Production of biodiesel over waste seashell-derived active and stable extrudate catalysts in a fixed-bed reactor

ABSTRACT

In this work, waste seashell (*Meretrix meretrix*) was used as a renewable calcium source to prepare a series of heterogeneous base catalysts for production of biodiesel, a mixture of fatty acid methyl esters (FAME), via transesterification of palm oil with methanol in a continuous-flow fixed-bed reactor. To avoid a severe pressure drop in the reactor column, the catalysts were prepared via the dissolution–precipitation method in the presence of zinc nitrate and alumina, shaped in an extrudate form, and calcined at different temperatures. The catalytic performance of the resulting extrudates in the transesterification depended on not only the active phase type, but also the cluster size of active phase, which was strongly determined by the calcination temperature. Synchrotron-based X-ray micro-computed tomography (micro-CT) was applied for the first time in the development of shaped catalysts. The pore structure of extrudate catalysts obtained at different temperatures was analyzed by nitrogen physisorption measurement, scanning electron microscopy (SEM), and micro-CT, and then correlated with their mechanical properties and catalytic performance. The micro-CT and low-magnification SEM visualized the macroporosity as air voids in the extrudate catalysts. Increasing the calcination temperature from 300 °C to 800 °C decreased the fraction of air voids, resulting in a severe drop of FAME yield due to mass transport problem. The addition of commercial methyl esters into the reaction improved the mass diffusion effectively, and enhanced the biodiesel production. The extrudate catalyst calcined at 300 °C had calcium hydroxide as a main active phase, and the highest macroporosity, which provided a stable FAME yield (>95 wt%) throughout the operation, and a high structural stability.

Keyword: Seashell; Extrudate catalyst; FAME; Fixed-bed reactor; Micro-CT