



CHEMISTRY

FALL 2018 CHEMISTRY COLLOQUIA

Supported by the University of Nebraska Research Council



Prof. Michael S. Strano, (MIT)

Sept. 21, 2018

**3:15
Refreshments**

**3:30 Seminar
112 Hamilton
Hall**

**Open to the
public**

New Functional Materials Enabled by 1D and 2D Nanomaterials

Our laboratory has been interested in how 1D and 2D electronic materials such as carbon nanotubes, graphene and transition metal dichalogenides, can manipulate electrons, phonons and photons in unique ways. This presentation will focus on recent advances from our laboratory at MIT to create materials with new combinations of functions and properties. Two-dimensional (2D) materials can uniquely span the physical dimensions of a surrounding composite matrix in the limit of maximum reinforcement. However, the alignment and assembly of continuous 2D components at high volume fraction remain challenging. We use a stacking and folding method to generate aligned graphene/polycarbonate composites with as many as 320 parallel layers spanning 0.032 to 0.11 millimeters in thickness that significantly increases the effective elastic modulus and strength at exceptionally low volume fractions of only 0.082%. An analogous transverse shear scrolling method generates Archimedean spiral fibers that demonstrate exotic, telescoping elongation at break of 110%, or 30 times greater than Kevlar. Both composites retain anisotropic electrical conduction along the graphene planar axis and transparency. These composites promise substantial mechanical reinforcement, electrical, and optical properties at highly reduced volume fraction. Additionally, we present a theory, experimentally validated, of how fluid phase equilibria is significantly altered when confined to nanometer scale dimensions, creating the potential to embed tunable phase change materials, as well as unique liquid or solid properties encapsulated within new matrices. Our theory, based on the Turbull number, can predict the solid/liquid coexistence for any fluid and any Nanoconfined system down to approximately 4 nm. Below this limit, we show remarkable departures experimentally. Fluid phase transitions inside isolated nanotubes deviate substantially from classical thermodynamics and also allow the study of ice nanotube (ice-NT) properties. Herein, we measure, using two different techniques, the diameter dependent phase boundaries of ice-NTs within isolated CNTs 1.05, 1.06, 1.15, 1.24, and 1.52nm in diameter using Raman spectroscopy. The results reveal both an exquisite sensitivity to diameter and substantially larger temperature elevations of the melting transition than theoretically predicted by as much as 100°C. Dynamic water filling and reversible freezing transitions were marked by 2 to 5cm⁻¹ shifts in the radial breathing mode (RBM) frequency, revealing reversible melting at 138°C and 102°C for 1.05 and 1.06nm single and double-walled CNTs, respectively. A near-ambient phase change at 15°C was observed for 1.52nm CNT, whereas freezing inside 1.24nm tube was suppressed at -30°C. These extreme phase transitions enable the study of ice-NT at high temperatures and their potential utilization as novel phase change materials. These new fabrication and thermodynamic concepts promise fundamentally new materials with unique combinations of properties.

UNIVERSITY OF
Nebraska
Lincoln COLLEGE OF
ARTS & SCIENCES