Bi-metallic CuO-NiO based multifunctional material for hydrogen production from sorption-enhanced chemical looping autothermal reforming of ethanol

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ABSTRACT

Bi-metallic CuO-NiO based multifunctional materials were developed and employed for H_2 production via sorption-enhanced chemical looping autothermal reforming (SE-CLAR) of ethanol. The effects of adding copper oxide (CuO) as a co-oxygen carrier and material preparation method on H_2 production performances, including activity, reusability, and energy penalty, were studied. The results revealed that adding CuO into one-body multifunctional material provided positive impacts on H_2 production performances. The use of multifunctional material could reduce reforming temperature to milder temperature at 500 °C. The key finding is that position of CuO in the multifunctional material showed a significant effect. Placing of CuO on the surface could enhance catalytic property whereas placing NiO closed to CaO could reduce heat for CaO regeneration. For the SE-CLAR operating temperature at 500 °C and steam to ethanol ratio (S/E) = 3, impregnation of NiO on the surface of homogeneous CuO-CaO-$Ca_{12}Al_{14}O_{33}$, NiO/CuO-CaO-$Ca_{12}Al_{14}O_{33}$, produced 83% H_2 purity for 30 min while impregnation of CuO on the surface of homogeneous NiO-CaO-$Ca_{12}Al_{14}O_{33}$, CuO/NiO-CaO-$Ca_{12}Al_{14}O_{33}$, produced 89% H_2 for 45 min. Sol-gel one-pot synthesis method of NiO-CuO-CaO-$Ca_{12}Al_{14}O_{33}$ produced 91% H_2 purity for 60 min. Complete regeneration temperature of CaO was achieved at 800 °C, which accounts for 14% thermal energy reduction for the CuO/NiO-CaO-$Ca_{12}Al_{14}O_{33}$. The NiO/CuO-CaO-$Ca_{12}Al_{14}O_{33}$ could maintain its performance on producing high H_2 purity for at least five consecutive operating cycles.

KEYWORDS

Hydrogen production; Bi-metallic multifunctional material; Sorption-enhanced chemical looping autothermal reforming; Ethanol reforming

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