CASE STUDY

Catalytic Fast Pyrolysis of PET Waste

This case study is based on a laboratory-scale research project conducted by the Universidad de Lima, Peru, focused on converting waste polyethylene terephthalate (PET) into value-added crude oil using fast catalytic pyrolysis — a chemical recycling approach that aligns with circular economy principles by addressing plastic waste management challenges. The study was carried out using a fixed-bed fast catalytic pyrolysis unit that includes an electric heating jacket, nitrogen inerting system, condenser, crude oil collection tank, and an exhaust gas treatment unit with activated carbon filtration. Waste PET flakes (4.5 mm) were processed under inert nitrogen atmosphere, with experimental work conducted in Lima, Peru and supporting simulation work performed using CHEMCAD software.

CHALLENGE

Mechanical recycling of PET is limited by polymer degradation after multiple cycles, leading to low-value waste streams. Globally, only a small fraction of PET is effectively recycled, contributing to environmental pollution and greenhouse gas emissions. The key challenge was to identify operating conditions and catalyst usage that maximize crude oil yield and quality from PET waste, while reducing energy requirements and enabling scalable process design supported by reliable simulation models.

SOLUTION

A fast catalytic pyrolysis process was developed using activated zeolite as a catalyst in a fixed-bed reactor. PET waste was processed at temperatures of 380°C, 430°C, and 480°C with catalyst loadings of 0%, 12.5%, and 25% by weight. Nitrogen was used to maintain inert conditions. The crude oil products were characterized using FTIR and quantitative 13C NMR. In parallel, the process was modeled and simulated using CHEMCAD software to validate experimental results and perform mass and energy balances.

RESULTS

The study demonstrated that catalyst loading had a stronger influence on crude oil quality than temperature alone. The optimal condition was identified at 430°C with a 12.5% zeolite catalyst-to-PET ratio, producing approximately 20% crude oil yield. This condition also achieved the highest aromatic C–C bond concentration (≈73%), indicating superior fuel quality. Higher catalyst loadings increased gas production but reduced liquid yield. Simulation results closely matched experimental data, confirming the robustness of the process model.

Adapted from from Cleaner Engineering and Technology, Volume 26, 2025, 100928, ISSN 2666-7908

KEY PERFORMANCE SUMMARY

TEMPERATURE (°C)	CATALYST RATIO (%)	CRUDE OIL YIELD (%)	AROMATIC C–C BONDS (%)
380	12.5	≈18	≈35
430	12.5	≈18	≈35
480	25	≈18	≈35

TANGIBLE BENEFITS

- Conversion of waste PET into valuable crude oil, supporting circular economy goals.
- Identification of optimal operating conditions that reduce reactor temperature and energy demand.
- Improved crude oil quality through controlled catalytic action.
- Validated CHEMCAD simulation enables scale-up, optimization, and techno-economic evaluation.
- Reduction of landfill disposal and potential greenhouse gas emissions from PET waste.

FIGURE 1 - Overall study results to convert PET waste into crude oil