Re-think Nature for Innovative Solutions to Grand Challenges
NSF Convergence Accelerator Workshop Report

Virtual Workshop Dates: September 30 & October 2, 2020

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Other Participants: See Appendix A for details.

Acknowledgement:

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Special thanks to ***Dr. Nakhiah C. Goulbourne*** *and* ***Dr. Linda Molnar****, Program Directors, National Science Foundation for the opportunity to bring area experts from the industry, academic*

institutions, non-profits, government, and other interested parties together at this NSF Convergence Accelerator Workshop.
We also want to express our sincere thanks to the support provided by the ***A. James School of Engineering****,* ***University of Maryland*** *for making this event possible.*

***** *see Appendix A for details*

Executive Summary

This report summarizes the findings of the National Science Foundation (NSF) Convergence Accelerator Workshop on “Re-think Nature for Innovative Solutions to Grand Challenges”. The workshop took place virtually via Zoom on September 30 and October 2, 2020.

The workshop brought together 82 participants from academic institutions, national laboratories, government agencies, industries and non-profit organizations. It featured 20 lightning talks by leading experts and key stakeholders from multiple disciplines and sectors, and it held in-depth discussions among the participants. The workshop attendees discussed extensively the complexity and severity of the grand challenges associated with environmental pollution, energy sustainability, access to clean and safe water, and climate change, and the participants brainstormed the topics and solutions for addressing such grand challenges in near and intermediate terms through convergence research on two major topics:

- Convergence research for nature-inspired solutions to replacement for petroleum-based plastics
- Convergence research for innovative solutions in the advanced materials space for sustainable infrastructure applicable to buildings, transportation, and water.

Major findings of challenges and convergent opportunities from the workshop are summarized in this report. Specifically, the report intends to:

- Depict the current understanding of the grand challenges stemming from the ever-growing environmental pollution due to petroleum-based plastics and the non-sustainable nature of traditional infrastructure materials;
- Present key challenges and opportunities for convergence in exploring nature-inspired solutions to address the two focal topics described above; and
- Identify the disciplines needed to understand and address the key challenges, and the stakeholders needed to be engaged and form integrated and coherent partnerships to form convergent teams in developing nature-inspired solutions for these grand challenges.

Key findings from the workshop include:

- There exists tremendous yet largely unexplored potential to explore nature-inspired solutions as a promising approach to address the grand challenges of petroleum-based plastics pollution and sustainable infrastructures.
- There have been groundbreaking research discoveries in the last several years to epitomize the remarkable potential of leveraging natural resources toward paradigm-shifting solutions to grand challenges in science and technology.
- A prioritization of research objectives alongside an array of clearly defined multi-dimensional criteria is needed to assess potential of replacement for petroleum-based plastics on sustainability and scalability.
- With the prioritization of research objectives and well-defined criteria as a key deliverable to Phase I, a more robust research agenda can be developed to enable the exploration of

nature-inspired solutions for petroleum-based plastics with the greatest impact/most traction in Phase II.

- On the topic of advanced materials for sustainable infrastructure, three themes of research are needed: new functional materials based on natural materials; new applications based on natural materials (e.g., water, automotive), and new analytical tools (e.g., modeling, manufacturing, etc.).
- In designing complex composite materials based on hybridization of nature-inspired, renewable, and recycled resources meant to minimize environmental and social impacts, the participants identified great potentials and opportunities for convergent and interdisciplinary research toward a promising solution.
- Key disciplines and stakeholders are identified for the convergent research needed to address the above two grand challenges.
- The societal impacts of the proposed convergence research are expected to be multifaceted and far-reaching, with the widespread carbon-neutral applications in addressing an array of global challenges on sustainability.
- The proposed convergence research is expected to initiate an innovation-cultivating ecosystem through collaboration among academia, industrial and government partners at regional, national and global scales.
- The proposed convergence research will also train future workforce with the mindset of harnessing nature to solve global challenges of humankind.

Introduction

The ever-advancing modern world has been accompanied by the emergence of grand challenges, from energy crisis, to access to clean water, to environmental pollution, and to curbing carbon emission.[1-3] Never before has the world faced such a need for sound scientific knowledge and expertise, to better understand and tackle these rising grand challenges. The complexity and severity of such grand challenges constantly grow, so that scientific research and technological advance in a single discipline can hardly lead to a viable solution. The need for convergence research across disciplines to tackle these grand challenges cannot be overstated. Natural and sustainable resources that are abundant on Earth hold great promise to provide solutions to an array of grand challenges, such as revolutionizing urban infrastructure, providing low-cost access to clean water, making solar-energy economical and addressing carbon sequestration. There have been groundbreaking research discoveries in the last several years that exemplify the remarkable potential in leveraging natural resources toward transitioning research outputs to societal use by creating opportunities for wood-based materials to replace non-renewable, petroleum-based materials in a broad range of products and applications.

By coherently integrating traditional wood science disciplines, such as wood chemistry and wood anatomy, with diverse disciplines including physics, biology, ecology, engineering, computer science, and public policy, convergence research on advanced wood is poised to accomplish cutting-edge breakthroughs on wood structure–property relationships and unprecedented innovation in sustainable wood utilization. The promising potential revealed by recent breakthroughs in advanced wood is high stake, offering a unique opportunity for the US to regain the R&D leadership in this emerging and fertile field. It is simply not affordable to miss this grand opportunity just as Canada, Scandinavia, and Japan pioneered the nanocellulose research 20 years ago while US lagged behind.[4-6]

Of the fifteen global challenges identified by the Millennium Project, the No. 1 global challenge is on how to achieve sustainable development for all.[7] Transition from non-sustainable and depleting resources (fossil fuels and their derivatives) to sustainable and earth-abundant resources (plants, solar, wind, etc.) is the key to address this No. 1 global challenge. The widespread carbon-neutral applications of the advanced wood research breakthroughs out of convergence research, such as lightweight vehicles, energy-efficient buildings and low-cost desalination of seawater, are expected to have multifaceted and far-reaching potential impacts in addressing an array of grand challenges.

