Optimizing catalytic tar-deoxygenation of fast pyrolysis vapors

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The concept of de-centralized smaller scale pyrolysis plants that locally valorize available biomass by densifying its energy content into a bio-crude is of increasing interest world-wide. Fast pyrolysis of biomass produces a high yield of bio-oil through well-established technologies at optimized temperature, pressure, and residence time of the liberated pyrolysis vapors. Operating conditions and chemical transformations that reduce the oil’s oxygen content and acid number to stabilize the oil deserve prioritized attention and allow further processing in oil refineries. Deoxygenation can be obtained by catalytic upgrading oversolid acid catalysts. A close coupled process operating at similar temperature and atmospheric pressure conditions to those preferred for optimum yields of bio-oil potentially offers economic advantages for zeolite deoxygenation over high pressure hydrotreating. To date, the medium pore size ZSM-5 zeolite yields a high aromatic yield and the least amount of coke in upgrading of pyrolysis vapors. However, coke formation in the reaction of pyrolysis vapors over the zeolites and steam dealumination still leads to rapid deactivation. Enhancement of ZSM-5 performance besides optimal Si/Al ratio and operating temperature is obtained by either synthesis modifications, or post-synthesis treatment. Incorporation of Ga to a ZSM-5 catalyst was shown to increase the aromatic yields considerably, and the combination of several types of catalysts in order to exploit their unique advantages was demonstrated for physically mixing with mesoporous catalysts and dual beds comprised of solid acid and basic catalysts. Despite promising laboratory results, long term experiments of pilot plants showing stable catalyst operation with multiple regeneration steps are needed to prove the economic attractiveness of bio-oil plants.

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