ABSTRACT

The aromatization of low valued readily available hydrocarbons in refinery has been of great interest over the past two decades to manufacture highly valued marketable products. In the recent past, the pyrolysis of municipal solid wastes (MSW) has been considered as a potential and innovative alternative for treating MSW, which resulting in different chemicals and fuel range hydrocarbons. Waste plastic disposal and excessive use of fossil fuels have caused environment concerns in the world. Both plastics and petroleum-derived fuels are hydrocarbons that contain the elements of carbon and hydrogen. The difference between them is that plastic molecules have longer carbon chains than those in LPG, petrol, and diesel fuels. Therefore, it is possible to convert waste plastic into fuels. The overall objectives of this study is to investigate the effect of thermocatalytic pyrolysis of waste plastics over commercial and natural catalyst in order to produce environmentally friendly fuel and valuable aromatics benzene, toluene, ethyl benzene and xylene (BTEX).

In this study, thermal and catalytic pyrolysis of waste plastics polyethylene (PE), polypropylene (PP) and polystyrene (PS) were carried out in a semi-batch in a nitrogen atmosphere. The valuable BTEX were effectively produced from waste plastics using commercial ZSM-5 and fly ash synthesized catalyst. The BTEX yield was enhanced significantly using multiphase catalytic pyrolysis of polyethylene, polypropylene and polystyrene. The BTEX content was significantly increased due to effective interaction between catalyst and target molecules i.e., lower paraffins within the reactor.

Low cost natural catalyst was synthesized from fly ash (FA) in 5 different synthesized form i.e., fly ash in natural form (FAN), fly ash calcined at 600 ^{o}C (FA-600), 700 ^{o}C (FA-700), 800 ^{o}C (FA-800) and 900 ^{o}C (FA-900). The thermal and catalytic pyrolysis both were conducted in a specially designed semi-batch reactor at the temperature range of 500–800

°C. The catalytic pyrolysis were performed in three different phases within the reactor batch by batch systematically, keeping the catalyst in a vapor phase (A-Type), liquid phase (B-type) and liquid and vapor phase/multiphase (C-Type), respectively. The optimum pyrolysis temperature for the production of BTEX was found to be 700 °C for both thermal and catalytic pyrolysis of waste plastic PE, PP and PS. Total aromatics (BTEX) of 10.75 wt. % for PE, 30.91 wt. % for PP and 13.58 wt. % for PS were obtained for thermal pyrolysis at a temperature of 700 °C. In contrary, the aromatic (BTEX) contents were significantly increased for the catalytic pyrolysis in A-type, B-type and C-type reactor arrangement. C-type reactor arrangement gives maximum BTEX content for all types of waste plastic due to selective cracking in both liquid and vapor phase. BET surface area analysis and SEM-EDX suggests that FA-800 catalyst could be the superior catalyst due to its maximum surface area 310.10 m^2/g and (Si/Al) ratio of 16.03. The maximum BTEX of 39.47 wt. % for PE, 53.12 wt. % for PP and 26.86 wt. % for PS was obtained for commercial catalyst ZSM-5 in C-type reactor arrangement. Whereas, it was 22.10 wt. % for PE, 43.43 wt. % for PP and 20.92 wt. % for PS using FA-800 catalyst. The results indicate that the performance of FA-800 catalyst is comparable to commercial ZSM-5 in terms of liquid yield and aromatics/BTEX content. The test results for catalyst stability indicates that the commercial ZSM-5 and synthesized FA-800 catalyst is stable upto 2nd run and slight change was observed in liquid yield and BTEX content. Regenerated catalyst showed similar results as that of fresh catalyst. Physicochemical properties of the pyrolysis oil shows that it can be used as alternative fuels and as a source of valuable chemicals such as benzene, toluene, ethyl benzene or xylene.

Keywords: *Waste plastic, Polyethylene, Polypropylene, Polystyrene, Multiphase pyrolysis, Aromatization, ZSM-5, BTEX, Fly ash, Regeneration.*