This Workshop brought together over 82 representatives from multi-disciplinary and complementary area disciplines and expertise from academia, industry, government agencies and non-profit organizations to address two critical topics:

- Convergence research for nature-inspired solutions to replacement for petroleum-based plastics
- Convergence research for innovative solutions to advanced materials for sustainable infrastructure applicable to buildings, transportation, and water

I. Workshop organization and reporting

a) Lightning talks
University of Maryland, The Pew Charitable Trusts, National Renewable Energy Laboratory, Ohio State University, University of Portsmouth, Tyton Bioscience, Rensselaer Polytechnic Institute, Spero Renewables, University of California Santabarbara, Michigan State University, Princeton University, University of Maine, Oak Ridge National Laboratory, Yale University, National Renewable Energy Laboratory, USDA Forest Product, North Texas University, University of California Merced, University of California Berkeley, Ford

b) Discussion
University of Maryland, The Pew Charitable Trusts, National Renewable Energy Laboratory, Ohio State University, University of Portsmouth, Tyton Bioscience, Rensselaer Polytechnic Institute, Spero Renewables, University of California Santabarbara, Michigan State University, Princeton University, University of Maine, Oak Ridge National Laboratory, Yale University, National Renewable Energy Laboratory, USDA Forest Product, North Texas University, University of California Merced, University of California Berkeley, Ford, BioLogiQ, Milliken & Co, Biological & System Engineering, Futamura, Dow, Massachusetts Institutes of Technology, UBC BioProducts Institute, USDA, Montana State University, DOE, Georgia Tech, Lawrence Berkeley National Laboratory, Argonne National Lab, ICF, University of California San Diego, Process Engineering, KTH Royal Institute of Technology, Royal Institute of Technology, Hasbro, UBC BioProducts Institute, InventWood, Northeastern University, Visolis Inc., Primitives Inc, LanzaTech

Workshop Attendees	**Numbers**	**Percentage**
Academic institutions	43	52%
Government labs/agencies	20	25%
Industry/nonprofit organizations	19	23%
Total	82	100%

II. Challenges and Convergent Opportunities

This section is organized into two subsections, with each corresponding to one of the two critical topics described in the Introduction (two focus sessions at the workshop). Each subsection consists of four parts, with the aim to answer four sets of questions in line with NSF C-Accel program scope. Answers to the questions integrate the inputs from both the lightning talk speakers of the workshop and the extensive discussions among all attendees during the workshop.

II.1 Session 1: Convergence research for nature-inspired solutions to replacement for petroleum-based plastics

II.1.1 Deliverables

Questions in line with NSF C-Accel program scope:

If this topic becomes a C-Accel track, what "deliverables" would the subsequently funded research & development efforts produce in the 1 year of Phase I plus two years of Phase II?

The workshop attendees of this focus session discussed in-depth on this aspect and agreed that the expected deliverables in the next few years should include a prioritization of research objectives alongside an array of clearly defined multi-dimensional criteria to assess potential of replacement for petroleum-based plastics on sustainability and scalability, as detailed below. It is thus expected that initial deliverables, such as those in Phase I, would aim to clearly define what solutions are most urgently needed, can penetrate into the market on shorter time scales, and would have a large enough impact. In doing so, this would enable Phase II research to focus on the interdisciplinary research necessary to address the problems associated with today's plastics.

Foremost amongst the questions that needs to be addressed is, what is the end-goal of find nature-inspired solutions to today's plastics while moving away from petroleum-based plastics? Is the ultimate end goal to reduce plastics in the environment, to reduce greenhouse gas (GHG) emissions, or discover solutions that would achieve both? Furthermore, how can new solutions compete with today's current plastics economy? By prioritizing the answers to these questions as a key deliverable to Phase I, and thus finding agreement and tractable solutions, a more robust research agenda can be designed to enable the exploration of nature-inspired solutions for petroleum-based plastics, in Phase II.

Based off the discussion at the workshop, and assuming that the discussion is consistent with the findings of a comprehensive Phase I deliverable, a key motivation for finding nature-inspired solutions to today's plastics would be to find ways reduce plastic pollution in the environment. As noted in the reports from the Pew Charitable Trusts,[8-9] global plastic pollution can be attributed to plastics leakage to the environment (e.g. microplastics from high-income countries, leakage from landfills, etc.), deportation of plastics to low-income countries, and complex material architectures that make recycling near impossible (e.g. flexible plastics, multilayer packaging, and textiles). Thus, Phase II should focus on moonshot solutions to these issues; specifically through the valorization of complex material architectures so that these will be collected and recycled. By incentivizing the reclamation and usage of these materials, environmental leakage can be reduced. In general, less focus should be placed on materials that possess a current recycling infrastructure. As an example, polyethylene terephthalate (PET) bottles should receive less focus than PET-based textiles as PET bottles already possess a recycling infrastructure while textiles do not.

Further discussion amongst the members of this focus session revealed that when nature-inspired solutions are developed for today's plastics by the leverage of bio-derived resources, it is imperative that these products have material properties on par with, or better than, today's incumbent materials. Additionally, whenever possible replacement materials should be designed with the end-of-life in mind. For example, when designing replacements for multilayer packaging plastics, it may be possible to leverage bio-derived materials to provide superior material performance (e.g. lower water permeabilites) that are inherently biodegradable. These materials could penetrate the market due to their performance while avoiding the negative impacts of pollution and higher life-cycle carbon footprint.

As evident by these aforementioned examples, the design space for tackling that today's plastics is large, if not near-infinite. Thus, one clear deliverable of this work is not only prioritizing research in this space, but clearly defining multi-dimensional criteria needed to assess the potential of emergent replacements for petroleum-based plastics. These criteria should include, but are not limited to:

- The performance requirement of research targets (e.g. mechanical properties, permeability, durability, etc.)
- Reductions in manufacturing burden, such as environmental impacts (e.g. GHG emission, biodegradability, toxicity, etc.)
- Economics (e.g. cost of materials, manufacturing, transportation, collection/waste disposal, externalities associated with production and pollution, etc.)
- Social impacts of the final products (e.g. convenience, ease of use/disposal, health impacts, perception on sustainability, etc.)

Questions in line with NSF C-Accel program scope:

How would those outputs tangibly impact society?

The expected tangible impacts of the above outputs on society are multifaced. Such impacts include massive global reduction in the amount of plastic released into the environment (air, land, water) which in turn would result in benefits to multiple ecosystems and human health. By providing society with a new family of biobased sustainable materials our convention materials space can be expanded further tailored to take on desirable performance attributes while enabling job creation (e.g. valorization will drive increased collection and recycling jobs). Furthermore, the reduced GHG emissions from the plastics industry can help fight climate change. Other benefits include: reduced cost to government of effective waste management; and public awareness of the needs for circular economy and sustainability.

