Dr. Anastasia L. Elias
W7-093 ECERF
Chemical and Materials Engineering
University of Alberta
Edmonton, Alberta, T6G 2V4
aelias@ualberta.ca
(780) 248-1589

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Research Interests

Micro- and nanofabrication techniques are presently being utilized to miniaturize a variety of systems, from disease diagnostic systems, to air quality monitoring devices, to airbag accelerometers (to name a few). In micro- and nanofabrication, materials are often selected based on familiarity rather than functionality. For example, many miniaturized devices and systems incorporate silicon, a material made popular by the microelectronics industry. While silicon is very useful in microchips due to its semiconducting properties, it is less useful in devices which require moving parts, such as actuators. For these types of devices, highly deformable materials such as polymers are a more obvious first choice. In the Elias group, research is focused on developing functional polymers (such as smart nanoparticle/polymer composites which can respond to changes in their surroundings), and devising fabrication techniques for patterning these materials on the micro- and nanoscale. Techniques presently being employed include soft-lithography, hot-embossing, and UV-replica molding. The goal of this research is to incorporating functional polymers into microfluidic and other miniaturized devices, with a focus on biomedical applications.

Facilities

Projects in the Elias lab make extensive use of the excellent fabrication and analysis facilities available at the University of Alberta, including the Micromachining and Nanofabrication Facility (NanoFab), and the Alberta Center for Surface Engineering and Science (ACSES). A key piece of equipment in the Elias lab is a dynamic mechanical analyzer (DMA 8000, Perkin Elmer) which is used for characterizing the stiffness and damping properties of polymer samples. This instrument includes an immersion tank, allowing the properties of wet samples to be explored.

Current Research Projects

Stimulus-Responsive Polymers

Stimulus responsive polymers (also called smart materials) which undergo a change in state when exposed to an appropriate stimulus (such as heat, light, or magnetic fields) are of interest for a variety of biomedical applications, ranging from drug delivery to on-chip technologies. We are presently developing magnetically-actuated polymer nanoparticle composites for incorporation into microfluidic actuator devices. Techniques for creating well-dispersed samples have been developed. The thermal, mechanical, optical and magnetic properties of a variety of composites are currently being characterized using techniques including scanning electron microscopy (SEM), differential scanning calorimetry (DSC), dynamic mechanical analysis, spectrophotometry, inductive heating, and frequency-resolved impedance analysis.

Materials for Biomedical Applications

We are designing and fabricating microfluidic devices for culturing cortical neurons in controlled environments, and understanding how the materials employed in these devices affect the behavior of the cells. Finite element modeling is being employed to investigate oxygen transport within devices to understand the effects of varying device geometries, materials, and perfusion rates.
The Elias group is presently engineering polymer coatings with controlled mechanical and chemical properties for improving the biocompatibility of smart neuroprostheses (devices which interface directly with the nervous system).