CHE Collaborative for Health & Environment

Webinar Highlights

Chemical Recycling of Plastics Part 2: Technical limits

Chemical recycling of plastics is an umbrella term for processes that use heat, pressure, chemicals, and/or other agents (e.g., enzymes) to create chemical products from plastics. There has been increasing interest in the potential of chemical recycling technologies to break down plastics into chemical products that can be used to make fuels, other chemicals, or new plastics. Proposals for, and construction of, chemical recycling facilities have increased globally, entailing significant public and private investments and potential impacts that range from the planetary to the local community scale.

In the second part of this webinar, **Dr. Nihan Karali** discussed the material recovery/loss, contamination, technological limits, and energy demand from common chemical recycling technologies for plastics.

Featured Speakers: Nihan Karali, PhD, who works at the intersection of energy, material, and environmental impacts of industrial production systems and Veena Singla, PhD, an affiliate at the University of California, San Francisco Program on Reproductive Health, speaking March 5, 2026.

This fact sheet has been created by CHE based on information presented in a webinar done in partnership with the Physicians and Scientists Network Addressing Plastics and Health (P-SNAP). Selected quotes in bold are from the webinar speaker(s). For the full set of resources provided by the webinar presenters, see the webinar page, where you'll also find associated Slides & Resources.

The Problem

Global plastic production in 2019 was about 460 million metric tons. From the 2019 value, this number is projected to continue growing from 2.5%–4% a year, which means plastic production could double or triple by 2050.

In 2019, about 6.3% of plastics were recycled, all through mechanical recycling. Mechanical recycling has many limitations which prevent recycling rates from being able to keep up with production. These limitations include:

- High contamination sensitivity – recycled materials must be clean, sorted, single-polymer streams
- Material quality loss – processing degrades molecular weight; after ~1 cycle, quality of material fails
- Downcycling, not circularity – recycled plastic materials cannot substitute for high value applications

Chemical recycling is being marketed as a solution to these limitations. However, as Dr. Karali explained, chemical recycling does not effectively avoid these issues.

Chemical recycling uses chemical processes to break down plastics into constituent parts. These parts can be used to manufacture new plastics or to serve as alternate chemicals or fuels. Chemical recycling can be broken up into three general categories – thermochemical recycling (pyrolysis and gasification), solvent-based dissolution (also called solvent-based purification), and depolymerization (also called solvolysis or re-monomerization). Karali noted that the terminology used around chemical recycling can be inconsistent.

Most chemical recycling processes are designed for specific polymers due to differences in polymer chemistry and process requirements. This means that the plastic inputs must be sorted much as they are for mechanical recycling.

Plastic products are also inherently contaminated with other materials that limit chemical recycling. Food residues, detergents, labels, adhesives, and dyes are common accompanying contaminants. Additionally, over 16,000 chemical additives have been identified in plastic products, incorporated during manufacturing to impart specific functional properties. These unwanted materials reduce the efficiency of chemical recycling, and can create safety hazards — for example, residual oxygen in pyrolysis feedstock can create fire risks. Beyond process efficiency, contaminants in the original material can also carry through into the recycled product, raising safety concerns.

Another problem is material degradation. Each recycling pass causes chain scission, thermal oxidation, molecular weight reduction, and discoloration. These cumulative changes progressively degrade polymer performance. As a result, most chemically recycled materials need to be blended with virgin materials or further purified before they can go into new products.

Material losses also accumulate at every stage of recycling. In pretreatment, 5%–30% of the plastic material from the start is lost. In the recycling process, another 15%–60% is lost. These losses represent plastic material that went into the recycling process but did not make it into the final recycled material.

Chemical recycling pathways are also inherently energy intensive. Each process has its own unique energy demands, such as the energy required to produce solvents for solvent-based dissolution or the heat required to drive pyrolysis. The energy demands for each process are intrinsic to that process. These processes can also create hazardous waste. Disposing of this waste, either through incineration or in a landfill, produces its own energy and/or greenhouse gas footprint. Karali questioned whether the intrinsic energy demands of each process — combined with the virgin material inputs required to compensate for material losses, contamination, and insufficient recovery rates — would ever allow chemical recycling to achieve meaningful greenhouse gas reductions.

Taken together, these limitations mean that chemical recycling is not a viable path to circularity. The energy and chemical demands, high contamination sensitivity, material degradation, and material losses all prevent chemical recycling from delivering true technological, environmental, economic, or societal benefits. Dr. Karali stressed that incremental optimization could not overcome these inherent limitations.

Recommendations

Dr. Karali argued that plastic products as they are currently designed are not meant to be recycled. Therefore, in order for recycling to become a viable solution, the products must be redesigned from the start. This would require finding ways to produce plastic products without the harmful chemicals that are currently used. Only then would recycling become a pathway to eliminating waste and meaningfully reducing the use of virgin materials.

“Plastic products are never designed to be recycled...If you look at this problem from the beginning, we need to have a different type of plastic product that can be safely recycled.”

To Find Out More

- Watch the March 5, 2026 webinar: [Chemical Recycling of Plastics: Health concerns & technological limits]()
- Read Karali’s presentation slides: [The Technical Limits of Chemical Recycling]()

- Read Singla's presentation slides: [Chemical recycling of plastic and health concerns]
- Watch Singla's Science Explainer: [Understanding "Chemical Recycling" in 9 minutes]
- Read our 2-part blog series about "advanced recycling":
  - ["Advanced Recycling" of Plastics: Largely waste disposal by another name (Part 1)]
  - ["Advanced Recycling" of Plastics: Largely waste disposal by another name (Part 2)]

About the Speakers

Nihan Karali, PhD works at the intersection of energy, material, and environmental impacts of industrial production systems. She focuses on identifying sustainable, non-polluting, and safe pathways for industrial production and consumption, including plastics production and recycling. Her recent research demonstrating that 75% of plastic production-related greenhouse gas emissions occur upstream of polymerization has been cited in over 100 international media outlets. The report has also been extensively cited in global plastic treaty related discussions and talks to fundamentally support expanding the treaty scope to encompass the full lifecycle. Her broader expertise includes energy consumption and environmental impact across sectors including heavy industry, chemicals, transport, and appliances. She holds a Ph.D. in Industrial Engineering.

Veena Singla, PhD is an affiliate at the University of California, San Francisco Program on Reproductive Health and the Environment and a Senior Fellow with Halt the Harm Network. She consults for non-profits and academia on environmental health science and policy. Her research investigates how toxic chemicals and pollution related to systems of materials use, production, and disposal, including plastics, threaten the health of impacted communities, especially those experiencing environmental injustices. Her work seeks to address health disparities linked to harmful environmental exposures using an interdisciplinary approach incorporating environmental health, exposure science, public health, and policy expertise. She focuses on advancing comprehensive solutions in collaboration with communities that center public health, racial and health equity. She received a B.S. from the University of California, Berkeley in chemistry and a Ph.D. in cell biology from the University of California, San Francisco.