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Article

Effects of α - and γ -cyclodextrin-modified impregnation method on physicochemical properties of Ni/SBA-15 and its catalytic performance in CO₂ reforming of methane

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ABSTRACT

Organic compounds containing multiple hydroxyl groups, namely α -cyclodextrin and γ -cyclodextrin, were used as additives for promoting Ni dispersion on supported Ni/SBA-15 catalysts. Catalysts prepared using modified and unmodified impregnation methods were characterized using N₂ adsorption-desorption isotherms, X-ray diffraction, transmission electron microscopy, temperature-programmed reduction, and thermogravimetric analysis, and their catalytic performance in the CO₂ reforming of methane (CRM) to syngas was evaluated. The results show that compared with Ni/SBA-15 prepared using a conventional impregnation method, the cyclodextrin-modified catalysts had smaller NiO particles. They also exhibited higher catalytic activity and had stronger ability to resist carbon deposition in the CRM. Mechanistic studies showed that for the unmodified catalysts, Ni²⁺ could migrate into the channels of SBA-15 as a result of concentration differences, and the Ni species were sintered during the following thermal treatment processes, and could not be well dispersed. In contrast, various types of complex were formed between Ni(NO₃)₂ and the cyclodextrins, and this would be favorable for Ni²⁺ being taken into the channels of the SBA-15. The presence of cyclodextrins was beneficial to the mutual isolation of Ni species, and finally resulted in better dispersion of Ni species.

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1. Introduction

In response to the depletion of petroleum reserves, the effective use of natural gas is being extensively studied. Among the methods of natural gas use, catalytic CO₂ reforming of methane (CRM) to produce syngas has attracted attention; it is environmentally friendly because it converts two greenhouse gases (CO₂ and CH₄) to syngas and finally high-value-added products [1–4].

Catalyst development is the bottleneck in the industria-

lization of CRM. Transitional metals are usually used. Noble metals such as Rh, Ru, Ir, and Pd show good catalytic performance in CRM, but their high prices limit their use. Ni-based catalysts are most widely used because of their low costs and high initial catalytic activity in CRM [5–8]. However, Ni-based catalysts suffer from carbon deposition. It has been reported that the size of Ni particles greatly influences the amounts of carbon deposited, and catalysts with smaller NiO particles have stronger ability to resist carbon deposition [9].

There are several ways to prepare well-dispersed Ni-based

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catalysts. Catalysts with hydrotalcite [10,11] and perovskite [12–14] structures can disperse Ni particles to some extent. However, these structures are apt to collapse at the high reaction temperatures (600–900 °C). Catalysts with small Ni particles can be obtained by loading Ni precursors onto supports with high specific surface areas and ordered mesoporous structures, such as MCM-41 and SBA-15, because of the confinement effects of the supports [15–17]. However, the Ni particles are sintered during thermal treatment.

In our previous study, we found that a modified impregnation method using β -cyclodextrin (β CD) was effective for preparing well-dispersed Ni-based catalysts and resisting Ni sintering during heat treatment and the CRM reaction [18]. In this study, the use of other CDs such as α CD and γ CD as promoting additives for improving the dispersion of Ni particles on the surface of Ni/SBA-15 was examined, and the properties and performance of α CD- and γ CD-modified catalysts were studied and compared with those of the unmodified one.

2. Experimental

2.1. Catalyst preparation

Poly(ethylene glycol)-*block*-poly(propylene glycol)-*block*-poly(ethylene glycol) (P123) of molecular mass 5800 was obtained from Aldrich. Tetraethyl orthosilicate (TEOS) of purity 99.5% was purchased from Acros. Hydrochloric acid (36%–38%) was purchased from Beijing Chemical Company. Analytical-grade $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ was provided by Shantou Xilong Chemical Company. α CD was purchased from Aladdin and γ CD was purchased from TCI Company. All reagents were used as received.

