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Research article

Long-term evaluation of palm oil mill effluent (POME) steam reforming over lanthanum-based perovskite oxides

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ABSTRACT

To replace the obsolete ponding system, palm oil mill effluent (POME) steam reforming (SR) over net-acidic $LaNiO_3$ and net-basic $LaCoO_3$ were proposed as the POME primary treatments, with promising H_2-rich syngas production. Herein, the long-term evaluation of POME SR was scrutinized with both catalysts under the optimal conditions (600 °C, 0.09 mL POME/min, 0.3 g catalyst, & 74–105 μm catalyst particle size) to examine the catalyst microstructure changes, transient process stability, and final effluent evaluation. Extensive characterization proved the (i) adsorption of POME vapour on catalysts before SR, (ii) deposition of carbon and minerals on spent SR catalysts, and (iii) dominance of coking deactivation over sintering deactivation at 600 °C. Despite its longer run, spent $LaCoO_3$ (50.54 wt%) had similar carbon deposition with spent $LaNiO_3$ (50.44 wt%), concurring with its excellent coke resistance. Spent $LaCoO_3$ (6.12 wt%; large protruding crystals) suffered a harsher mineral deposition than spent $LaNiO_3$ (3.71 wt%; thin film coating), confirming that lower reactivity increased residence time of reactants. Transient syngas evolution of both SR catalysts was relatively steady up to 4 h but perturbed by coking deactivation thereafter. $La_2O_2CO_3$ acted as an intermediate species that hastened the coke removal via reverse Boudouard reaction upon its decarbonation. $La_2O_2CO_3$ decarbonation occurred continuously in $LaCoO_3$ system but intermittently in $LaNiO_3$ system. $LaNiO_3$ system only lasted for 13 h as its compact ash blocked the gas flow. $LaCoO_3$ system lasted longer (17 h) with its porous ash, but it eventually failed because KCl crystallites blocked its active sites. Relatively, $LaCoO_3$ system offered greater net H_2 production (72.78%) and POME treatment volume (30.77%) than $LaNiO_3$ system. SR could attain appreciable POME degradation (>97% COD, BOD_5, TSS, & colour intensity). Withal, SR-treated POME should be polished to further reduce its incompliant COD and BOD_5.

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