Detection and Characterization of Chiral Nano-Samples Using Photo-induced Force

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Detection and characterization of chiral particles (materials) are of supreme importance in chemistry and biology since the fundamental building blocks of life, i.e., proteins and nucleic acids are built of chiral amino acids and chiral sugar. In this work, we propose a novel high resolution microscopy technique for detection and characterization of chiral samples down to sub-100 nm based on photo-induced force microscopy. Unlike conventional techniques like circular dichroism which are vulnerable to background noise and require a considerable amount of sample, thanks to the capabilities of photo-induced force microscopy in exploiting near-field information, we introduce a fundamentally new measurement method to resolve the existing limitations. We delve into the differential photo-induced optical force ΔF exerted on an achiral probe in the vicinity of a chiral sample, when left and right circularly polarized beams separately excite the sample-probe interactive system. We show that ΔF is entangled with the enantiomer type of the sample, enabling enantio-specific detection of chiral inclusions. Moreover, we demonstrate that ΔF is linearly dependent on both the chiral response of the sample and the electric response of the tip and is inversely related to the quartic power of probe-sample distance. We provide physical insight into the transfer of optical activity from the chiral sample to the achiral tip based on a rigorous analytical approach. We support our theoretical achievements by several numerical examples, highlighting the potential application of the derived analytic properties. Lastly, we demonstrate the sensitivity of our method to enantio-specify nanoscale chiral samples. By establishing this high resolution measurement technique for biomedical applications, we essentially advance the characterization of chiral samples for controlling constructive reaction between drugs and receptors in human body.