



**Novel Application of Bio-char as a Catalyst
in the
Low Temperature SRC-deNO_x Process**

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- SCR unit located up stream of air pre-heaters, FGD and particulate control devices to meet temperature requirements (300 – 400 °C).
- SCR unit aids in the conversion of SO_2 to SO_3 and the production of ammonia salts ($(\text{NH}_4)\text{SO}_4$ / $(\text{NH}_4)\text{HSO}_4$) known for their respective corrosive and fouling nature.
- SCR unit replacement costly and performed during an outage.



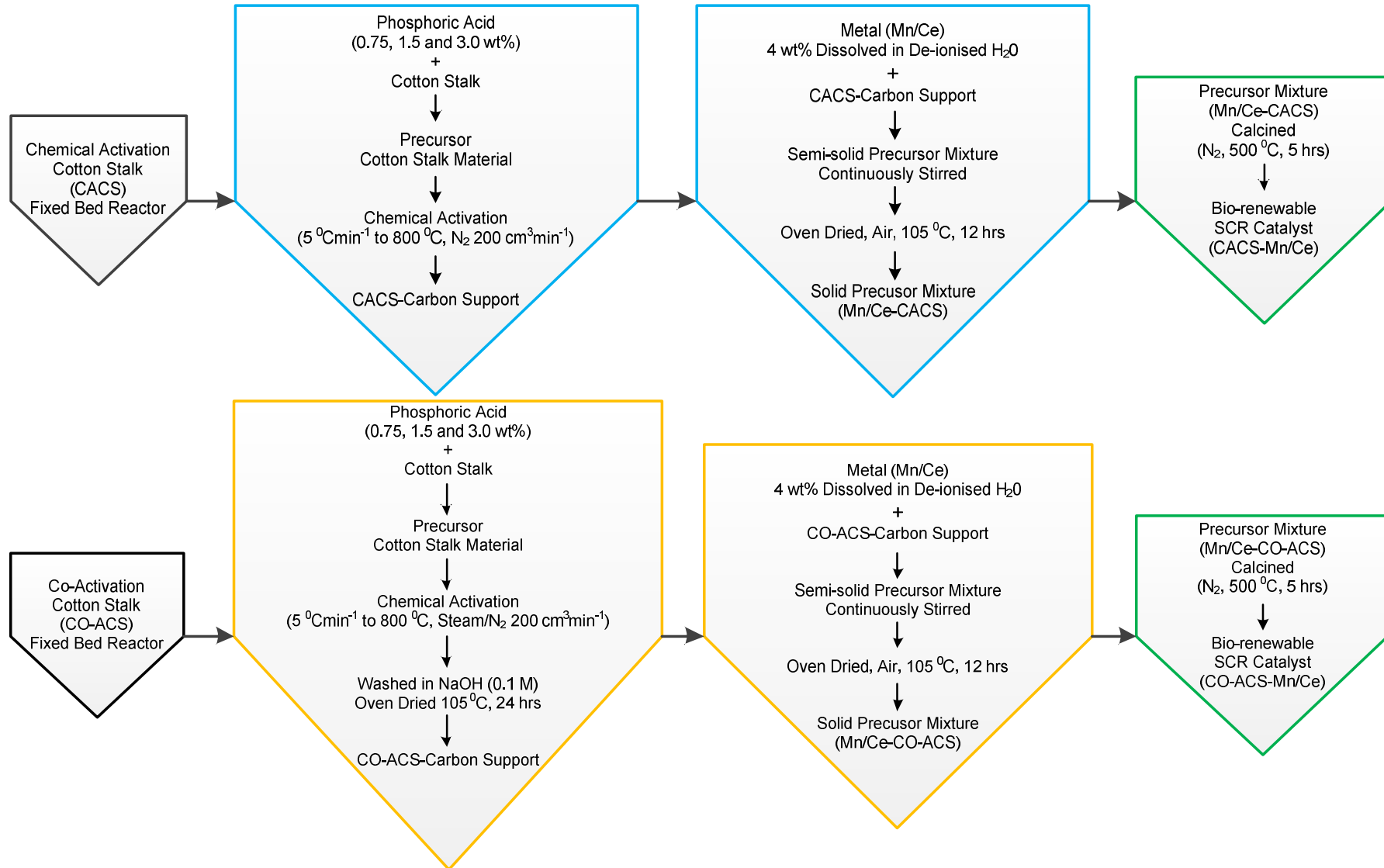
- Low temperature SCR (100 – 200 °C) down stream of air pre-heaters, FGD and particulate control devices.
- Low temperature SCR avoids conversion of SO_2 to SO_3 and the production of ammonia salts.
- Novel use of a waste derived SCR catalyst represents a way of combining waste disposal, energy recovery and pollution control (NO) in one process.
- Oxides of Manganese (Mn) and Cerium (Ce) demonstrate excellent performance at low temperatures due to unique redox and acid-base properties.

