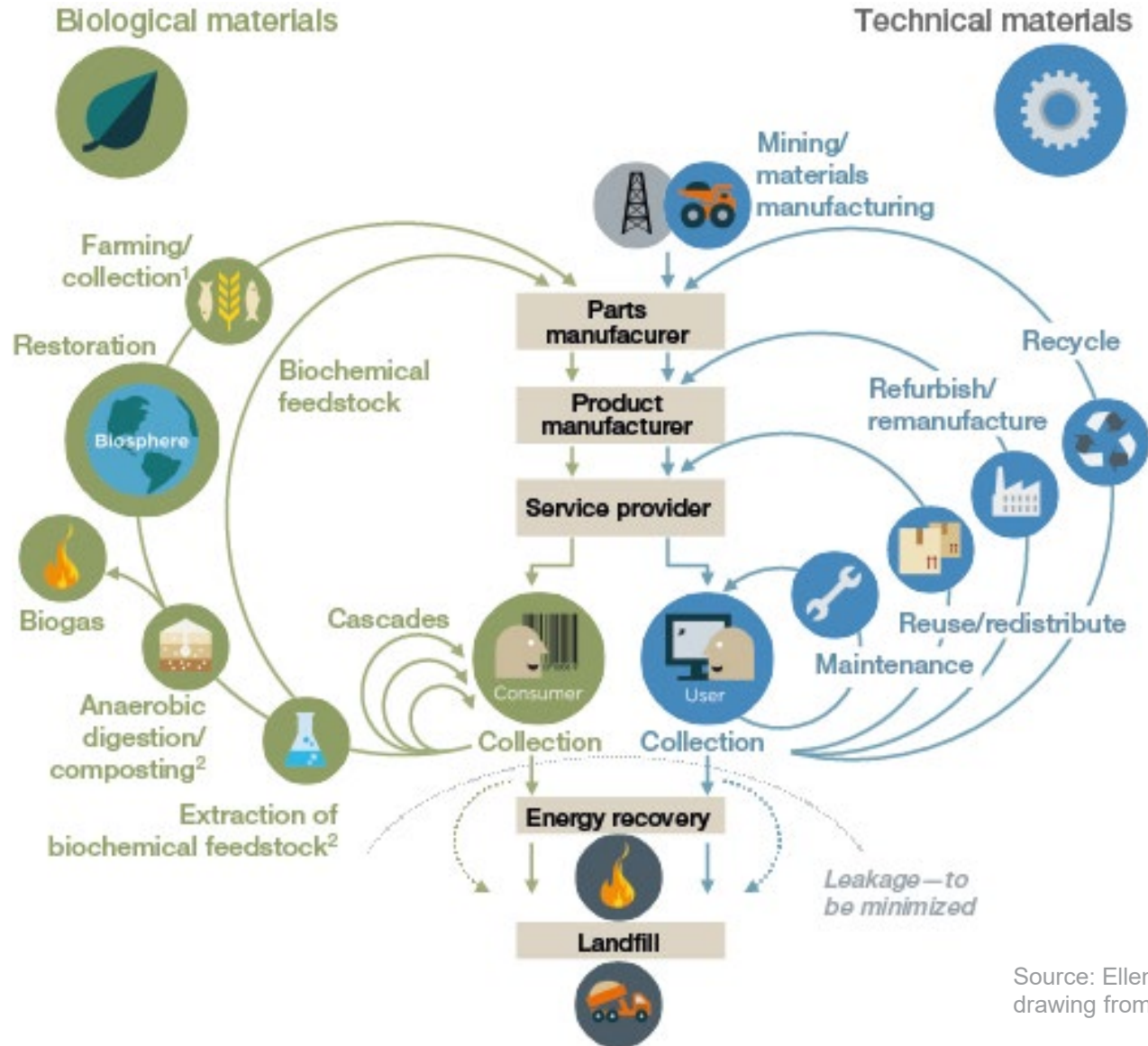


NIST Climate Portfolio Update: Circular Economy

Keeping atoms and molecules inside the economy, producing value, and out of unwanted sinks such as the environment (air, water, soil, etc)

What is the Circular Economy?



