Single particle chirality

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Chiroptical activity serves as an important tool for manipulating light or for characterizing spatial arrangements in molecules, proteins (and other polymers), crystals and nanostructures. The difficulty to measure Circular Dichroism (CD) of individual nano-objects have been challenged recently by using near field techniques[1] or dark-field[2] of randomly generated non symmetric structures . Here, we present a study in which CD absorption spectroscopy of individual, well defined fabricated (left and right chirality) Gammadions was directly measured**.**

Our experimental setup for measuring the spectroscopy of individual nanostructure follows the approach of Sandoghdar and coworkers[3] who demonstrated single molecule detection by optical absorption. We expand the spectral range to the entire visible spectrum, together with accurate polarization control to enable CD spectroscopy. Our light source consists of a broadband Supercontinuum source, filtered by Acousto-optic tunable filter. We use a moderately high NA polarization maintaining objective to increase the sensitivity of measuring interaction between the beam and particles, while still maintaining pure states of polarization states at the sample. We scan through the spectral range, and spatially over the sample of interest, and preform spectroscopic absorption and reflectance measurement on individual particles. A liquid crystal retarder cycles 30-100 times between Left/Right circular polarization states, to differentiate between the corresponding absorptions, and thus measure dissymmetry caused by a single nanoparticle.

We show that at 600nm wavelength, a right handed 160nm chiral gammadion leads to a negative dissymmetry value at the shapes center. The dissymmetry is of the order of 10^{-4}. This distinct CD, is reversed in sign when measuring CD on an equivalent left handed Gammadion. Wide spectral range measurements were performed on 500nm Au Gammadions. The experimental spectra of the CD of left handed and right handed Gammadions show strong similarity to our FDTD simulations.

In summary, we have successfully shown bright, far-field CD spectroscopy of single nano-objects, with a distinct ability to distinguish between the CD responses of two enantiomers and to map the spatial CD distribution on the nanoscale.

REFERENCES

1. Narushima, T. & Okamoto, H. Strong Nanoscale Optical Activity Localized in Two-Dimensional Chiral Metal Nanostructures. *J. Phys. Chem. C* **117,** 23964–23969 (2013).
2. Smith, K. W. *et al.* Chiral and Achiral Nanodumbbell Dimers: The Effect of Geometry on Plasmonic Properties. *ACS Nano* **10,** 6180–6188 (2016).
3. Kukura, P., Celebrano, M., Renn, and Sandoghdar, V., Imaging a single quantum dot when it is dark. *Nano Lett.* **9,** 926–9 (2009).