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High selective hydrocarbon and hydrogen products from catalytic pyrolysis of rice husk: Role of the ordered mesoporous silica derived from rice husk ash for Ni-nanocatalyst performance

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ABSTRACT

This study successfully synthesized ordered mesoporous silica using a sodium silicate solution derived from high-purity silica extracted from rice husk (98.09%), aiming to catalyst support for integrating fast catalytic upgrading of rice husk. The ordered mesoporous silica, including MCM-41 and KIT-6, were synthesized by co-assembly with additional surfactants, consisting of Cetyl trimethylammonium bromide (CTAB) and Pluronic P123, respectively. A series of 10 wt.% Ni on MCM-41 (Ni/HMS1) and KIT-6 (Ni/HMS2) were synthesized via ethylene glycol ultrasound-assisted wetness impregnation, which enhanced bio-oil quality by reducing oxygen compounds. This method also improved NiO reducibility up to 91.41%, with nickel phyllosilicate playing a pivotal role in preventing Ni-metallic sintering during the reduction process. The well-dispersed small Ni particles yielded high Ni performance in deoxygenation. Moreover, the order of pore size and structure of the hexagonal nanochannel structures influenced the selective hydrocarbon products in bio-oil. Ni/HMS1, with smaller pore sizes (3–5 nm), achieved a balanced hydrocarbon composition with aromatic (44.91%) and aliphatic (15.65%) components, while Ni/HMS2, having larger pores (8–10 nm), predominantly contained aromatic hydrocarbons (67.45%). The

Abbreviations: CTAB, Cetyl trimethylammonium bromide; BET, Brunauer-Emmett-Teller; BJH, Barrett-Joyner-Halenda; CTAB, Cetyl trimethylammonium bromide; EDS, Energy dispersive X-ray spectroscopy; EG, Ethylene glycol; GC-MS, Gas Chromatograph –mass spectrometry; H₂-TPR, Hydrogen temperature-programmed reduction; HMS, Hexa-mesoporous silica; IUPAC, International Union of Pure and Applied Chemistry; NH₃-TPD, Ammonia temperature-programmed desorption; NIST, National Institute of Standards and Technology; Pluronic P123, Poly(ethylene glycol)-*block*-poly(propylene glycol)-*block*-poly(ethylene glycol); RH, Rice husk; RHA, Rice husk ash; SAXD, Small-angle X-ray diffraction; SEM, Scanning electron microscopy.

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