The Circular Economy transforms our throwaway economy into one where waste is eliminated, resources are circulated, and nature is regenerated



Definition for NIST:

Keeping atoms and molecules inside the economy, producing value, and out of unwanted sinks such as the environment (air, water, soil, etc)

SOS 2.0: system of economic activities that is restorative to the environment, enables resources to maintain their highest values and aims for the elimination of waste through superior design



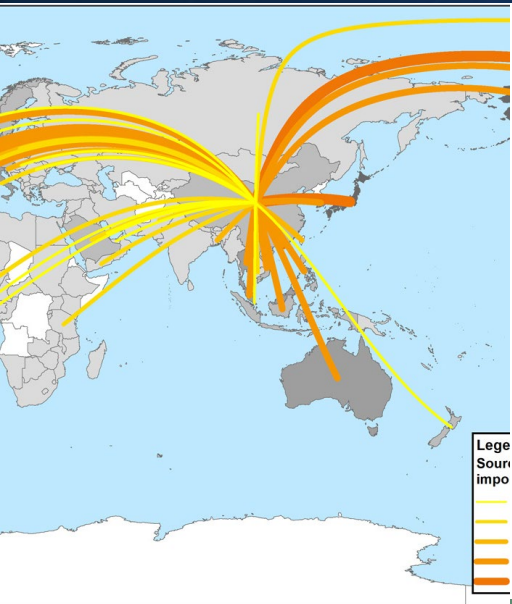
Organization

We are structured roughly around materials classes

Beginning with Polymers/Plastics

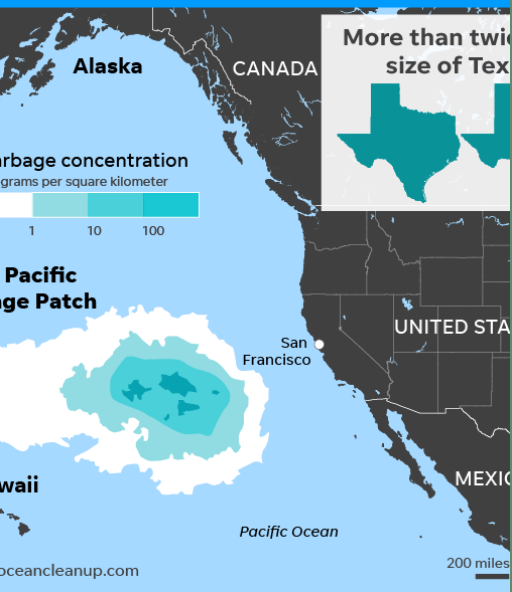
UN Draft Language (9/21): products and materials are designed so that they can be reused, remanufactured or recycled and therefore maintained in the economy for as long as possible along with the resources they are made of, and the generation of waste, especially hazardous waste, is avoided or minimised, and greenhouse gas emissions are prevented and reduced

Two Converging Issues with Plastic Waste



- Global trade disruption in plastic waste
- Markets increasingly limited for traditional methods of collection and sortation
- Opportunities for new mechanical pathways and new technologies (e.g. chemical processes)

Science Advances, 2018, DOI: [10.1126/sciadv.aat0131](https://doi.org/10.1126/sciadv.aat0131)

