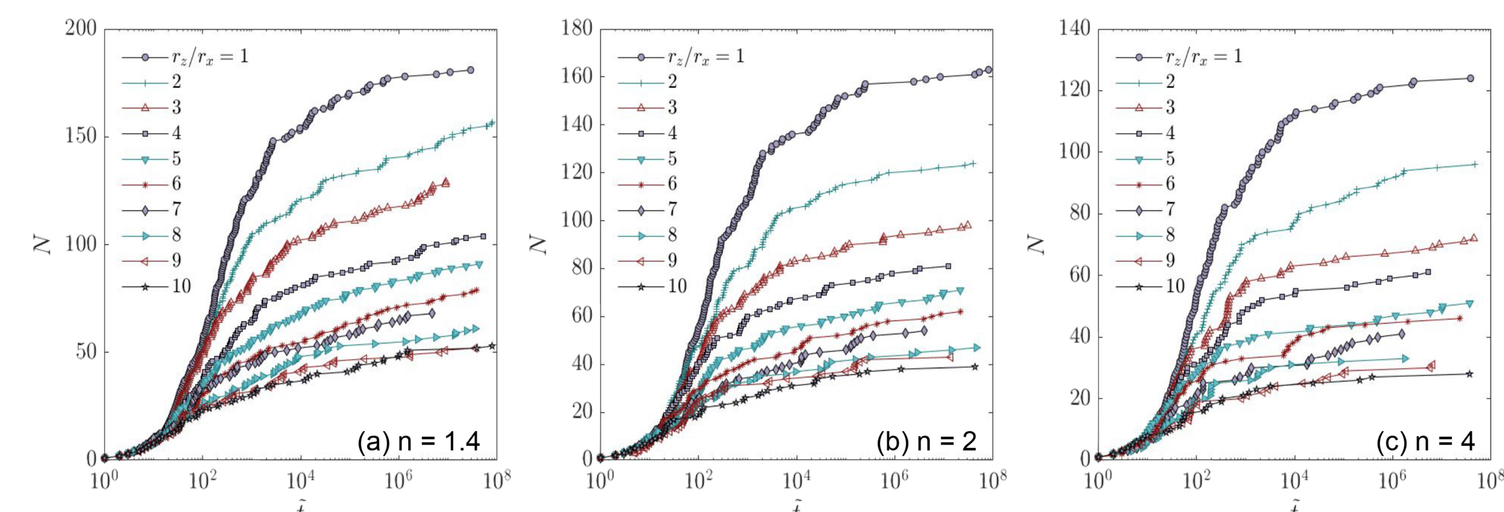


Figure 5. Comparison of Random Sequential Adsorption curves of different aspect ratios r_z/r_x and spikes shapes (a) n = 1.4, (b) n = 2, and (c) n = 4.