Chemical Activation and Co-activation Processes

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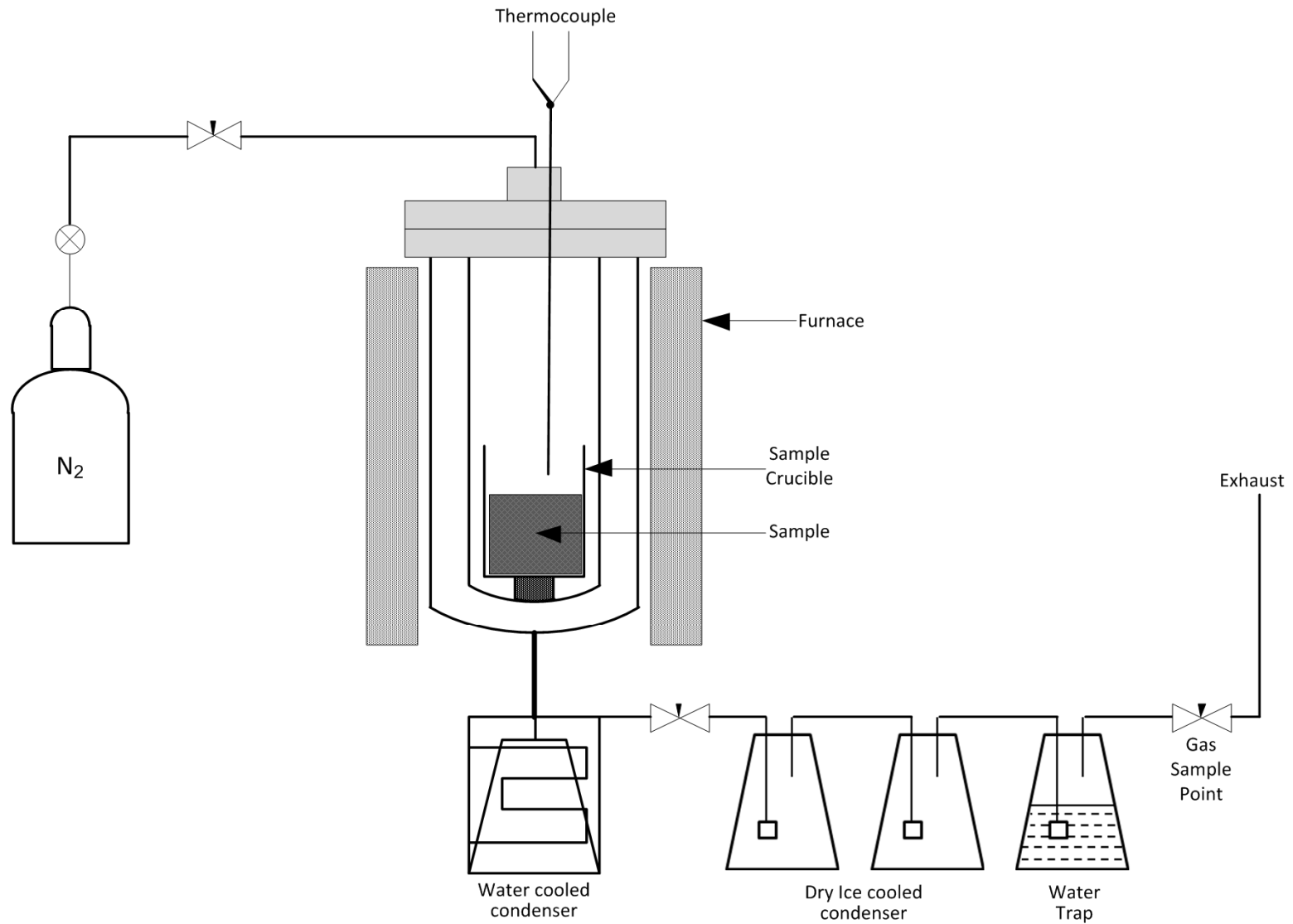