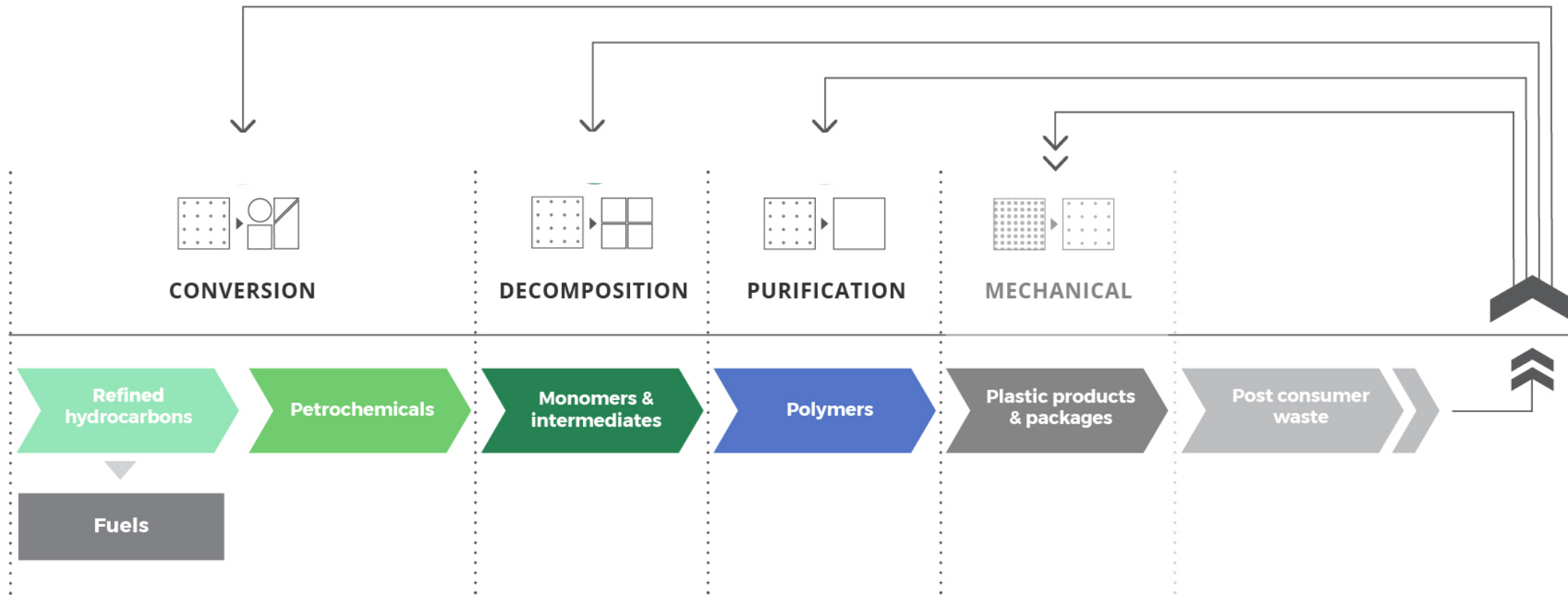


- Increasing awareness of environmental impacts of plastic debris, from macro- to micro-scale
- Quantification challenges and data scarcity problems



World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, *The New Plastics Economy – Rethinking the future of plastics* (2016)

Circular Polymers



“Accelerating Circular Supply Chains for Plastics”
Center for the Circular Economy @ ClosedLoopPartners.com

NIST Discretionary Start-Up: Polymers

Data & Decision Tools

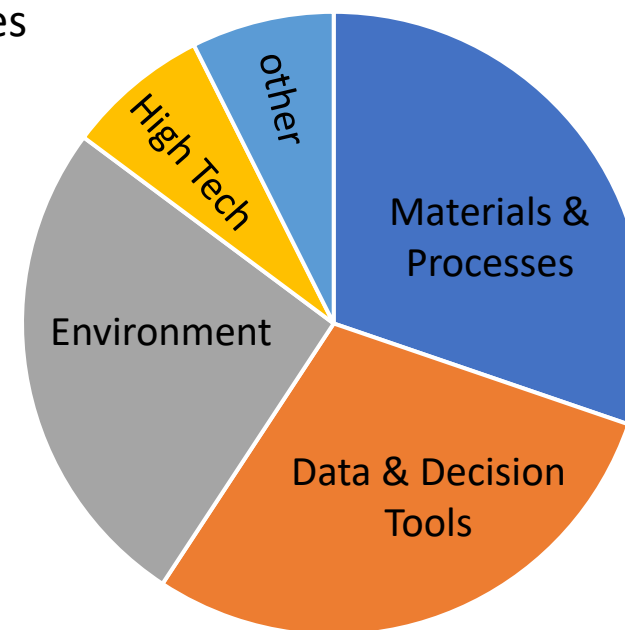
- Supply Chain Resilience
- Life-cycle Data and Economics
- Material Flows/Mass Balance
- Reference Data Sets, Data Infrastructure & Documentary Standards

