Industry Stakeholder Presentations

Sustainable Chemistry in Laundry

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Lightning round perspectives on sustainable chemistry in consumer and commercial products

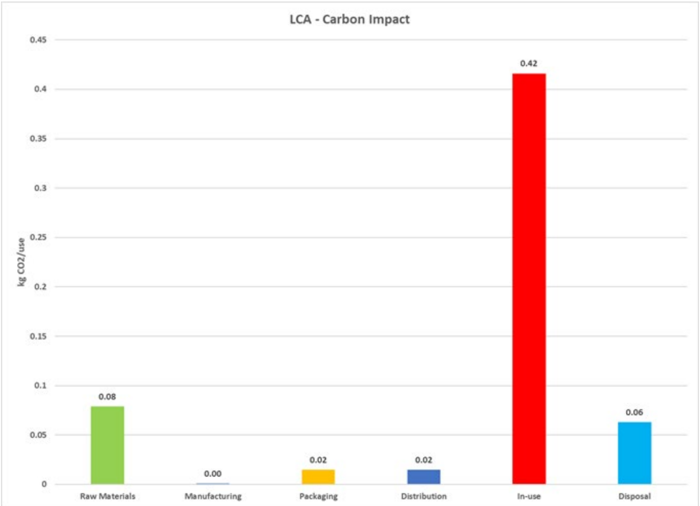
Sustainable Chemistry-Related Opportunities

Current Sustainable Chemistry Practices

- Enabling **Cold water wash**
  - 70-90% reduction in Use Phase energy and #1 LCA driver
- **Extending clothing longevity** – prevent fading, shrink/shape changes, pilling
- **Renewable/plant-based** products with no tradeoffs – Tide purclean, Downy Nature Blends
- Implement continued **lower impact** materials
- Design to enable **60% less plastic** per dose
- 100% **wind powered electricity** operations

Future Opportunities for Sustainable Chemistry

- **Continue Cold** journey via products, consumer behavior, and machine design
- **Reduced carbon impact for raw materials** –production impact, reduce mass at same performance, new sourcing ala carbon capture/renewable
- Further **Fabric Longevity** benefits
- **Circularity** beyond packaging to formula



RD&D needed to incorporate sustainable chemistry

Barriers to Sustainable Chemistry

- **Effectiveness and cost** vs incumbent materials/technology
- **Scale** to supply large businesses
- **Registration requirements** (time, $) of innovative materials (e.g. TSCA, preservative or AB actives)
- Progress vs Perfection
- **Installed machine** base –challenge in laundry

RD&D Needs Related to AMO's Mission

- **No trade-offs** – effectiveness/cost/scale
- **Lower carbon/energy impact surfactants** or substitutes (enzymes, materials to boost surfactancy to enable lower levels)
  - If renewable - true LCA improvement and responsible sourcing
- Breakthroughs in **cold water efficacy**

Circular flooring with Sustainable Chemistry

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Vision: Change the business imperative by leading in Responsible Economy

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Sustainable Chemistry-Related Opportunities

Current Sustainable Chemistry Practices

- Value Proposition of the Product
- Assessing raw material input,
  3000+ globally
- Type of cycle
- ID Hazard/Risk
- Regrettable substitute?
- Feedstock selection
- Circular Design

SUSTAINABLE DESIGN

- Differentiation, Product
  Leadership

SHORT TERM GOAL

- Creating Pull vs. Push

MARKET TRANSFORMATION

Future Opportunities for Sustainable Chemistry

- Fair and equitable benefit for stakeholders
- Connection to greater good;
  - SDGs
  - Circular Economy

RD&D needed to incorporate sustainable chemistry

Barriers to Sustainable Chemistry

- Communicate value proposition to stakeholders
- Regulatory landscape
- Collaboration incentives

RD&D Needs Related to AMO's Mission

- Collaboration Innovation Opportunity, Value Proposition
- Value Proposition, demonstration, stakeholder life-cycle perspective
- Rapid commercialization of Green Chemistry solutions