II.1.2 Convergence

Questions in line with NSF C-Accel program scope:

What different disciplines and disciplinary approaches/methods are needed to understand and address the challenges? What disciplines would need to be engaged for this track to be successful? Is there a good potential for integration and real collaboration among the disciplines?

Despite the heavy focus in this space around materials design, it is fundamentally necessary to broaden the expertise to understand and address the global challenge of petroleum-based plastics pollution. This includes facilitation and collaboration amongst academia, government, industry, and civil society stakeholders. At minimum, the following stakeholders should be engaged:

- Materials scientists and engineers (e.g., polymer chemistry/physics, mechanical engineering, process engineering, etc.) to explore innovative materials solutions to replace petroleum-based plastics and their performance;
- Ecologists to identify through environmental impacts and trade-offs;
- Public health experts to assess human health impacts of reducing plastic products & potential impacts of substitutes;
- Waste management experts (academics and practitioners);
- Life cycle analysis (LCA) experts to determine GHG effects;
- Political scientists to identify likely political trade-offs in implementation at scale; effectiveness of policies in driving innovation/pollution/waste management solutions
- Other policy experts to help understand public education and awareness around plastic issues
- Honest brokers from industry to discuss the real desire for alternative products vs. greenwashing and identify the assumptions/hidden needs. (e.g., what are they willing to pay to achieve an outcome?)

Depending on the scale of ambition, and further broaden the scale of solutions other disciplines and expertise may be beneficial. This can include:

- Anthropologists to determine social acceptability and estimate social license;
- Input from development banks likely to fund projects (e.g., World Bank, ADB, USAID, etc.) to discuss needs for infrastructure funding;
- Economists to identify trade-offs; conduct benefit-cost assessments
- Financiers / venture capitalists / bankers to communicate investment needs/expected ROI
- Innovation experts to help startups transition through the valley of death.
- Representatives from informal sectors (e.g., affiliated unions, nonprofits) to communicate small-scale business need in developing economies

The integration and real collaboration among stakeholders and practitioners in the above disciplines will be the key to the success to address the global environmental challenge due to petroleum-based plastics pollution. Clearly in designing complex composite materials based on hybridization of nature-inspired, renewable, recycled, and virgin resources meant to minimize environmental and social impacts, there is a great potential and opportunity for convergent and interdisciplinary research toward a promising solution. As such, this work has the potential to be revolutionary in the number of stakeholders that need to be engaged; which in turn, may lead to a faster implementation of new technologies.

II.1.3 Partnership:

Questions in line with NSF C-Accel program scope:

What different types of organizations and stakeholders would be engaged by this topic? How would they be engaged? What would they want or contribute?

Similar to what was mentioned above, organizations and stakeholders from various sectors will be needed to get engaged to work together to address the global challenge of petroleum-based plastics pollution, which include:

Academics / Universities

- Creative contents - primary innovators/researchers
- Core competencies across all disciplines (Architecture to Zoology)

Government and civil society

- Shared agreement on ultimate goal
- Feedback on social acceptability/license

National Laboratories

- Extensive infrastructure for measurement-based R&D
- Special expertise in LCA and TEA
- Professional publicity offices
- Computational resources

NGOs / Non-profits

- Identification of policy change needs
- Global networks to speed implementation
- Coordinating knowledge co-production
- Independent (interest-free) validation
- Grassroots engagement

Industry

- Special expertise in process economics, and environmental, health and safety (EH&S) compliance
- Supply chain expertise
- Product design needs, trade-offs
- Information on importance of cost vs. performance
- Venture capitalists
- Entrepreneurs

In addressing this global challenge of petroleum-based plastics pollution, it is necessary to engage stakeholders across the entire production chain and also to include a strong social science cohort for public adoption, as well as policy makers to develop appropriate regulation including carbon credits. For example, state governments need to put return value on recyclables, such as Michigan's 10 cent/glass bottle returned. Taking the case of Tyton BioSciences LLC as another example of a potential model of convergent partnership. TytonBio's 10-year goal is to have their chemical recycling technology successfully recycle 10 billion garments, which is 10% of annual production in the apparel industry. This goal will save 100 million trees (by replacing pulp from trees with cotton previously destined for incineration or to the landfill). To realize this goal, in the next 3 years they must succeed in scaling their technology and innovation demonstrated in a consumer brand product. Commercializing their technical innovation for real change in the apparel & footwear industry will require interdisciplinary work between information technology, consumer science (insights & behaviors), industrial and product design, manufacturing and operations of traditional pulp & paper and chemical engineering unit operations. Currently, TytonBio is working with waste collection infrastructure, local city councils and regional economic development, national research labs (NREL and PNNL), applied research and service providers in academia, innovation organizations at multinational companies, and end-to-end supply chain in achieving their 10-year goal. Such an interdisciplinary and convergent model, if successfully implemented, will be able to translate to packaging and other consumer good products.

II.2 Session 2: Convergence research for advanced materials for sustainable infrastructure

II.2.1 Deliverables

Questions in line with NSF C-Accel program scope:

If this topic becomes a C-Accel track, what "deliverables" would the subsequently funded research & development efforts produce in the 1 year of Phase I plus two years of Phase II?

Sustainable infrastructure development is the key to address the global energy-water-carbon challenges we face. Advanced materials, especially natural materials play a core role in the sustainable infrastructure development. The convergence research of these advanced materials involves manufacturing, material structure and properties, and functions and applications. On the focal topic of convergence research for advanced materials for sustainable infrastructure, the attendees of the workshop have come up with the following list of outcomes in the next few years, which can be categorized into three themes:

(1) New functional materials based on natural materials;
(2) New applications based on natural materials (e.g., water, automotive), and
(3) New tools (e.g., modeling, manufacturing, etc.).

- **New functional materials based on natural materials**

Natural materials, such as wood, cellulose, and other high plants, are among the best choices of sustainable materials development. With suitable engineering techniques, various new functional materials can be made from natural materials. Take wood as an example, its structure, compositions, and surface properties can be engineered at multiple scales to manipulate mechanics, fluidics, ions, phonons, photons, which imparts wood with new functions for a range of new applications, such as lightweight, high-strength structural materials, water treatment and desalination, energy storage and conversion, carbon capture and utilization, thermal management, optical management, green electronics, biotechnologies, etc.

Cellulose derived from various biomass is another important material source for new bio-based functional materials development, including but not limited to: (1) cellulose-based adhesive product development; (2) reduced environmental effects, compostable alternatives for Styrofoam packaging; (3) new lightweight materials from nature for better fuel efficiency (e.g., cellulosic composites with high strength, high stiffness, corrosion resistance and recyclability).