New Processes & Materials

- Mechanical, Biological and Chemical cycling routes
- Fit-for-Purpose design rules
- Automated synthesis / AI platforms
- Reference materials & data

Environmental Impacts

- Marine Debris
- Nano- and Micro-plastics
- Sampling methods
- New Measurements (Characterization)
- Reference materials

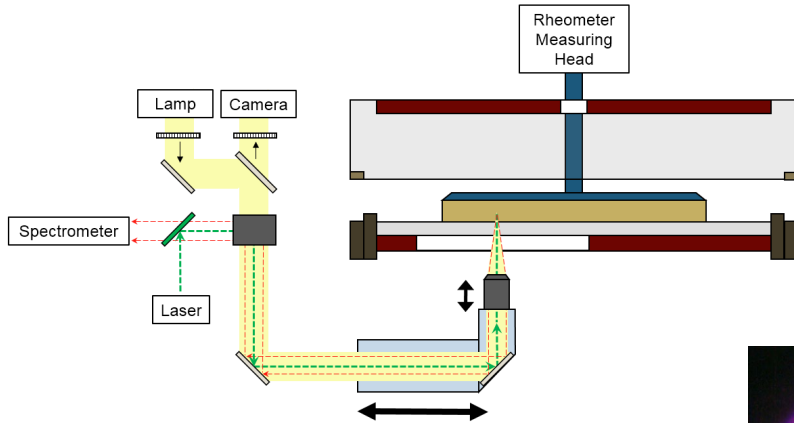


Investment Portfolio

MML, lead
EL, primary partner
PML, participating PI
NCNR, ITL, collaborating staff

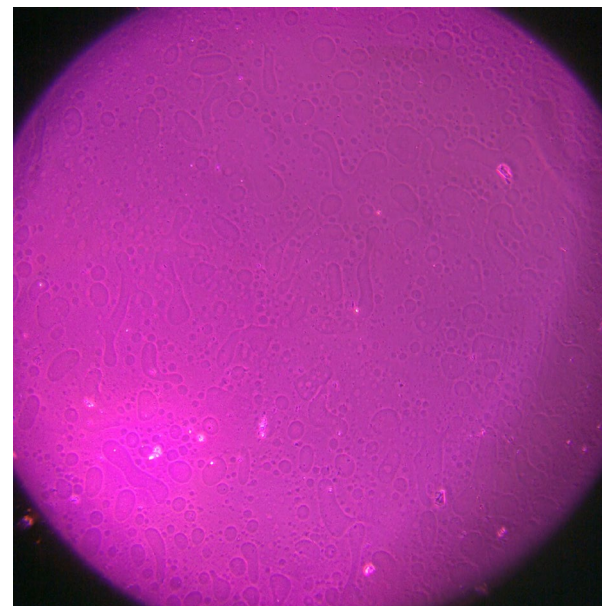
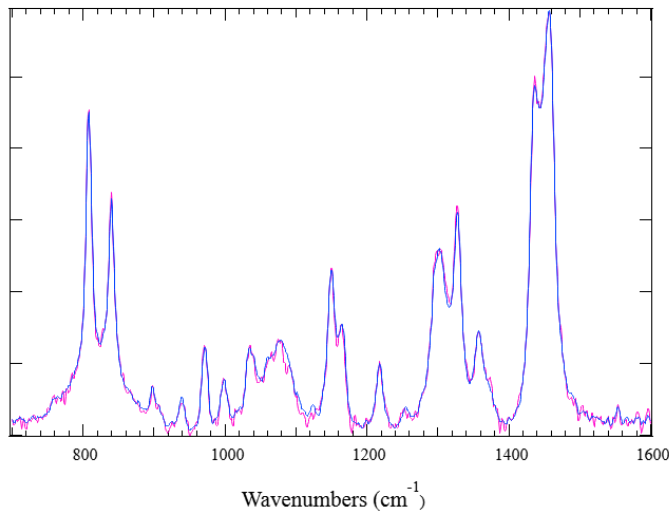
Opportunities for **all parts**
of **NIST!**

