SUMMARY FOR PUBLIC RELEASE

Applicant: University of Minnesota (lead institution)
Principal Investigator: Paul J. Dauenhauer, PhD., University of Minnesota
Project Title: BOTTLE – Recyclable and Biodegradable Manufacturing and Processing of Plastics and Polymers based on Renewable Branched Caprolactones
Major Participants: National Renewable Energy Laboratory (Gregg Beckham), Massachusetts Institute of Technology (Yuriy Roman-Leshkov), BASF (Jacob Brutman, Arunabha Kundu, Samantha Gee)

The introduction of renewable polymers includes the concurrent development of strategies to decompose and/or recycle these materials for minimal waste and reuse. In this effort, collaborative teams will pursue the development of a chemical process to utilize branched alkyl-caprolactone monomers derived from both biomass and recycled waste plastic to create new, advanced polyurethane and elastomer materials. Polymers based on alkyl-caprolactones have unique physical properties due to the branched functionality disrupting conventional straight-chain polyester interactions, while the ester functionality imparts significant capability for biodegradation and catalytic recycling. The **overarching goal** of this research effort is to develop a process that can manufacture these advanced materials from alkyl-caprolactone monomers from both biomass and recycled waste polymer in a manner that is economically competitive with existing materials.

The proposed effort addresses three areas combining contributions from four institutions. While lignin-derived monomers will be obtained from the existing NREL reductive catalytic fractionation (RCF) sub-process, three new **objectives** will be to develop new sub-processes based on existing laboratory research addressing: (i) catalytic conversion of lignin to alkyl-caprolactone, (ii) alkyl-caprolactone polymerization to advanced polyurethanes and polyester elastomers, and (iii) decomposition of polymers back to the monomer, alkyl-caprolactone, via catalytic extrusion of polyurethane and polyester elastomers. A fourth objective addresses the process design and techno-economic analysis of the four sub-processes combined into a complete process to manufacture and recycle these alkyl-caprolactone-based polymers.

The conducted research tasks will utilize **unique and collaborative research methods** and capabilities from the major participants. Monomer production in collaboration with the University of Minnesota, BASF, and MIT will utilize novel catalytic materials to achieve highly selective overall yield of alkyl-caprolactones. The polymerization effort in collaboration between BASF and the University of Minnesota will aim for more sustainable, green-chemistry polymerization methods to minimize waste and increase processing efficiency. Polymer recycling tasks in collaboration between NREL and Minnesota will implement unique, extrusion-based catalytic processes to recover alkyl-caprolactone monomers. And process design and techno-economic analysis between the University of Minnesota and BASF will combine all sub-processes together including the recycling sub-process to achieve cost-competitive technology.

The conducted development and research tasks will **benefit society** by advancing renewable and recyclable materials to reduce consumer waste. Additionally, the advanced physical characteristics of the polyurethane and polyester elastomers provide advanced materials that open up new markets and businesses for American manufacturers and deliver new products to American consumers. At the completion of this project, the **targeted outcome** is the development of a new industrial process to make recyclable alkyl-caprolactones that are economically competitive with existing polyurethane and polyester materials.