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INFLUENCE OF PARAMETRS OF GLASS-FIBER CATALYST PACKING ON ITS APPARENT ACTIVITY IN NO, CO, C_3H_8 MIXTURE

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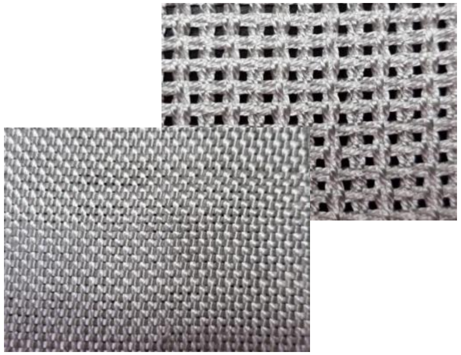
Introduction

At present time there is necessity to remove nitrogen oxides in gas mixtures where carbon monoxide and hydrocarbons are present, e.g. diesel fuel. One of the most promising approaches to remove pollutants is catalytic gas purification based on **glass-fiber catalysts**.

Glass-fiber catalysts possess:

- ✓ High mass transfer efficiency;
- ✓ Extra-low pressure drop;
- ✓ High activity in NO reduction, CO and C_3H_8 oxidation.



The structure of cartridge and the preparation method is suggested to make contribution to catalytic activity. **The aim of this study** is to investigate the effect of preparation method and structured elements.

Glass-fiber catalysts

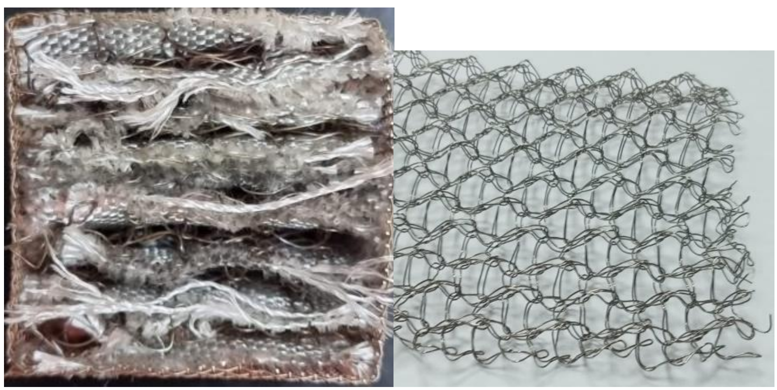
Pt was used as the active component for synthesis of GFC samples. The thermostable glass-fiber fabric was used as a support. The precursor was supported by both the conventional impregnation method (Pt/GFC–i) and by spraying (Pt/Zr/GFC–i) the precursor solution on the surface of glass-fiber fabric.

Catalyst	Pt/GFC - i	Pt/GFC - s	Pt/Zr/GFC-i
Synthesis method	conventional impregnation +surface thermal synthesis	Spraying + surface thermal synthesis	Impregnation + washing + incineration
Content of platinum, wt.%	0,085	0,022	0,026

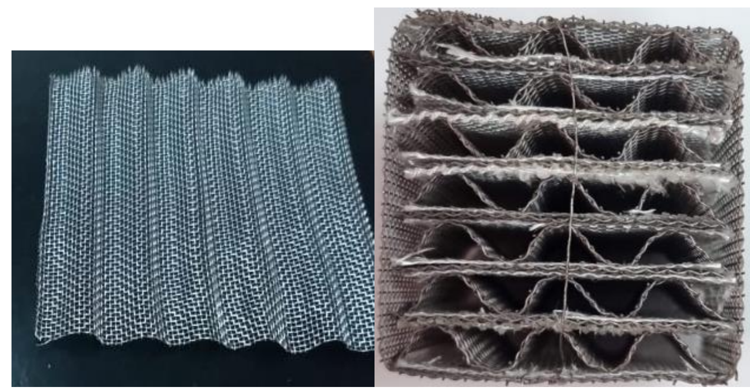
Pt/GFC–i is is a commercial catalyst IC-12-S111 [1]
Pt/Zr/GFC–i is is a commercial catalyst IC-12-S102 [2]

Glass-fiber catalysts

The catalyst cartridge is a system of alternating layers of fiberglass, corrugated and flat metal mesh or fiberglass and volume metal mesh. The catalyst cartridge has the shape of a parallelepiped with parameters 52 × 44 × 44 mm. The channels height (distance between the layers of glass cloth) may vary.