The SBA-15 support (815 m^2/g) was prepared with P123 as a template and TEOS as the precursor [19]. The catalysts prepared using α CD and γ CD are denoted by Ni/SBA-15- α CD and Ni/SBA-15- γ CD, respectively. The molar ratio $n(\text{CD})/n(\text{Ni})$ was 1/50. Ni/SBA-15 prepared using the conventional impregnation method (without CDs), denoted by Ni/SBA-15-im, was used as a reference. The detailed preparation procedures are described in the literature [18]; the theoretical loadings of Ni for all the catalysts were 4.8 wt%.

2.2. Catalyst characterization

The specific surface areas of the fresh catalysts were measured by the N_2 adsorption-desorption method using a Micromeritics ASAP 2010 C analyzer. Before the measurements, the catalysts were degassed at 200 °C for 2 h.

X-ray diffraction (XRD) was used to investigate the crystalline phases of the Ni species in the catalysts. The XRD patterns were obtained with a Rigaku X-ray diffractometer using Ni-filtered $\text{Cu } K_\alpha$ radiation at 40 kV and 200 mA. The crystal sizes of the NiO particles were determined by the X-ray line-broadening method using the Scherrer equation.

The actual loadings of Ni on the fresh catalysts were determined using X-ray fluorescence (XRF; XRF-1800).

The catalyst morphology and NiO particle size were examined by transmission electronic microscopy (TEM) using a

Tecnai G² 20 instrument. Before measurements, the samples were crushed and dispersed on copper meshes with ethanol as the solvent.

The reduction behavior of the catalysts was characterized using temperature-programmed H_2 reduction (H_2 -TPR), and the TPR profiles were recorded with a Quantachrome adsorption instrument; details of the procedure are available in the literature [18].

The mass spectra of aqueous solutions of the promoter (α CD or γ CD) and $\text{Ni}(\text{NO}_3)_2$ were obtained using a mass spectrometric detector (Turbomass) to identify the interactions between the promoters and $\text{Ni}(\text{NO}_3)_2$.

2.3. Catalytic performance

CRM to syngas was conducted in a fixed-bed quartz reactor with an inner diameter of 5 mm at atmospheric pressure. Before the reaction, a portion of the catalyst (0.20 g) was reduced with 20% H_2 /80% Ar at 600 °C for 2 h. The temperature was raised to the reaction temperature (700 °C), and then CH_4 (99.9%) and CO_2 (99.9%) in a molar ratio of 1/1 were introduced into the reactor at a total flow rate of 43 mL/min. The flow rate of the gaseous products was measured with a soap-flowmeter, and the components were analyzed using online gas chromatography. The relative amounts of gases in the products were calculated using the normalization method. The equations used for calculating CH_4 conversion, CO_2 conversion, and selectivity are shown below:

$$\begin{aligned}\text{CH}_4 \text{ conversion} &= \frac{V_{\text{in}}(\text{CH}_4) - V_{\text{out}}(\text{CH}_4)}{V_{\text{in}}(\text{CH}_4)} \\ \text{CO}_2 \text{ conversion} &= \frac{V_{\text{in}}(\text{CO}_2) - V_{\text{out}}(\text{CO}_2)}{V_{\text{in}}(\text{CO}_2)} \\ \text{CO selectivity} &= \frac{V_{\text{out}}(\text{CO})}{[V_{\text{in}}(\text{CO}_2) - V_{\text{out}}(\text{CO}_2)] + [V_{\text{in}}(\text{CH}_4) - V_{\text{out}}(\text{CH}_4)]} \\ \text{H}_2 \text{ selectivity} &= \frac{V_{\text{out}}(\text{H}_2)}{2 \times [V_{\text{in}}(\text{CH}_4) - V_{\text{out}}(\text{CH}_4)]}\end{aligned}$$

3. Results and discussion

3.1. Textural properties of fresh catalysts

The textural properties of the SBA-15 support and the fresh catalysts (Ni/SBA-15- α CD, Ni/SBA-15- γ CD, and Ni/SBA-15-im) were determined using N_2 adsorption-desorption; the isotherms and pore size distributions are shown in Fig. 1. All the catalysts had type IV adsorption-desorption isotherms with H_2 hysteresis loops (Fig. 1(a)). These are typical of the ordered mesoporous structure of SBA-15, i.e., Ni loading and modification with promoters did not destroy the SBA-15 structure. The average pore sizes of these catalysts were 4–6 nm and were similar to each other (Fig. 1(b)).

