# Project 90162

Since the start of this project in March of 2004 two main goals have been achieved. First, the laboratory facilities of the Center for Surfaces, Polymers and Colloids (SPC) at the University of Washington have been updated with the purchase and installation of two state-of-the-art analysis tools. Second, a study of the sedimentation behavior of high density colloidal solids in complex media has been performed. The results of this study were presented at the 78th ACS Colloid and Surface Science Symposium at Yale University in New Haven, CT, and have been submitted for publication to the Journal of Colloid and Interface Science. Both the new equipment and the results of the initial study will help to gain insight into the physical properties of Hanford transuranic waste sludge. The first piece of equipment purchased was the Brookhaven Zeta PALS. The Zeta PALS has been installed and professional training in its operation has taken place. This tool has a wide range of capabilities that will prove vital to the project. First, it can operate in a dynamic light scattering (DLS) mode. This mode of operation provides quick particle size information when the standard photon correlation analysis is used. DLS has also been used in the past to perform analyses that provide other system information that could be useful in this project. The second and more exceptional capability of the Zeta PALS is phase analysis light scattering (PALS). This type of light scattering is used in combination with an electrophoretic cell where zeta potential measurements can be performed. The unique PALS system allows for the measurement of very low zeta potentials previously inaccessible by traditional zeta potential analysis tools. This is essential for this project since the Hanford transuranic waste sludge is a system of colloidal solids in a high salt medium. These types of systems typically have imperceptibly small zeta potentials. However, the Zeta PALS system should allow measurement of zeta potentials in these types of systems. Zeta potential studies of waste sludge simulants in combination with rheological and other light scattering studies will provide insight into the cause and rate of aggregate formation under quiescent conditions as well as under shear. The second piece of equipment purchased was the Physica Modular Compact Rheometer (MCR) 300. This instrument has been installed and professional training has taken place. The major reason for choosing this particular rheometer is its modular design. This feature allows for future add-ons that will likely prove indispensable for research in this project. The MCR 300 is a versatile device that will measure system response to multiple types of applied force. It is capable of running in a controlled strain as well as controlled stress modes which give stress-strain curves and viscosity as a function of either stress or strain rate. The MCR 300 will also run in an oscillatory mode which gives us the capability of probing the viscoelastic nature of a sample. These types of measurements can be made on any of four different measuring systems each with their own benefits. A temperature control unit for this rheometer is a valuable addition to the lab that will help investigate the dependence of rheological properties on system temperature. The modular nature of this unit will become important when optical access capabilities are installed. There is an off the self small angle light scattering (SALS) unit that can be attached to the rheometer making what is referred to as rheo-SALS measurements possible. This along with direct microscopic optical access to samples under shear will make it possible to investigate the relationship between rheological properties and colloid aggregate structure. Also aggregate formation and structure under shear will be directly observable. This capability will make a large impact in learning about the physical nature of Hanford transuranic waste sluge. Over the past five months while this equipment were being chosen, specified, purchased, installed, and trained upon, there was experimental work going on with existing SPC center lab equipment. This work was concerned with the sedimentation behavior of heavy, or dense, colloids in complex media. It was found that the current criterion for stability against sedimentation was not sufficient to predict stability. These results could provide useful insight into the sedimentation behavior of tank wastes. Model systems of large dense colloidal spheres suspended in a fluid with a yield stress were studied. Rotational and oscillatory rheometry in combination with sedimentation and centrifugation experiments were performed to investigate the validity of the accepted criterion for sedimentation stability. It was previously argued that if the normal force due to the yield stress of a suspending medium is greater than the gravitational force on a suspended particle then the particle would be suspended indefinitely. It was found, however, that this condition is not sufficient. A second requirement for stability against sedimentation involves the viscoelastic character of the suspending medium. For a medium to prevent the sedimentation of a suspended particle the elastic nature of the medium must dominate the viscous nature. This can be easily quantified by the loss tangent with the critical value being unity. That is, if the loss tangent is greater than one the suspension is unstable and will settle under gravity. As mentioned, these results were presented at a major symposium and have been submitted for publication in a well respected scientific journal. Over the initial five months of the project significant progress has been made. The laboratory is now ideally set up for the type of fundamental work that will be necessary in this project. Also, enough research progress has been made to publish a full journal article.