Thermogravimetric analysis and the optimisation of bio-oil yield from fixed-bed pyrolysis of rice husk using response surface methodology (RSM)

Abstract

The effects of pyrolysis temperature, heating rate, particle size, holding time, and gas flow rate were investigated to optimize bio-oil yield from rice husk pyrolysis. Thermogravimetric analysis showed thermal degradation of hemicellulose, cellulose and lignin, indicating faster decomposition of cellulose compared to lignin. The optimisation process was analysed by employing central composite design (CCD) in response surface methodology (RSM) using Design Expert Version 7.5.1 (StatEase, USA). A two-level fractional factorial was initially carried out and followed by RSM. The statistical analysis showed that pyrolysis temperature, heating rate, particle size and holding time significantly affected the bio-oil yield. By utilising response surface method, these four factors were investigated, analysed and optimal conditions were obtained at pyrolysis temperature of 473.37 °C, heating rate of 100 °C/min, particle size of 0.6 mm and holding time of 1 min. Confirmation runs gave 48.30% and 47.80% of bio-oil yield compared to 48.10% of predicted value. Furthermore, the pyrolytic bio-oils obtained from fixed-bed pyrolysis were examined using gas chromatographic/mass spectroscopy (GC/MS), Fourier transform infrared (FTIR) methods, elemental analyzer, pH probe and bomb calorimeter.