Fixed Bed Reactor Chemical Activation

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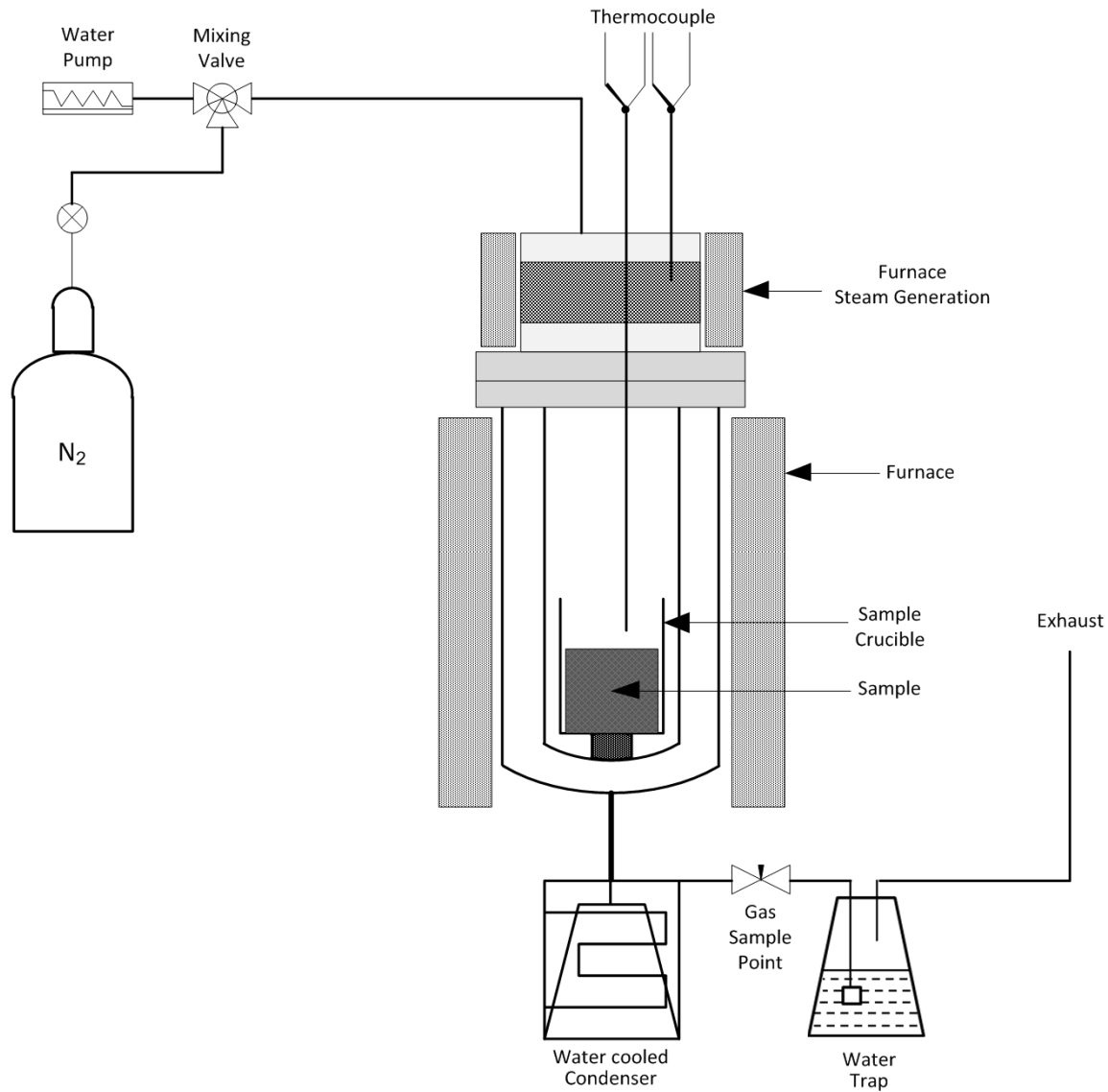