The specific surface areas of these catalysts are listed in Table 1. The data show that the α CD- and γ CD-modified catalysts had similar specific surface areas, in the range of 529–580

Fig. 1. N_2 adsorption-desorption isotherms (a) and pore size distributions (b) of fresh Ni/SBA-15 catalysts. *From [18].

m^2/g , i.e., lower than that of the SBA-15 support ($815 m^2/g$).

The Ni contents of these catalysts were analyzed using XRF; the results are listed in Table 1. The Ni contents of all the catalysts were around 4.8–5.5 wt%, close to the theoretical value.

3.2. Crystal structure of fresh catalysts

The crystal structure of the fresh catalysts was determined using XRD; the results are shown in Fig. 2. In the small-angle XRD patterns (Fig. 2(a)), there were diffraction peaks at 1° – 2° ; this indicates that all the catalysts maintained the ordered mesoporous structure of SBA-15 even after calcination at $650^\circ C$. In the wide-angle XRD patterns (Fig. 2(b)), there was a wide and broad peak at 10° – 30° , ascribed to amorphous silica. Furthermore, similar to the results obtained for a β CD-modified catalyst (Ni/SBA-15- β CD) [18], in the wide-angle XRD patterns of the α CD- and γ CD-modified catalysts, the NiO peaks (at 37.5° ,

Fig. 2. Small-angle (a) and wide-angle (b) XRD patterns of fresh Ni/SBA-15 catalysts. *From [18].

43.4° , and 63.0°) were too weak to be used to calculate the NiO particle sizes using the Scherrer equation. However, the NiO peaks in the profile of the unmodified Ni/SBA-15-im catalyst were sharp, and the average NiO size was 9.1 nm (from the Scherrer equation). These results show that α CD and γ CD improved Ni dispersion on the modified catalysts.

3.3. Morphology and size of NiO particles in fresh catalysts

The morphology and size of the NiO particles in these Ni/SBA-15 catalysts were studied using TEM; the results are shown in Fig. 3. In the TEM images of all the catalysts, the ordered mesoporous structure of SBA-15 can be observed, consistent with the Brunauer–Emmett–Teller (BET) results and XRD patterns. In addition, NiO particles of size 10–20 nm can be clearly observed on the unmodified Ni/SBA-15-im. The SBA-15 channel size is 4–6 nm [18], therefore it can be conjectured that in Ni/SBA-15-im the NiO particles are mostly distributed on the outer surfaces of SBA-15. In contrast, similar to the results for Ni/SBA-15- β CD in our previous study [18], no NiO particles could be seen in the TEM images of the α CD- or γ CD-modified catalysts, although energy-dispersive X-ray spectroscopy showed the presence of Ni species in the two catalysts (figure not shown). These results show that as in the case of Ni/SBA-15- β CD, the NiO particles in Ni/SBA-15- α CD and Ni/SBA-15- γ CD were too small to be observed by TEM. It can be speculated that the NiO particles are dispersed inside the SBA-15 channels.

Table 1
Textural properties of SBA-15 support and Ni/SBA-15 catalysts.

Catalyst	Pore volume ^a (cm^3/g)	Specific surface area ^a (m^2/g)	Ni content ^b (%)	Carbon deposited ^c (%)
SBA-15 *	0.86	815	—	—
Ni/SBA-15-im *	0.54	580	4.9	28.9
Ni/SBA-15- α CD	0.59	534	5.5	3.8
Ni/SBA-15- γ CD	0.58	529	4.8	4.9

^a Measured by N_2 adsorption-desorption method. ^b Measured by XRF.