Wood, cellulose and other bio-sourced materials can also be hybridized with other sustainable materials for improved properties and new functions. A range of new functional materials can be developed based on the sustainable utilization of lignocelluloses.

- **New applications based on natural materials (e.g., water-energy nexus, automotive, energy-efficient buildings, etc.)**

With new functions imparted, bio-based composites can find a range of new applications, such as water-energy nexus, automotive, energy-efficient buildings, among others.

For example, the new applications on low-cost access to water will include modular, inexpensive, solar-powered zero liquid discharge (ZLD) technology; transforming the current brine management by merging energy-intensive brine concentration and crystallization in one simple step for a fraction of the cost of existing systems; significantly reducing the pond area or expand the treatment capacity by retrofitting the technology to existing solar evaporation ponds, enabling convenient mineral separation, valuable material recovery, and safe solid disposal.

The new applications of natural materials in automotive will include increased use of sustainable recycled composite in auto parts; addressing the knowledge gap regarding the use of natural fillers and recycled polymers; and improve noise, vibration, and harshness (NVH), thermal stability and insulation properties and antimicrobial properties.

For energy-efficient buildings application, bio-based functional materials offer various benefits such as light-weighting, high mechanical strength, low carbon footprint, excellent thermal efficiency (saving energy) and so on.

- **New tools (e.g., characterization, modeling, manufacturing etc.)**

New tools such as characterization tools, modeling tools and manufacturing tools are important for the development of advanced functional materials from natural materials. The new tools that are needed to achieve the goal of convergence research for advanced materials for sustainable infrastructure include:

- Advanced characterization and modeling tools for the fundamentally understanding of the source – structure – property – function relationships for cellulose and other natural materials; baseline understanding needed to leverage the source-dependent tunability of natural materials.
- Develop structure/property/function relationships that span length scales: understand how molecular-level changes propagate across length and time scale to impact performance and use this fundamental knowledgebase to support technology development and deployment.
- In-silico design and optimization of new bio-derived materials: new bio-based molecules and composites can be evaluated in-silico cheaper and faster than in the lab; using high performance computing resources, much larger parameter space can be covered; and suggest targets for genetic modification of plants.
- Advanced manufacturing tools to create knowledge for converting renewable raw materials (forest products) into value added products; Minimize embodied energy, carbon footprint, cost, and waste in manufacturing.

- Knowledge on process chemistry, cell wall structure and easily processable building blocks

Questions in line with NSF C-Accel program scope:

How would those outputs tangibly impact society?

With the expected outcomes described above, the convergent research on this focal topic will benefit our society on the following aspects:

- Lower carbon emission and contribute to a net zero society and circular economy
- Sustainable and green approach – beneficial to the environment and livelihood
- Increased public awareness on appropriate use of polymers through our sustainable products
- Reduced dependence of society on fossil fuel resources and address climate change; Create green and high paying jobs, particularly in rural areas with abundant biomass resources.
- Enabling design of everyday projects from natural materials that have broad economic, educational, and societal benefits.
- The quantitative information of potential environmental, economic, and social implications of different technology and policy options are the foundation for science-based, sustainability-informed development of technology and policy, which have direct impacts and will shape the future of our society.

II.2.2 Convergence

Questions in line with NSF C-Accel program scope:

What different disciplines and disciplinary approaches/methods are needed to understand and address the challenges? What disciplines would need to be engaged for this track to be successful? Is there a good potential for integration and real collaboration among the disciplines?

The design, simulation, manufacturing and development of novel, high-performance biocomposites for various functional applications will require collaboration from multiple disciplines, including materials science, physics, chemistry, chemical engineering, mechanical engineering, environmental engineering, automation and tooling, computer programming, social science, physics, economics, and public policy. Integration and collaboration across disciplines are needed to address complex sustainability-related challenges in (1) new functional materials based on natural materials; (2) new applications based on natural materials (e.g., water-energy nexus, automotive, energy-efficient buildings, etc.) and (3) new tools (e.g., characterization, modeling, manufacturing, etc.). There is good collaboration potential across these disciplines to address complex sustainability-related challenges. In addition, good infrastructure is needed to support interdisciplinary research (e.g., more funding opportunities) and reward faculty and scholars who are leading interdisciplinary collaboration (e.g., no strong incentive for junior faculty to move towards this direction if the tenure process does not give a significant weight for interdisciplinary work and collaboration).

II.2.3 Partnership:

What different types of organizations and stakeholders would be engaged by this topic? How would they be engaged? What would they want or contribute?

We expected the following different types of organizations and stakeholders would be engaged by this topic:

- Academic institutions
- National laboratories or federal research institutes (USDA, NREL, ORNL, NIST, etc.)
- NGOs
- Funding agencies (e.g., NSF, DOE, etc.)
- Industrial stakeholders for technology transformation (e.g., forest products industry, agricultural industry, chemical industry, automotive industry, building industry, packaging industry, water treatment industry, etc.)
- Chemical and materials companies
- Local communities that may be affected by different manufacturing or technology development
- Local government agencies and organizations that oversee and manage infrastructure projects

We need to develop intensive engagement with universities, research institutes, manufacturers, and national labs, as well as policymakers in government agencies and local communities that may be affected by different manufacturing or technology development. We can engage them by working with researchers such as social scientists, economists, or policy scientists who already have established good connections. A good interdisciplinary-collaborative project should be around one compelling research question with well-developed hypotheses that can be tested by scholars in different disciplines. Partnerships between academia, industry, and funding agencies are critical to transform novel products and processes to the marketplace.

II. 3 Track Coherence:

Questions in line with NSF C-Accel program scope:

Do each of the sub-topics proposed have a way to fit together so that the set of projects supported create an integrated whole?

The over-arching coherence between the two focal topics of the workshop resides on sustainability, which surges as a major global challenge with multifaceted fronts. The two focal topics of this workshop are the examples with growing concern and broader societal impacts. While the solution to the challenge of plastic pollution and that to the challenge of sustainable infrastructure could be fundamentally distinct, it is possible to integrate the pursue of such solutions into a convergent focus: seeking inspiration from the Mother Nature. From biomass-based materials as sustainable substitutes of petroleum-based plastics, to wood-based ultra-strong yet renewable structural materials as a potential replacement of steel, the potential emerging from recent scientific discoveries is both promising and vast, only revealing the tip of the iceberg.

