CIC biomaGUNE
CENTER FOR COOPERATIVE RESEARCH IN BIOMATERIALS

SEMINAR

Monday, 16th July, 12.00 pm, Seminar Room

Host: Dr. Ralf Richter

Mechanical and structural studies of internal lipid-containing bacteriophage PRD1

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Protection of the viral genome during extracellular travel is an absolute requirement for virus survival and replication. Once the viral particle attaches to the host cell, the ejection of the genomic material can begin. In addition to the almost universal proteinaceous capsids, certain viruses possess a membrane layer that encloses their double-stranded (ds) DNA genome within the protein shell. While the mechanical properties of other viruses have been studied before, this thesis investigates a virus with a membrane under its protein capsid. Using enterobacterial virus PRD1 as a prototype of tail-less, membrane-containing viruses, and a combination of nanoindentation assays by atomic force microscopy and finite element modelling we show that the hierarchical architecture of PRD1 (protein shell, proteo-lipidic vesicle, dsDNA) provides greater stability against mechanical stress than achieved by other dsDNA icosahedral viruses that lack a membrane. The combination of a stiff and brittle proteinaceous shell coupled with a soft and compliant membrane vesicle yields a tough composite nanomaterial well-suited to protect the viral DNA during extracellular transport. Furthermore, we look at the structure and mechanical properties involving the assembly of the DNA ejection tube of such a virus. While studies have solved the structure of various tailed viruses, here we investigate a phage that forms the DNA ejection tube upon attachment. We employed cryo electron microscopy (cryo-EM) reconstruction to show that this viral particle is producing a structured, non-helical tube, with a seven-fold axial symmetry, that is formed using the proteo-lipidic membrane. In combination with atomic force microscopy (AFM) nanoindentation assays, we visualize individual tube producing particles, and showed that the PRD1's tube has a stiffness comparable to similar tubular structures, such as thick lipid tubules, or tubular-shaped tobacco mosaic virus (TMV). Hints regarding the tube's ability to self-heal are present, when external mechanical pressure is released after compression beyond the yield point. These results provide the first insight into the relationship between structure, mechanical properties and function of membrane-containing viruses. They could benefit nanoengineers that could incorporate the composite design of PRD1 in their quest for more stable nanoparticles, but also the quest for novel pharmaceutical solutions that deal with anti-bacterial resistance, and bacterial infections in general, as this proteo-lipidic nanotube can drill holes into the bacterial envelope.

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