EMERGING TECHNOLOGIES: BEYOND MECHANICAL RECYCLING

Prapti Muhuri, Manager, Recycling & Recovery, ACC

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Why do we use plastics?

• Lightweight, versatile, durable
• Prevents food waste, reduces food spoilage
• Low cost
• Wide range of applications
Plastics Packaging Recovery (U.S.)

Low recovery rate driving concerns about plastics packaging and waste

- Recycled: 14.6%
- WTE: 16.8%
- Landfilled: 68.6%
The Plastics Economy Today

3% of Energy

1. Plastic Production
2. Fabrication
3. Use
4. Post-Use Collection

Mechanical Recycling

Energy Recovery

Landfill

Consumer Reuse
Plastics Division Sustainability Goals

✓ 2040 Goal
• 100% of plastics packaging is reused, recycled or recovered

✓ 2030 Interim Goal
• 100% of plastics packaging is recyclable/recoverable

✓ Best Practice Goal
• 100% of Division’s U.S. manufacturing sites participate in Operation Clean Sweep Blue by 2020, with all North American sites by 2022
Seven Initiatives to Achieve Commitments

1) Define, Inventory, and Target
2) Design Packaging to Enable Recovery
3) Create Circular Business Models
4) Invest in Access and Infrastructure
5) Invest in New Disruptive Technology
6) Educate Consumers and Change Behavior
7) Expand Stakeholder Partnerships
Plastics in a Circular Economy

3% of Energy

1. Fabrication
2. Use
3. Post-Use Collection
4. Mechanical Recycling
5. Reclaiming and Reprocessing

- Plastic Production
- Energy/Chemical Companies
- Waxes and Lubricants
- Basic Chemicals
- Other Products
- Transportation Fuels

- Monomers
The Buzz Around Chemical Recycling

GreenBiz
The 5 things you need to know about chemical recycling

CBS THIS MORNING

Solving the recycled plastics puzzle
Rob Kaplan
Thursday, September 21, 2017 - 1:35am

Chemical recycling could be the answer to our single-use plastic problem
What is Chemical Recycling?

*Leveraging chemistry to convert post-use plastics into valuable products which extend the life of the plastic*

Outputs:
- Virgin Like Plastics
- Specialty Chemicals
- Basic building blocks (monomers)
- Chemical feedstocks (naphtha)
- Fuels

These products are then used as alternative to fossil based products.
Complementary to Mechanical Recycling

VISION FOR A CIRCULAR ECONOMY

Specialty Chemicals → Plastic Production → Product Creation → Consumer Use & Reuse → Post-Use Collection

Plastics – #1 to #7

Mechanical Recycling

Chemical Recycling
Types of Chemical Recycling

1) Define, Inventory, and Target
2) Invent New Circular Business Models
3) Increase Access and Infrastructure

Products of Chemical Recycling

1) Define, Inventory, and Target
2) Invent New Circular Business Models
3) Increase Access and Infrastructure

40 Facilities Already in Operation

### Defining Stages of Maturity

#### Concept
- Public announcement made about intended research

##### Karlsruhe Institute of Technology
- AmberCycle (moral fiber)
- Axens
- Biocellection
- Illinois Sustainable Technology Center
- The Pennsylvania State University
- Tyton Biosciences
- University of Portsmouth
- University of Ulster

#### Lab
- Technology is being researched and tested at a lab

##### BASF ChemCycling
- Battery Resources
- Bioparatech
- BioKeyle
- ByFusion
- Cogent Energy Systems
- Connera Technologies
- Cyner Recycling
- Environ
- Ewun
- Evemu
- FWD Energy
- Generated Materials Recovery
- Genomaxica
- Green EnviroTech Holdings
- IBM VolCat
- Jet Plastics
- Kyoto Institute of Technology
- MBA Polymers
- Modular Genetics, Inc
- Omifusion
- Opus12
- Origin Materials
- PESB
- Quality Circular Polymers
- ReNewCell
- Recenso GmbH
- Rensselaer Polytechnic Institute
- RESYNTEX
- saperatec
- Sep-Al
- Sustane Technologies, Inc
- Teijin
- The Inhibited Fiber Company
- Total Corbion
- Valron
- VinyLoop

