Exploring Mg-Substituted $LaNi_xMg_{1−x}O_3$ Perovskites for Efficient Methane Reforming

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INTRODUCTION

Dry reforming of methane (DRM) combines methane and carbon dioxide, utilizing two greenhouse gases to produce hydrogen, making it an environmentally significant process[1]. However, catalyst deactivation due to coke formation remains a critical challenge[2]. This study focuses on developing and testing $LaNi_xMg_{1−x}O_3$ perovskite-type oxides (x = 0 to 1 in increments of 0.2) as potential catalysts resistant to coke formation[3]. The novelty lies in the role of Mg substitution in stabilizing the catalyst structure and enhancing performance, with implications for sustainable hydrogen production.

EXPERIMENTAL/THEORETICAL STUDY

$LaNi_xMg_{1−x}O_3$ catalysts were synthesized using solution combustion synthesis (SCS), followed by calcination at 600 °C for 2 hours. The materials were characterized using XRD, TPR, SEM, and TGA analysis. Catalysts were reduced under a 20% H_2/N_2 atmosphere at 600 °C for 2 hours before being tested in DRM. The reactions were conducted in a continuous flow setup at atmospheric pressure with temperatures up to 750 °C

RESULTS AND DISCUSSION

The results revealed that partial substitution of Ni with Mg improved CO_2 and CH_4 conversion rates. Among the tested catalysts, $LaNi_{0.4}Mg_{0.6}O_3$ achieved the highest CO_2 conversion (87%), while $LaNi_{0.6}Mg_{0.4}O_3$ exhibited optimal CH_4 conversion (76%) at 750 °C. A Design of Experiment analysis using Minitab identified $LaNi_{0.5}Mg_{0.5}O_3$ as the optimal composition, yielding conversion rates of 86% for CO_2 and 77% for CH_4 with 39-hour stability, validated by experimental testing. TPR analysis also indicated that Mg incorporation increased reduction peak temperatures, demonstrating enhanced structural stability compared to $LaNiO_3$.
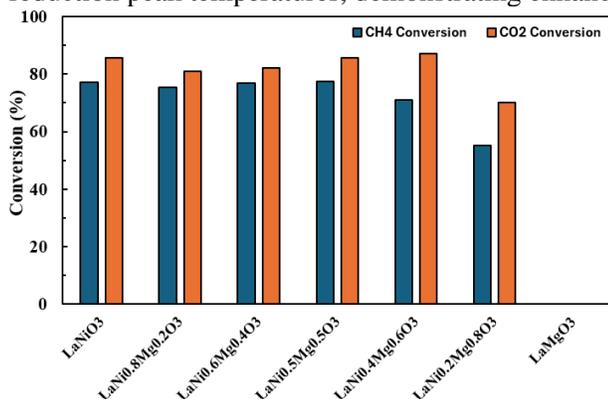

Fig. 1 $LaNi_xMg_{1-x}O_3$ perovskites performance in DRM reaction at 750 °C.

CONCLUSION

Mg substitution improves structural stability by increasing reduction temperatures and balancing reducibility. However, higher Mg levels hinders perovskite formation, leading to spinel and oxide phases. Overall, Mg doping enhances the stability of $LaNiO_3$-based perovskites while maintaining effective catalytic performance for DRM.

REFERENCES

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