^c Measured by TGA. *From [18].

Fig. 3. TEM images of fresh Ni/SBA-15 catalysts. (a) Ni/SBA-15-im from [18]; (b) Ni/SBA-15- α CD; (c) Ni/SBA-15- γ CD.

3.4. Reduction behavior of Ni/SBA-15 catalysts modified with different promoters

The reduction behavior of NiO and the interactions between NiO particles and the supports was investigated using H_2 -TPR; the results are shown in Fig. 4. Only one wide NiO reduction peak, at 600 °C, can be observed for the Ni/SBA-15-im catalyst. The NiO reduction profiles of the Ni/SBA-15 catalysts modified with α CD or γ CD were similar to each other; there were two NiO reduction peaks for each of the CD-modified catalysts, with one centered at 400–500 °C and the other centered at 700–800 °C. Generally, the positions of the NiO reduction peaks reflect the NiO particle sizes and the strength of the interactions between NiO and the supports. The lower the NiO reduction temperature on the catalyst, the larger the NiO particles and the weaker the interactions between NiO and the support [20]. It can therefore be speculated that modification with α CD or γ CD greatly decreased the size of the NiO particles, and that the interactions between NiO and the support were much improved over the α CD- and γ CD-modified catalysts.

3.5. Catalytic performance of Ni/SBA-15 catalysts in CRM to syngas

The catalytic performance of the Ni/SBA-15 catalysts in CRM to syngas under the reaction conditions of atmospheric pressure, 700 °C, and gas hourly space velocity (GHSV) 1.28×10^4 mL/(g h) was evaluated. The results are shown in Fig. 5. Ni/SBA-15-im showed the lowest CH_4 and CO_2 conversions (the

Fig. 4. TPR profiles of fresh Ni/SBA-15 catalysts. *From [18].

initial CO_2 conversion was 85% and the initial CH_4 conversion was 71%). The CH_4 conversion increased to 85% and the CO_2 conversion increased to about 95% over the CD-modified catalysts, i.e., modification with CDs improved the catalytic activity.

Long-term stability tests showed that the conversion of CH_4 and CO_2 decreased gradually over Ni/SBA-15-im during 50 h, whereas the modified catalysts showed excellent stability. As in the case of modification with β CD, modification with α CD or γ CD not only improved the activity but also enhanced the stability of the Ni/SBA-15 catalyst.

3.6. Textural properties of spent catalysts

The crystal structure of the spent Ni/SBA-15 catalysts was examined using XRD; the results are shown in Fig. 6. The Ni and C diffraction peaks for the unmodified Ni/SBA-15-im catalyst are much sharper than the corresponding peaks for the CD-mo-

Fig. 5. Catalytic performance of Ni/SBA-15 catalysts in CRM to syngas. Reaction conditions: atmospheric pressure, 700 °C, $V(CH_4)/V(CO_2) = 1$, GHSV = 1.28×10^4 mL/(g h). *From [18].

Fig. 6. XRD patterns of spent Ni/SBA-15 catalysts after CRM. *From [18].

dified catalysts. The sharper Ni peak indicates that aggregation was severe and much larger Ni particles were formed on Ni/SBA-15-im during CRM, and the sharper peak for C implies that larger amounts of C were deposited on Ni/SBA-15-im.

The amounts of C deposited were determined using thermogravimetric analysis (TGA); the results are shown in Fig. 7. The mass loss at temperatures lower than 200 °C was ascribed to removal of adsorbed water, whereas the mass loss at about 600 °C arose from oxidation of deposited carbon. The amount of deposited carbon was calculated from the mass loss at about 600 °C; the results are listed in Table 1. The amounts of C deposited on the CD-modified samples (3.8%–4.9%) were much lower than those deposited on Ni/SBA-15-im (28.9%), showing that modification with CDs improved the anti-carbon-deposition properties of the Ni-based catalysts.

