KaiLian Davis
Honors Summer Capstone Project Proposal: Interaction of Spiky Particles with Substrates
Mentor: Dr. Isaac Torres-Díaz, Department of Chemical and Materials Engineering, UAH
Project Start Date: May 20th, 2020
Project End Date: July 29th, 2020

Area of Focus:

Colloidal nanoparticles are of interest for biomedical applications, such as drug delivery, hyperthermia, biosensors, and imaging. The therapeutic delivery process of these nanoparticles is currently being studied to maximize cellular uptake and delivery capacity. There several different types of colloidal particles which vary in shape, surface anisotropy, branchiness, and internally structured configurations. These differences change the interaction between the particle and its intended substrate. Particle-substrate interactions are studied relative to the interaction kinetics, as well as the chemical properties of the particle, where the preferred equilibrium particle orientation is represented by the minimum of the interaction energy landscape.

Bio-inspired colloidal particles with shape anisotropy are of interest since they could enhance the cellular uptake. One type of bio-inspired colloidal particle is the spiky particle, which has different morphologies such as rambutan and raspberry. This particle shape is seen in nature as pollen or a bur seed. It has a unique topography that has been studied with respect to its increased loading capacity and interaction with the cell membrane. They have also been studied in their role for intracellular delivery. Another important aspect of the particle is its chemical composition. Many nanoparticle delivery systems use organic, inorganic, or hybrid-based materials, such as gold and iron-oxide, which are biologically compatible nanoparticles. The properties of these materials have existing values that can be evaluated for compatibility in theory with a particular substrate, such as a cell membrane.

Previous work with Dr. Isaac Torres-Díaz has included quantifying particle-substrate interactions using the DLVO theory, which combines Van der Waals and electrostatic interaction energy. By following this model, which utilizes a surface integration method, I will apply the methodology for a spiky particle to develop a method for effective drug delivery.

Description of the Project:

In this project, I will study spiky particles in theory, then use those results to create simulations of the particles. Overall my end goal is to complete experimental work on spiky particles. I will investigate the interactions of a spiky particle with a planar substrate, specifically the DLVO interactions as a function of their position and orientation. I will develop an algorithm using MATLAB to quantify the equilibrium configuration of the bio-inspired spiky particle. I will analyze the data and write reports on my data.

Goal/Product of the Project:

The goal of my project is to publish my results in a peer-reviewed journal. I will also publish my results in Perpetua, as well as applicable poster sessions in my field at UAH. Other goals of my project include regularly presenting to other lab members and practicing my oral presentation skills, as well as formatting and understanding the data. I will also become more familiar with MATLAB, Mathematica, Fortran, and other computational and simulation tools used in the lab.