Sustainable biofuel production approach: critical methanol green transesterification by efficient and stable heterogeneous catalyst

ABSTRACT

Bi-metallic integrated Ce_x-$Ca_{1-x}O$ catalysts with various Ce:Ca atomic ratios are synthesized through a homogeneous co-precipitation route. The synthesized heterogeneous base catalyst for transesterification of unrefined jatropha crude oil (UJCO) under near-critical methanol is the first to be reported by our group. Incorporating inorganic oxides within the metal-metal-oxide (Ce – O – Ce) increases the catalytic activity due to the highly uniform dispersion of lattice CaO on the catalyst's surface and hence predominantly increases the surface's active sites. The near-critical methanol transesterification activity results in the excellent catalytic performance of Ce_x-$Ca_{1-x}O$ when Ce:Ca at an atomic ratio of 1:1. However, its reactivity plunges when Ca species are overloaded on the composite's surface (Ce:Ca atomic ratio of 1:4). The maximum biodiesel yield of 93.39% is achieved at an optimized reaction condition of 20 min, 18 methanol/UJCO molar ratio, 260 °C (10 MPa), and 1 wt.%. In addition, the fuel properties of synthesized biodiesel are investigated and compared in accordance with international standards. This synthesized catalyst demonstrates superior activity, outstanding stability (toward moisture and FFA contents), and reusability (without needed regeneration), making it a potential candidate as a green catalyst.