APPLICATIONS AND BENEFITS OF CORDIERITE COMPOSITE HONEYCOMB STRUCTURE FOR DIESEL EMISSIONS CONTROL

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Abstract

Stable oxygen concentration in exhausts is a prime factor in catalytic purification of the vehicle exhausts. Catalytic coating of Nanostructured CeO2 is added into ceramic support to adjust the oxygen concentration because it possesses a unique oxygen storage capacity (OSC). This paper, the cordierite-CeO2 composite ceramic with oxygen storage capacity was prepared as a support material for catalytic converters. The oxygen storage-release performance of the ceramics, adsorption process of oxygen and the oxygen storage, was examined by a gas chromatography. Results show that the novel cordierite-CeO2 composite ceramic is helpful in improving the purification effect of vehicle exhausts.

Keywords: Cordierite, CeO2, Oxygen storage capacity, Ceramic.

I. INTRODUCTION

The environmental impact on global warming has lead the authorities to regulate the automobile manufacturers to reduce the exhaust emissions. In order to meet the standards, the automobile manufacturers have developed engine management systems and catalytic converters to reduce the exhaust emissions. The purpose of the catalytic converters is to purify the engine exhaust by promoting reaction of undesired components. Cordierite materials are widely used for a number of technological applications and as catalytic converters.

In the present paper, the purification of exhaust gases on the vehicle catalytic converter the cordierite ceramic composite was considered for study. Nanostructured CeO2 was considered and studied using gas chromatography.

In a previous work, the results showed that the oxygen storage is essential in order to reduce emissions and traps on the cordierite ceramic.

II. EXPERIMENTAL PROCEDURES

The cordierite-CeO2 composite ceramics were prepared using Sintering methods. The trap has a cell geometry with porosity of 50% was investigated. The phase composition and microstructure of the ceramics were characterized in order to judge their possibility as the catalytic support with oxygen storage capacity.

A. Preparation of cordierite-CeO2 ceramics

Commercial Alumina, Silica, magnesia and ceria were used in the preparation. The powders were intensively mixed in different proportions at room temperature, which were [6] ground through ball milling for 3 h. The ground powders were selected to be in a granularity range of 74-63 μm by two screeners of 200# and 230# (ASTM E11-58T). Finally, the powders were sintered at 1300oC for 2 h for the measurement of OSC. The samples were coated with CeO2.

B. Characterization of phase and microstructure of ceramics

The phase composition of samples was identified by an X-ray powder diffractometer, with Cu-Kα radiation and applied voltage of 40kV and current of 120mA, and at a scanning speed of 4o /min. The surface morphology of samples was analyzed by a scanning electron microscope. The surface of the samples was mechanically polished and deposited a layer of gold by an ion-sputtering method.

C. Measurement of OSC

The samples for OSC were inspected by a gas chromatography. Helium gas was used as carrier gas. The samples were heated from room temperature to 1000°C [3]with a heating speed of 5°C/min to completely remove free oxygen from them, so that the temperature for releasing oxygen can be inspected during this process. At 1000oC, the samples were deoxidised by hydrogen at for 45 min and swept over by helium gas at 450°C for 45 min to remove undesirable gas compositions.

The samples were then conducted to measure the oxygen storage by an oxygen titration method.

III. RESULTS AND DISCUSSION

A. Phase composition and microstructure of ceramics

As shown by XRD phase identification in Fig.1 the ceramics composed [5] of α-cordierite and CeO2 dispersed in the cordierite matrix of the ceramics. On observation it is found that the size of the CeO2 is less that

175nm.The CeO2 has a unique property, the smaller is the particle size, the larger the surface area of the particle and higher the oxygen storage capacity.

The mechanical properties of cordierite and stability as a support for catalysis [6] in the operating range are extremely good much. As the sintering temperature is 450°C to obtain the pure cordierite phase. The CeO2 as a composite material in the cordierite possess good oxygen storage.

The XRD pattern of sample shows the phases of α-cordierite and CeO2 was clearly observed in Fig.3

