The emerging world of nanotechnology has been of great interest within the last few decades. In this regard, nanomaterials have since been implemented in a number of commercial applications including: aerospace technology, coatings, sensors, and biomedical technology. This work aimed to elucidate upon the applications of transition metal nanomaterials in two separate experimental studies.

The first of these studies involved the investigation of two-dimensional molybdenum disulfide (MoS$_2$) nanoparticles, and their role in the toughening mechanism of epoxy composites. Two separate exfoliation techniques were implanted to target the influence surface chemistry of the nanomaterial and solvent quality had on the bulk thermal, mechanical and chemical properties of the nanocomposite system. A suite of characterization tools including UV-Vis spectrophotometry, differential scanning calorimetry, thermal gravimetric analysis, dynamic mechanical analysis, FT-IR spectroscopy, transmission electron microscopy (TEM), scanning electron microscopy (SEM) and atomic force microscopy (AFM) were executed to provide detailed information regarding property changes. In addition, a method was developed to monitor the nanoscale fracture mechanics of MoS$_2$-epoxy nanocomposites using micro-tensile testing and SEM upon altered films. Results concluded that surface functionality of MoS$_2$ within the studied models played a significant role in the toughening mechanism of epoxy composites. In addition, it was found that solvent quality greatly contributes to the curing behavior, as well as the chemical network formation of the material system.

The second study involved a systematic investigation of the toxicity mechanism behind positively charged cetyltrimethyl ammonium bromide (CTAB)-capped silver nanoparticles (AgNPs) in Sprague-Dawley rats. To fully assess the toxic effects within the studied specimens, CTAB-capped AgNPs, as well as Ag$^+$ and CTAB solutions were orally administered to experimental and control groups, respectively for an 18-day period. At the termination of the exposure, rats were sacrificed and tissues of interest were harvested including: the digestive gland (jejunum), liver, spleen, brain and bone (tibia). These tissues were then subjected to a panel of pathological analyses including: hematology, histology, quantification of Ag using graphite furnace atomic absorption spectroscopy (GFAAS), and bone analysis using Raman spectroscopy. Findings suggested that each chemical component of CTAB-capped AgNPs possessed a unique role in the overall toxicity, with all species causing significant alterations in the blood, tissue and bone makeup of the rat specimens.