Numerical study of 5-hydroxymethylfurfural production in an innovative winged solar biomass reactor

Yuting Zhuo [a*], Qiyuan Li, Robert A. Taylor [b], Jason Scott [a], Yansong Shen [a]

[a] School of Chemical Engineering, The University of New South Wales (UNSW), Kensington, New South Wales 2052, Australia

[b] School of Mechanical and Manufacturing Engineering, The University of New South Wales (UNSW), Kensington, New South Wales 2052, Australia

y.zhuo@unsw.edu.au

5-Hydroxymethylfurfural, as a biomass-derived alcohol, is a promising intermediate for value-added chemicals and hydrogen production (electrolysis). To produce this valuable product in an environmentally friendly way and minimise its energy consumption, an innovative winged solar-driven biomass reactor is built. This reactor combines the concept of the solar concentrator and phase-change material to efficiently utilise and store the solar energy for hydrolysis reaction requirements. A transient computational fluid dynamics model is developed to describe the energy transfer during the phase change material liquidation and solidification along with the daily solar radiation. Also, the heat and mass transfer phenomena during the 5-Hydroxymethylfurfural production are illustrated. This numerical model is validated against the experimental measurements, and it is employed to numerically evaluate the reactor's performance under different operating schemes. The simulation results indicate that the amount and type of the charged phase change materials affect the yield of 5-Hydroxymethylfurfural and the by-products due to the heat storage capacity. In addition, the heat absorption and desorption of the phase change material make the inner tube reactor maintain a mild heating environment and extend the reaction time, which improves the system efficiency. This model provides a cost-effective way to understand and optimise the solar-driven reactors.

Keywords: Phase change material, Solar-driven reactor, CFD, Numerical modelling