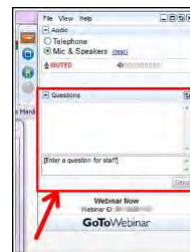




Have Questions?



Type them into questions box!

“Why am I muted?”

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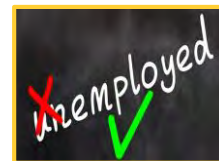
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7

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ACS Department of Diversity Programs

Advancing ACS's Core Value of Diversity, Inclusion & Respect



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Strategic Goals

- Grow a robust, diverse, and engaged global organization that encompasses the broader polymer enterprise.
- Provide a portfolio of resources to educate and empower our members to thrive in the polymer enterprise.
- Effectively communicate the importance and activities of the polymer community to our members, polymer practitioners, and the public at large.

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Consider spotlighting your event with other notables in the field on POLY's community event calendar!

Email: carfech@vt.edu with details of your contribution to the POLY Calendar.

Visit the calendar to view upcoming POLY events, POLY Community Calendar: <http://bit.ly/polycalendar>

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- How to Design Better Biomedicine: Polymeric Materials and Nanomaterials
- Semi-Conducting Polymers: The New Horizons and Unmet Future Challenges
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- Opportunities in Photochemistry: Photocatalysis of Polymer Synthesis and Properties

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October 17 - 20, 2021

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Organizers: Hillmyer, Epps, and Robertson

CONTROLLED RADICAL POLYMERIZATION

November 14 - 17, 2021

Hotel Emeline (Formerly the Downtown Doubletree)

Charleston, SC USA

Organizers: Matyjaszewski, Tsarevsky, Gao, and Sumertin

SILICON-CONTAINING POLYMERS AND COMPOSITES

December 1 - 4, 2021

Omni San Diego

San Diego, CA USA

Organizers: J. Furgal, C. Hartmann-Thompson, H. Gao, and B. Sumertin

Workshop Chair: Marc Hillmyer (hillmyer@umkc.edu) or contact: Lena.Proke@uowar.edu.au

www.polyacs.org



Succeeding in a Global Environment

Successfully Working Across Cultures



Date: Wednesday, July 7, 2021 @ 2-3pm ET
 Speaker: Ramki Subramanian, DowAksa USA
 Moderator: Tom Halleran, American Chemical Society

[Register for Free!](#)

What You Will Learn:

- Why there are many aspects to culture and what are some of the many similarities & differences across those aspects
- Why your ability to work effectively across cultures is an important contributor to success
- How your overall career is a marathon, but the environment can change rapidly, requiring you to constantly observe and adapt to the culture around you

Co-produced with: ACS Careers

Working Together to Design Safer Laboratories



Date: Thursday, July 8, 2021 @ 2-3pm ET
 Speakers: Michael R. Labosky, Massachusetts Institute of Technology / Ellen Sweet, Cornell University / Melinda Box, North Carolina State University
 Moderator: Ralph Stuart, Keene State College

[Register for Free!](#)

What You Will Learn:

- How to use the lab ventilation system to work more safely
- Who is involved in designing safe laboratory spaces and the practical considerations involved in this work
- How lab buildings were built in the past and why it is important for researchers to be engaged in the design process

Co-produced with: ACS Division of Chemical Health and Safety and the ACS Committee on Chemical Safety

Making the Most Out of Your Ph.D. Journey

Research, Skills, and The Great Beyond



Date: Wednesday, July 14, 2021 @ 6-7pm IST (8:30am ET)
 Speaker: Sarbajit Banerjee, Texas A&M University and ACS Omega
 Moderator: Deeksha Gupta, American Chemical Society

[Register for Free!](#)

What You Will Learn:

- How to identify fit with a specific graduate program and research group
- How to use your time graduate school to consider different career opportunities and align your journey to your intended career aspirations
- What resources exist to help with your PhD journey

Co-produced with: ACS International catering to an audience based in India

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Designing Bio-Sourced Polymers

that Enable Recycling



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Designing Bio-Sourced Polymers that Enable Recycling

**STEFAN MECKING**Chair of Chemical Materials Science, Department
of Chemistry, University of Konstanz**MARK JONES**Executive External Strategy and Communications
Fellow, Dow Chemical (retired)

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Designing Bio-Sourced Polymers that Enable Recycling

Prof. Dr. Stefan Mecking
Chair of Chemical Materials Science
Department of Chemistry

stefan.mecking@uni-konstanz.de
<https://cms.uni-konstanz.de/mecking/>

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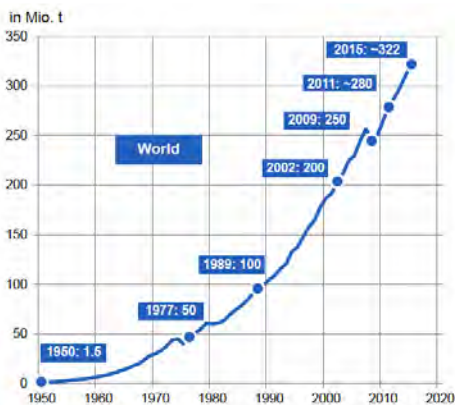


Recyclability played no role in the design of today's plastics and products (though some of them can be recycled well)

17

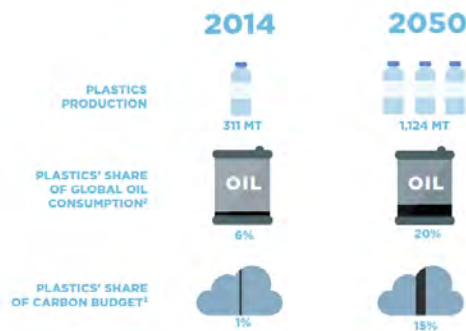
Why it matters

The success of plastics up to today.....



