Abstract for Public Release

North Carolina Agricultural & Technical State University (NC A&T), in partnership with the Dow Chemical Company, North Carolina State University, the University of Michigan, Ann Arbor, California Institute of Technology, Manhattan College, and University of South Carolina/Idaho National Laboratory propose a research program entitled 'Catalytic Deconstruction of Plasma-treated Single-Use Plastics to Value-added Chemicals and Novel Materials'. Our vision is to combine a tunable, non-equilibrium, nonthermal plasma treatment (NTP) with chemical processing to offer an improvement in efficiency over conventional recycling processes and, in the longer term, a viable economic and environmentally friendly solution to plastic recycling. We will demonstrate the use of NTP to aid the depolymerization and catalytic deconstruction of plastic waste to create tailored streams of monomers and precursors to produce new, higher value products.

We will investigate the interaction of non-equilibrium plasmas at atmospheric pressure with plastics in both aqueous and gaseous environments. Multiple plasma-based approaches to plastic decomposition, ranging from plasma-liquid interfaces to hybrid plasma-based augmentation of pyrolysis, will be carried out with novel catalysts. The depolymerization products of the waste polyethylene (PE) or polypropylene (PP) will be examined using Mass Spectrometry, Nuclear Magnetic Resonance, Raman, or FTIR analysis. Computational models of plasma conditions in the gas phase and at the gas-liquid interface will guide tuning of the plasma conditions for maximal selectivity and activity for scission, dehydrogenation, and rearrangement reactions. We will explore the impact of the catalyst to modify the liquid phase from plasma treatment via catalytic oxidation and reduction reactions and to enhance selectivity and activity for the desired products - olefinic monomers and aromatic intermediates. Plasma treatment is expected to produce extensive peripheral functionalization of the polymeric material, with or without chain cleavage. Long-chain products can directly serve as the backbone for new polymers, while short fragments derived from further chemical and thermal fragmentation can be converted to monomers and other value-added chemicals.

The proposed technology would reduce the need to produce new plastics and, thus, stabilize the current growth of plastics production. The techno-economic analysis and life cycle analysis. Calculations based on 1 Kg of all products show that the total GHG emissions can be estimated to be 0.41 Kg CO_{2eq} /Kg products which is about 1.6 Kg CO_{2eq} / Kg products less than current petroleum-based feed metrics.

If successful, the proposed plan at maturity will make circular feedstocks (ethylene, propylene, butylene) from waste polyolefins which can be integrated with existing fossil ethylene/propylene cracker plants. The integrated gas/liquid phase plasma and upcycling technology will also make high value polymer precursors like polyols and aromatics (BTX) which can be potential feedstocks for higher value products such as polyurethanes. The proposed technology will have a significant environmental and economic impact by reducing the amount of plastics in landfills and creating new jobs to convert the waste plastic into more sustainable feedstocks for new value-added products. This would be an economic and environmental gain for under-represented and low-income communities which are often disproportionately affected by pollution.