Catalyst design with volume metal mesh

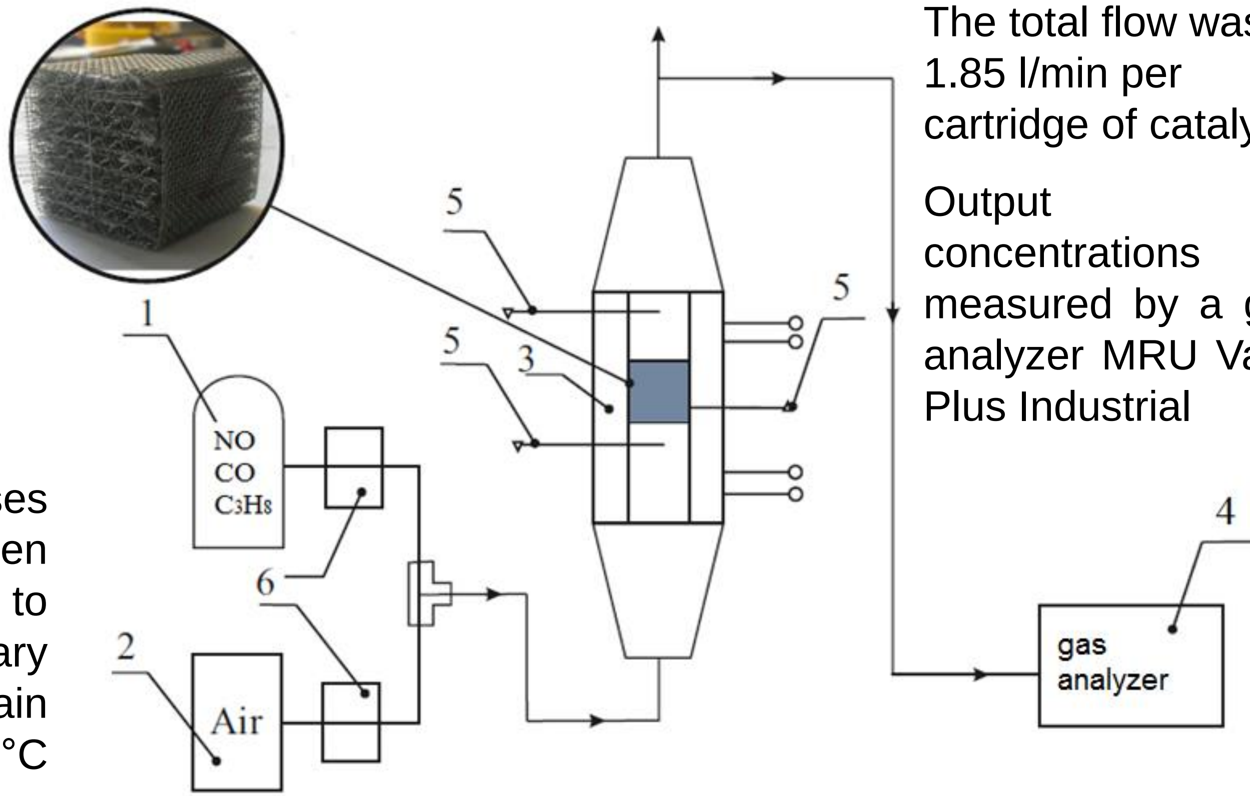


Catalyst design with corrugated and flat metal mesh (right)

Experiments

The gas mixture of CO, NO, C_3H_8 is mixed with air and passes into the reactor, where the catalyst cartridge is installed. The concentrations of CO, C_3H_8 and NO are ~ 80 ppm, ~ 120 ppm and ~ 50 ppm, respectively.

