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Johnson Matthey Highlights

A selection of recent publications by Johnson Matthey R&D staff and collaborators

NON-PEER REVIEWED FEATURE

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Steam Reforming of Hydrocarbons for Synthesis Gas Production

M. Fowles and M. Carlsson, *Top. Catal.*, 2021, **64**, 856

This article is dedicated to the career of Mike Spencer. It describes the process and history of steam reforming for the production of synthesis gas (syngas) for manufacture of ammonia and methanol. The history of the development of tubular reforming is also described and the catalysts, technology and industrial operation of plants are briefly reviewed. Several newer technologies which aim to increase efficacy and reduce environmental impact, such as adiabatic reforming, autothermal reforming and gas heated reforming, are also discussed.

Backpressure Prediction for Flow-Through Monoliths and Wall-Flow Filters Using 1-Dimensional Models: Entrance Effect Pressure Change, Developing Flow and Validation Using Length-Varying Techniques

T. C. Watling, Y. Van Lishout and I. D. Rees, *Emiss. Control Sci. Technol.*, 2021, **7**, 247

A model for the prediction of backpressure in flow-through monoliths and particulate filters (PFs) is proposed and validated against literature results. Parts were progressively shortened in order to measure backpressure as a function of part length. Pressure was fixed at the inlet and pressure change at the exit was zero. Testing in both orientations of the PF doubles the available data since a PF becomes a partial PF after one cut. Partial PF data can be used to validate the balance equations of a full PF since they are governed by the same differential equations. CFD results for a channel with an upstream contraction were also used for model validation.

The Effect of Deposition Parameters on Microstructure and Electrochemical Performance of Reactively Sputtered Iridium Oxide Coatings

N. Page, J. Lucchi, J. Buchan, A. Fones, H. Hamilton, T. Scabarozi, L. Yu, S. Amini and J. Hettinger, *Mater. Today Commun.*, 2021, **29**, 102967

IrO_2 thin films used as electrode coatings in neurostimulation devices were synthesised using pulsed-DC reactive magnetron sputtering and characterised by surface analysis methods and cyclic voltammetry. Unusual platelet microstructure associated with IrO_2 (011) orientation was observed. Microstructure of the films was influenced by the deposition conditions. The platelets were present when the (011) orientation of IrO_2 was found in the X-ray diffraction spectra. Platelet microstructure improves the electrochemical performance by 20-fold as measured by cyclic voltammetry. Platelet microstructure was found to depend strongly on substrate temperature and oxygen concentration in the gas mixture.

A New Application of the Commercial High Temperature Water Gas Shift Catalyst for Reduction of CO_2 Emissions in the Iron and Steel Industry: Lab-Scale Catalyst Evaluation

L. Lukashuk, L. G. A. van de Water, H. A. J. van Dijk, P. D. Cobden, D. L. Dodds, T. I. Hyde and M. J. Watson, *Int. J. Hydrogen Energy*, 2021, **46**, (79), 39023

A commercial iron-based high temperature water gas shift (HTWGS) catalyst (KATALCO™ 71-6) was investigated for production of hydrogen from blast furnace gas (BFG) from iron and steel manufacturing. At laboratory-scale the catalyst demonstrated high water gas shift activity and stability; low methanation at reduced steam to CO ratios; and high resistance towards H_2S in the feed. KATALCO™ 71-6 was demonstrated to be robust towards BFG process conditions. The iron-based HTWGS catalyst KATALCO™

71-6 appears to be suitable for the production of hydrogen from BFG streams.

Global Kinetic Model of a Three-Way-Catalyst-Coated Gasoline Particulate Filter: Catalytic Effects of Soot Accumulation

J. De Abreu Goes, L. Olsson and T. C. Watling, *Ind. Eng. Chem. Res.*, 2021, **60**, (47), 16899

A global kinetic model of TWC-coated gasoline particulate filters was developed to gain understanding of the relevant kinetic mechanisms in clean and real soot-loaded filters. Reaction rate expressions for CO, C_2H_4 and C_7H_8 conversion over a model $Pd/CeZr/Al_2O_3$ catalyst hydrothermally treated at 650ºC were included in the model. The experimental trends observed during this study have enabled a new rate expression to be proposed for ethylene. The model satisfactorily predicted the conversion of all three reductants under different experimental conditions (**Figure 1**).

