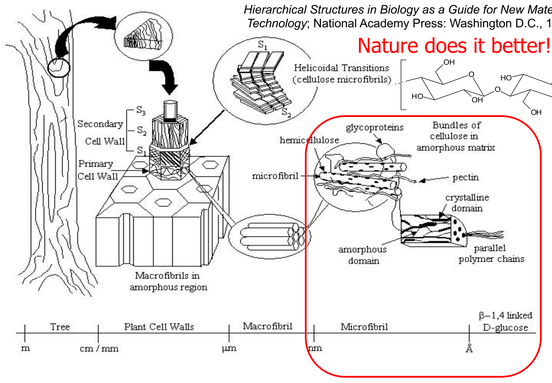
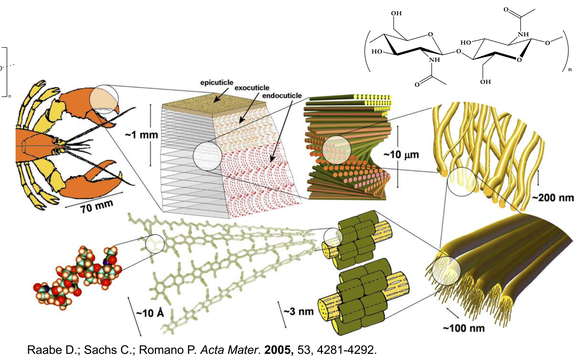
Virginia Tech
Department of Chemistry
Esker Research Group

Plants, invertebrate exoskeletons and cell membranes are sources of inspiration for designing new materials over a wide range of length scales. Nonetheless, fundamental knowledge about the interactions between components in these systems and the biochemical processes that govern their assembly are still required if these systems are to be tapped for applications in biofuels, biomaterials, and drug delivery. Our group primarily uses surface plasmon resonance (SPR), quartz crystal microbalance with dissipation monitoring (QCM-D) and atomic force microscopy (AFM) to study enzyme kinetics and self-assembly in systems comprised of natural and synthetic polymers. Specific areas of interest include hemicellulose assembly onto cellulose as found in the primary cell walls of plants, lignification as it occurs in the secondary cell walls of plants, and the interactions of proteins with cellulose, chitin and other polysaccharides.





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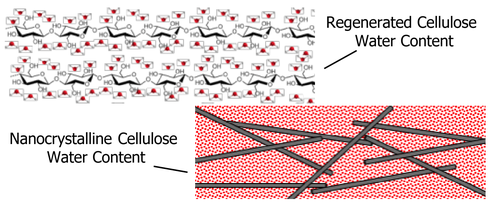
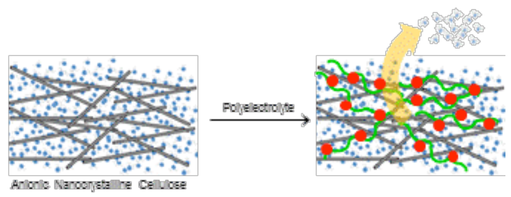
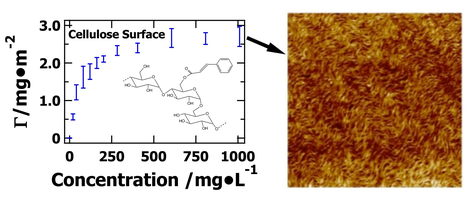
In plant cell walls, cellulose exists as microfibrils that serve as a scaffold. In primary cell walls, hemicelluloses and pectins (polysaccharides) bind to cellulose to form networks for growing cell walls. In secondary cell walls, lignin forms to hold the now dead cells together and is a principle component of the tracheid system for water and mineral transport. While hydrogen bonding is ubiquitous in polysaccharides, the competition for hydrogen bonds with water means that hydrophobicity and electrostatics strongly impact polysaccharide assembly onto cellulose. The same films our group has developed to study interactions between polysaccharides are perfect "chips" for studying enzymatic processes at surfaces. Native cellulases are often a mixture of endogluconases, exogluconases and β-glucosidases. We use our techniques to study mixtures and purified enzymes. More recently, we have extended these efforts to study lignification through a surface initiated polymerization, as well as the subsequent degradation of the film. These efforts allow us to apply surface science techniques to provide new insights. Our efforts address fundamental differences in interactions between components of primary and secondary plant cell walls that will lead to better efficiency in the production of biofuels and new materials based upon renewable resources.