The temperature increases from 20 °C to 500 °C, then decreases from 500 °C to 100°C, while the stationary state is fixed at a certain temperature at 50 °C intervals.



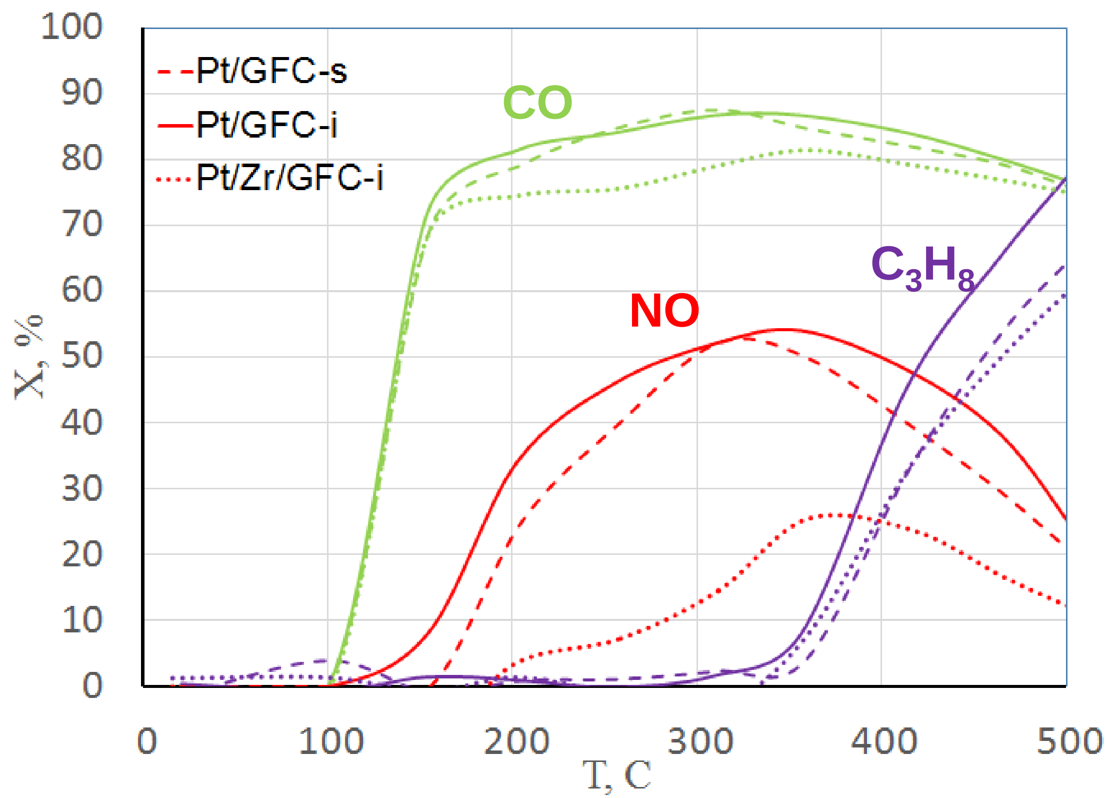
The total flow was 1.85 l/min per cartridge of catalyst.

Output concentrations are measured by a gas analyzer MRU Vario Plus Industrial

Scheme of experimental setup: 1 – NO, CO, C_3H_8 cylinder, 2 – air source, 3 – reactor, 4 – gas analyzer, 5 – thermocouples, 6 – flow-mass controllers.