Source: Stahl-Zentrum/International Iron and Steel Institute (ISI), PlasticsEurope Market Research Group (PEMRG) / Consultic Marketing & Industrieberatung GmbH

.....future predictions



Adapted from: World Economic Forum, 'The New Plastics Economy: Rethinking the Future of Plastics', 2016.

² Total oil consumption expected to grow slower (0.5% p.a.) than plastics production (3.8% until 2030 then 3.5% to 2050)
³ Carbon from plastics includes energy used in production and carbon released through incineration and/or energy recovery after-use. The latter is based on 14% incinerated and/or energy recovery in 2014 and 20% in 2050. Carbon budget based on 2 degrees scenario

Original Sources: Plastics Europe; ICIS Supply and Demand; IEA World Energy Outlook (2015) global GDP projection 2013–2040, assumed to continue to 2050; Ocean Conservancy and McKinsey Center for Business and Environment, Stemming the Tide: Land-based strategies for a plastic-free ocean (2015); IEA World Energy Outlook 2015 central 'New Policies' scenario oil demand projection 2014–2040, assumed to continue to 2050; J. Hopewell et al., 'Plastics recycling: Challenges and opportunities', Philosophical Transactions of the Royal Society B, 2009; IEA CO2 emissions from fuel combustion (2014); IEA World Energy Outlook Special Report: Energy and Climate Change (2015); Carbon Tracker Initiative, Unburnable Carbon (2013)

18

The role of polymers is further increasing



Polymers are essential to all modern technologies, and often the most benign technical solution

- energy generation and storage
- mobility
- communication
- health
- food and water supply
-



From Science to enable sustainable plastics. White paper from the 8th Chemical Sciences and Society Summit (CSS), London, 2020

19

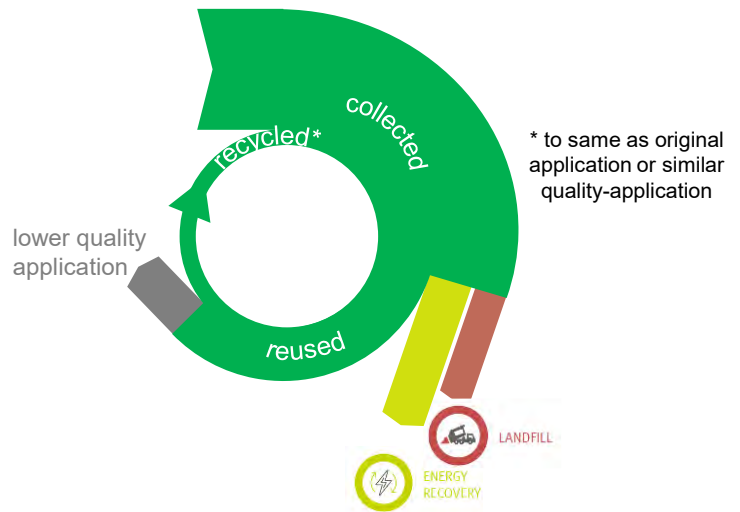
Recycling



Symbols



Current status (in Western Europe)



Wikimedia Commons

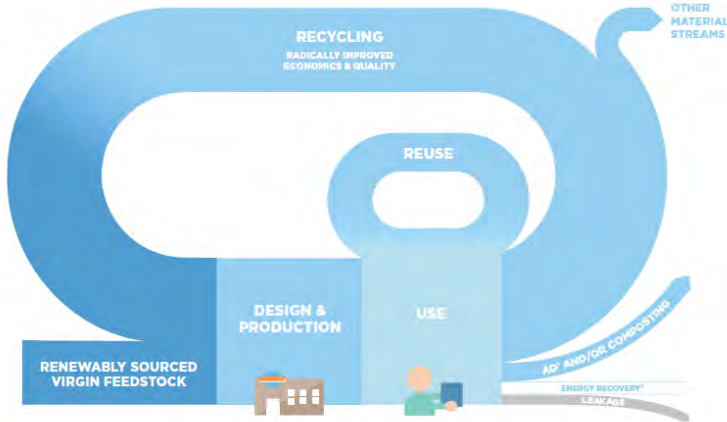
Adapted from 'Plastics – The facts 2020', Plastics Europe

20

Closed-loop recycling

Ambitions of the New Plastics Economy According to the World Economic Forum

1 CREATE AN EFFECTIVE AFTER-USE PLASTICS ECONOMY



Closed-loop recycling: Recycling of plastics into the same or similar-quality applications

1 Closed-loop recycling: Recycling of plastics into the same or similar-quality application

2 Cascaded recycling: Recycling of plastics into other, lower-value applications

Source: Project Mainstream analysis – for details please refer to the extended version of the report available on the website of the Ellen MacArthur Foundation: www.ellenmacarthurfoundation.org