Modified Fixed Bed Reactor Co-activation

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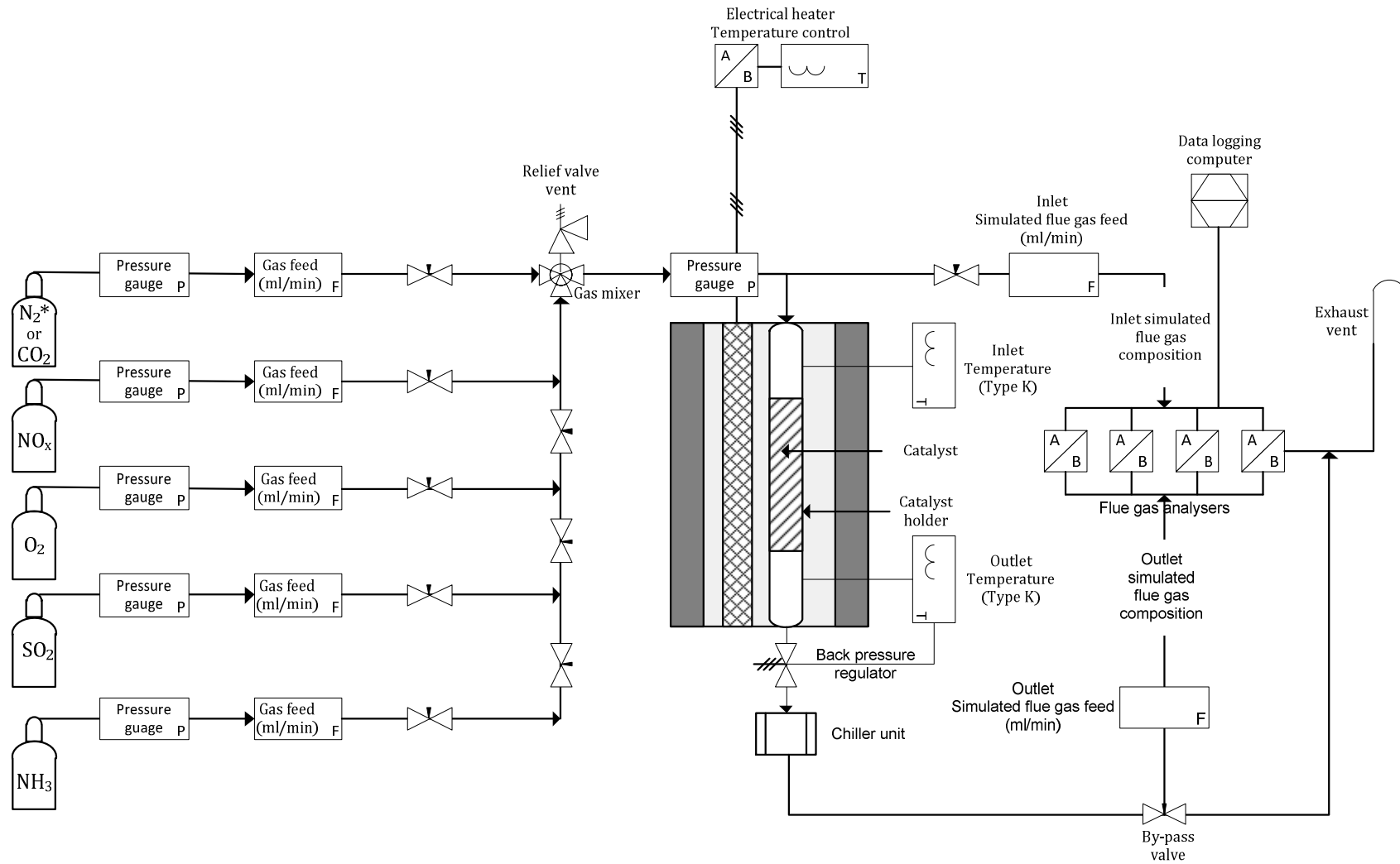
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Fixed Bed SCR Reactor FACULTY OF ENGINEERING



