Industrial-scale continuous chemical recycling of mixed plastic waste into cracker-ready oil *via* thin-film pyrolysis.

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BUSS ChemTech AG has developed a state-of-the-art continuous thin-film pyrolysis reactor for converting mixed plastic waste into high-quality pyrolysis oil. We approach pyrolysis primarily as a heat transfer challenge with the goal of designing a reactor that provides similar heat transfer rates irrespective of scale. The reactor's unique helical design (**Fig. 1a,b**) channels molten plastic waste into a thin film between the blades and the reactor's outer casing. Formation of the thin film ensures scale-independent heat transfer, enabling consistently efficient pyrolysis as the reactor scales from 100 kg/h to 1,250 kg/h and higher, equivalent to 10,000+ tons/year of waste processed.

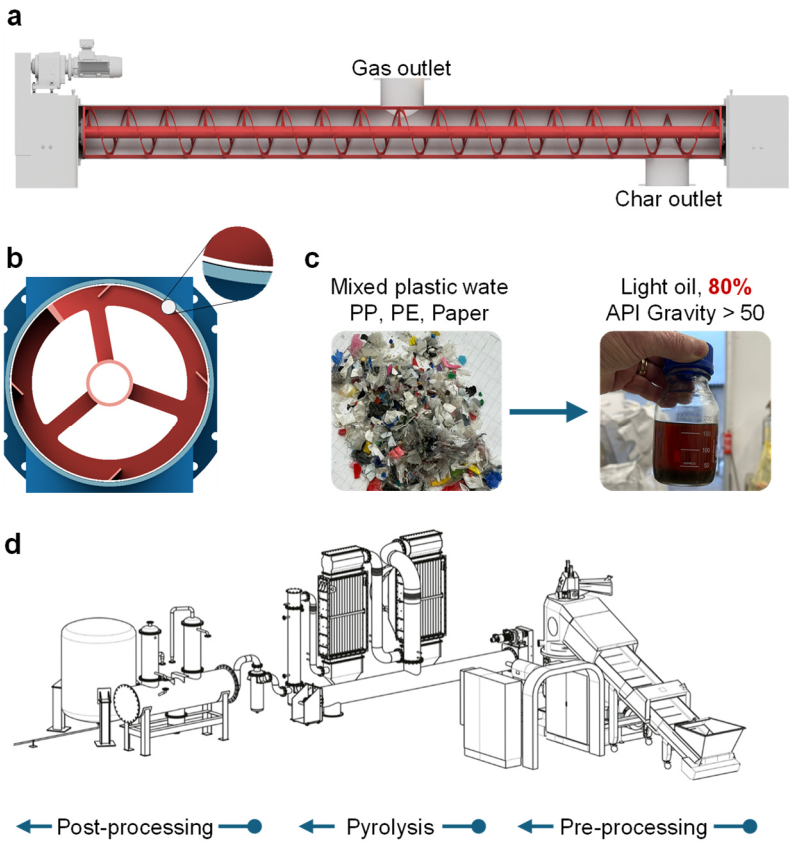

Figure 1. a BUSS pyrolysis reactor with its helical interior **b** Reactor cross-section showing the close clearance between the helix (in red) and the reactor casing (in blue) **c** Representative light oil recovered from pyrolysis **d** Schematic of BUSS chemical recycling plant

Efficient heat transfer along the thin film allows a more precise tuning of reaction kinetics and results in high quality pyrolysis oil across scales. By altering the pitch and rotation speed of the helix, we can conveniently adjust the residence time, limit unwanted side reactions and direct the selectivity of pyrolysis as per desired output. The close clearance between the helix and reactor casing (**Fig. 1b**) additionally provides a self-cleaning action leading up to longer uninterrupted operations (*ca.* 8000 h) and shorter maintenance periods. Remarkably, the design allows sufficient space for free movement of gaseous products, preventing local pressure build-ups and temperature hotspots. This ensures homogeneous kinetics over the reactor length, an issue often encountered in conventional screw extruders.[1] On pilot scale non-catalytic reactions (450-550 ℃) at *ca.* 100 kg/h with mixed polyolefins waste (PE, PP, paper, textiles, coloring additives), we achieve high quality oil (API gravity > 50, light oil) yields of up to *ca.* 80%. (**Fig. 1c**) In addition to the high throughput, the reactor offers wide possibilities when combined with the use of catalysts, advanced pre-treatment of feed and post-treatment of the recovered pyrolysis oil in a single line. (**Fig. 1d**)

References

[1] Vergnes, B., & Berzin, F. (2006). Modeling of reactive systems in twin-screw extrusion: challenges and applications. *Comptes Rendus Chimie*, *9*(11-12), 1409-1418.