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Appendix A Introduction to the workshop lightning talk presenters and the list of workshop attendees

Lead Organizer: Teng Li, University of Maryland

Co-Organizers: Liangbing Hu, University of Maryland; **Zhiyong Jason Ren,** Princeton University; **Nicholas Rorrer,** National Renewable Energy Laboratory

Dr. Nakhiah C. Goulbourne, Program Director, NSF
Dr. Linda Molnar, Program Director, NSF

Session 1. Convergence research for nature-inspired solutions to replacement for petroleum-based plastics

Teng Li, Keystone Professor, Director, Laboratory for Advanced Sustainable Materials and Technology, Dept. Mechanical Engineering, University of Maryland.
Dr. Li's research centers on fundamental understanding of mechanics of materials and structures in advanced technologies and complex systems, Recent research interests include sustainable materials, low-dimensional nanomaterials, energy storage materials, machine-learning accelerated materials discovery, soft materials and flexible/stretchable electronics. Dr. Li is the recipient of the R&D 100 Award (2018).

Jim Palardy, Project Director, Conservation Science, Pew Charitable Trusts
Dr. Palardy identifies and develops research projects in science and economics that inform research-driven policy recommendations. He also contributes technical expertise to Pew's ongoing environmental projects and strategic planning efforts to inform conservation policy and frame solutions to global environmental challenges.

Nicholas Rorrer, Biomaterials Development & Polymer Engineering, National Renewable Energy Laboratory
Dr. Rorrer specializes in synthesizing polymers from biomass, which includes separating monomers from fermentation media, purifying the separated monomers, and subsequently polymerizing the monomers. He works on the development of novel materials from bioderived monomers to enable performance differentiation/ advantaged materials over their petroleum derived counterparts. He has also begun to investigate methods to improve PET recycling or enable PET upcycling.

Katrina Cornish, Ohio Research Scholar/Endowed Chair Bioemergent Materials, Dept. Food, Agricultural and Biological Engineering, Ohio State University
Dr. Cornish is a global expert on alternate rubber and latex production, processing and products with >30 years in rubber biosynthesis, physiology, germplasm improvement, production systems innovation, and alternative feedstocks in the Government, Commercial and University sectors. Shd is a fellow of the National Academy of Inventors and the American Association for the Advancement of Science, and founder and CEO of EnergyEne, Inc,. She leads a program on alternate rubber production, bio-based fillers, and exploitation of opportunity feedstocks from agriculture and food processing wastes for value-added products and biofuels.

John McGeehan, Professor of Structural Biology, Dir. Center for Enzyme Innovation, University of Portsmouth
Dr. McGeehan's technical expertise in protein biophysics focuses on structural biology addressing the global challenge of man-made plastic polymers for bio-based recycling and upcycling applications. His research employs a range of hydrodynamic and spectroscopic methods in parallel with X-ray crystallography to reveal the detailed mechanisms of enzyme function. Recent accomplishments include the characterisation and engineering of an enzyme, PETase, that can digest polyethylene terephthalate (PET), a common plastic found in single-use plastic bottles and clothing (Austin et al. 2018).

Julie Willoughby, Head of Innovation and Operations, Tyton Bioscience
Dr. Willoughby has a history of successfully innovating and scaling new processes and has extensive networks in chemical manufacturing, consumer products and production, and upstream research. She combines deep industry knowledge with expertise in surface science, polymer physics and chemistry, soft matter, coatings, and biomaterials to drive new product and technology development, with prior senior leadership and scientific roles at Nike, MeadWestvaco and Dow Corning.

Richard Gross, Professor, Constellation Chair, Chemistry and Chemical Biology, Rensselaer Polytechnic Institute
Dr. Gross' research is motivated by the urgent need to develop sustainable chemicals and materials to meet the demands of a rapidly rising global population while mitigating risks of increased green-house gas emissions associated with climate change. He applies chemical and biocatalysts to develop efficient green routes to low molar mass molecules, polymers and materials.

Mahdi Abu-Omar, Professor, Mellichamp Chair of Green Chemistry, University of California, Santa Barbara; Founder & CEO, Spero Renewables
Dr. Abu-Omar is active in two areas of research, biomass conversion and bio-inspired chemistry, to discover and develop new transformations and molecules that can serve as monomers for new materials and/or precursors to renewable liquid fuels. Spero Renewables is a green chemistry company that develops technologies for plant-based alternatives to products manufactured with petrochemicals. Spero utilizes its proprietary technology to unlock the resources of readily available biomass for making natural and environmentally friendly products.

Winnie Lau, Senior Manager, Preventing Ocean Plastics, Pew Charitable Trusts
Dr. Lau works on proposing strategies to reduce the global ocean plastic pollution problem. She has also worked on Pew's international conservation unit, developing new projects, and partnerships in Asia. With 14 years of experience integrating science, international policy, resource management and development, Dr. Lau brings excellence in inspiring diverse stakeholders to achieve a common goal.

John Dorgan, David L & Denise M. Lamp Endowment Chair, Chemical Engineering & Materials Science, Michigan State University
Dr. Dorgan is an expert in polymeric materials emphasizing the development of sustainable technologies to meet the world's challenges. His research focuses on polymer science with an emphasis on "Green" polymers made from renewable resources. Such carbon fibers are critical to lightweight vehicles and advanced wind turbines. Within the very real constraints of thermodynamics, transport processes, and economics I am seeking to enhance the sustainability of our industrial systems.

Session 2. Convergent research on advanced materials for sustainable infrastructure

Liangbing Hu, Herbert Rabin Distinguished Professor, Director, Center for Materials Innovation, Dept. Materials Science & Engineering, University of Maryland
Dr. Hu seeks to understand and explore the characteristics of emerging nanomaterials with large aspect ratios such as fibers, tubes and sheets and their hybrids. We are interested in nanoscale fundamental science and large-scale applications through nanomanufacturing. His research group focuses on materials innovations, device integrations, and manufacturing with ongoing research activities on wood nanotechnologies. Dr. Hu is the recipient of the R&D 100 Award (2018).

Zhiyong Jason Ren, Professor, Civil and Environmental Engineering; Acting Director & Associate Director for Research, Andlinger Center for Energy and the Environment, Princeton University
Dr. Ren works on Water-Energy Nexus especially in areas of energy and resource recovery during environmental processes such as wastewater treatment and reuse, water desalination, remediation, and carbon capture and utilization. He is the recipient of the 2020 Walter L. Huber Civil Engineering Research Prize (American Society of Civil Engineers) for "producing groundbreaking technological advancements that are transforming water infrastructure for energy and resource recovery. His leadership in pilot-scale applications and entrepreneurial start-ups makes him a model of university-industry partnership."