Polyolefin Compatibilization



Rheo-Raman-Microscope

Raman spectroscopy with multivariate curve resolution (MCR)

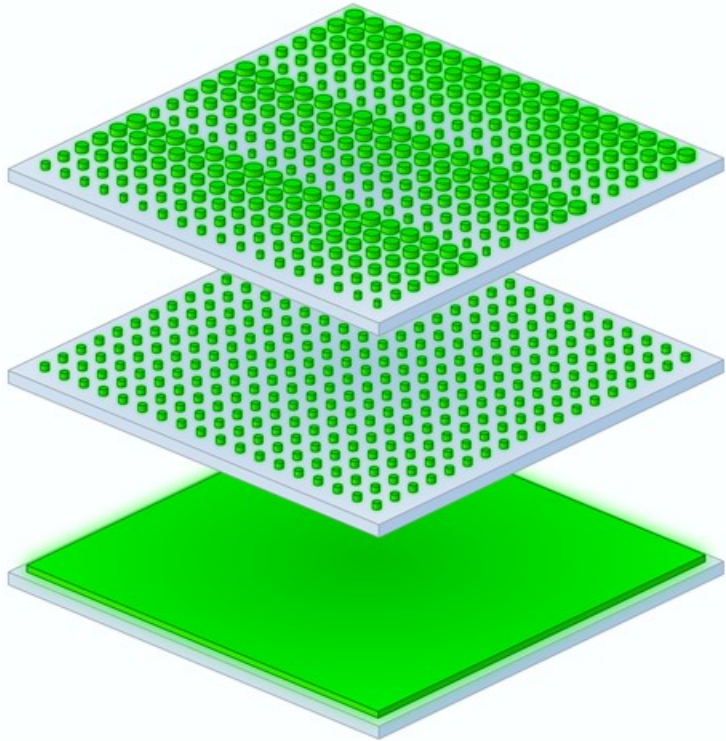


Crystallization of 50/50 HDPE/iPP blend during cooling (100x Speedup)

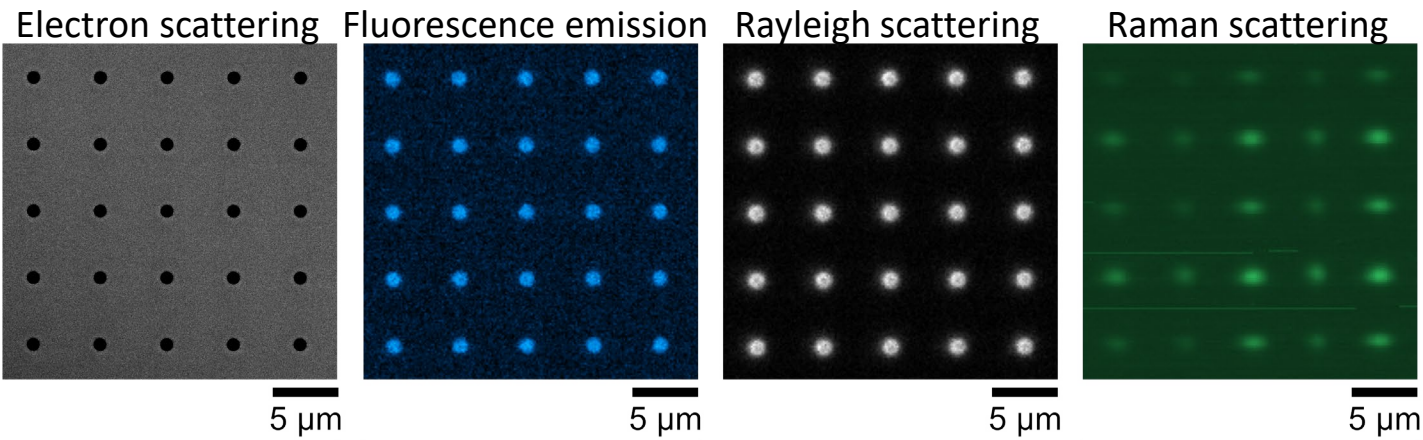
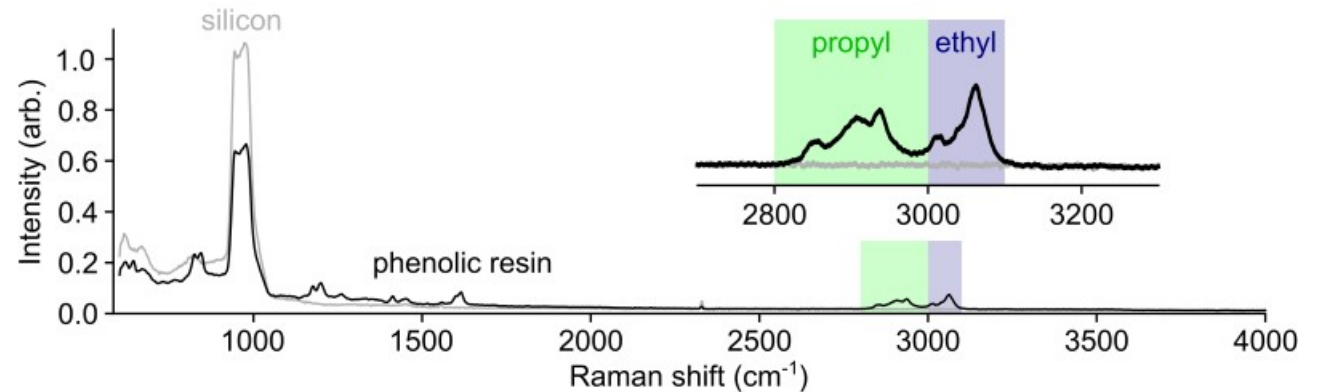
- NIST developed rheo-Raman-microscope provides unprecedented view of hierarchical kinetics in mixed polyolefins, leading to strategies to enhance mechanical properties
- MCR allows quantification of % crystallinity of both HDPE and iPP simultaneously during process