Cargill Bio-Industrial Sustainable Chemistry

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Serving industrial and consumer markets with sustainable chemistries based on a wide variety of agricultural and bio-based feedstocks, leveraging Cargill's access to global commodity markets and supply chains

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Sustainable Chemistry-Related Opportunities

Current Sustainable Chemistry Practices

- Dielectric Fluids FR3®
- Asphalt additives for PG modification (Anova®)
- Asphalt additives for rejuvenation
- Antistrip Additives for asphalt
- Polyols for flexible foam (BiOH®)
- Polyols for rigid foam insulation
- Cleaner burning waxes for candles (Naturewax®)
- Lubricants for metalworking
- Renewable binders for fiberglass insulation
- Dedust oils for insulation

Future Opportunities for Sustainable Chemistry

- Plasticizers
- Immersion Cooling fluids
- Bio-adhesives
- Packaging solutions
- Bio-based barrier coatings
- Green Diesel

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Barriers to Sustainable Chemistry

- Conversion of application to sustainable chemistries
- Awareness of availability and performance of bio-alternatives
- Performance skepticism vs. traditional petro products
- Breaking industry barriers
- Initial Cost vs Total cost of ownership
- Transparency of environmental benefit (LCA, CO_2)
- Consistent standards around environmental benefits
- Lack of a carbon price mechanism

RD&D Needs Related to AMO's Mission

- Applications insight
- Academic strength in bio/sustainable chemistry fundamentals (funding)
- Development of future bio-focused STEM talent
- Research on standards and methods of environmental benefits
- Research on Manufacturing Optimization for bio-based products

Sustainable Chemistry in Action

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Sustainable Chemistry-Related Opportunities

Current Sustainable Chemistry Practices

- Program built using the 12 Principles of Green Chemistry as the backbone
- Focus on a transparent, data driven approach
    - GHS Data
    - SDS Data
    - Manufacturing Footprint
- Design for Sustainability (DfS)
    - Development
    - Consulting
    - Re-engineering Programs
- DOZN – Quantitative Green Chemistry Analysis tool
- Driving sustainability into products
    - Introducing innovation in commoditized categories
    - Efficacy without compromise

Future Opportunities for Sustainable Chemistry

- Scaled domestic sustainable chemistry manufacturing with a focus on biorenewable solvents
- Funding at the academic level for collaborations between Industry and Academia
- Regulatory framework catch-up to other global leaders
- Enhancing capabilities in Process Intensification

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Barriers to Sustainable Chemistry

- **Higher Education**
  - Lack of student preparation for future requirements
  - ROI of GC to job readiness
- **Industry Investment**
- **Vision/Targets**
  - What are we collectively working towards?
  - Are there areas of focus
- **Value Chain Engagement**
  - Connecting the chain from R&D, to formulators, to manufacturers to B2C to consumers
- **Enough options for meaningful substitutions**
  - There are plenty of easy wins
  - How do we leap frog and aim for transformational?

RD&D Needs Related to AMO's Mission

- **Investment in scale-up capacity for biorenewable solvents with lower hazard and toxicity profiles**
- **Standardized green chemistry data for decision making**
- **Next generation green chemistry materials investment to increase the toolbox**
- **Process Intensification implementation and scaling**

Sustainable Chemistry

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With our innovative products and processes, we provide sustainable solutions for global needs. Our sustainability strategy IS our business strategy.

