

Lattice strain control of the activity of cobalt catalysts produced by combustion synthesis

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Catalysts based on cobalt, aluminum and magnesium oxides, doped with Zn, Mg, Al, B and Ba were synthesized using combustion synthesis (either self-propagating high temperature synthesis, SHS or Solution Combustion Synthesis, SCS) and were investigated for dry reforming of methane. The doping atomic ratios of Co/metal ranged from 10:0.2 to 10:3.0. Solution combustion synthesis of Co(II) nitrates with one of Zn, Mg, Al, Ba metal nitrates and boric acid resulted in formation of high surface area nano-sized catalysts. The dry reforming reaction was carried out in a fixed bed reactor at 750 – 900°C and at atmospheric pressure with gas ratio in a stream of CO₂:CH₄:N₂ (1:1:1). The total flow rate of reactants was 860h⁻¹. Of all catalysts tested, Co/Me (10:0.5) and Co/Me (10:2) exhibited the highest activity at these specified conditions. X-ray diffraction (XRD) measurements revealed the presence of CoB₂O₄, CoAl₂O₄, Co₂AlO₄, CoO, ZnCo₂O₄, CoMg₃O₄, Co₃MgO₄, Ba₂CoO₄, Co₃(BO₃)₂ in the catalysts.

Lattice spacing analysis reveal that the dopant ions substitute for various metal ions in the oxides under the present synthesis conditions. A lattice expansion occurs in the case of the Co/Mg catalysts while a lattice contraction was found for the Co/Zn catalysts (fig.1). A correlation between cobalt spinel crystal lattice spacings and activity of catalysts (fig. 2) was observed. By considering lattice strains resulting from the above ionic substitutions it was possible to arrive at reactivity–lattice strains relationships that provides guidelines for tuning catalytic activity.

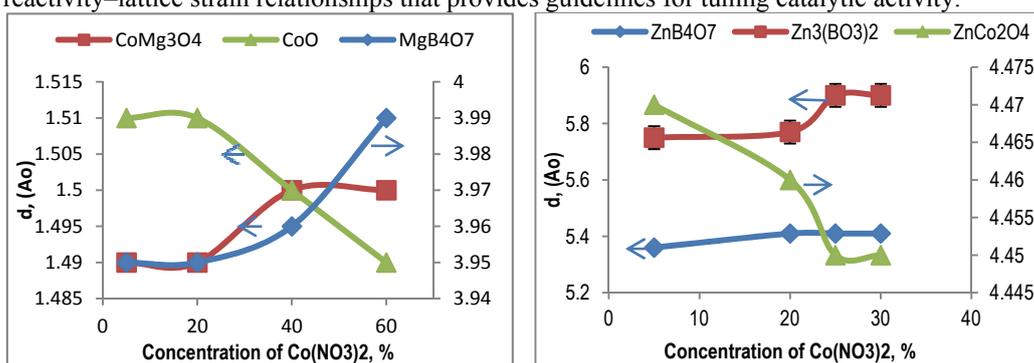


Fig.1. Influence of initial batch composition on the cobalt spinels crystal lattice spacings

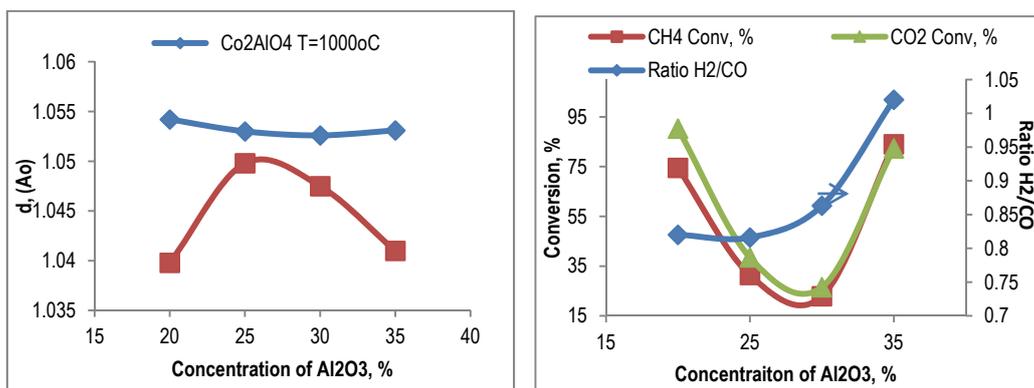


Fig.2 Influence of catalyst composition on the crystal lattice spacings and CH₄ and CO₂ conversion

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