Project # 1936963
SUSTAINABLE RUBBER PRODUCTS: INNOVATION, SCIENCE AND ENGINEERING" = SuRPrISE

Judit Puskas (PI), Katrina Cornish (OSU), Julie Kornfield (Caltech), Gregory McKenna (Texas Tech), Richard Gross (RPI), Abbas Ghassemi (MERCED), Gary Hamed (UAkron)

Funded by the National Science Foundation

Targeted Societal Impact: Plastic and rubber waste have created an enormous societal impact. We must find solutions to address sustainable production and recycling, closing the loop. The proposed ERC will focus on renewal of rubber technology, revolutionizing a field that has been based on science and engineering from the last millennium. Bio-based AND fully recyclable polymers are sorely needed since humankind is being overtaken by plastic and rubber waste.

Fully recyclable bio-based polymers include DNA, proteins, carbohydrates, terpenoids, lignins and self-assembled structures such as biomineralized tissues, hormones, and so-forth. The proposed ERC will emphasize bio-based elastomers and rubbers, a sub-class of the terpenoids which include resins and structures fundamental to life (vitamins, hormones, etc.). The History Channel, Modern Marvels series, aired a program in 2004 about natural rubber and its impact on our lives and stated that "*our four most important natural resources are air, water, petroleum and rubber*". A 2015 *Rubber Journal Asia* article asked, "*What would industrial progress be without natural rubber? It's hardly imaginable*". Most recently, Amazon Prime launched a new streaming on line series "*This Giant Beast That is the Global Economy*" and in the third episode "*The Rubber Episode*" host Kal Penn highlights the blind spot in the free market economy of natural rubber supply and security. Demand for natural (NR) and synthetic rubber (SR) is rapidly increasing with global economic development and is expected to double by 2030. New plantings of hand-tapped *Hevea brasiliensis* rubber trees (hevea) are heavily restricted, because of a moratorium on unsustainable deforestation, whereas SR is derived from fossil fuels and is neither sustainable nor recyclable. Specifically, car tires contain rubbers crosslinked with sulfur in a vulcanization process credited to Charles Goodyear and the bonds are not biodegradable. Making the bonds exclusively disulfide bonds or inventing new chemical crosslinks may lead to an SR matching the properties of NR, and tires would become fully recyclable![3] PI Puskas has recently advanced this field with the development of a living Reversible Recombination Radical Polymerization (R3P) that leads the way towards such chemistry.

Rationale: The 2017 study from the National Academies of Sciences, Engineering, and Medicine [NASEM study], "A New Vision for Center-Based Engineering Research" recommended placing a greater emphasis on forming research centers focused on solving convergent problems that address challenges with significant societal impact. Convergent problems require the integration of knowledge, tools, and ways of thinking from physical, mathematical, life/health sciences, social sciences, computational sciences, and engineering disciplines. The planned ERC **"Sustainable Rubber Products: Innovation, Science and Engineering" = SuRPrISE** will create a strong interdisciplinary science and engineering infrastructure and will bring the assembled skills together to address the challenges of

maintaining the essential technology of rubber materials while solving the waste problem caused by the present non-recyclability of rubber.