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Sustainable Chemistry-Related Opportunities

Current Sustainable Chemistry Practices

- ChemCycling, Alliance to End Plastic Waste, DOE BOTTLE, Circularity, TPU FutureCraft Loop sneakers
- Lithium-ion battery recycling for Co and Li
- Macroalgae as renewable feedstock for consumer goods
- Environmental product declaration (EPD) for concrete
- Methane pyrolysis for clean hydrogen production to support the hydrogen economy
- Sustainable solutions steering – All products characterized as Accelerator, Performer, Transitioner, or Challenged

Future Opportunities for Sustainable Chemistry

- Chemical, organism and enzymatic deconstruction of plastics to useful chemicals. Design to deconstruct
- R&D focus on battery design for recycling beyond EV's
- Commercial processes for transformation of macroalgae into platform chemicals
- R&D to enable economic pathways to carbon-neutral concrete
- New reactor designs for clean hydrogen production
- Coordinated FOA's between Federal and State programs e.g. DOE and NYSERDA

RD&D needed to incorporate sustainable chemistry

Barriers to Sustainable Chemistry

- Economics of upcycling plastics is impaired by cost of petroleum
- Quantifiable standards for sustainable chemistry (metrics)
- Firms tied to their existing manufacturing platforms for multiple products due to high investment cost. Green chemistry product may be niche
- Supply chain complexity. B-to-B needs ≠ B-to-C
- Product availability from multiple sources
- Regulatory landscape, recertification & reformulation

RD&D Needs Related to AMO's Mission

- Bio-based solutions to polymer design and synthesis
- White biotechnology R&D to enable manufacture of products more efficiently than with conventional chemical processes. WB Challenge FOA to make…
- Quantification of sustainability attributes of green chemistry and processes combined with technoeconomic analysis in FOA's
- Integrate 12 principles of green chemistry into future FOA's

Sustainable Chemistry in Consumer Products

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Our Purpose

To protect, heal and nurture in the relentless pursuit of a cleaner, healthier world

Our Fight

Making access to the highest quality hygiene, wellness and nourishment a right, not a privilege

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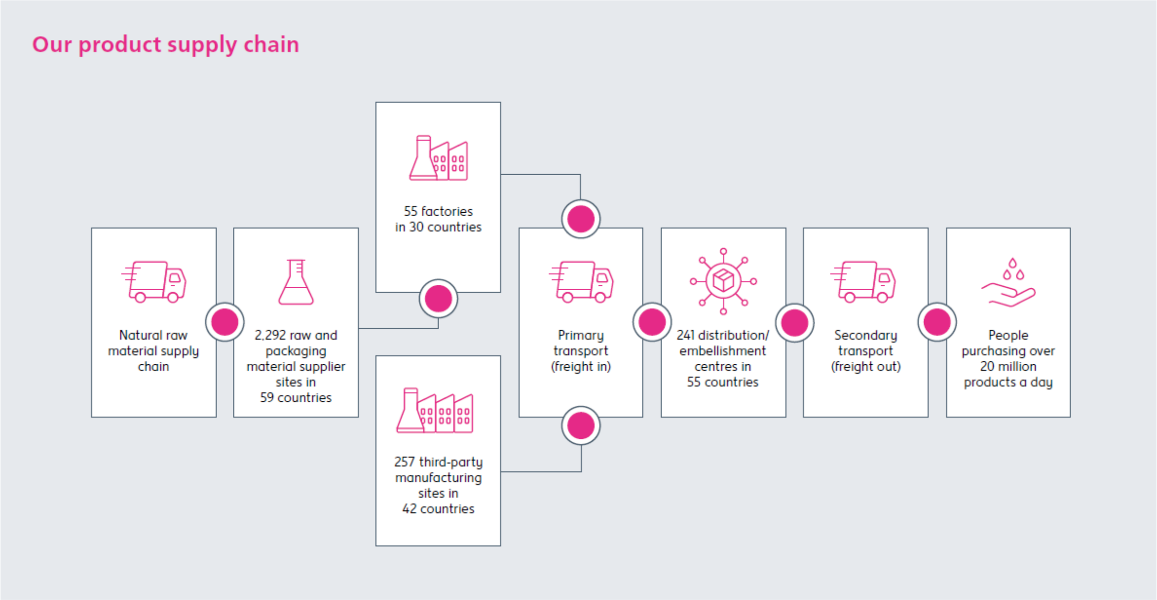
Sustainable Chemistry-Related Opportunities