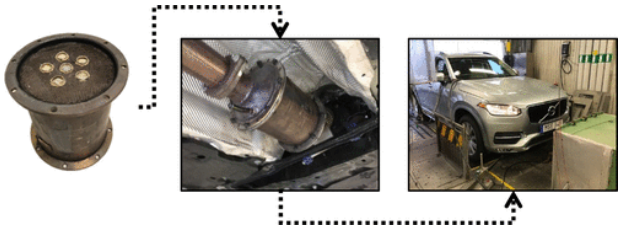

Fig. 1. Real soot collection procedure based on 10 h running aggressive RDE cycles in the vehicle chassis dynamometer. The injection timing and lambda set-point were modified to accelerate the soot collection. Reproduced from J. De Abreu Goes *et al.*, *Ind. Eng. Chem. Res.*, 2021, **60**, (47), 16899. Copyright 2021 American Chemical Society

Chemical Looping Reforming for Syngas Generation at Real Process Conditions in Packed Bed Reactors: An Experimental Demonstration

P. A. Argyris, C. Leeuwe, S. Zaheer Abbas, A. Amieiro, S. Poultson, D. Wails and V. Spallina, *Chem. Eng. J.*, 2022, **435**, (2), 134883

Chemical looping reforming (CLR) can combine autothermal operation with integrated CO_2 capture for syngas production. Here, CLR is demonstrated in packed bed reactors under pressures up to 5 bar at laboratory scale. A nickel-based oxygen carrier was tested under relevant conditions for >400 h. Four continuous cycles of oxidation–reduction-reforming and purges were tested. Oxidation, reduction and dry reforming processes were examined at 400–900ºC, 1–5 bar, 10–40 NLPM and different inlet gas compositions. The impact of pressure, initial solid temperature and composition in CLR was also studied.

Zeolite Supported Pd Catalysts for the Complete Oxidation of Methane: A Critical Review

H.-Y. Chen, J. Lu, J. M. Fedeyko and A. Raj, *Appl. Catal., A*, 2022, **633**, 118534

A critical review of zeolite supported palladium catalysts for complete methane oxidation. Recent literature reports on the development of zeolite supported palladium catalysts for the complete oxidation of methane are summarised. Different types of zeolite framework structures were found to have little influence on the methane oxidation activity or the on-stream stability of the supported palladium catalysts. However, the silicon:aluminium ratio of a zeolite support plays a critical role. Siliceous zeolites consistently outperform the counterparts with a low silicon:aluminium ratio in light-off activity and on-stream stability in both dry and wet feed.

Optimization of Non-thermal Plasma-Assisted Catalytic Oxidation for Methane Emissions Abatement as an Exhaust Aftertreatment Technology

R. Gholami, C. Stere, S. Chansai, A. Singhania, A. Goguet, P. Hinde, P. Millington and C. Hardacre, *Plasma Chem. Plasma Process.*, 2022, **42**, 709

Biogas methane-powered vehicles produce fewer greenhouse gas emissions in comparison to conventional fuel vehicles. This study investigates non-thermal plasma (NTP) assisted catalytic methane oxidation for low-temperature methane slip abatement. High CH_4 conversion and CO_2 selectivity could be obtained using NTP-catalysis at low temperature. Pd/Al_2O_3 was the best performing of the catalysts tested. CH_4 conversion efficiency was also found to depend on the feed gas components, gas hourly space velocity and method of introducing the activation energy. The study concludes that an oxidation catalyst combined with plasma to target hydrocarbon and CH_4 oxidation, followed by an ammonia-SCR system to convert the NOx formed in plasma assisted zone is the most suitable aftertreatment option.