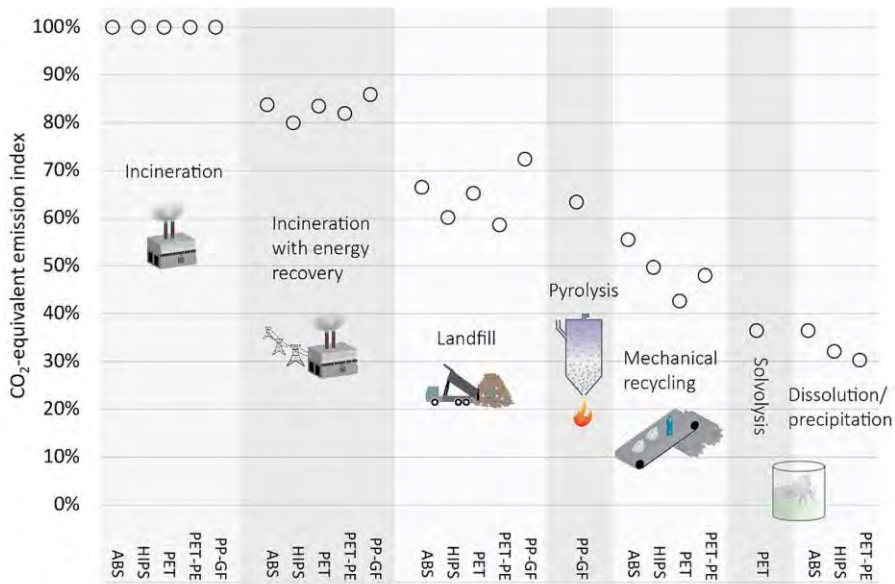
3 DECOUPLE PLASTICS FROM FOSSIL FEEDSTOCKS

2 DRASTICALLY REDUCE THE LEAKAGE OF PLASTICS INTO NATURAL SYSTEMS & OTHER NEGATIVE EXTERNALITIES

From: World Economic Forum, 'The New Plastics Economy: Rethinking the Future of Plastics', 2016.

21

Impact of different fates of plastics after use

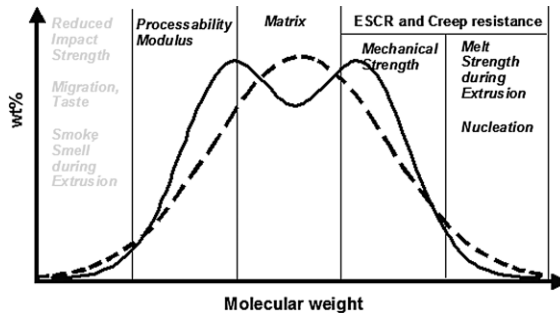


22

B. Weckhuysen et al. *Angew. Chem. Int. Ed.* **2020**, *59*, 15402 – 15423.

Plastics exist in an enormous variety of grades

Example of how molecular characteristics impact processing and applications properties



From M. Gahleitner in „Tailor Made Polymers“, Wiley-VCH, Eds. J. R. Severn & J. C. Chadwick, 2008.



actually summarizes
a range of different grades

In addition to variety of the matrix:

- Additives like stabilizers, nucleating agents....
- Fillers / fibres in composites
- Other polymers in multilayer films
-

23

Audience Survey Question

ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT



Which of these three polymers has the lowest ceiling temperature?

- Poly(methylmethacrylate) (PMMA)
- Polyethylene
- Poly(tetrafluoroethylene) (PTFE, Teflon™)
- All three have the same ceiling temperature

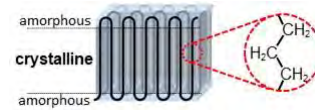


24

Polyethylene

- largest synthetic plastic (100 mio t/a)
- a myriad of applications
 - ← excellent mechanical properties from crystallinity
 - ← good processability
- many different types and grades (HDPE, LLDPE, LDPE, UHMWPE, waxes, oligomers...)

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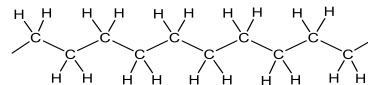
27

Polyethylene – Interesting Challenges

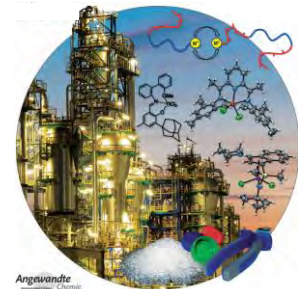
- **Feedstock: crude oil**
 - finite resource
 - recovery and supply bear risks



- **Persistent nature**
 - hydrocarbon chains, no break points
 - very apolar and hydrophobic



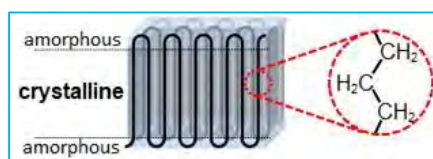
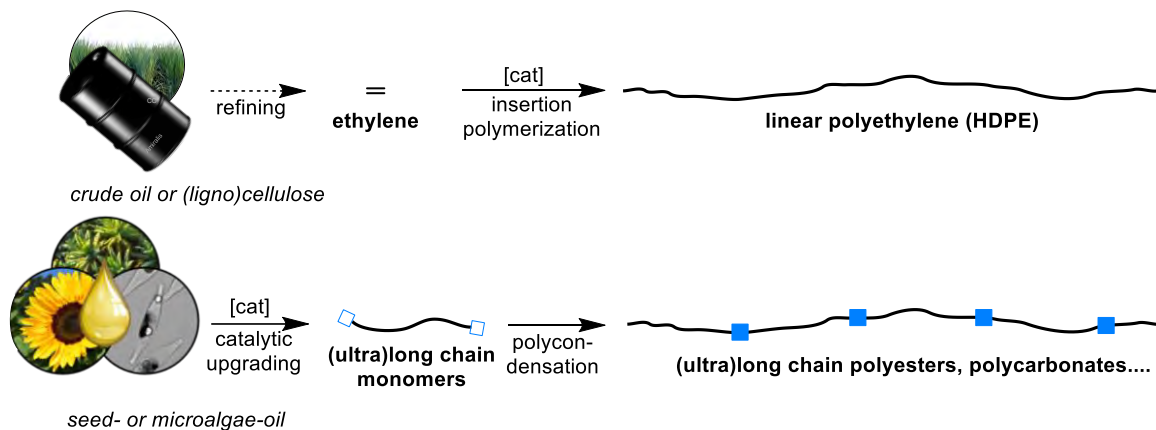
- **Recycling**
 - many different performance grades
 - breakdown to monomer efficiency $\leq 10\%$, $800\text{ }^\circ\text{C}$