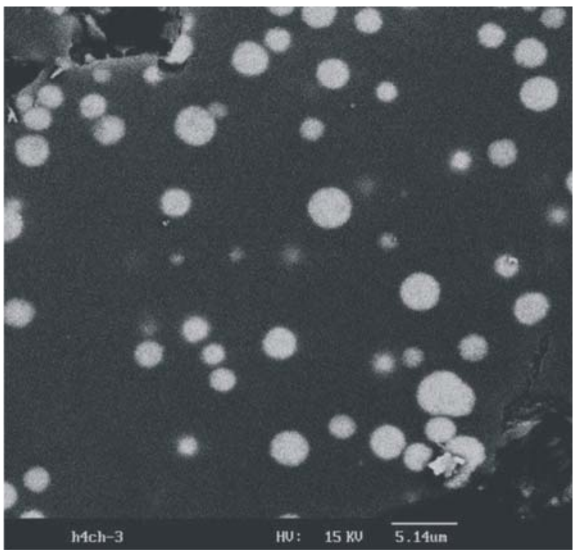


Fig.1. SEM morphology of cordierite and CeO2 Sample

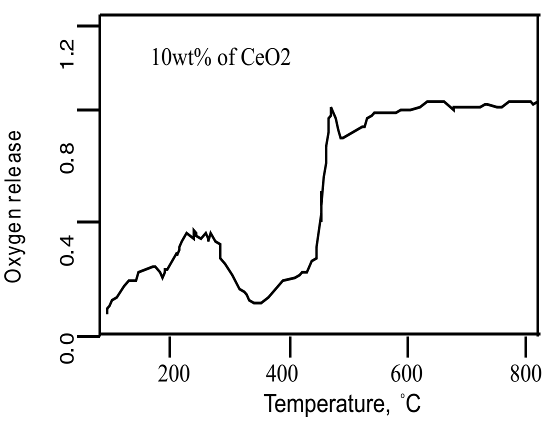


Fig. 2. TPR pattern for cordierite- CeO2

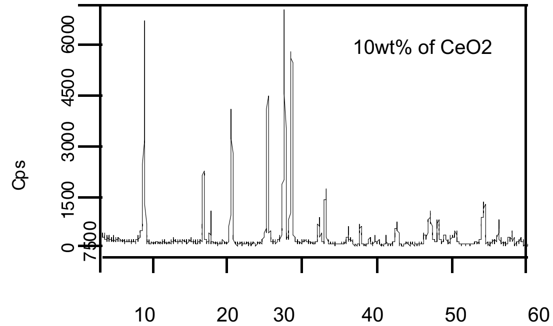


Fig. 3. XRD Pattern of sample with 10 wt% of CeO2, + Cordierite; * CeO2

B. Oxygen storage of ceramics

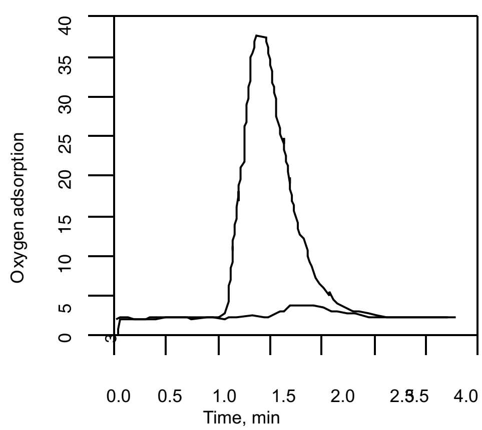
Fig. 2 shows sample releasing oxygen at temperatures below 250°C minimum and maximum 700°C.This range, clearly indicates the oxygen storage capacity of the ceramic composite.

In the Fig.4, the oxygen intake at the entry point of the converter is represented in line1 and oxygen remaining detected at exhaust in line2. The area between these lines represents the amount of oxygen stored in the samples.

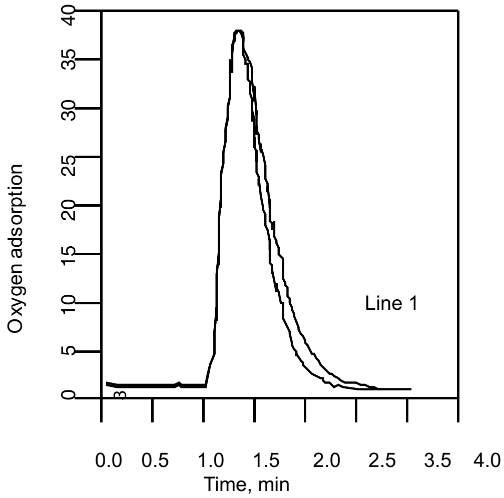
As indicated the pure CeO2 possess greater oxygen storage in comparison with ceramic composite. However, the cordierite in the presence of CeO2 with 10wt% possesses the expected capacity of oxygen storage and may increase with increase in CeO2 wt %.

Considering the mass of ceramics, which is much greater than that of catalytic coating. The oxygen storage capacity ceramics is less compared to the cordierite-CeO2.

Therefore, the Cordierite-CeO2 possesses enough oxygen storage capacity and is suitable to use as a catalytic support



(a) Pure CeO2 powder



(b) 10wt% 0f CeO2

Fig. 4. Oxygen storage curves

IV. CONCLUSION

Cordierite-CeO2 composite ceramics possess sufficient oxygen storage, with CeO2 particles uniformly dispersed in cordierite matrix. The smaller the size of CeO2 particle, the larger the surface area of the particle and higher the oxygen storage capacity. To conclude the nanostructured CeO2 possess excellent oxygen storage, which are aggregated by the small ones less than 200nm in diameter.

REFERENCES

[1] Paolo Scardi, Angelo and Francesco,1994, Thermal Stability of Cordierite Catalyst Supports Contaminated by Fe2O3, ZNO and V2O5. J. E. Ceramic soc., 13, pp. 275 – 282.

[2] Burch, S., Keyser, M., Potter, T., Benson, D., 1994 _ThermalAnalysis and Testing of a Vacuum Insulated Catalytic Converter,_SAE Technical Paper #941998.

[3] Benson, D.K., and Potter, T.F., 1995 U.S. Patent #5,477,676, _Method and Apparatus for Thermal Management of Vehicle Exhaust Systems_.

[4] Blandong, Jixin, Shujuan, Naijia, Manfred, Reinhard and Rolf, 2004, Study on metal-MFI /Cordierite as promising catalysts for selective catalytic reduction of nitric oxide by propane in excess oxygen. J. Catal.228, pp. 12-22.

[5] Shi, Liu, Yang, Liang, Pan and Gu, 2002, Evaluation of Cordierite ceria composite ceramics with oxygen storage capacity, J. E. Ceramic soc., 22 , pp. 1251-1256.

[6] Sang and Waltraud, 2003, Fabrication of low thermal expansion and low dielectric ceramic substrates by control of microstructure, J. E. Ceramic soc.,pp. 118-121.

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