Comparison of impregnated and sprayed catalysts

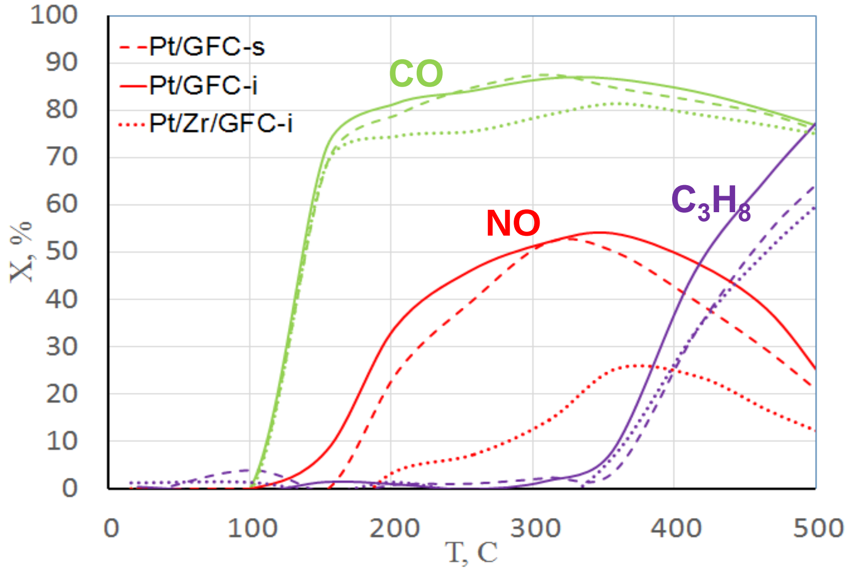
CO (green), NO (red), C_3H_8 (blue) conversion vs temperature at Pt/GFC-i (solid), Pt/GFC-s (dash) and Pt/GFC-102 (point) volume metal mesh

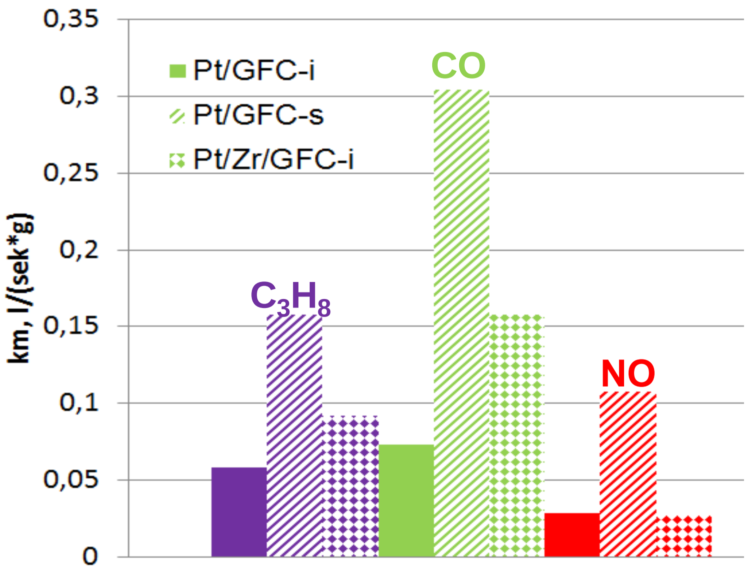


Conversion of CO starts at the low temperature and reaches 70% at 150 ℃. However, with a further rising temperature the CO conversion increases slowly without reaching 100% due to external diffusion inhibition of reaction. At temperatures above 400°C further CO conversion decreases and conversion of C_3H_8 begins, indicating that propane is oxidized to form both CO2 and CO. The NO conversion begins at 200 ℃, goes through a maximum and then decreases with increasing temperature due to more active involvement of oxygen as an oxidant instead of NO.

Comparison of impregnated and sprayed catalysts

It is seen that the activity of sample synthesized by impregnation is slightly more active. However, it should be noted that content of platinum in the sample obtained by impregnation is 4 times higher than that in the sample obtained by spraying, 0.085 wt% and 0.022 wt%, respectively.