- **Technological background**
 - traditional polymerization catalysts very sensitive
 - do not allow for introduction of polar groups

28

Concept for polyethylenes with in-chain breakpoints



29

Phil. Trans. Royal Soc. A 2020, 378, 20190266.

Equilibrium reaction vs. kinetic selectivity



ACS Catalysis

Review

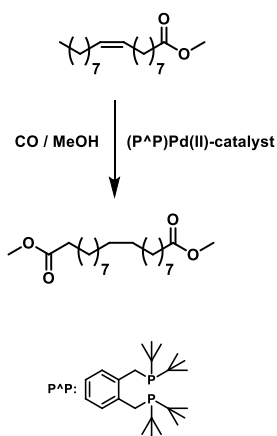
pubs.acs.org/acscatalysis



30

V. Goldbach et al. *ACS Catal.* **2015**, 5, 5951-5972

Isomerizing alkoxy carbonylation of plant oil

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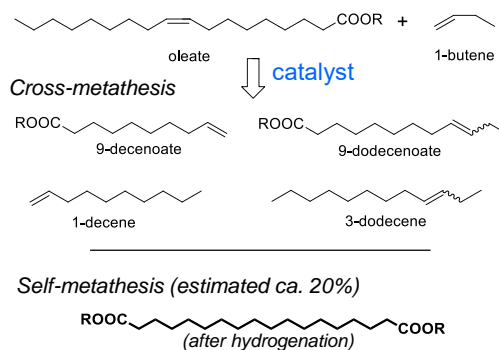
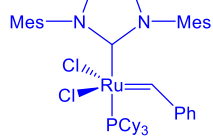
conversion 90 %
 selectivity 90 %
 yield: 115 g
 > 99 % purity

HO-sunflower oil
(methyl ester)

31

 P. Roesle et al., *J. Am. Chem. Soc.* **2014**, *136*, 16871-81.

Large scale production of long-chain monomer as a sideproduct

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 Biorefinery
 Gresik, Indonesia
 Capacity: 180.000 t/a

32

 S. Chikkali & S. Mecking, *Angew. Chem. Int. Ed.* **2012**, *51*, 5802 - 5808.

Sources of long-chain dicarboxylic monomers

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- **Olefin metathesis**

Commercial large scale plant for biorefining of palm operated since 2013

- **Isomerizing Carbonylation**

Lab-scale, very clean product from various seed and microalgae oils
Carbonylation of ethylene with same catalyst large scale since 2008

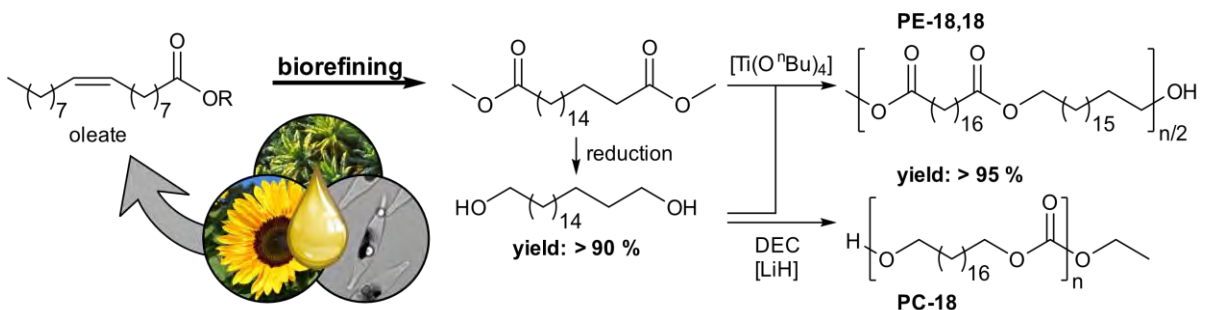
- **Biotechnological ω -Oxidation**

Operated commercially for C₁₄ by Cathay, Shanghai
Pilot plant for C₁₈ operated in US since 1990s by Henkel (now Emery Oleochemical)