Medhi Tajvidi, Associate Professor of Renewable Nanomaterials. University of Maine
Dr. Tajvidi's areas of research interest are production, characterization and performance evaluation of renewable nanomaterials and their composites, with core emphasis on the utilization of cellulose nanomaterials in high volume applications such as coatings, packaging and building products.

Alan Luo, FEF Key Professor, Materials Science & Engineering; Professor, Integrated Systems Engineering, Ohio State University
Dr. Luo was a GM Technical Fellow at General Motors Global Research and Development Center (Warren, MI, USA) with 20 years of industrial experience. His research expertise include lightweight materials, advanced manufacturing processes, and lightweight design and integrated computational materials engineering.

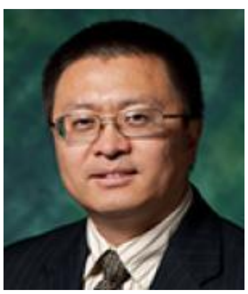
Soydan Ozcans, Senior R&D Scientist, Energy & Transportation Science Division, Oak Ridge National Laboratory; Joint Associate Professor, Mechanical Engineering, University of Tennessee Knoxville
Dr. Ozcans's research addresses the broad and vital issue of identifying novel, high value biomaterials from biomass, and viable processes for their preparation for composite and additive manufacturing applications. He also leads the Composite Recycling Effort for Institute for Advanced Manufacturing Composite Innovation by facilitating the development of composite recycling technologies and utilizing various composite techniques to repurpose them into useful applications.

Yuan Yao, Assistant Professor of Industrial Ecology and Sustainable Systems, School of the Environment, Yale University
Dr. Yao focuses on sustainable solutions that can support industrial development without compromising the environment or depleting the resources, in areas such as industrial ecology, sustainable engineering, and machine learning to develop systems analysis tools to support engineering and policy decisions towards sustainability. Her area research expertise include:

Life Cycle Assessment, Techno-Economic Analysis, dynamic modeling, process simulation, data analytics, energy analysis, carbon footprint accounting.

Peter Ciesielski, Senior Research Scientist, National Renewable Energy Laboratory
Dr. Ciesielski works to improve ways by which biomass can be used as a sustainable and renewable source of fuels, chemicals, and materials through microscopy and quantitative analysis modeling techniques - nanostructural characterization using 3-D electron tomography; modeling of higher-order architecture of biomass and plant cell wall; biomass particle modeling to understand intra-particle transport phenomena that can affect the observed rates of catalytic conversion processes.

Junyong (JY) Zhu, Research General Engineer, Forest Product Laboratory, USDA Forest Service
Dr. Zhy is a scientific team leader in woody biomass utilization for sugar/biofuel, chemicals, fiber, and cellulose nanomaterials production at the US Forest Service, Forest Products Laboratory (the only U.S. National Lab in Wood Utilization). His research interests are the economical and sustainable production of lignocellulosic nanomaterials, and the lignin utilization by fractionating lignin from lignocelluloses with tailored properties for efficient downstream conversion to valuable bio-products and chemicals.



Sheldon Shi, Professor, Mechanical Engineering, North Texas University
Dr. Shi serves as the Division Director and Chair of the Forest Products Society since 2006 and has been actively involved in the Society of Wood Science and Technology for 15 years. His research interests and areas of expertise are wood composites/bioproduct engineering, manufacture processes of renewable biocomposites, and energy efficient building structures and materials, among others.

Ashlie Martini, Professor, Mechanical Engineering, University of California, Merced
Tribology is critically important to addressing some of the world's key issues related to energy efficiency and the economic and societal implications of energy usage because so much energy is lost to friction in mechanical components.. Dr. Martini's research focus is on the applications of multi-scale simulations and measurements to understand fundamental mechanisms underlying tribological phenomena with research in: solid and liquid lubricants, tribochemistry, and nanoscale contact and sliding. Dr. Matinini is actively finding ways to minimize friction and wear through new technologies in tribology is critical to a greener and more sustainable world.

Baoxia Mi, Assoc. Professor, Energy, Civil Infrastructure & Climate, Environmental Engineering, University of California, Berkeley
Dr. Mi studies physicochemical processes emphasizing nanomaterials and membrane science and technology to address some of the most challenging issues in sustainable water supply (desalination, drinking water purification, wastewater reuse), renewable energy production, and public health protection. Mi's research activities center on new integrated membrane systems and processes such as forward osmosis (FO), pressure retarded osmosis (PRO), and membrane distillation (MD). Mi's recent effort has been on the development of novel, anti-fouling, high-performance PRO membranes and optimization of the PRO process. We are also studying an integrated FO and MD system for water purification using sustainable energy sources (e.g., waste heat, solar energy, geothermal).

Alper Kiziltas, Technical Expert, Ford Motor Company
Dr. Kiziltas brings a unique combination of global cross-functional leadership skills, product, manufacturing and business excellence, strategic research and advanced portfolio development to identify options and alternative approaches that consider all facets of sustainable decision making. He led research to implementation of 10 innovative automotive materials including: tree-based cellulose composites, coffee chaff and rice hull filled PP and 100% recycled PP from post-consumer carpet for under the hood applications, and first global high-volume implementation of graphene reinforced foam. More recently, he worked on the global implementation of recycled polypropylene-based injection molded parts as the first recycle product application at Ford Otosan, Turkey.