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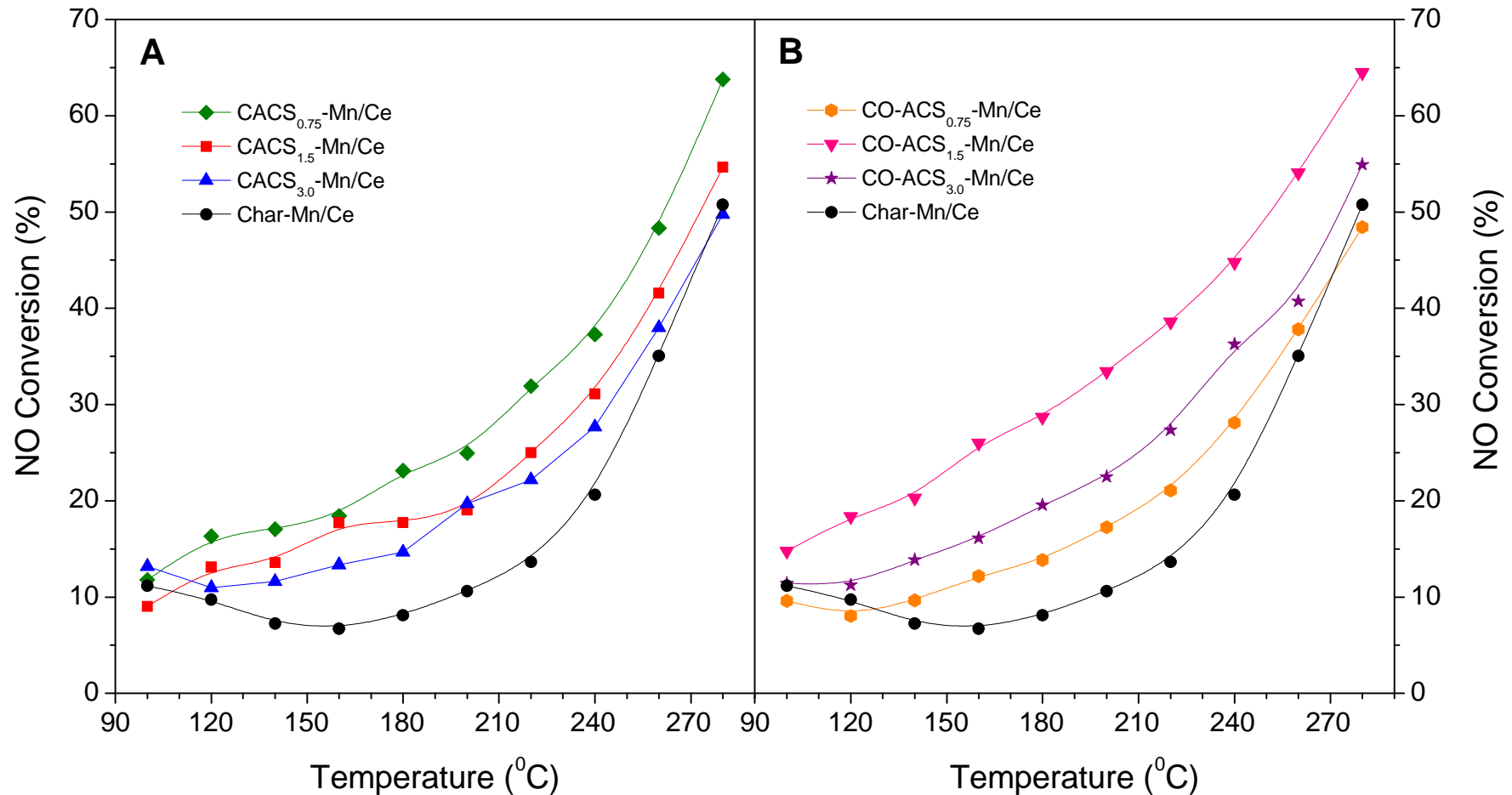
Chemical Activation