33

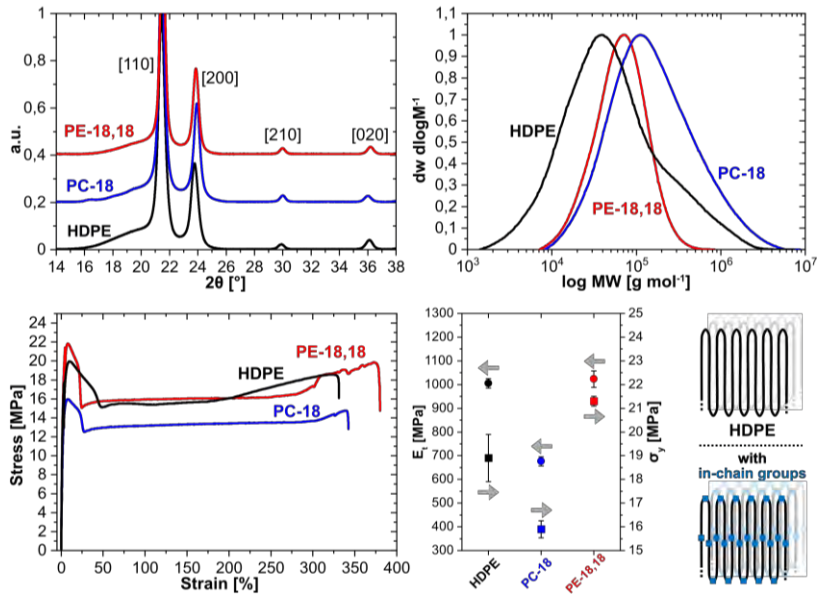
Polyethylene-like Polymers

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34

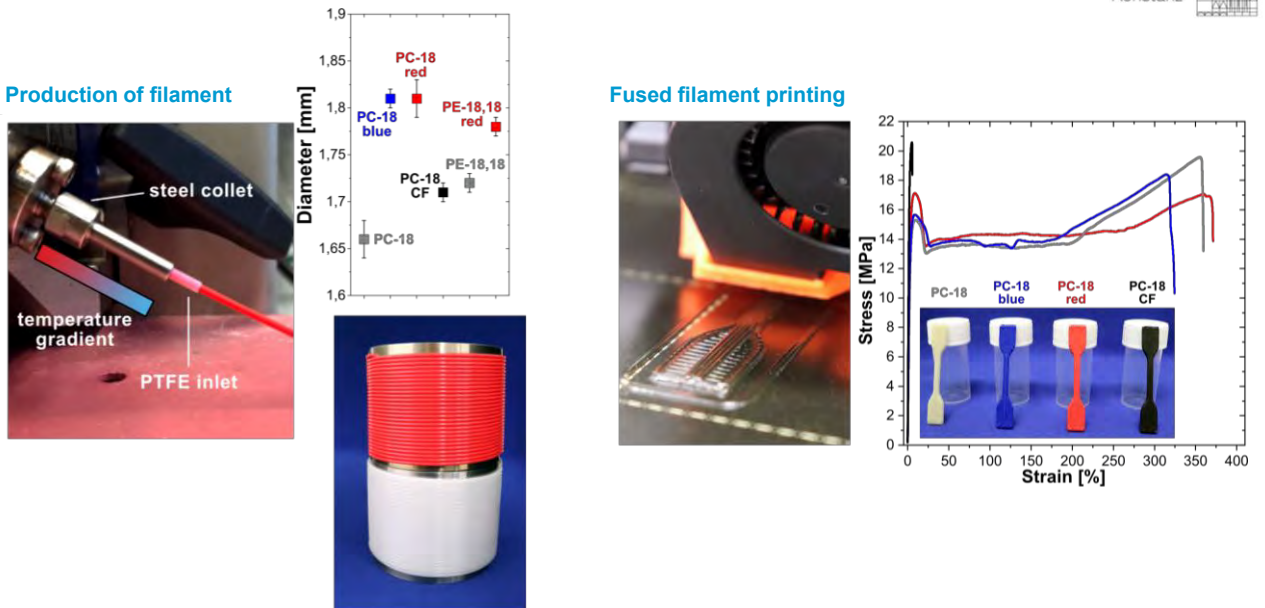
Polyethylene-like Polymers



35

M. Häußler, M. Eck et al. *Nature* 2021, 590, 423 – 427.

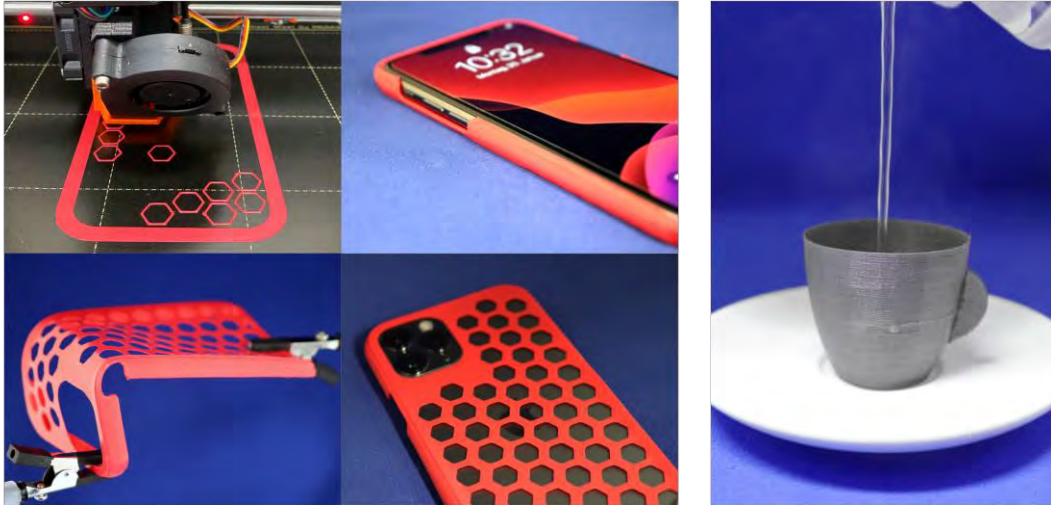
Additive Manufacturing with Polyethylene-like Polymers