#### Pilot
- A small pilot demonstrates the technology

##### Agile Process Chemicals LLP
- Anhui Ourson Environmental Technologies
- Aquafli
- Biest
- Klean Industries
- perPETual
- Plastic Energy
- SABIC Innovative Plastics

#### Early Commercial
- Technology is upscaled to an industrial scale

##### CarBioS
- CarBioS
- Climax Global Energy
- GoBio
- Goep
- Gr3n
- Jeplan
- Next Generation
- Polycycl
- Polystyveet
- Reclaimed EcoEnergy
- Resinate Materials Group
- Resynergi
- Worn Again Technologies

#### Growth
- Technology is being implemented in various parts of the world

##### Galactic
- Geo-Tech Polymers
- Golden Renewable Energy GreenMantra Technologies
- Ionics
- JBI Plastic2Oil
- Jeplan
- Loop Industries
- Natureworks
- New Hope Energy
- Nexus Fuels
- PureCycle Technologies
- Pyrowave
- Recycling Technologies
- ReNew ELP
- Renewlogy
- Sierra Energy
- Vortex

#### Undefined

More Engagement Needed

250 partners and investors are already engaged with technology providers

Brands
Private Capital Providers
Petro-chemical & Plastics Industry
Gov’t & NGOs
The Environmental Benefits Are Significant

By converting post-use plastics into ultra-low-sulfur diesel, we reduce:\(^2,^3\)

- **WATER CONSUMPTION**
  - -58%

- **TRADITIONAL ENERGY USE**
  - -96%


\(^3\) When compared to traditional manufacturing processes.
How chemical recycling prevents dioxin formation

- Material is heated in a closed, oxygen-deprived environment
  - i.e. Not combustion

- No atmospheric oxygen or halogens

- Products spend virtually no time at the dioxin formation temperature
Economic Benefits

- $120B addressable market in North America
  - Technology owners can profitably transform post-use plastics

- Moderately developed markets in the U.S.
  - Alabama, Florida, Georgia, Louisiana, Texas
  - => high-potential market for pyrolysis
Recent Announcements (N.A.)

Agilyx, Delta Refinery Subsidiary Sign Deal to Convert Waste Plastics into Jet Fuel

Brightmark Energy Closes $260M in Financing for Plastics-to-fuel Plant

Regenyx Process Recycles 'Throw Away' Polystyrene

BP deal will help RES Polyflow open first commercial plastics-to-fuel plant

Renewlogy Converting Landfill-Bound Plastics to Fuel

ReVital Polymers, Pyrowave and INEOS Styrolution partner to launch polystyrene recycling consortium

GreenMantra and INEOS collaborate on chemical recycling

Eastman announces second chemical recycling technology
Recent Announcements (Global)

1. SABIC And Customers Launch Certified Circular Polymers From Mixed Plastic Waste
2. Polystyvert, Total partner to recycle post-consumer polystyrene
3. Shell to Invest in Rotterdam Green Methanol Plant
4. BASF hits milestone with 'chemically-recycled' prototypes

Plastics company LyondellBasell has announced plans to drive chemical recycling of plastic materials forward.

Unilever Joins Partnership to Turn PET Waste into Virgin Grade Materia

Tupperware to debut products made from Sabic's certified circular polymers

Dow, Fuenix Ecogy Group partner on plastics recycling project
Advocating on behalf of technologies that leverage chemistry to convert post-use plastics into new plastics, chemicals, fuels and other products.
Removing Barriers to Chemical Recycling

- Legislation enacted (8)
- Legislative activity (4)
- Regulation in progress (2)
Texas part of national push for laws promoting fledgling chemical recycling industry

ACC pushes chemical recycling legislation

State lawmakers give chemical recycling a boost
1) Define, Inventory, and Target
2) Invent New Circular Business Models
3) Increase Access and Infrastructure

Stay Connected

@ChemRecycling
Chemical Recycling Alliance
Prapti Muhuri
Manager, Recycling and Recovery
ACC Plastics Division
prapti_muhuri@americanchemistry.com
(202) 249-6703