Graduate Seminar in Environmental Engineering

Catalytic Upcycling of Single-Use Polyolefins into Lubricants: A Path Forward for Circular Economy

by Assistant Professor Gökhan Çelik

November 17th, 2021 at 15.40

Abstract:

Polymers are ubiquitous, critical to the function of modern life, and manufactured in tremendous quantities. The widespread use of polymers has resulted in an enormous amount of polymer waste, which has a long lifetime in the environment and is inefficient to recycle. Current technologies fail to recover or mitigate polymer waste before entering environmental pathway, resulting in one of the world's biggest environmental problems facing humanity. The polymer waste is a threat to the environment; however, it is also an untapped resource of energy-rich hydrocarbons. If the large macromolecules that make polymers could be chemically transformed or "upcycled" into value-added chemicals, the energy and value put into the polymers could be reclaimed and turned into new applications. Here, we focus on developing efficient and innovative catalytic materials for converting waste polymers into more valuable products in a selective manner – catalytic upcycling.

More specifically, catalytic upcycling of polyethylene (PE) was studied over a Pt-based catalyst where the active sites are spatially-organized on the well-defined surfaces of $SrTiO_3$ nanocuboid supports by atomic layer deposition. $Pt/SrTiO_3$ was shown to be capable of completely converting PE (Mn = 7,700 – 158,000 Da) into hydrocarbon polymers of relatively uniform fragments by hydrogenolysis at 300 °C in the presence of H_2 (170 psi) under solvent-free conditions. The product which was obtained by the catalytic conversion of polyolefin waste can be used as high-quality liquid lubricants. By making use of experimental and theoretical approaches (including solid-state NMR and DFT computations) from a broad range of fundamental sciences, we concluded that the selective hydrogenolysis is more likely to take place on well-dispersed active sites and stems from unique interactions of PE with the surface of $Pt/SrTiO_3$, as evidenced by.

This talk will demonstrate the conversion of discarded plastics to lubricants is not only possible but in fact economically worthwhile, as evidenced by life cycle and techno-economic analyses, resulting in lubricants superior to conventional mineral oils, as evidenced by tribology measurements. This talk will also demonstrate how catalytic upcycling of waste polymers creates an incentive for harvesting discarded plastics from the environment and closes the gap in circular economy.

Shot Bio:

Gokhan Celik is an Assistant Professor and TUBITAK 2232 fellow in chemical engineering department at Middle East Technical University (METU). He received his B.S. and M.Sc. at METU and his Ph.D. at the Ohio State University, where his research focused on the development of stimulu-induced "smart" materials for catalytic treatment of water contaminated with chlorinated hydrocarbons. He then moved to the Chemical Sciences and Engineering Division of Argonne National Laboratory and conducted his postdoctoral research on upcycling of waste polyolefins and rational catalyst design for reactions involved in hydrocarbon processing. Gokhan is now establishing a research laboratory at METU to tackle the challenges in energy, environment, and resource by catalysis engineering and kinetics.