SCR-deNO _x Catalyst	Ce/Mn (Molar Ratio)	Temperature (°C)	H ₃ PO ₄ (wt% Ratio)	Hold Time (Hrs)	Atmosphere	BET Surface Area (m ² g ⁻¹)	Pore Diameter (nm)
CACS _{0.75} -Mn/Ce	1:2	800	0.75:1	2	N ₂	826.95	2.74
CACS _{1.5} -Mn/Ce	1:2	800	1.5:1	2	N ₂	1100.63	3.79
CACS _{3.0} -Mn/Ce	1:2	800	3.0:1	2	N ₂	1184.83	5.26

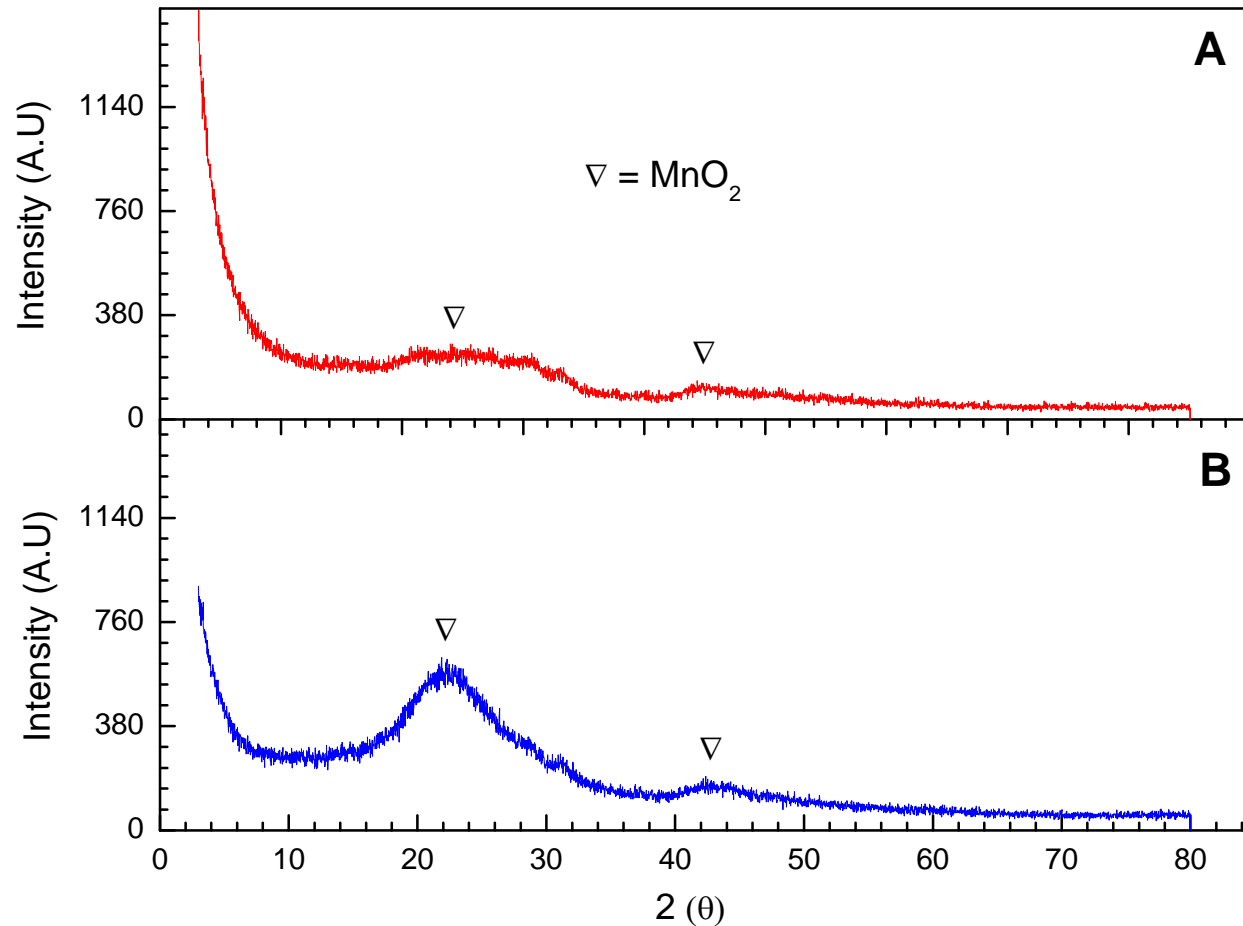
Co- Activation

CO-ACS _{0.75} -Mn/Ce	1:2	800	0.75:1	2	N ₂ /Steam	1293.90	2.46
CO-ACS _{1.5} -Mn/Ce	1:2	800	1.5:1	2	N ₂ /Steam	1613.63	3.45
CO-ACS _{1.5} -Mn/Ce	1:2	800	3.0:1	2	N ₂ /Steam	1541.00	4.61

Experimental conditions employed to chemically activate (CACS) and co-activate (CO-ACS) cotton stalk impregnated with Ce/Mn.



NO conversion (%) of chemically activated (CACS_x-Mn/Ce) and co-activated (CO-ACS_x-Mn/Ce) cotton stalk derived SCR-deNO_x catalysts impregnated with Mn/Ce. A = CACS_x-Mn/Ce, B= CO-ACS_x-Mn/Ce.



X-ray diffraction patterns of chemically activated ($\text{CACS}_x\text{-Mn/Ce}$) and co-activated ($\text{CO-ACS}_x\text{-Mn/Ce}$) cotton stalk derived SCR-de NO_x catalysts impregnated with Mn/Ce. A = $\text{CACS}_{1.5}\text{-Mn/Ce}$, B = $\text{CO-ACS}_{1.5}\text{-Mn/Ce}$.



- NO conversion efficiencies were seen to range from ~48 % to 68 % for both CACS_x-Mn/Ce and CO-ACS_x-Mn/Ce.
- The catalysts ability to oxidize NO to NO₂ is crucial for the overall conversion of NO to N₂:



- The required excess of O₂ for reactions 1 and 2 to occur is significantly reduced impacting on reactions 3 to 5.



- The redox potential of the catalysts is dependent on the transition metals (valency) ability to maximize reaction rates between NO and NH₃ in the presence of O₂ on their respective active sites.
