An NMR toolbox to study the surface of nanocrystals;

Enabling superconducting, memristive and catalytic applications

Colloidal nanocrystals are hybrid objects in which the properties of core and surface both determine the characteristics of the entire nanocrystal (Figure 1). The surface is often capped by (in)organic ligands which determine colloidal stability and the physical and chemical properties. As a result, nanocrystal surface chemistry, i.e., the understanding of and control over the ligand shell, has become one of the central themes in nanocrystal research.

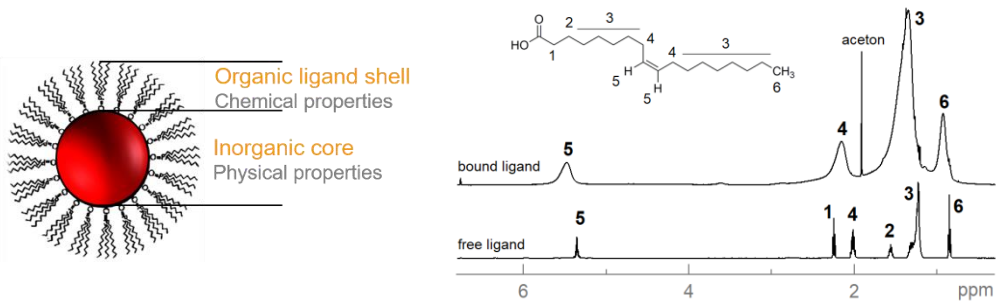

Figure 1. (left) representation of a nanocrystal. (right) NMR spectrum of oleic acid; free, or bound to a nanocrystal.

Here, we study the organic ligands through solution NMR spectroscopy. First, the various NMR tools which provide information specific to nanocrystal surfaces are introduced. We will also discuss the origin of the NMR line broadening of nanocrystal-bound ligands (Figure 1).[1] To demonstrate the strength and versatility of the toolbox, several case studies are presented. For example, we will discuss the dynamic nature of ligands on $CsPbBr_3$ perovskite nanocrystals,[2] and the binding motif for dissociated carboxylic acids on metal oxide nanocrystals.[3] The latter motif can be leveraged for catalysis.[4] Furthermore, I will show how surface chemistry can be used to enable superconducting nanocomposities,[5] nanoribbon memristors,[6] and photon upconversion. Finally, we discuss the non-innocence of solvents during nanocrystal synthesis.[7] Several popular solvents polymerize or decompose and contaminate the nanocrystal product. Strategies to remove the contaminants are discussed.

As such, we establish surface chemistry as a key enabler in a variety of applications and NMR as the method of choice for characterizing the surface. This is a versatile field, with fundamental chemistry and spectroscopy leading to exiting innovations in physics and engineering and finally solving real-life problems.

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