Current Sustainable Chemistry Practices

1. Value chain approach
2. Carbon footprint reduction
3. Measurement & Reporting



Future Opportunities for Sustainable Chemistry

1. **Manufacturing** – decarbonize & reduce energy/water/waste/emissions/etc to transformative, regenerative solutions
2. **Materials** - apply principles of Green Chemistry and embed design principles in consumer-facing brands

RD&D needed to incorporate sustainable chemistry

Barriers to Sustainable Chemistry

- Complex and technical topics requiring systematic change
- Lack of transparency
- Lack of incentives to change

RD&D Needs Related to AMO's Mission

- Identify & prioritize key initiatives to drive sustainable chemistry agenda over the next 5 – 10 years
  - Renewable feedstocks
  - Catalysis
  - Carbon capture (CO2 to soda ash)
  - Circularity

Sustainability in Healthcare

Presenter Name: Rick Williamson
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Mission: Elimination of toxic chemicals in the healthcare supply chain

Sustainable Chemistry-Related Opportunities

Current Sustainable Chemistry Practices

- Only IV Therapy manufacturer offering a full line of IV Fluid containers not made with PVC, DEHP, BPA & Natural Rubber Latex to help protect susceptible populations:
  - Critically ill neonates
  - Pregnant and lactating women
  - Pediatric patients
  - Adolescent boys
  - Peritoneal dialysis and chemotherapy patients
- Zero landfill use
- Recycle or reuse nearly 100% of all recyclable materials.
- PA facility reuses waste water, saving 4 million gallons of water each year.

Future Opportunities for Sustainable Chemistry

- Aspirational goal: The elimination of toxins in medical supplies to become the industry standard and desired for all IV uses, rather than an exception and specialty product. Start with the elimination of Phthalates in IV solutions.

RD&D needed to incorporate sustainable chemistry

Barriers to Sustainable Chemistry

- The need for a circular approach: From raw material through end-user product and safe waste/recycling alternatives
- Knowledge: Understanding regulations and what is required to eliminate toxins
- Price competition and end customer lack of awareness
- Costs and Resources. Must have dedicated resources to research materials and mold, bond, test alternatives in multiple products.
- A truly economic solution for alternative sterilization
- A truly economic substitute for PVC tubing.
- A ruly economic packaging alternatives.

RD&D Needs Related to AMO's Mission

- Dedicated and trained Chemists focused on highest risk materials for which we should research latest green materials and opportunities.
- Packaging Engineers dedicated to alternative packaging materials and processes.
- Senior Management and Leadership support & awareness and alignment to the long term strategy of the company
- Economical advantage of the healthy products
- System to handle green chemistry data that engineers have access to while developing new products.

Sustainable Chemistry in Manufacturing Processes – An Industry Perspective

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A leader in the world of durable plastics and committed to being fully circular…

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Sustainable Chemistry-Related Opportunities

Current Sustainable Chemistry Practices

- 2025 Sustainability Goals
  - Align research and development with the UN sustainability goal
  - Apply own dedicated sustainability standards to all suppliers
  - Reduce own specific green-house gas emissions by 50%
  - Improve living conditions of 10 million people in underserved markets
  - Use carbon in the most intelligent way

Future Opportunities for Sustainable Chemistry

- **Focus points for commitment to circularity**
  - Alternative sources for raw material
  - Innovative recycling
  - Joint solutions
  - Renewable energy

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Barriers to Sustainable Chemistry

- Cultural barriers
- Market barriers
- Regulatory barriers
- Technology barriers

RD&D Needs Related to AMO's Mission

- Opportunities for new circular materials, processes, and products that are designed to be circular
- Opportunities to make legacy materials, processes, and products more circular
- Opportunities to limit leakage from present and future material cycles

Biomanufacturing: Designing for Performance in a Post-Petroleum World

Dr. Scott Franklin, Co-Founder Chief Science Officer
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- Checkerspot is a 2020 Fast Company Innovation by Design award winning materials innovation company. Named by Chemical & Engineering News as a Top 10 start-up to watch in 2018, their technology is at the nexus of genomics, biology, materials science, and fabrication.
- Checkerspot's direct to consumer brand, WNDR Alpine is bringing to life what is possible when high performance meets sustainability in the unforgiving backcountry. Their recently launched, award winning ski the Vital 100 is pushing the boundaries of the future of design and materials enabled by Biotechnology.
- Checkerspot is also working in partnership with W.L. Gore (makers of Gore-TEX) and Beyond Surface Technologies (makers of miDori® Bio-wick) to develop PFAS free Durable Water Repellent performance materials.

