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Micro- and nano-tomography with nanoparticles

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The new generation synchrotron and X-ray Free Electron Laser facilities mark an important milestone on the development of x-ray science. Two examples will be presented to illustrate the bright potential of x-rays. The extremely bright hard-x-rays provide a unique opportunity to synthesize metal nanoparticles of high quality with high throughput. On the other hand, the same high brightness x-ray photons enable the phase contrast imaging and transmission x-ray microscopy of unprecedented performance. The nanoparticles synthesized by x-rays and the x-ray characterization already impacted life science by tackle important questions, such as the tumor related micro-angiogenesis. With the capability to characterize quantitative all the structural factor of the microvasculature of complete tumor region or an organ, aided with the innovative use of nanoparticles, we could conclude that the phenotype dependent tumor angiogenesis in mouse glioma models.
Using the excellent performances of the SACLA (RIKEN/HARIMA, Japan) x-ray free electron laser (X-FEL), coherent diffraction imaging (CDI) was successfully implemented to image individual liposome particles in water, with or without inserted doxorubicin nanorods. In spite of the low cross section of the original ingredients, the diffracted intensity of drug-free liposomes was sufficient for spatial reconstruction yielding quantitative structural information. For particles containing doxorubicin, the structural parameters of the nanorods can be extracted from CDI. Furthermore, the measurement of the electron density of the solution enclosed in each liposome provides direct evidence of the incorporation of ammonium sulphate into the nanorods. This is an important test for extending the X-FEL analysis of individual nanoparticles to low cross-section-systems in solution, and also for its potential use to optimize the manufacturing of drug nanocarriers.

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