36

M. Häußler, M. Eck et al. *Nature* 2021, 590, 423 – 427.

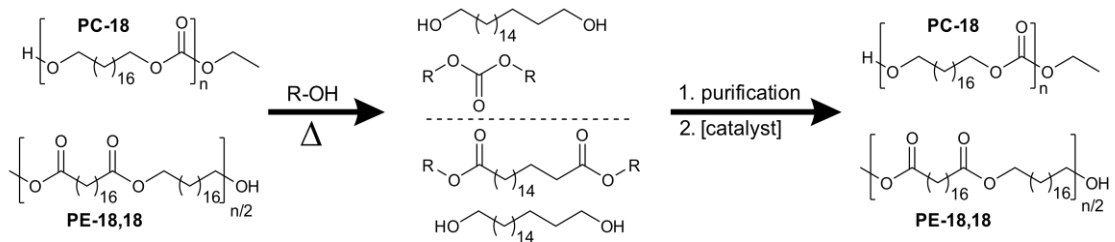
Additive Manufacturing with Polyethylene-like Polymers



37

M. Häußler, M. Eck et al. *Nature* 2021, 590, 423 – 427.

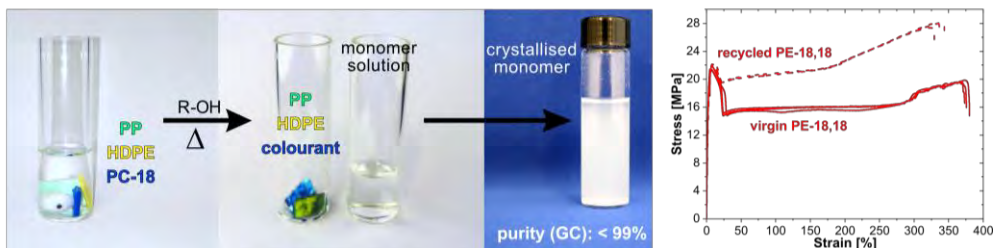
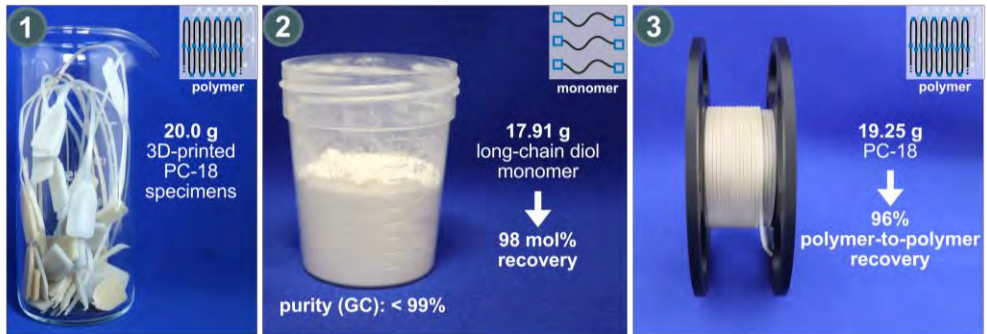
Closed-Loop Recycling of Polyethylene-like Polymers



38

M. Häußler, M. Eck et al. *Nature* 2021, 590, 423 – 427.

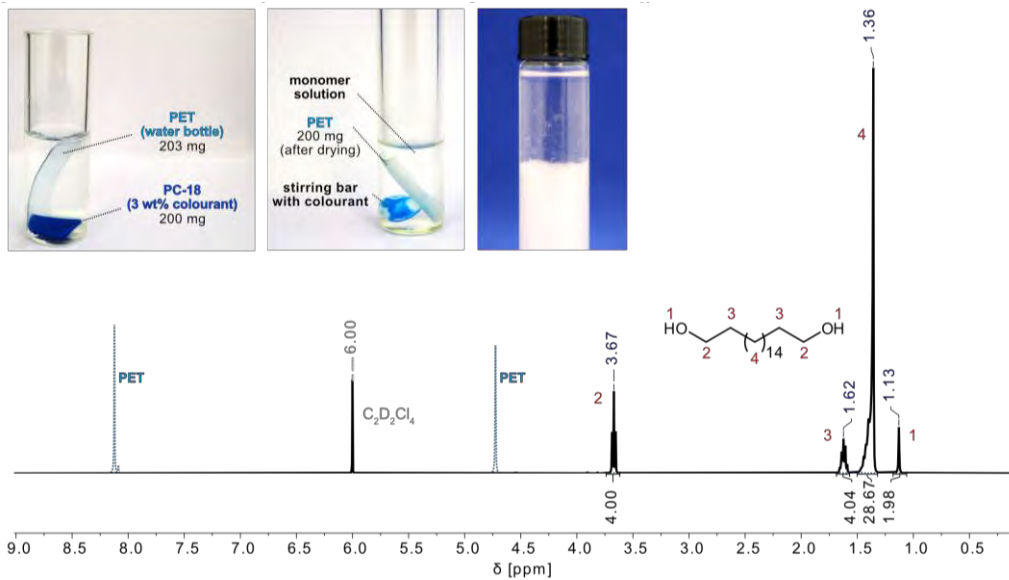
Closed-Loop Recycling of Polyethylene-like Polymers