Sustainable Chemistry-Related Opportunities

Checkerspot

Certified B Corporation

Current Sustainable Chemistry Practices

- Biomanufacturing and innovation is expanding the palette of available molecular building blocks to link performance and sustainability more closely than ever before.
- Our vertically integrated approach, allows us to view each process, from production of raw materials through manufacture of finished goods, through a sustainability lens.
- Optimization of chemistries has resulted in elimination of harmful solvents, significant increases in product output and decreases in raw material inputs.

Future Opportunities for Sustainable Chemistry

- New molecules derived from unique oils, are allowing for novel, more sustainable chemistries, much of which will occur in-vivo.
- The future of biomanufacturing is about deep integration. By building a fully integrated Biomanufacturing process that is product and performance focused we have an opportunity to rapidly iterate from the molecular level to the material and product level . We believe that is the white space to be developed together.

RD&D needed to incorporate sustainable chemistry

Checkerspot

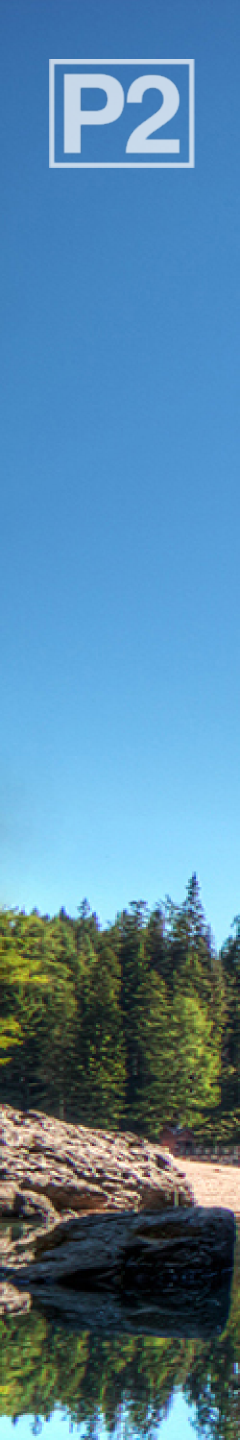
Certified B Corporation

Barriers to Sustainable Chemistry

- The US supply chain from input to conversion to material is fragmented and siloed, while its infrastructure is not optimized to take advantage of new, biotechnology enabled molecules.
- Lack of deep, vertical integration from new materials through to product production, stifles discovery and learnings.
- Lack of applications and product development by petrochemical industry.
- There is a need to re-focus efforts on relevant feedstocks for biomanufacturing in the US and how to dramatically improve their sustainability, looking at the LCA from field to final feedstock.

RD&D Needs Related to AMO's Mission

- The AMO and the National Labs are uniquely positioned to re-imagine what is possible in biomanufacturing from molecule to material to product. The US government has an opportunity to build, invest and lead in the world in this new materials economy.
- Government investment in a fully vertically integrated product focused, biomanufacturing complex that goes from fermentation to DSP, to Chemical conversion to material production and product creation would be a powerful approach to rapid iteration in the development and adoption of sustainable processes and material production.
- Biology is the best chemist. By working with companies who are developing microbes that can do chemistry *in vivo,* there are myriad opportunities to utilize more sustainable chemistries in the creation of better products.