Kalman Migler, Derek Huang (NRC)
*Materials Science and Engineering
Division, MML*

Model Nanoparticles for Dynamic Studies

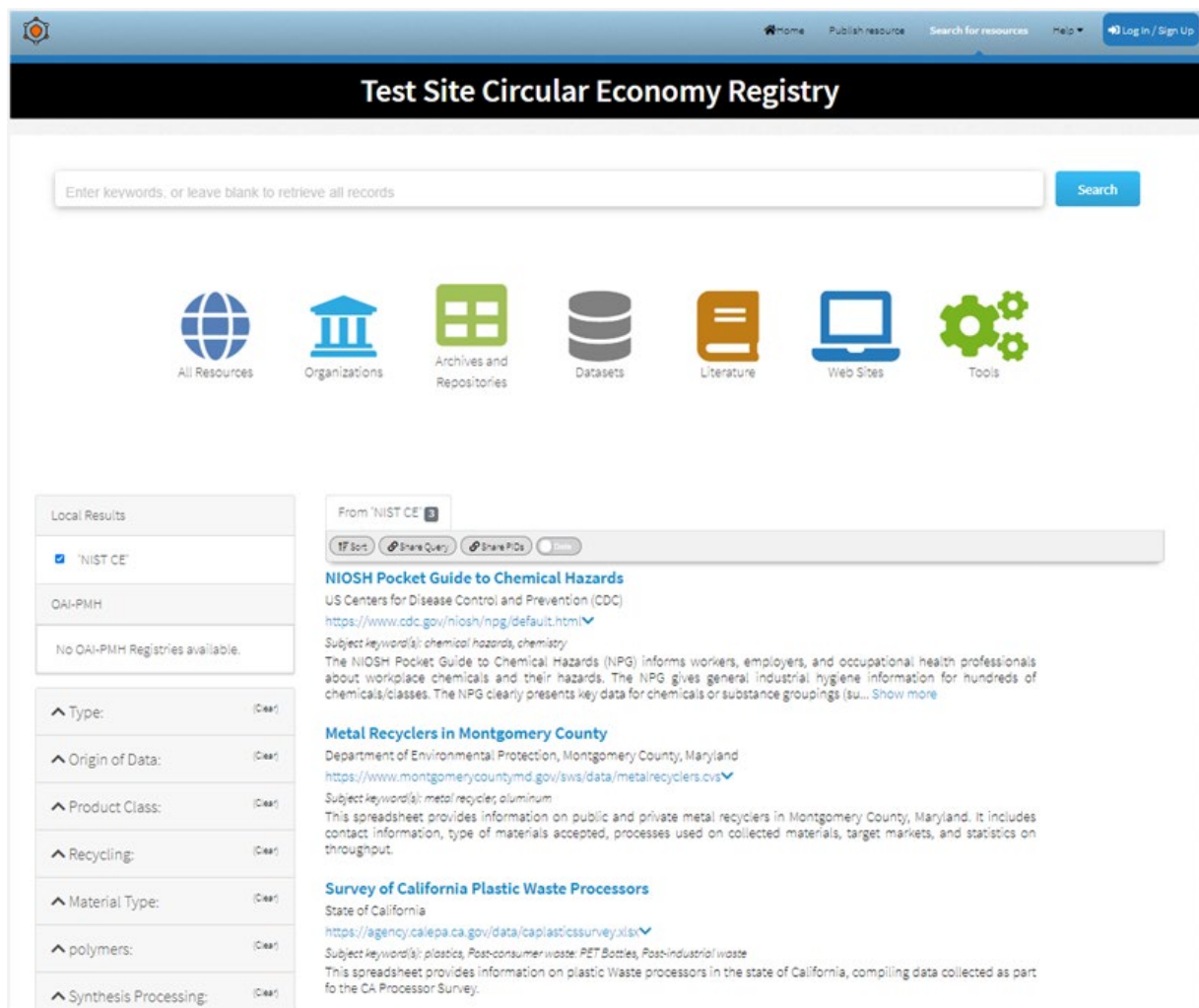


- Goal: both stationary and released, uniform nanoparticles (100 nm to 1 μm) for standards and calibrations
- Arrays of nanoplastic in phenolic resin fabricated
- Raman microspectroscopy complete (spectra shown for thin films)



Sam Stavis, Andy Madison(NRC)
*Microsystems and Nanotechnology
Division, PML*

Circular Economy Resource Registry



- Platform on CDCS framework (w/ ITL)
- Draft Schema (XML), Complete
- Test Site active
- Core data set being implemented
 - *shared resource types, CE specific metadata*
 - *search & faceted browsing*
 - *custom CE web views*
 - *Publishing*
 - *API access supports interoperability*

Gretchen Greene, Ray Plante, Kelsea Schumacher, Ben Long (ITL), Ali Daoudi

Office of Data Informatics, MML



January 2021

Circular Economy in the High-Tech World:

- eWaste
- Solar waste
- Battery waste

Kelsea Schumacher
and Marty Green



May 2021

Assessment of Mass Balance Accounting Methods for Polymers:

- Basis of congressional report mandated by SOS 2.0