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39

 M. Häußler, M. Eck et al. *Nature* 2021, 590, 423 – 427.

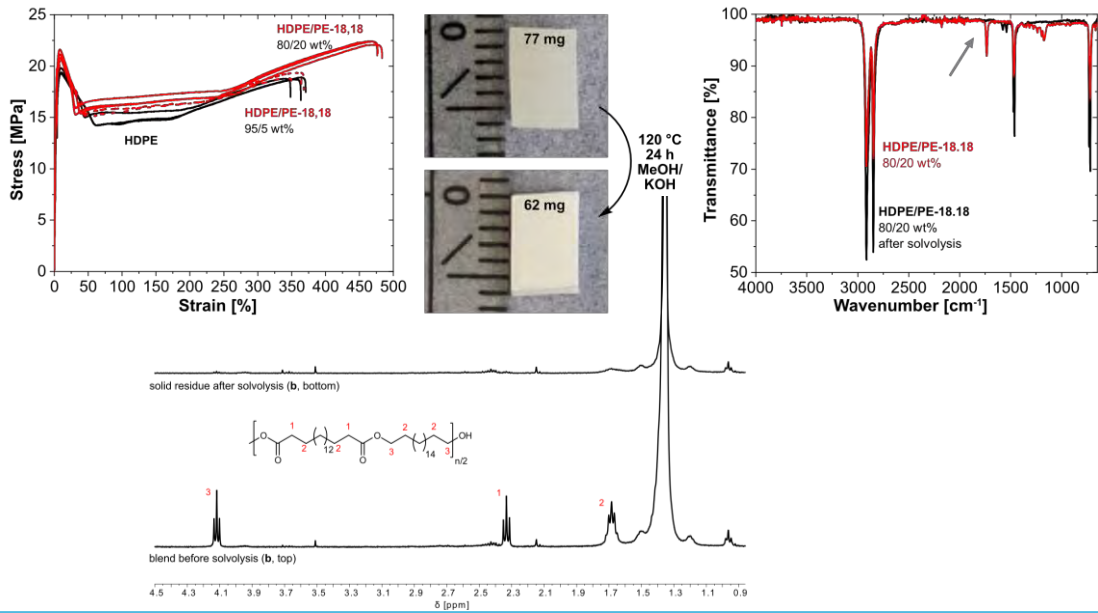
Recycling in the presence of PET

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 M. Häußler, M. Eck et al. *Nature* 2021, 590, 423 – 427.