List of Workshop Participants - attendance at 58

Key: G = Government laboratories/agencies; A = Academic institution; I = Industry

Name	**Affiliation**	**Primary area of expertise**	
Benavides, P. Thathiana	Energy systems analyst, ANL	Environmental sustainability - environmental analysis for biofuel and bioproducts including plastics	**G**
Bian, Yanhong	Graduate student, Princeton University	Carbon capture technologies, Carbon storage, Sustainable materials, Sustainable infrastructure technologies for water transport, Environmental sustainability, Machine learning / artificial intelligence methodologies, Economic analysis and impact	**A**
Cable, Josh	CEO, InventWood LLC	Sustainable materials, e.g., cellulose, wood	**I**

Cassidy, Chris	National Renewable Energy Coordinator, USDA	Net-negative fuels or biofuels, Sustainable materials, e.g., cellulose, wood, Energy utilization and analysis, Economic analysis and impact, Plastic degradation, recycling, upcycling, Polymer science	**G**
Chaudhuri, Santanu	Professor, University of Illinois	Carbon capture technologies, Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Machine learning / artificial intelligence methodologies, Plastic degradation, recycling, upcycling, Polymer science	**A**
Chen, Bo	Postdoc, University of Maryland, College Park	Sustainable infrastructure technologies for buildings, Environmental sustainability, Energy utilization and analysis, Economic analysis and impact	**A**
Chen, Chaoji	Postdoc, University of Maryland, College Park	Sustainable materials, e.g., cellulose, wood, Environmental sustainability	**A**
Chen, Junhong	Professor, University of Chicago/ANL	Sustainable materials, e.g., cellulose, wood; Ecomanufacturing of sensors and battery devices	**A**
Chen, Qiongyu	Graduate student, Univ. of Maryland	Sustainable materials, e.g., cellulose, wood, Energy utilization and analysis, Machine learning / artificial intelligence methodologies, Plastic degradation, recycling, upcycling, Polymer science	**A**
Chen, Xi	Associate research scholar, Princeton University	Carbon capture technologies, Carbon storage, Net-negative fuels or biofuels, Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for water transport, Environmental sustainability	**A**
Chen, Xiaowen	Senior Research Engineer, NREL	Net-negative fuels or biofuels, Sustainable materials, e.g., cellulose, wood, Plastic degradation, recycling, upcycling, Polymer science	**G**
Christie, Kofi	Postdoc, Princeton University	Sustainable materials, e.g., cellulose, wood, Energy utilization and analysis, Polymer science; Membrane development for wastewater treatment	**A**
Cui, Shuang	Researcher, NREL	Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for water transport, Sustainable infrastructure technologies for buildings, Environmental sustainability, Machine learning / artificial intelligence methodologies, Polymer science	**G**

Dai, Jiaqi	Chief Technology Officer, InventWood LLC	Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for buildings, Sustainable infrastructure technologies for transportation	**I**
Dou, Chang	Engineer, LBNL	Sustainable materials, e.g., cellulose, wood, Plastic degradation, recycling, upcycling	**G**
Drennan, Corinne	Manager, Process Engineering, PNNL	Net-negative fuels or biofuels, Environmental sustainability	**G**
Dunn, Jennifer	Research Associate Professor, Northwestern University	Net-negative fuels or biofuels, Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Energy utilization and analysis, Plastic degradation, recycling, upcycling	**A**
Gong, Amy	CSO, InventWood LLC	Sustainable materials, e.g., cellulose, wood, Environmental sustainability	**I**
Gracida-Alvarez, Ulises	Postdoc, ANL	Environmental sustainability, Energy utilization and analysis, Plastic degradation, recycling, upcycling	**G**
Gustafsson, Emil	Sr. Research Project Manager, UBC BioProducts Institute	Sustainable materials, e.g., cellulose, wood	**A**
He, Shuaiming	Research Associate, University of Maryland	Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for buildings, Plastic degradation, recycling, upcycling	**A**
Jang, Nate	Materials Engineer, InventWood, LLC	Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for water transport, Sustainable infrastructure technologies for buildings	**I**
Jensen, Rasmus Overgaard	Biofoundry Manager, LanzaTech	Carbon capture technologies, Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Plastic degradation, recycling, upcycling	**I**
Jing, Shuangshuang	University of Maryland	Sustainable materials, e.g., cellulose, wood, Polymer science	**A**

Kan, Viirj	CEO & Director of Design Innovation, Primitives Biodesign	Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Plastic degradation, recycling, upcycling, Polymer science, biomimetic design	**I**
KTH	KTH Royal Institute of Technology	Sustainable materials, e.g., cellulose, wood	**A**
Lee, Brian	VP of Biotechnology, Visolis Inc.	Carbon capture technologies, Net-negative fuels or biofuels, Plastic degradation, recycling, upcycling	**I**
Legatt, Michelle	Principal Sustainable Materials Engineer, Hasbro	Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Economic analysis and impact, Plastic degradation, recycling, upcycling	**I**
Li, Yuanyuan	Assistant professor, Royal Institute of Technology	Sustainable materials, e.g., cellulose, wood	**A**
Li, Yudong	Postdoc, NREL	Sustainable materials, e.g., cellulose, wood; Renewable energy souce from biomass materials	**G**
Lin, Shaoting	Postdoc, MIT	Sustainable infrastructure technologies for water transport, Sustainable infrastructure technologies for buildings, Environmental sustainability, Plastic degradation, recycling, upcycling, Polymer science	**A**
Liu, Ping	Professor, UCSD	Carbon capture technologies, Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for buildings, Sustainable infrastructure technologies for transportation	**A**
Liu, Yu	Postdoc, University of Maryland	Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for buildings, Environmental sustainability	**A**
Madenjian, Lisa	Principle TS&D Scientist, Dow	Environmental sustainability, Plastic degradation, recycling, upcycling, Polymer science	**I**
McCurdy, Mike	Managing Director, Fuels & Power, ICF	Carbon capture technologies, Carbon storage, Net-negative fuels or biofuels, Sustainable materials, e.g., cellulose, wood, Energy utilization and analysis, Regulatory Policies, Economic analysis and impact, Plastic degradation, recycling, upcycling	**I**

Meggers, Forrest	Assistant Professor, Princeton Univeristy	Carbon capture technologies, Carbon storage, Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for water transport, Sustainable infrastructure technologies for buildings, Sustainable infrastructure technologies for transportation, Environmental sustainability, Energy utilization and analysis, Regulatory Policies	**A**
Meredith, Carson	Professor & Executive Director, Georgia Tech	Carbon capture technologies, Sustainable materials, e.g., cellulose, wood, Plastic degradation, recycling, upcycling, Polymer science	**A**
Meyer, Paul	Postdoc, NREL	Polymer science	**G**
Miranda, Raul	Program Manager, Chemical, Geo and Bio Sciences, BES, DOE	Carbon capture technologies, Net-negative fuels or biofuels, Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Energy utilization and analysis, Machine learning / artificial intelligence methodologies, Plastic degradation, recycling, upcycling	**G**
Orts, William	Research Leader/ Bioproducts, USDA	Carbon capture technologies, Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Plastic degradation, recycling, upcycling, Polymer science	**G**
Pang, Zhenqian	Postdoc, University of Maryland	Sustainable materials, e.g., cellulose, wood	**A**
Pereira, Bruno Rufato	Chief Sustainability Officer, BioLogiQ	Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Plastic degradation, recycling, upcycling, Polymer science	**I**
Pikus, Liza	VP, Strategy, InventWood, LLC	Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Machine learning / artificial intelligence methodologies, Economic analysis and impact	**I**
Ryan, Cecily	Assistant Professor, Montana State University	Carbon storage, Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for buildings, Sustainable infrastructure technologies for transportation, Environmental sustainability, Plastic degradation, recycling, upcycling, Polymer science	**A**
Sones, Richard	Director Partner Innovations, UBC BioProducts Institute	Sustainable materials, e.g., cellulose, wood	**A**

