Bacterial Surface Charge Density Determined Via Saturation of Adsorbed Ions

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ABSTRACT

Bacterial surface charge is a critical characteristic of the cell's interfacial physiology that influences how the cell interacts with the local environment. A direct, sensitive, and accurate experimental technique capable of quantifying bacterial surface charge is needed to better understand molecular adaptations in interfacial physiology in response to environmental changes. We introduce here the method of second harmonic light scattering (SHS) which is capable of detecting the number of molecular ions adsorbed as counter charges on the exterior bacterial surface, thereby providing a measure of the surface charge. In this first demonstration, we detect the small molecular cation, malachite green, electrostatically adsorbed on the surface of representative strains of Gram-positive and Gram-negative bacteria. Surprisingly, the SHS deduced molecular transport rates through the different cellular ultra-structures are revealed to be nearly identical. However, the adsorption saturation densities on the exterior surfaces of the two bacteria were shown to be characteristically distinct. The negative charge density of the lipopolysaccharide coated outer surface of Gram-negative *E. coli* (6.6 ± 1.3 nm^{-2}) was deduced to be seven times larger than that of the protein surface layer of Gram-positive *L. rhamnosus* (1.0 ± 0.2 nm^{-2}). The feasibility of SHS deduced bacterial surface charge density for Gram-type differentiation is presented.