Kelsea Schumacher, Kate Beers, Kalman Migler, KC Morris and Josh Kneifel



September 2021

Facilitating a Circular Economy for Textiles:

- Technical challenges
- Environmental impacts
- Government viewpoints

Kelsea Schumacher
and Amanda Forster

Relationships and Future Opportunities: Domestic

- 3 Department of State working groups: Plastic Waste, Circular Economy, and UNEP/UNEA preparations
 - Increasing DOC coordination w/ ITA and NOAA
- EPA National Recycling Strategy (expected Sept 2021)
 - SOS 2.0 studies (Innovative Uses of Plastic Waste, Minimizing Creation of New Plastic Waste)
- MOU with NSF on Emerging Frontiers Research Institutes
 - 5 NSF Workshops in 10 months (Convergence Accelerator, DMR and CBET)
- Multiple partnerships with industry, academia and other National Labs
 - Chevron Phillips, Braskem, Dow, Eastman, Argonne National Lab, Brookhaven National Lab, Hawai'i Pacific University, Johns Hopkins University, University of Maryland, Woods Hole Oceanographic Inst.
- Trade associations engaged across multiple projects
 - ACC, APR, BIO, The Vinyl Institute, etc
- Early discussions with FDA, USDA and NSTC Sustainable Chemistry working group





