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Studies on Lotus and Rice Leaf Surfaces by Using RIMAPS Technique

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It is already known that RIMAPS (Rotated Image with Maximum Average Power Spectrum) technique allows finding the main directions of any surface topography and describing it by simple geometrical figures [1]. It has already been applied to the study of metallic surfaces and biological samples [2] [3]. This research work describes the micropatterning of lotus (*Nelumbo nucifera*) and rice (*Oryza sativa*) leaf surfaces by analyzing their RIMAPS spectra. These surfaces are superhydrophobic, which means that their static contact angles are greater than 150º and their sliding angles (SA) are less than 10º [4]. The surface of the lotus leaf is uniformly textured with 10 μm size protrusions (figure 1). The arrangement of these protrusions seems to be random and the sliding angle (3º) is the same in any direction. In the case of the rice leaf (figure 2), epidermal cells, stomas and papillae (diameter of 4 μm) are arranged in one-dimensional order parallel to the apex direction. The SA is different if it is measured following the apex direction (SA of 4º) or following the perpendicular direction (SA of 12º). Therefore, its superhydrophobic condition is greatly influenced by the lineal arrangement of papillae. Water droplets move harder along the perpendicular direction than the parallel one.

RIMAPS spectra of both surfaces are quite different. The spectrum of the lotus leaf (figure 3, red line) is similar to the spectrum obtained by a combination of geometrical forms such as a circle and straight lines [1]. Therefore, the micropatterning of the surface can be represented by a simple circle (papillae morphology) plus many straight lines in different directions (secondary alignments of papillae), which means a quite uniform distribution of papillae. The rice leaf shows a spectrum similar to a straight line. Maximum values, at approximately 5º and 185º (figure 3, black line), indicate the main direction of the arrangement (apex direction), and values at 100º and 280º the perpendicular direction. The micropatterning of the surface can be represented by two perpendicular straight lines. If we observe the rice leaf with a higher magnification (1000X and 2000X), we can see that the lineal arrangement is still present but no so well defined as in the previous case. RIMAPS spectrum highlights this situation. In figure 4 the spectrum of the rice leaf seen with a higher magnification (1000x) is compared to the spectrum of the previous lotus leaf (600X). Clearly, both spectra are quite similar. If we continue magnifying the visual field of the rice leaf (figure 5, 2000X), the RIMAPS spectrum does not show anymore two main maxima seen with a magnification of 500X, only a set of similar maxima values produced by the different alignment of papillae (figure 6). In summary, RIMAPS spectrum is a useful tool for analyzing the anisotropy of a micropattern quantitatively and finding out the minimum size of the visual field where the pattern looses its anisotropy.

References

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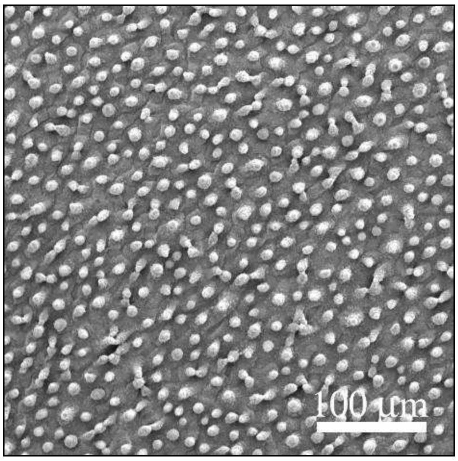

Figure 1. Scanning electron microscope (SEM) image of a lotus leaf (600x).

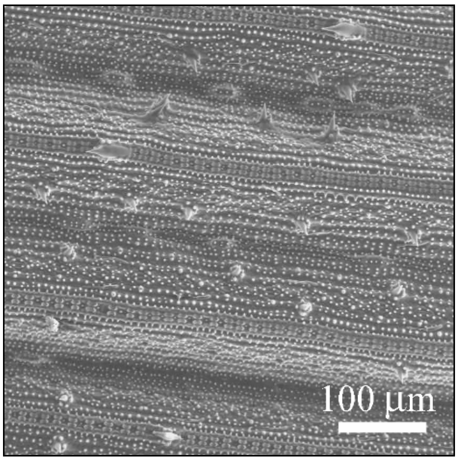

Figure 2. SEM image of a rice leaf (500x).

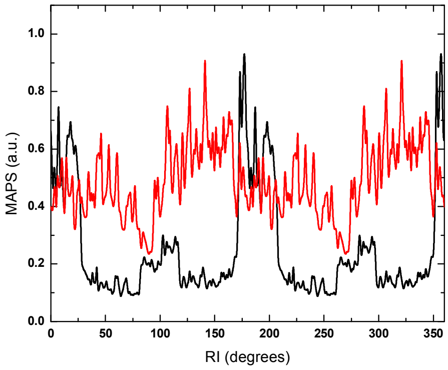

Figure 3. RIMAPS spectra. Red line: lotus leaf (figure 1); black line: rice leaf (figure 2)

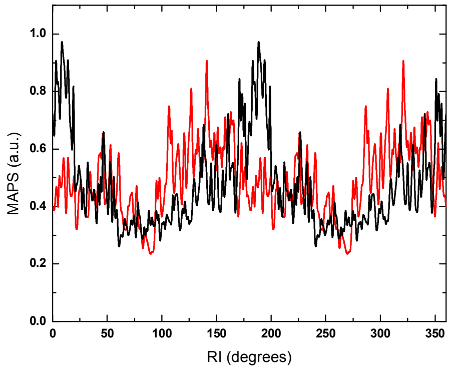

Figure 4: RIMPS spectra. Red line: lotus leaf (600x); black line: rice leaf (1000x).

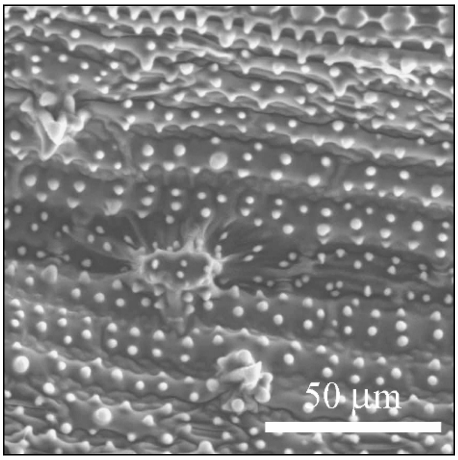

Figure 5. SEM image of a rice leaf (2000x).

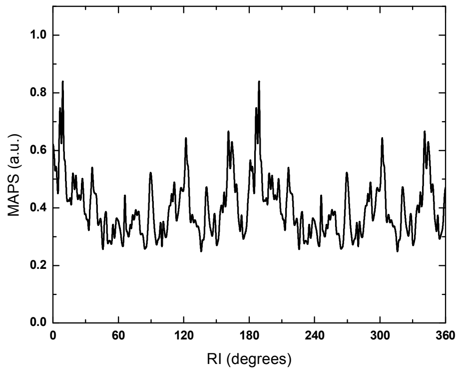

Figure 6. RIMAPS spectrum of figure 5.

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