Catalytic Copyrolysis of Biomass and High-Density Polyethylene over Mesoporous Solid Acids

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Rapid depletion of fossil fuels and greenhouse gas emissions caused by their large-scale utilization necessitate the search for sustainable and renewable resources for future supply of energy and chemicals. Lignocellulosic biomass is a potential option to be substituted for fossil fuels since it is abundantly available and the biomass-derived fuels are carbon-neutral. Pyrolysis, as one of the most promising technologies for exploitation of biomass, results in a highly oxygenate bio-oil which needs further catalytic upgrading in order to be converted to valuable chemicals and fuels [1]. Hence, catalytic pyrolysis including both pyrolysis and catalytic upgrading in one single unit has high potential to be an economically feasible method for single-step production of biomass-based chemicals. However, one significant challenge of such process is extensive formation of coke and catalyst deactivation due to low hydrogen to carbon effective ratio of biomass. One solution for this problem is catalytic copyrolysis in which a hydrogen-rich material is co-fed with biomass in order to supply hydrogen to the hydrocarbon pool inside catalyst.

In this work, catalytic copyrolysis of yellow poplar and high-density polyethylene (HDPE) was performed using mesoporous solid acids such as meso MFI, meso Y, Al-MCM-48 and Al-SBA-15. The main purpose of this research was to find an optimum catalyst mesoporosity for the maximum synergy between biomass and HDPE. This synergy is expected to enhance the yield of hydrocarbon production to a value higher than that achieved by separate conversion of biomass and HDPE. Use of mesoporous materials as catalyst showed to be highly effective since large channels of such catalysts facilitates the diffusion of pyrolysis-derived compounds of large molecular size inside catalyst leading to enhanced accessibility of reactants to catalyst acid sites. For instance, as shown in Fig. 1, meso MFI resulted in remarkable synergistic effect between yellow poplar and HDPE; the separate catalytic pyrolysis gave BTEX and total aromatic hydrocarbon yields of 6.38 and 9.85 wt% from yellow poplar and 13.43 and 16.98 wt% from HDPE, while catalytic copyrolysis with yellow poplar/HDPE ratio of 50:50 resulted in the yields of 13.94 and 20.28 wt %, respectively.

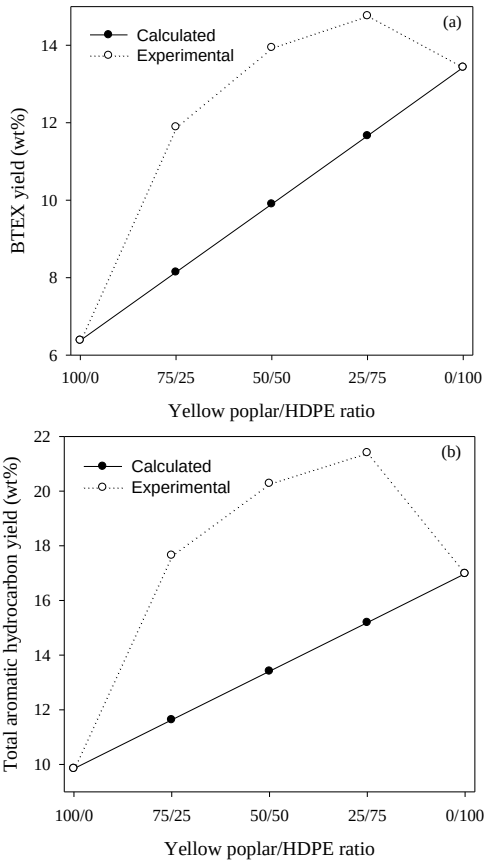

Fig. 1. Experimental and calculated yields of (a) BTEX (benzene, toluene, ethylbenzene and xylenes) and (b) total aromatic hydrocarbons (Reaction temperature, 600 ℃; Catalyst to feed ratio, 10:1).

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