P2 Science is a spin-out from Yale University

- **Upgrading** forestry industry waste-streams to make
  - Fragrance and flavor ingredients.
  - Cosmetics and personal care ingredients
- **Process intensification** – guiding principle of manufacturing
  - Miniaturized process plant and equipment with extremely high throughput
  - Very small amount of chemicals present at any time (1,000 X reduced)
  - Means tiny environmental footprint, highly controllable and safe process
- Enables P2 to make **innovative, renewable** products from US raw materials with negligible environmental impact.
- **P2 is best in the world** at what we do: Low-impact manufacturing of specialty ingredients for consumer products. We have investors from France, Germany, Malaysia and the USA.

Barriers

- **Scientific Talent**
  - Hiring engineers and chemists has been a challenge
  - STEM education to upgrade the US human capital is key
  - Doesn’t matter so much if the talent background is in green / sustainable fields. Need good, logical quantitative thinkers.
- **Precision Engineering**
  - Sourcing highly specialized engineered equipment and parts has been a challenge
- **Navigating government research labs**
  - It seems there are relevant projects underway in government labs, but hard for us to figure out who is doing what and how to collaborate?

SIRONIX RENEWABLES

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Developing better-performing, eco-friendly surfactants for cleaning and personal care products

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Sustainable Chemistry-Related Opportunities

Current Sustainable Chemistry Practices

- Renewable feedstocks – design better performing ingredients
- Energy efficiency - process intensification
- Design for degradation – improved environmental profiles of chemicals

Future Opportunities for Sustainable Chemistry

- Prevention - use of waste feedstocks

RD&D needed to incorporate sustainable chemistry

Barriers to Sustainable Chemistry

- Supply chain transparency and collaboration
- Regulatory challenges – TSCA ‘new chemical bias’
- Mismatch between investor timeline & technology commercialization timeline

RD&D Needs Related to AMO’s Mission

- Project scale-up and deployment
  - Access to cheap capital
  - Pilot manufacturing resources

KALION, INC.

Sustaining Exceptional Performance by Derisking

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Better Performance with Nature

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Sustainable Chemistry-Related Opportunities

Current Sustainable Chemistry Practices

- We review our processes with an eye towards the Life Cycle Assessment (LCA) performance.
- Our fermentation based process for production offers better performance than the traditional chemical production process
- We offer our glucaric acid-based materials to other innovators to strengthen their products to improve their performance and LCA profiles

Future Opportunities for Sustainable Chemistry

- As production facilities use more sustainable energy sources, the better the LCA profile of our material
- As more production facilities institute recycling loops in their production practices the easier it is for innovators to scale their technologies
- Improve dramatically the recycling of natural fibers
- Enhancing the mechanical strength of naturally sourced fibers like manmade cellulosic fibers by 50 – 100% using renewable sources like glucaric acid
- Replacing phosphates in water treatment and other processes with glucaric acid to reduce improve plant performance and reduce eutrophication issues
- Reducing the energy required to produce innovative materials like carbon fiber that lightweights materials
- Producing nylon 6,6 from renewable sources

RD&D needed to incorporate sustainable chemistry

Barriers to Sustainable Chemistry

- Removing technical risks of introducing innovative production technologies
  - Flexible large scale pilot facilities are missing that offer different downstream technologies so that the best approaches can be identified and adopted.
- Removing market risks of introducing innovative sustainable materials
  - Deeper understanding of innovative materials that are more common in sustainable materials (e.g., more oxygenated molecules) that may have enhanced properties rather than drop-in replacements that do not offer new capabilities
  - Missing ability to produce sufficient amounts of innovative materials with novel sustainable production processes so industry can validate

RD&D Needs Related to AMO's Mission

- Pilot-scale facilities that incorporate multiple downstream approaches especially for the development of new materials
- Pilot-scale facilities that full incorporate recycling loops that enhance sustainable chemistry practices such as recycling water but also other materials.
- Pilot scale facilities that can have the solids handling capabilities essential to scaling new materials versus new liquid fuels
- Enhanced partnership opportunities so that innovative material combinations can be tested and validated for the market
- Greater access to aerobic fermentation facilities versus anerobic facilities more common in fuels