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Circular Carbon via Gasification of Complex Waste Streams

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The transition toward a circular and climate-neutral chemical industry requires technologies capable of converting complex waste streams into valuable secondary raw materials. Gasification has emerged as a promising pathway because it can accommodate a broad variety of carbon-containing residues, including those that are incompatible with mechanical or molecular recycling technologies. Demonstrating the recyclability of diverse feedstocks through gasification is therefore essential to closing industrial carbon loops and reducing reliance on fossil resources.

Within this context, two representative pilot studies were conducted to explore the gasification behavior of complex residual materials. Automotive Shredder Residue (ASR) and post-consumer adsorption hygiene products (AHP) such as diapers were investigated as illustrative examples for highly heterogeneous, conventionally non-recyclable waste streams. The AHP gasification project demonstrated the successful production of stable synthesis gas, confirming its technical feasibility even for highly complex feedstocks. The ASR gasification project extended beyond syngas generation and demonstrated the full conversion pathway from heterogeneous waste to value-added chemical products. The produced synthesis gas was further processed into Fischer–Tropsch intermediates and ultimately converted into polyurethane (PU) used in automotive steering wheels, thereby closing the loop from end-of-life automotive waste to high-value polymer products.This demonstrates that gasification can serve as a robust recycling route for complex waste materials that currently lack viable alternatives and can integrate seamlessly into existing chemical value chains.

Beyond the two example feedstocks examined here, additional gasification initiatives are underway to investigate a wider range of residues—including mixed plastics, composite packaging waste, textile fractions, and biomass-derived industrial by-products. Furthermore, electrification of gasification is being explored as a promising approach to enable higher carbon recycling rates through improved process control and energy efficiency. While this emerging technological pathway offers significant potential, it is currently still in the research and development stage and requires further validation prior to industrial implementation.