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Kinetic Study of Plastic Waste Gasification Reactions

Aim

The aim is to understand the gasification reaction mechanisms for different plastic wastes, and generate reaction schemes to be used in a 1-D reactor model.

Justification

Over the recent decades the annual amount of municipal solid waste (MSW), including plastic wastes has increased. These wastes have to be treated wisely to close the circular economy loop (Figure 1), as well as decrease the environmental impact. Landfilling is one of the easiest and oldest methods to discard plastic wastes. However, land shortage and environmental impact make this option the least desirable one. Gasification reactions, the goal of which is to crack large plastic polymer molecules and convert them preferably to syngas (H_2+CO), is considered as one of the promising chemical recycling routes of plastic wastes [1].

Figure 1 Schematic diagram of plastic waste gasification recycling route

Apart from the intrinsic gasification reactions, it is crucial to design the process efficiently so that production rate increases while equipment volume and environmental impact decreases (Process Intensification). This goal is going to be achieved through realization of Gas Solid Vortex Reactor (GSVR) concept [2] in plastic waste gasification at the LCT. The GSVR makes use of centrifugal force instead of gravitational forces against the drag force, which results in high slip velocity between phases and consequently, increasing the rates of heat and mass transfer. Hence the GSVR is a possible methodology of Process Intensification in plastic waste chemical recycling.

To assist with the design of the process, coupled computational fluid dynamics (CFD) with kinetic models of plastic waste gasification in the GSVR will be needed. In order to fully understand the process, chemical reactions and transport phenomena needs to be resolved by 3D CFD calculations. For this, an accurate and complete chemical kinetic model is needed. In this work, an adequate understanding of gasification reaction kinetics will be developed through the generation of kinetic model. This model will initially be used in simplified reactor geometries to extract the most relevant reactions. The latter will then be integrated with CFD simulations of the GSVR.

Program

1. Literature study on kinetics of different plastic waste gasification reactions.
2. Generation of a kinetic model using in-house software [3].
3. Performing 1-D reactor simulations with the new kinetic model using ANSYS Chemkin / Cantera.
4. Implementing the relevant reactions in a CFD framework to model the GSVR.

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[2] J. De Wilde, Gas-solid fluidized beds in vortex chambers, Chem. Eng. Process., 85 (**2014**) 256-290.
[3] R. Van de Vijver, N.M. Vandewiele, P.L. Bhoorasingh, B.L. Slakman, F. Seyedzadeh Khanshan, H.-H. Carstensen, M.-F. Reyniers, G.B. Marin, R.H. West, K.M. Van Geem, Automatic Mechanism and Kinetic Model Generation for Gas- and Solution-Phase Processes: A Perspective on Best Practices, Recent Advances, and Future Challenges, International Journal of Chemical Kinetics, 47 (**2015**) 199-231.

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