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Detailed Investigation of Thermal Degradation Mechanism and Product Characterization of Co-Pyrolysis of Indian Oil Shale with Rubber Seed Shell

Authors : Bhargav Baruah, Ali Shemsedin Reshad, Pankaj Tiwari

Abstract : This work presents a detailed study on the thermal degradation kinetics of co-pyrolysis of oil shale of Upper Assam, India with rubber seed shell, and lab-scale pyrolysis to investigate the influence of pyrolysis parameters on product yield and composition of products. The physicochemical characteristics of oil shale and rubber seed shell were studied by proximate analysis, elemental analysis, Fourier transform infrared spectroscopy and X-ray diffraction. The physicochemical study showed the mixture to be of low moisture, high ash, siliceous, sour with the presence of aliphatic, aromatic, and phenolic compounds. The thermal decomposition of the oil shale with rubber seed shell was studied using thermogravimetric analysis at heating rates of 5, 10, 20, 30, and 50 °C/min. The kinetic study of the oil shale pyrolysis process was performed on the thermogravimetric (TGA) data using three model-free isoconversional methods viz. Friedman, Flynn Wall Ozawa (FWO), and Kissinger Akahira Sunnose (KAS). The reaction mechanisms were determined using the Criado master plot. The understanding of the composition of Indian oil shale and rubber seed shell and pyrolysis process kinetics can help to establish the experimental parameters for the extraction of valuable products from the mixture. Response surface methodology (RSM) was employed usinf central composite design (CCD) model to setup the lab-scale experiment using TGA data, and optimization of process parameters viz. heating rate, temperature, and particle size. The samples were pre-dried at 115°C for 24 hours prior to pyrolysis. The pyrolysis temperatures were set from 450 to 650 °C, at heating rates of 2 to 20°C/min. The retention time was set between 2 to 8 hours. The optimum oil yield was observed at 5°C/min and 550°C with a retention time of 5 hours. The pyrolytic oil and gas obtained at optimum conditions were subjected to characterization using Fourier transform infrared spectroscopy (FT-IR) gas chromatography and mass spectrometry (GC-MS) and nuclear magnetic resonance spectroscopy (NMR).

Keywords : Indian oil shale, rubber seed shell, co-pyrolysis, isoconversional methods, gas chromatography, nuclear magnetic resonance, Fourier transform infrared spectroscopy
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