Roughness

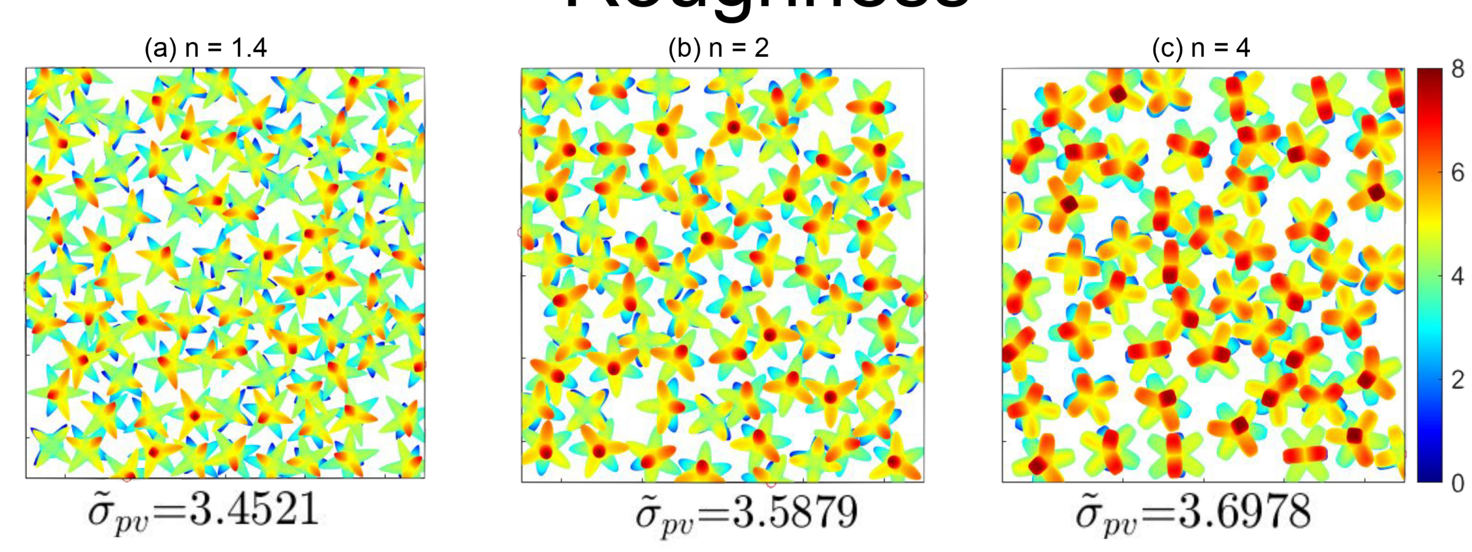


Figure 6. Roughness of adsorbed particle structures using spiky particles with a superellipsoid parameter (a) n = 1.4, (b) n = 2, and (c) n = 4.

Pair correlation function

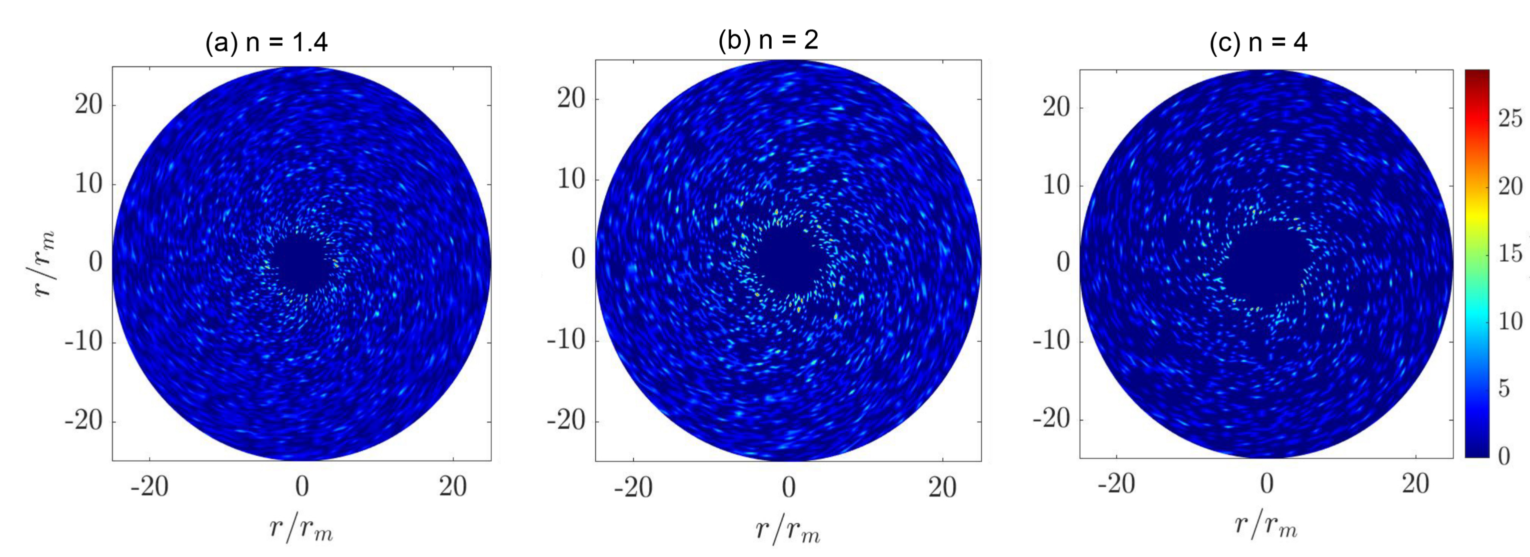


Figure 7. The pair correlation function of adsorbed particle structures, with superellipsoid parameters (a) n = 1.4, (b) n = 2, and (c) n = 4.

Conclusions and Future Work

- The maximum number of adsorbed particles decreases as particles aspect ratio increases. Furthermore, the number of adsorbed particles decreases as the shape parameter (n) increases.
- The average roughness increases as the spike shape parameter increases. But the particle-particle separation decreases.
- We create representative 3D-printed models of the particles studied.
- In the future we will study more aspect ratios and particle morphologies and begin adding multi-scale fouling particles.

Acknowledgements

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