Dispersions and self-assembly of colloidal 2D nanoplatelets in liquids and polymer matrices

**ABSTRACT**

Colloidal self-assembly of two-dimensional (2D) nanoplatelets, such as clay and graphene, has been extensively investigated to prepare oriented mesophases for structural and functional applications. Controlling the dispersion and organization of nanoplatelets in solvents and polymer matrices at the nanoscale is crucial to realizing their full potential. Inspired by highly aligned platelet-based lamellar structures observed in natural materials such as nacre, several assembly techniques have been developed which include layer-by-layer assembly, electrophoretic deposition, air/water interface assembly, etc. However, the above approaches typically share the limitations of requiring time-consuming sequential depositions or excessive energy consumption, and suffer from limited robustness and poor stability in humid environments, which severely limit large-scale applications.

The objective of this research is to gain a fundamental understanding of nanoplatelet self-assembly behavior, and to efficiently control nanoplatelet mesophases in solvents and polymers via a simple and scalable manner. In this study, we investigated colloidal self-assembly behaviors based on alpha-zirconium phosphate (ZrP) nanoplatelets as a model nanoparticle. Various oligomers were employed to modify surfaces of ZrP nanoplatelets via proton exchange interaction. The exfoliated ZrP layers in epoxy form a long-range smectic order aligned parallel to the substrate surface. Detailed lyotropic behavior of the ZrP smectic mesophases in a number of solvents was characterized using small-angle X-ray scattering. These highly aligned nanocomposites exhibit exceptional physical properties, which include outstanding oxygen barrier properties, low viscosity under shear, superb mechanical rigidity and strength, excellent fire retardation and corrosion resistance properties.

In this dissertation, the fundamental principles responsible for the formation of long-range liquid crystalline order of nanoplatelets in solvents and polymer matrices are systematically investigated. The proposed research will benefit the design, synthesis, structure and property optimization, and applications of high-performance nanocomposites.

**SELECTED PUBLICATION**