- Saturation of the active sites is suggested to occur rapidly allowing for an increased excess of NH₃ and NO to pass un-reacted over the catalyst.
- The low metal loading of 4 wt% is thought to be mainly responsible for the conservative NO reductions.
- Historical literature has demonstrated NO reductions >95% for metal loadings ranging from 10 - 30 wt% at temperatures between 150 and 230 °C.



- The raw cotton stalk and pyrolysed char have shown a potential for possible application in the low temperature SCR-deNO_x process.
- NO reduction far more dependent on the wt% of the metal loading than the physical parameters such as the pore size, pore structure and surface area.
- The addition of phosphoric acid significantly increased the BET surface area (m²g⁻¹) for CACS_x-Mn/Ce and CO-ACS_x-Mn/Ce catalysts.
- Higher NO reductions can be realised by an increase in the metal loadings of Mn/Ce.



- The influence of the activation methods in conjunction with H_3PO_4 on NO reduction are complex and require further investigation.
- Investigate the highest NO reductions associated with metal loading (4 wt% - 30 wt%).
- SCR experiments using a variety of other waste materials as a catalytic support (MSW, waste plastics and waste tyres).
- SCR experiments to be conducted in a synthesised flue gas containing both particulates, SO_2 and H_2O as well as Hg.
- Investigate application of low temperature catalyst in NO emission control from heavy duty vehicle engines.

Acknowledgements



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