Synergistic Interactions between Sewage Sludge and Plastics during Co-pyrolysis

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Thermogravimetric analysis was used to compare the synergistic interactions and kinetics of co-pyrolysis of sewage sludge (SS), polypropylene (PP), and high-density polyethylene (HDPE) to determine its bioenergy potential and viability as a waste valorization method.

Thermogravimetric analysis was used to examine the pyrolysis of SS, PP, and HDPE. Because of its three-dimensional spherical structure which could prevent heat from transferring to the particles' inner core, SS pyrolysis showed a limitation of heat transfer at greater heating rates compared to PP and HDPE. Three polyolefin proportions (20, 50, and 80%) were used to examine the co-pyrolysis of SS/PP and SS/HDPE. For all ratios of SS/PP and 20% SS/HDPE, co-pyrolysis increased volatile conversion and degradation rates synergistically.

According to the evolved gas analyses, the increased dehydration and decarboxylation processes could be attributed to interactions between the polyolefin H-radicals and the oxygenated intermediates of SS. Due to the lesser degree of HDPE degradation, greater molecular weight compounds were produced for 50% and 80% SS/HDPE.

With the help of master plot analysis and iso-conversional model-free approaches, the activation energy and reaction mechanism of pyrolysis and co-pyrolysis, respectively, were determined. Thermogravimetric-mass spectrometry was used to track evolved gases. The overall volatile conversion, degradation rates, and activation energies were all increased synergistically by co-pyrolysis. Based on the examination of evolved gases, the synergistic rise in H_2O and CO_2 evolution supports the larger extent of dehydration and decarboxylation processes during co-pyrolysis. Diffusion and geometric contraction could be responsible for the reactions between sewage sludge and polyolefins, respectively. The rate-limiting mechanism of co-pyrolysis was found to be diffusion control. Overall, the findings are helpful for designing waste-to-energy reactors that can co-pyrolyze polyethylene, high-density polyethylene, and sewage sludge to harness their bioenergy potential.