THE APPLICATION OF SMALL-ANGLE SCATTERING TECHNIQUES IN THE DESIGN AND CHARACTERIZATION OF PHARMACEUTICAL MATERIALS

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The design and development of new materials tailored for a specific pharmaceutical application requires detailed information relating the structure to the properties exhibited by the material. Because the structural characteristics that are of interest in pharmaceutical applications often are on scales from nanometers to hundreds of nanometers, x-ray (SAXS) and neutron (SANS) small-angle scattering techniques, which are highly effective probes of structure over these length scales, serve as an essential part of the suite of characterization techniques. Further, because of the nature of the interactions of neutrons and x-rays with the light elements prevalent in pharmaceutical materials, SAXS and SANS can be used to study these materials in the bulk and in solution.

X-ray or neutron scattering data cannot be used directly to solve for structural information even though the scattering arises directly from the structure of the sample. This is because there is no practical objective lens for neutron or x-rays that can be used to form an image of the sample. However, by taking advantage of the physics of neutron and x-ray interactions with matter the contrast between different parts of the structure can be varied to help provide a unique determination of the structure in a manner analogous to isomorphous replacement or anomalous x-ray diffraction. For neutrons this is done by substituting deuterium for hydrogen in some parts of the system; thus using the strong differences in scattering between hydrogen and deuterium to alter the contrast between the components. There are analogous techniques for x-rays, albeit, they are more difficult to implement. Resonant effects with soft x-rays is one development on the horizon. These techniques combined with differences in x-ray and neutron contrasts can be used to unravel complex structure, providing insights into material structure that otherwise would not be possible.

We will provide examples of how SAXS and SANS are used in the design and characterization of pharmaceutical materials. In particular we will highlight our efforts to understand the structure of self-assembling systems to provide rules for the design of materials tailored for advanced applications.