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Low temperature complete combustion of CH_4 emitted from CNG vehicles over Ce-doped Nano Co-Mn catalyst

S. K. Gautam*, R. Prasad and S. Trivedi

Department of Chemical Engineering & Technology, IIT (BHU), Varanasi-221005, India
*Email: shivam.kgautam.che14@itbhu.ac.in

Compressed natural gas (CNG) is becoming a popular cleaner alternative fuel to gasoline/diesel and is used widely throughout the world owing to its several advantages. However, due to incomplete combustion, CNG vehicles emit significant amount of methane (CH_4) in the exhaust which is of great environmental concerns. CH_4 is a greenhouse gas having 21 times more global warming potential than CO_2. It is therefore essential to reduce anthropogenic CH_4 emissions. Catalytic oxidation is one of the best methods to control CH_4 emission. Platinum group metals (PGM) catalysts are highly active for CH_4 oxidation. Due to their expensiveness and rare availability, it is vital to find a substitute of PGM catalyst.

The aim of present work was to develop a cost effective, Ce doped Co-Mn catalysts ($Co_5Mn_{1-x}Ce_x$, x=0.1-0.5) for CH_4 oxidation at low temperature within the range of vehicle exhaust temperature (150-450°C). The catalysts (A, B, C, & D) with definite doping of Ce were prepared by co-precipitation method and calcined in a reactive 4.5%CO-air mixture to produce oxygen deficient catalyst (Table 1). The catalysts were characterized by XRD, FTIR and N_2-physisorption. The activity test of catalysts were performed in a fixed bed tubular reactor under the following conditions: 500 mg catalyst, 1.5% CH_4 in air, total flow rate 100 ml/min, heating rate 1°C/min, temperature range: ambient to 450°C. The gaseous reactants and products were analysed by an on-line GC equipped with porapack q-column, methanizer and FID detector.

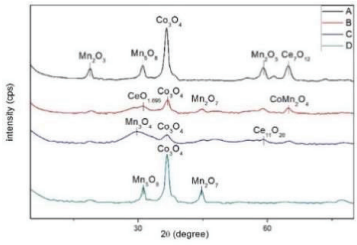

Figure 1: XRD Pattern of catalyst A, B, C and D

XRD pattern of the catalysts are presented in Figure 1. The intensity of XRD peaks increase in order C < B < A < D. The diffraction peaks of cat-C ($Co_5Mn_{0.9}Ce_{0.1}O_x$) show that it is almost amorphous. The crystallite sizes of the various cobaltite catalysts were calculated using the Debye-Scherrer eq. 1, as given in Table 2.

$$d = 0.89\lambda/\beta \cos\theta \quad (1)$$

Table 1: Crystallite size of prepared catalyst samples

Catalyst ID	Catalyst	Crystallite Size (nm)
A	$Co_5Mn_{0.5}Ce_{0.5}O_x$	4.72
B	$Co_5Mn_{0.7}Ce_{0.3}O_x$	9.03
C	$Co_5Mn_{0.9}Ce_{0.1}O_x$	14.59
D	Co_5MnO_x	10.62

The activity test results showed that performance of Ce doped catalysts was better than un-doped one. The lowest temperature for total combustion of CH_4 over the best catalyst was 407°C (Figure 2). Table 2 shows light off characteristics of the catalysts. The activity order of the catalysts is as follows: $Co_5Mn_{0.9}Ce_{0.1}O_x$ (407°C) > $Co_5Mn_{0.7}Ce_{0.3}O_x$ (465°C) > $Co_5Mn_{0.5}Ce_{0.5}O_x$ (495°C) > Co_5MnO_x (545°C). Doping appropriate amount of Ce enhances the activity of catalyst, Ce provides extra O for CH_4 oxidation.

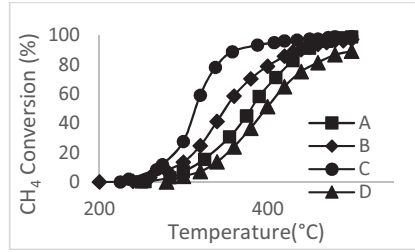

Figure 2: Activity test performance of Ce-promoted catalysts for CH_4 oxidation

Table 2: Light off temperature for Ce promoted catalysts.

Catalyst ID	Catalyst	T_{10} (°C)	T_{50} (°C)	T_{90} (°C)
A	$Co_5Mn_{0.5}Ce_{0.5}O_x$	310	380	450
B	$Co_5Mn_{0.7}Ce_{0.3}O_x$	290	350	440
C	$Co_5Mn_{0.9}Ce_{0.1}O_x$	270	315	360
D	Co_5MnO_x	330	400	510

References

1. Junhua Li, Xi Liang, Shicheng Xu, Jiming Hao, Appl. Catal. B, 90 (2009) 307.
2. Jinghuan Chen, Webno Shi, Junhua Li, Catal. Today, 175 (2011) 216.
3. Maninder Kumar, Gaurav Rattan, Ram Prasad, Canadian Chem. Tran., 3 (2015) 381.