3.7. Possible mechanism of improved dispersion of Ni particles by promoters

As stated above, compared with the Ni/SBA-15-im catalyst prepared by the traditional impregnation method, Ni/SBA-15 catalysts prepared by modified impregnation methods using α CD or γ CD had smaller NiO particles and exhibited stronger

Fig. 7. TGA results for C deposited on spent Ni/SBA-15 catalysts after CRM. *From [18].

ability to resist C deposition in CRM to syngas. In a previous study [18], the mechanism of the improvement of Ni particle dispersion by β CD was investigated. In this study, the reasons for the improvement in NiO particle dispersion by α CD or γ CD during catalyst preparation processes were examined and confirmed. Aqueous solutions of $\text{Ni}(\text{NO}_3)_2$ and the promoter (α CD or γ CD) were prepared and analyzed using mass spectrometry. For both solutions, peaks attributed to complexes formed between Ni^{2+} and α CD or γ CD were observed in the MS positive scan (α CD + 2Ni^{2+} , α CD + 5Ni^{2+} , or γ CD + 2Ni^{2+}), and peaks attributed to complexes formed between NO_3^- and α CD or γ CD were observed in the MS negative scan (α CD + NO_3^- , α CD + 4NO_3^- , or γ CD + 2NO_3^-). These results show that interactions occurred between $\text{Ni}(\text{NO}_3)_2$ and the promoter (α CD or γ CD). It has been reported that α CD and γ CD can encapsulate metal cations [21]. It can therefore be speculated that when α CD- or γ CD-modified impregnation methods are used to prepare the catalysts, Ni^{2+} species are encapsulated within the CD cavities, and NO_3^- ions connect with the CD hydroxyl groups through hydrogen bonds to achieve charge balance (Fig. 8). Ni^{2+} then migrates into the SBA-15 channels together with the CDs, in the form shown in Fig. 8. These Ni species do not aggregate easily because of the presence of the CDs, which separate the Ni spe-

Fig. 8. Possible mechanism of Ni dispersion improved by (a) α CD and (b) γ CD.

Graphical Abstract

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Effects of α - and γ -cyclodextrin-modified impregnation method on physicochemical properties of Ni/SBA-15 and its catalytic performance in CO₂ reforming of methane

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α - and γ -cyclodextrins improved Ni dispersion. Compared with Ni/SBA-15-im, the Ni/SBA-15- α CD and Ni/SBA-15- γ CD had higher activity and stronger ability to resist carbon deposition in CO₂ reforming of methane.

cies and protect them from sintering. However, in the preparation of Ni/SBA-15-im by the conventional impregnation process, Ni²⁺ migrates into the SBA-15 channels under the action of concentration gradient, and the Ni species are sintered during thermal treatment and cannot be well dispersed.

4. Conclusions

α CD and γ CD were suitable promoters for improving the dispersion of Ni over Ni/SBA-15 catalysts. α CD or γ CD exerted effects similar to that of β CD. Compared with the unmodified Ni/SBA-15-im catalyst, the Ni/SBA-15- α CD and Ni/SBA-15- γ CD catalysts had much smaller Ni particles and gave better catalytic performance in CRM to syngas. A mechanistic study showed that interactions occurred between Ni(NO₃)₂ and the CDs, and these changed the states of the Ni species and affected NiO dispersion.