Catalyst activity in terms of the amount of active component

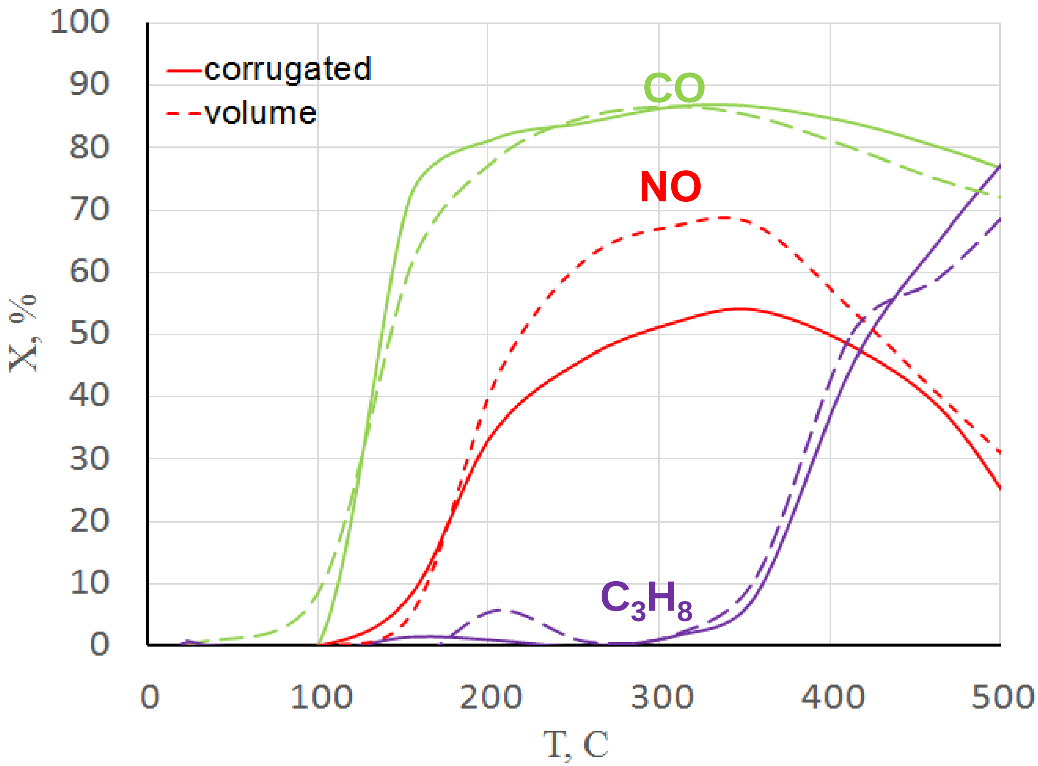
$$k_{mPt} = -\frac{u}{mC_{Pt}} \ln(1 - x)$$

km is calculated for the maximum conversion of each substance.

Consequently, the activity of the sample obtained by spraying is approximately 3 – 4 times higher than that of the impregnating catalyst and 2 times higher than that Pt/GFC-102

Comparison of GFC cartridges with different packing geometry

CO (green), **NO (red)**, **C_3H_8 (blue)** conversion vs temperature at Pt/GFC-i corrugated and flat metal mesh (solid) and volume metal mesh (dash)



The geometry of structured elements doesn't appear to significantly affect the catalytic activity of CO and propane oxidation but produces definite difference in NOx reduction rate, with higher reduction activity for cartridges with volume metal mesh.

Conclusion

It is seen that the activity of sample synthesized by impregnation is slightly more active due to the higher platinum content. The activity in terms of the amount of active component of sample synthesized by spraying is 3 times higher than that in the sample obtained by conventional impregnation and 2 times higher than sample synthesized by impregnation and incineration

The geometry of the structuring elements affects mass transfer efficiency, providing faster access of reagents to the catalyst surface. However, the effect of packing geometry at low flow rates was not found for CO and propane oxidation. It should be noted that diffusion inhibition affects NO reduction, volume metal mesh provides more efficient mass transfer and higher NO conversion, than corrugated and flat metal .

References

[1] A.N.Zagoruiko, S.A.Lopatin. Structured Glass-Fiber Catalysts. Francis & Taylor group, CRC Press, 2019, 158 p., https://doi.org/10.1201/9780429317569
[2] B.S. Balzhinimaev, E.A. Paukshtis, S.V. Vanag, A.P. Suknev, A.N. Zagoruiko, Glassfiber catalysts: Novel oxidation catalysts, catalytic technologies for environmental protection, Catal. Today 151, 2010, 195–199.

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