Virus attachment to surfaces: Assessing relative contributions of electrostatic, van der Waals, and acid-base interactions

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3546D Engineering Building
Ph.D. advisor: Dr. Volodymyr V. Tarabara

Abstract:
Adhesion to surfaces plays an important role in determining pathogen transport and fate in the environment. Countertops, hospital walls, hair and skin are examples of surfaces of particular interest. While bacterial adhesion is relatively well understood, less is known about interactions of viruses with surfaces of different charges, hydrophobicities and morphologies. In this study, the attachment of bacteriophage MS2 and human adenovirus 40 (HAdV40) onto polyelectrolyte- and paint-coated surfaces has been investigated using an approach that combines experimental studies and theoretical modeling. The extended Derjaguin-Landau-Verwey-Overbeek (XDLVO) model was used to calculate the energy of virus-surface interaction. The theoretical predictions were validated in experiments that used quartz crystal microbalance with dissipation (QCM-D) to measure the mass of deposited viruses. The polyelectrolyte-coated surfaces were designed by assembling a polyelectrolyte multilayer via alternate deposition of the negatively-charged poly(styrene-4-sulfonate) and positively-charged poly(dimethyl diallyl ammonium chloride). The paint-coated surfaces were prepared by spin-coating three household paints (water-based acrylic latex, water-based alkyd, and oil-based alkyd), which differed in terms of their chemical composition, surface charge and hydrophobicity. Experimentally observed trends in experiments MS2 deposition onto the polyelectrolyte–coated surfaces were consistent with XDLVO predictions: a) deposition onto the positively-charged surface was significantly (~ 5 to 6 times) higher than on a negatively charged one and b) deposition was enhanced at higher ionic strengths of the background electrolyte. The kinetics of deposition depended on the salinity: lower salinity led to faster deposition and a shorter time to steady-state. The experimental data on HAdV40 adhesion to the household paints was also in a qualitative agreement with predictions by the XDLVO theory. The quantitative discrepancies between QCM-D experiments and XDLVO theory were attributed to details of the surface morphology and the chemical heterogeneity of the paint layer. For both viruses and all surfaces studied, the electrostatic and hydrophobic interactions were found to govern virus deposition behavior with van der Waals interactions playing a comparatively minor role. The approach demonstrated in this study can guide the design of surfaces that resist virus adhesion. Polymeric coatings and paints so formulated should help reduce human exposure to viruses.