Stack, Robert	Program Manager, Physical Biosciences, BES, DOE	Carbon storage, Sustainable materials, e.g., cellulose, wood, Plastic degradation, recycling, upcycling	**G**
Sun, Ning	Research Scientist, Biological & System Engineering, LBL	Sustainable materials, e.g., cellulose, wood	**G**
Tao, Ling	Analysis platform lead and Sr. engineer, NREL	Carbon capture technologies, Net-negative fuels or biofuels, Environmental sustainability, Energy utilization and analysis, Regulatory Policies, Economic analysis and impact	**G**
Trenor, Scott	Principal Scientist/Global Sustainability Lead, Milliken & Co	Net-negative fuels or biofuels, Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for buildings, Plastic degradation, recycling, upcycling, Polymer science	**I**
Urgun-Demirtas, Meltem	Group Leader, ANL	Net-negative fuels or biofuels, Environmental sustainability, Plastic degradation, recycling, upcycling	**G**
Williams, Kelly	Sustainability Strategist, Futamura	Sustainable materials, e.g., cellulose, wood, Plastic degradation, recycling, upcycling	**I**
Wilson, Rebecca	Director of Materials Engineering, Primitives Inc	Environmental sustainability, Plastic degradation, recycling, upcycling, Polymer science	**I**
Wu, Meiling	Postdoc, University of Maryland	Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for water transport, Polymer science	**A**
Yan, Jipeng	ABPDU: Advanced biofuels and bioproducts, LBL	Sustainable materials, e.g., cellulose, wood, Machine learning / artificial intelligence methodologies, Plastic degradation, recycling, upcycling	**G**
Yang, Meiqi	Graduate student, Princeton University	Carbon capture technologies, Carbon storage, Sustainable materials, e.g., cellulose, wood, Sustainable infrastructure technologies for water transport, Environmental sustainability, Energy utilization and analysis, Machine learning / artificial intelligence methodologies	**A**

Zhao, Ji-Cheng (JC)	Professor, Chair, University of Maryland	Materials Science	**A**
Zheng, Sunxiang	Postdoc, Princeton University	Carbon capture technologies, Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Polymer science	**A**
Zhu, Hongli	Assistant Professor, Northeastern Univ.	Sustainable materials, e.g., cellulose, wood, Environmental sustainability, Energy utilization and analysis, Plastic degradation, recycling, upcycling, Polymer science	**A**

Appendix B Workshop agenda

Session 1: Convergence research for nature-inspired solutions to replacement for petroleum-based plastics
Date/time: 1:00-5:00 pm US eastern time, Wednesday, 30 September 2020

1:00 pm Teng Li, University of Maryland

- Opening remarks

1:10 pm Nakhiah C. Goulbourne, Program Director, NSF

- Overview of NSF Convergence Accelerator Program

1:15 -2:30 pm Invited lightening talks (Part 1)

- Breaking the Plastic Wave, **Jim Palardy**, The Pew Charitable Trusts
- Upcycling Plastics with Bio-based Building Blocks, **Nicholas Rorrer**, National Renewable Energy Laboratory
- Convergent Rubber Science and Engineering, **Katrina Cornish**, Ohio State University
- Structure-led engineering of natural enzymes to tackle plastic pollution, **John McGeehan**, University of Portsmouth
- Untapped Resources - Driving Fashion with Science, **Julie Willoughby**, Tyton Bioscience

2:30 - 2:40 pm Break

2:40 pm Robert Briber, Interim Dean, A. James Clark School of Engineering, University of Maryland

- Welcome remark

2:45 - 3:45 pm Invited lightening talks (Part 2)

- Redesigning Polyethylene for Chemical Recycling to Monomeres and Biodegradability, **Richard Gross**, Rensselaer Polytechnic Institute
- Materials from Lignin to Enable the Circular Economy, **Mahdi Abu-Omar**, Spero Renewables/UCSB
- Characteristics of scalable replacement for plastics, **Winnie Lau**, The Pew Charitable Trusts
- Industrial Ecology: Materials Design through Biomimicry, **John Dorgan**, Michigan State University

3:45 - 5:00 pm Open discussion and concluding remarks

Session 2: Convergence research for advanced materials for sustainable infrastructure
Date/time: 1:00-5:30 pm US eastern time, Friday, 2 October 2020

1:00 pm Teng Li, University of Maryland

- Overview of NSF Convergence Accelerator Program and our workshop focus

1:05 -3:05 pm Invited lightening talks (Part 1)

- Wood Nanotechnologies, **Liangbing Hu**, University of Maryland
- Material innovations for a circular infrastructure economy, **Jason Ren**, Princeton University
- Making ends meet: the future of forest products, **Medhi Tajvidi**, University of Maine
- Sustainable Materials and Vehicle Lightweighting, **Alan Luo**, Ohio State University
- High Volume Bio-derived Renewable Composite Feedstocks for Big Area Additive Bio-Manufacturing, **Soydan Ozcans**, Oak Ridge National Laboratory
- Systems Modeling Approaches to Support Decision-Making for Sustainable Materials, **Yuan Yao**, Yale University

3:05 - 3:15 pm Break

3:15 -4:15 pm Invited lightening talks (Part 2)

- Mechanics of cellulose nanomaterials across length scales, **Ashlie Martini**, University of California, Merced
- Material and Process Innovation for Clean Water, **Baoxia Mi**, University of California, Berkeley
- Wood industry, processing and scale up, **Sheldon Shi**, North Texas University
- Understanding Emergent Properties of Lignocellulosic Materials through Multiscale Modeling, **Peter Ciesielski**, National Renewable Energy Laboratory
- Sustainable fractionation of lignocelluloses, **JY Zhu**, USDA Forest Product Laboratory
- Sustainable materials for automotive applications, **Alper Kiziltas**, Ford

4:15 - 5:30 pm Open discussion and concluding remarks