

## Ethylene production from ethanol dehydration over mesoporous SBA-15 catalyst derived from palm oil clinker waste

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### ABSTRACT

The silica-rich palm oil clinker (POC) from oil palm agroindustry is often dumped in landfill. This work investigated the valorisation of POC into Santa Barbara Amorphous-15 (SBA-15) catalyst, the modulation of its surface acidity, and its application in dehydration of ethanol to ethylene. With commercial SBA-15 [SBA-15(*Comm.*)] as reference, the successful fabrication of POC-derived SBA-15 [POC-SBA-15(pH = 3, 5, and 7)] were validated by spectroscopic and microscopic characterisation. From the results of temperature-programmed desorption of ammonia, the SBA-15(*Comm.*) have high strong acidity while POC-SBA-15 exhibit enriched weak-moderate acidity. For ethanol dehydration over SBA-15 at 200–400 °C, the ethanol conversion (XC<sub>2</sub>H<sub>5</sub>OH) and ethylene selectivity (SC<sub>2</sub>H<sub>4</sub>) rise with temperature. The catalytic activity was ranked as SBA-15(*Comm.*) < POC-SBA-15(3) < POC-SBA-15(7) < POC-SBA-15(5). Spent catalysts characterisation unanimously confirms the least carbon deposition on POC-SBA-15(5), which subsequently used to study the effect of initial ethanol concentration and liquid hourly space velocity (LHSV). When 99.5 wt% ethanol diluted to 50 wt%, the competitive adsorption between ethanol and water reduces XC<sub>2</sub>H<sub>5</sub>OH but enhances SC<sub>2</sub>H<sub>4</sub>. Further ethanol dilution (≤30 wt%) deteriorates SC<sub>2</sub>H<sub>4</sub> following remarkable ethanol steam reforming at elevated temperature (≥350 °C). For 50 wt% ethanol dehydration over POC-SBA-15(5) at 400 °C, a greater LHSV furnishes a higher ethanol partial pressure that increases XC<sub>2</sub>H<sub>5</sub>OH but decreases SC<sub>2</sub>H<sub>4</sub>. When LHSV >16 mL/g·h, the saturation of finite active sites with adsorbates renders the drastic declination of XC<sub>2</sub>H<sub>5</sub>OH and SC<sub>2</sub>H<sub>4</sub>. For ethanol dehydration over POC-SBA-15(5), the optimal conditions are temperature of 400 °C, initial ethanol concentration of 50 wt%, and LHSV of 16 mL/g·h. Fresh POC-SBA-15(5) steadily catalyses the optimal process (73.33% XC<sub>2</sub>H<sub>5</sub>OH and 84.70% SC<sub>2</sub>H<sub>4</sub>) up to 105 h. Meanwhile, regenerated POC-SBA-15(5) achieves a lower catalytic activity (71.95% XC<sub>2</sub>H<sub>5</sub>OH and 81.96% SC<sub>2</sub>H<sub>4</sub>).

**KEYWORDS**

Palm oil clinker; Mesoporous SBA-15; Ethanol dehydration; Ethylene; Surface acidity; Operating conditions

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