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Penetration of Microparticles across Mucus Barriers: A Colloidal Probe Microscopic Approach

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Mucus represents "first defense line" of all mucosal surfaces, such as gastrointestinal, cervical, ocular, respiratory lines against chemical, enzymatic, microbial, and mechanical insult. While pathogenic colonization by microbes starts from adhesion on mucus surface, they have to overcome the mechanical integrity of mucus gels in order to reach the apical surface of epithelial cells. Ironically, this defensive behavior of mucus gels acts as physical barrier when it is needed to deliver drug molecules or functional foods to target cells or tissues. Mucoadhesive polymers have been proposed as one of potent ways to enable the traverse of drug-loaded particles through mucus gel layers based on strong entanglement with mucin network. Nevertheless, it is often not sufficient to reach ultimate goal, i.e. delivery of drugs to target cells, due to relatively short turnover time and frequent clearance of mucus gels. It is thus necessary to develop more effective means to engineer particles that can efficiently "penetrate through" the barrier for this purpose. In this study, we have employed atomic force microscopy (AFM) as an experimental approach/model to characterize the nanomechanical properties of mucus gels and the interaction with microbes and drug/function nutrients. Mucus was acquired by scraping from a freshly slaughtered pig's stomach and intestine, and was further cleaned according to a standard procedure. Polyethylene (PE) or silica (SiOx) colloidal particles were attached to AFM probes, representing model microbes or drug molecules interacting with mucus layers. Young's moduli of both mucus samples were determined to be in kPa range. In-depth discussion on the mechanical properties of pig intestine mucus, the influence of size and surface chemistry of the colloidal probe on the compression/penetration, as well as the force/energy required for a micro-sized particle to overcome and penetrate through the mucus layers will be provided.

Biography:

Dr. Seunghwan Lee completed PhD in physical chemistry in 2000(University of Houston), then worked in the field of biotribology and biomimetic lubrication at ETHZ, Switzerland until 2008.Since 2009, he has been leading a research group focusing on biotribology of mucin, mucus, orthopaedic implants, and antifouling properties at the Department of Mechanical Engineering, DTU, Denmark.