References

- [1] Bae J W, Kim A R, Baek S C, Jun K W. *React Kinet Mech Catal*, 2011, 104: 377
- [2] Murata S, Hatanaka N, Kidena K, Nomura M. *J Jpn Petrol Inst*, 2006, 49: 240
- [3] Fidalgo B, Menendez J A. *Chin J Catal* (催化学报), 2011, 32: 207
- [4] Song C S, Pan W. *Catal Today*, 2004, 98: 463
- [5] Tang S, Ji L, Lin J, Zeng H C, Tan K L, Li K. *J Catal*, 2000, 194: 424
- [6] Kim D K, Stöwe K, Müller F, Maier W F. *J Catal*, 2007, 247: 101
- [7] Laosiripojana N, Sutthisripok W, Assabumrungrat S. *Chem Eng J*, 2005, 112: 13
- [8] Huang J, Ma R X, Gao Z H, Shen C F, Huang W. *Chin J Catal* (黄健, 马人熊, 高志华, 沈朝峰, 黄伟. 催化学报), 2012, 33: 637
- [9] Bitter J H, Seshan K, Lercher J A. *J Catal*, 1999, 183: 336
- [10] Zhang J, Zhao N, Wei W, Sun Y H. *Int J Hydrogen Energy*, 2010, 35: 11776
- [11] Serrano-Lotina A, Martin A J, Folgado M A, Daza L. *Int J Hydrogen Energy*, 2012, 37: 12342
- [12] Gallego G S, Mondragon F, Barrault J, Tatibouet J M, Batiot-Dupeyrat C. *Appl Catal A*, 2006, 311: 164
- [13] Moradi G R, Rahmanzadeh M, Sharifnia S. *Chem Eng J*, 2010, 162: 787
- [14] Choudhary V R, Mondal K C. *Appl Energy*, 2006, 83: 1024
- [15] Zhang M L, Ji S F, Hu L H, Yin F X, Li C Y, Liu H. *Chin J Catal* (张美丽, 季生福, 胡林华, 银凤翔, 李成岳, 刘辉. 催化学报), 2006, 27: 777
- [16] Albarazi A, Beaunier P, DaCosta P. *Int J Hydrogen Energy*, 2013, 38: 217
- [17] Liu D P, Quek X Y, Cheo W N E, Lau R, Borgna A, Yang Y H. *J Catal*, 2009, 266: 380
- [18] Liu H M, Li Y M, Wu H, Takayama H, Miyake T, He D H. *Catal Commun*, 2012, 28: 168
- [19] Zhou W, He D H. *Green Chem*, 2009, 11: 1146
- [20] Dong W S, Roh H S, Jun K W, Park S E, Oh Y S. *Appl Catal A*, 2002, 226: 63
- [21] Szejtli J. *Pure Appl Chem*, 2004, 76: 1825

α -和 γ -环糊精改性法制备的Ni/SBA-15催化剂的物化性质及其在甲烷二氧化碳重整中的催化性能

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摘要: 以多羟基有机物 α -或 γ -环糊精为分散促进剂制备了Ni/SBA-15催化剂, 通过N₂吸附-脱附、X射线衍射、透射电镜、程序升温还原和热重等手段对该催化剂的物理化学性质进行了表征, 并将其应用于甲烷二氧化碳重整(CRM)制合成气反应。结果显示, 与采用传统浸渍法制备的Ni/SBA-15催化剂相比, 采用 α -或 γ -环糊精改性法制备的催化剂具有更小的NiO颗粒, 并在CRM中显示出更高的催化活性及更强的抗积碳性能。机理研究表明, 采用传统浸渍法制备Ni/SBA-15催化剂时, 浸渍液中的Ni²⁺主要在浓度梯度

的作用下逐渐进入到SBA-15孔道内部, Ni^{2+} 水合物容易团聚, 分散程度较低; 而采用 α -或 γ -环糊精改性方法制备催化剂时, 在水溶液中 Ni^{2+} 与环糊精形成包覆物, 环糊精携带 Ni^{2+} 进入SBA-15孔道内, 并且环糊精的存在使得 Ni^{2+} 之间相互隔离, 以高度分散形态存在于SBA-15孔道表面, 有利于后续热处理中NiO在载体上较好地分散。

关键词: 镍; 分散度; 甲烷二氧化碳重整; 环糊精; 积碳

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