

Bio-Based Nanocomposites for Sustainability and Advanced Separations

Dr. Esteban E. Ureña-Benavides

This seminar describes applied research in two distinct topics of bio-based nanocomposites and advanced separations, which are the basis for creating “smart” materials with switchable properties. The first topic is the control of chain alignment and mechanical properties of cellulose nanocrystals/alginate nanocomposite fibers. These nanocomposites are biomimetic of native cellulose fibers in which the crystallites spiral around the fiber axis, leading to a range of mechanical properties dependent on spiral angle and chain orientation. The fiber micro-structure is controlled by processing parameters and related to the self-assembly in the fluid phase before wet spinning. An increase of 123 % of storage modulus is achieved by tuning nanocrystals load and stretch. The second part of the talk describes “smart” solvents with switchable physical properties. Molecular liquids can be “switched” to ionic liquids or solids upon addition of CO₂, and reversed to the initial state after mild heating. This reversibility allows turning a homogenous mixture into a heterogeneous system to achieve low energy separations and solvent recyclability. “Smart” solvent separations have been applied to the synthesis of polystyrene, protection/deprotection of amine groups and CO₂ capture from flue gases. The two topics presented herein are concomitant in the development of “switchable” membranes and gels for sustainable separations. Future research will result in self-regenerating membranes for water purification, precious metal catalyst recyclability and CO₂ foams with controlled stability for long-term greenhouse gas underground storage.