Ni exsolved nanoparticles from a $La_{1-\alpha}Ni_{1-x}Cr_xO_3$ perovskite for Methane Steam Reforming

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Significance and Relevance

Exsolution is promising in catalysis due to its ability to produce uniformly distributed, anchored metallic nanoparticles, enhancing resistance to coking and agglomeration. ABO_3 perovskites, such as $La_{1-\alpha}Ni_{1-x}Cr_xO_3$, provide ideal structural stability and flexibility for this process. The reducibility of the B-site cation, like nickel, is vital for nanoparticle formation in applications like methane steam reforming. Additionally, A-site vacancies induce distortions that facilitate cation migration, partial substitution at the B-site is necessary to preserve the integrity of the perovskite structure. The $La_{1-\alpha}Ni_{1-x}Cr_xO_3$ design integrates these attributes, offering a highly efficient and stable catalyst for advanced catalytic applications.

Preferred and 2nd choice for the topic: H_2 storage and transportation, green H_2 production, hydrogen vectors
Preferred presentation: Oral only

Introduction and Motivations

The Methane Steam Reforming (MSR) is the most commonly used process for hydrogen production from fossil fuels due to its high hydrogen-to-carbon ratio and low by-product formation compared to other methods[1,2]. Although this conventional reforming method is well-established, it comes with several drawbacks. One major issue is the deactivation of catalysts due to sintering or coke formation at high temperatures, which leads to a decline in catalytic activity[3, 4].

This study focuses on utilizing exsolution from an ABO_3 perovskite as a method for synthesizing well-dispersed metallic nanoparticles that are anchored to their matrix. This approach enhances stability and resistance to carbon deposition. Specifically, the ongoing research evaluates the catalytic activity and stability in MSR using exsolved Ni nanoparticles from a $La_{1-\alpha}Ni_{1-x}Cr_xO_3$ perovskite. The investigation includes examining stoichiometric factors, A-site deficiencies, and partial substitution of the B-site.

Results and Discussion

The $La_{1-\alpha}Ni_{1-x}Cr_xO_3$ perovskites were prepared using the Pechini sol-gel method, as illustrated in Fig. 1A. The reactions conducted thus far (see Fig. 1B) have demonstrated enhanced performance during the second run for stoichiometric perovskites ($\alpha = 0$), suggesting **exsolution and reconstruction processes driven by the feed gas**. Notably, the sample with no partial substitution (S1) achieved 100% conversion of CH_4 at approximately 600°C in the second run, showing higher conversion rates at lower temperatures compared to traditional catalysts. **Furthermore, the exsolved nanoparticles from A-site deficient perovskites displayed initial catalytic activity at lower temperatures than their stoichiometric counterparts**.

These findings, supported by characterization reports, imply successful production of exsolved Ni nanoparticles from A-site deficient perovskites. **They also demonstrate higher crystallinity or an increased surface quantity of Ni^0 under exsolution conditions (H_2 atmosphere)**. Significantly, these conditions create active sites that facilitate reactions at lower temperatures than conventional industrial catalysts, highlighting their potential for further stability assessments.

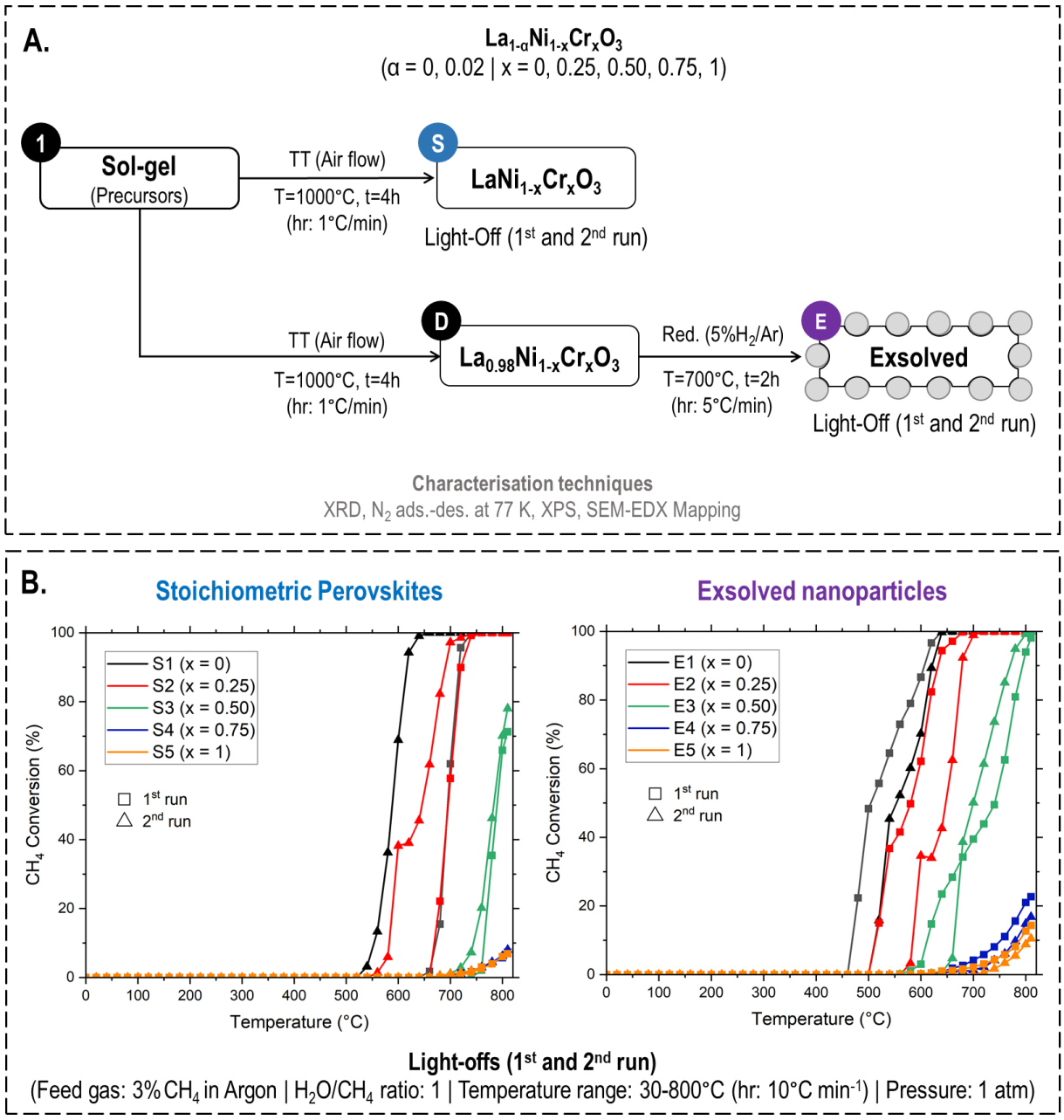

Fig. 1. Schematic summary showing A. the synthesis route and experimental conditions for the preparation of stoichiometric (S) and A-site deficiency (D) perovskites and exsolved nanoparticles (E), and B. light-offs for methane steam reforming reaction.

References

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