"Equilibrium Water Content of Model Cellulose Substrates Determined via Solvent Exchange and Quartz Crystal Microbalance with Dissipation Monitoring," Kittle, J. D.; Du, X.; Jiang, F.; Qian, C.; Heinze, T.; Roman, M.; Esker, A. R. *Biomacromolecules* **2011,** *12*, 2881-2887.



"Enhanced Dewatering of Polyelectrolyte Nanocomposites by Hydrophobic Polyelectrolytes," Kittle, J. D.; Wondraczek, H.; Wang, C.; Jiang, F.; Roman, M.; Heinze, T.; Esker, A. R. *Langmuir* **2012,** *28*, 8348-8358.



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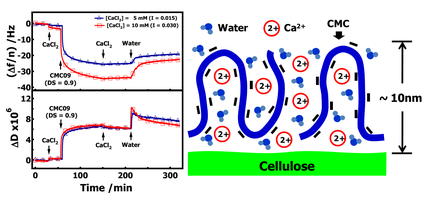

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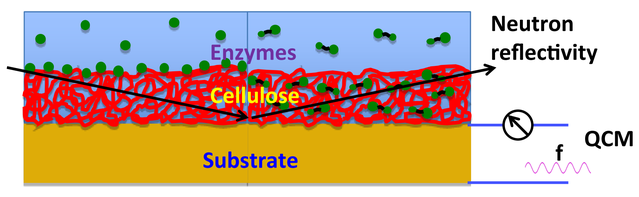

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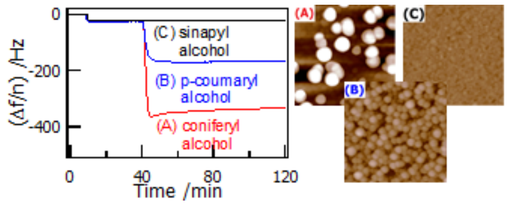
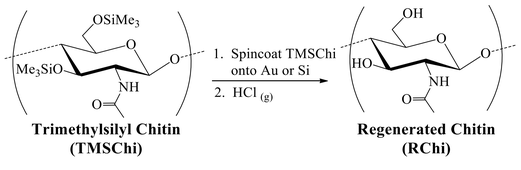


"Surface-initiated Dehydrogenative Polymerization of Monolignols: A Quartz Crystal Microbalance with Dissipation Monitoring and Atomic Force Microscopy Study," Wang, C.; Qian, C.; Roman, M.; Glasser, W. G.; Esker, A. R. *Biomacromolecules* **2013,** *14*, 3964-3972.

For invertebrate exoskeletons, chitin's role is analogous to cellulose in plants. The acetylation found in chitin, leads to low solubility and makes the molecule difficult to process. In contrast, partially deacetylated chitin, chitosan, is water soluble and widely used as a biomaterial. Our group creates highly acetylated chitin films using trimethylsilyl chitin and studies the interactions of these materials with enzymes and proteins. We are particularly interested in the hemostatic properties of chitin derivatives and analogs relative to other polysaccharides and biomineralization.



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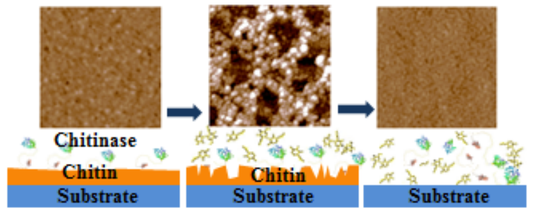

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Alan R. Esker
aesker@vt.edu
(540) 231-4601

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