Asia-Pacific
Economic Cooperation

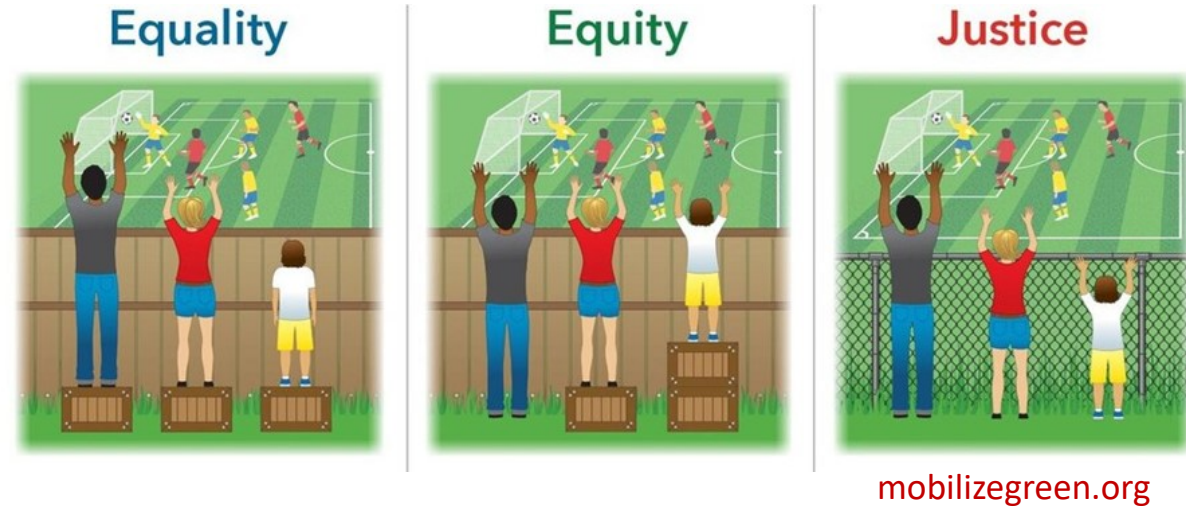


ASTM INTERNATIONAL

- **JRC-NIST Virtual Workshop on Nanoplastics Research (Jenn Lynch, et al.)**
- **APEC (Jenn Lynch) and ASTM workshops (KC Morris)**
- **ISO/TC 323 Circular Economy**
 - 5 working groups (NIST on US TAG)
- **Policy & Government (Plastic Pollution/CE):**
 - UNEP negotiations coincide with similar discussions and negotiations within OECD, WTO, G7 and G20
 - Plans for symposia (PacifiChem, ACS, etc) and conferences (GRC)
 - US-France bilateral + joint meeting with the French embassy
 - SIM working groups on waste management and circular infrastructure in the Americas

Related Priorities / Opportunities

- **Carbon Capture**
- **Resilience**
- **Infrastructure**
 - Physical
 - Societal
- **Supply Chain**
 - CHIPS Act / NDAA
- **Bioeconomy, Biomanufacturing**
- **Equity and Environmental Justice**
- **Proposed expansions of AMO, MEP**
- **New NSF Technology Directorate**



CE expansion plans

- High-Tech/Critical Minerals
- Textiles
- Concrete/Built Environment
- Biomass/Food Waste
- Expansion of plastics activities

Thank You!

Kelsea Schumacher

Stephanie Hooker

KC Morris

Kalman Migler

Gretchen Greene

Sam Stavis

Josh Kneifel

Amanda Forster

Martin Green

Jennifer Lynch

Sara Orski

LiPiin Sung

John Schiel

Jack Douglas

Elijah Peterson

Zach Trautt

Debra Audus

Tyler Martin

Peter Beaucage

Adam Pintar

Ray Plante

Ben Long

David Goodwin

Ana Barrios

Aaron Burkey

Kevin Brady

Ali Daoudi

John Giddens

Derek Huang

Robert Ivancic

Andrew Madison

Katy Shaw

Chase Thompson