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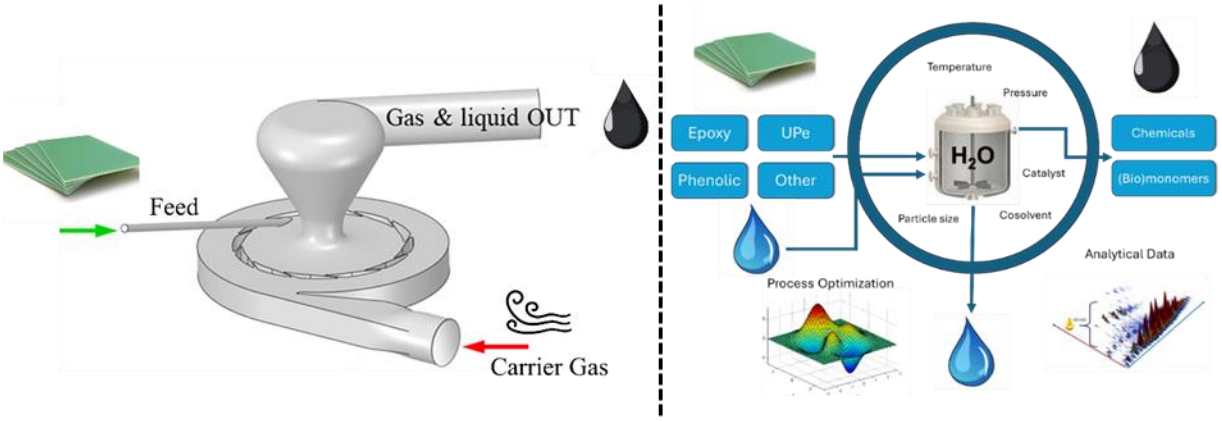
Valorization of waste thermosets by means of (supercritical water) pyrolysis

Aim

A detailed study on the pyrolysis and hydrothermal liquefaction of waste thermosets/composites is conducted using the Vortex reactor setup and high-pressure autoclave coupled with LCT's state of the art GCxGC analytical machines. This research aims to find the key differences between the oil products from both methods.



Scheme 1: Schematic representation of pyrolysis in the Vortex reactor (left) and a high-pressure autoclave (right).

Justification

Thermosetting polymers, such as epoxy and polyester resins, are widely used due to their strength and heat resistance, especially in composite materials for industries like wind energy and automotive applications.[1] Once cured, these polymers (i.e. epoxy) form a rigid, three-dimensional, cross-linked structure, resulting in exceptional strength and heat resistance.[2] However, contrary to their thermoplastic counterparts, thermosets cannot be remelted or reshaped efficiently, posing **significant challenges for recycling**, particularly end-of-life composites. Mechanically recycling often means crushing and/or shredding the materials into smaller particles so it can be used as filler materials in concrete or asphalt.[3] (Supercritical water) Pyrolysis involves the thermal decomposition of polymers without oxygen, either with or without catalysts and/or water as medium.[4,5]

This thesis aims to provide a comprehensive understanding of (supercritical water) pyrolysis for thermoset waste by conducting experiments on both pyrolysis and hydrothermal pyrolysis. The study focuses on analyzing the pyrolysis oil produced from each method to evaluate their efficiency and viability. This research introduces **two novel approaches** for managing end-of-life thermosets, aiming to recover valuable chemicals and support **a circular economy**. Since supercritical water serves as a reaction medium for thermoset waste, it is expected to yield a distinct product composition. However, due to its high energy requirements, the process must be economically justified. By comparing the analytical results, the student **will critically assess both methods** and, based on the student's newfound expertise, determine **the most suitable approach for thermoset waste valorization**.

Program

1. Review of the available literature of waste thermoset recycling.
2. Learn GCxGC analysis and reactor operation.
3. Conduct experiments on Vortex reactor setup and high-pressure autoclave.
4. Analyze the obtained oil and propose which method is more suited for valorization.

[1] An, W. et al., *Green Chem.* 24, (2022).
[2] Krauklis, A. E. et al., *J. Compos. Sci.* (2021).
[3] Liu, Y. et al., *J. Clean Prod.* (2017).
[4] Oliveux, G. et al., *Prog. Mater. Sci.* (2015).
[5] Kusenberg, M. et al., *Fuel Pro. Tech.* (2022).

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