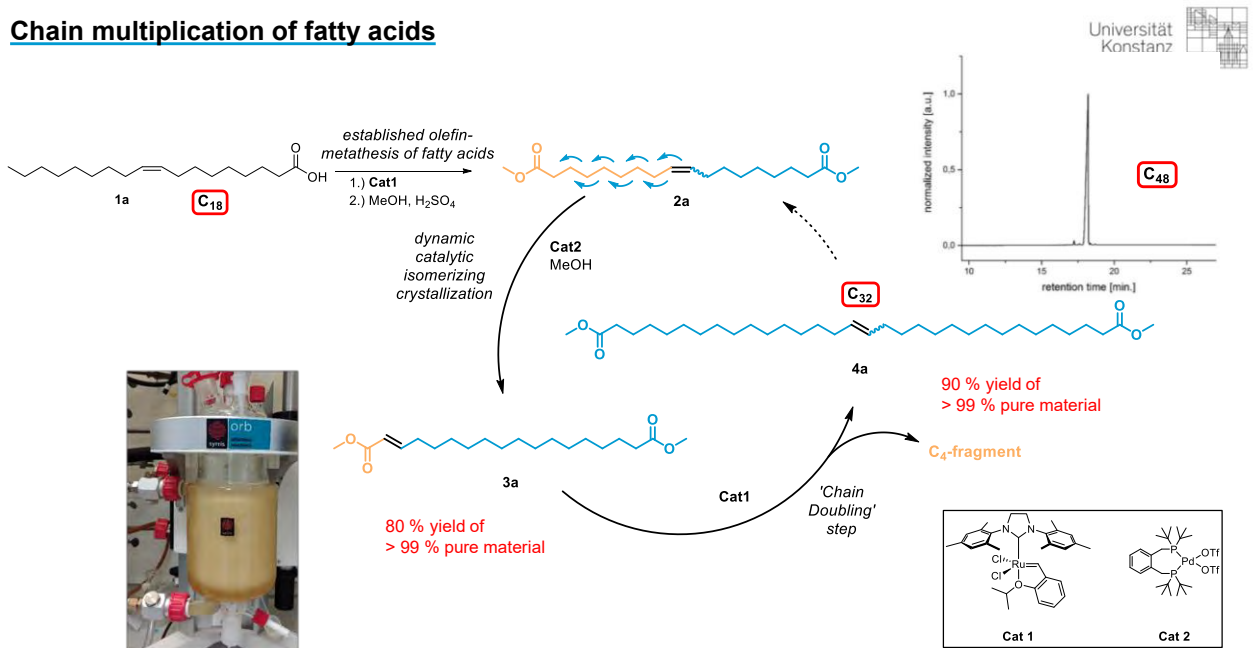
Blends with HDPE and recycling



41

M. Häußler, M. Eck et al. *Nature* 2021, 590, 423 – 427.

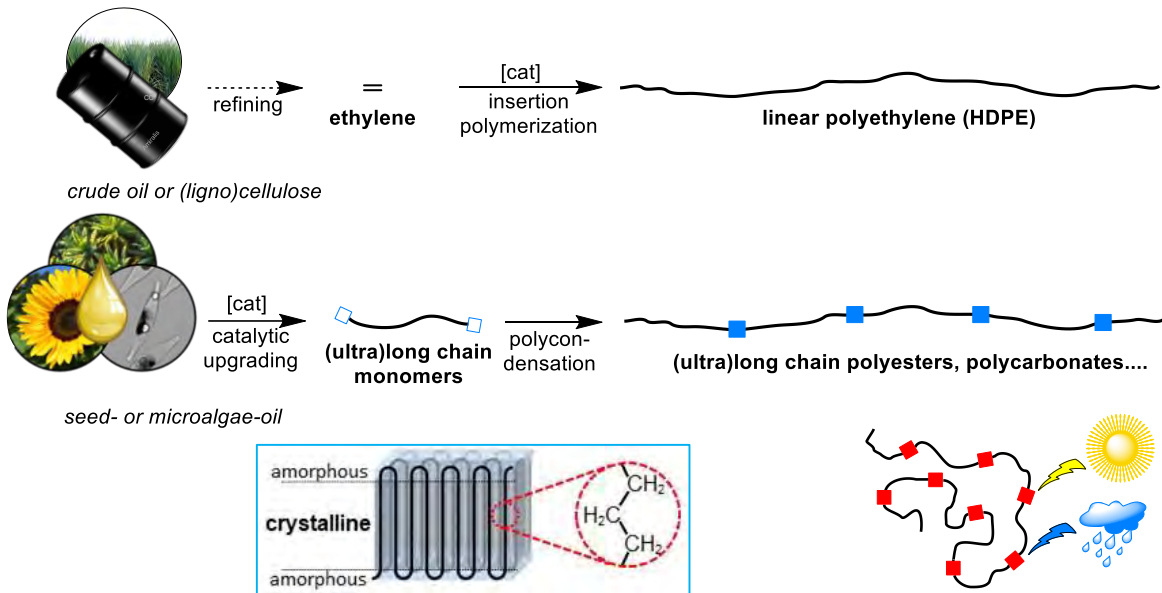
Chain multiplication of fatty acids



42

T. Witt, M. Häußler et al. *Angew. Chem. Int. Ed.* 2017, 56, 7589 – 7594

Concept for polyethylenes with in-chain breakpoints



43

Summary

- scalable catalytic approaches
- feedstocks available
- high molecular weight, processable & mechanically durable materials
- fully recyclable through monomer
- breakpoints for hydrolytic degradation

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Plastics are so valuable they need to be made much better use of than is currently the case.

Closed-loop chemical recycling is one possible way.

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Thank you

PhD students and postdocs

Alumni

Dorothee Quinzler
Samir Chikkali
Florian Stempfle
Patrick Ortmann
Philipp Roesle
Verena Goldbach
Hanna Busch
Etienne Grau
Timo Witt
Dennis Pingen
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Designing Bio-Sourced Polymers

that Enable Recycling



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ASK YOUR QUESTIONS AND MAKE YOUR COMMENTS IN THE QUESTIONS PANEL NOW! 47



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Designing Bio-Sourced Polymers that Enable Recycling



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Chair of Chemical Materials Science, Department
of Chemistry, University of Konstanz



MARK JONES

Executive External Strategy and Communications
Fellow, Dow Chemical (retired)

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ACS Technical Division

Polymer Chemistry (POLY)

POLY DIVISION

Strategic Goals

Grow a robust, diverse, and engaged global organization that encompasses the broader polymer enterprise.

Provide a portfolio of resources to educate and empower our members to thrive in the polymer enterprise.

Effectively communicate the importance and activities of the polymer community to our members, polymer practitioners and the public at large.

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San Diego, CA USA

Organizers: J. Furgal, C. Hartmann-Thompson, H. Gao, and B. Sumerlin

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Succeeding in a Global Environment

Successfully Working Across Cultures



Date: Wednesday, July 7, 2021 @ 2-3pm ET
 Speaker: Ramki Subramanian, DowAksa USA
 Moderator: Tom Halleran, American Chemical Society

[Register for Free!](#)

What You Will Learn:

- Why there are many aspects to culture and what are some of the many similarities & differences across those aspects
- Why your ability to work effectively across cultures is an important contributor to success
- How your overall career is a marathon, but the environment can change rapidly, requiring you to constantly observe and adapt to the culture around you

Co-produced with: ACS Careers

Working Together to Design Safer Laboratories



Date: Thursday, July 8, 2021 @ 2-3pm ET
 Speakers: Michael R. Labosky, Massachusetts Institute of Technology / Ellen Sweet, Cornell University / Melinda Box, North Carolina State University
 Moderator: Ralph Stuart, Keene State College

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What You Will Learn:

- How to use the lab ventilation system to work more safely
- Who is involved in designing safe laboratory spaces and the practical considerations involved in this work
- How lab buildings were built in the past and why it is important for researchers to be engaged in the design process

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Making the Most Out of Your Ph.D. Journey

Research, Skills, and The Great Beyond



Date: Wednesday, July 14, 2021 @ 6-7pm IST (8:30am ET)
 Speaker: Sarbajit Banerjee, Texas A&M University and ACS Omega
 Moderator: Deeksha Gupta, American Chemical Society

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What You Will Learn:

- How to identify fit with a specific graduate program and research group
- How to use your time graduate school to consider different career opportunities and align your journey to your intended career aspirations
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