UNIVERSITY OF LEEDS

This is a repository copy of *Optimised PEI impregnation of activated carbons - Enhancement of CO2 capture under post-combustion conditions*.

White Rose Research Online URL for this paper:
http://eprints.whiterose.ac.uk/89498/

Version: Accepted Version

Conference or Workshop Item:
Salituro, A, Westwood, AVK, Ross, A et al. (1 more author) (Accepted: 2015) Optimised PEI impregnation of activated carbons - Enhancement of CO2 capture under post-combustion conditions. In: 14th Annual Carbon Capture, Utilization and Storage Conference, 28 Apr - 01 May 2015, Pittsburgh, Pennsylvania, USA.

Reuse
Unless indicated otherwise, fulltext items are protected by copyright with all rights reserved. The copyright exception in section 29 of the Copyright, Designs and Patents Act 1988 allows the making of a single copy solely for the purpose of non-commercial research or private study within the limits of fair dealing. The publisher or other rights-holder may allow further reproduction and re-use of this version - refer to the White Rose Research Online record for this item. Where records identify the publisher as the copyright holder, users can verify any specific terms of use on the publisher's website.

Takedown
If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

White Rose university consortium
Universities of Leeds, Sheffield & York

eprints@whiterose.ac.uk
https://eprints.whiterose.ac.uk/

UKCCS RESEARCH CENTRE

School of Chemical and Process Engineering (SCAPE)
FACULTY OF ENGINEERING

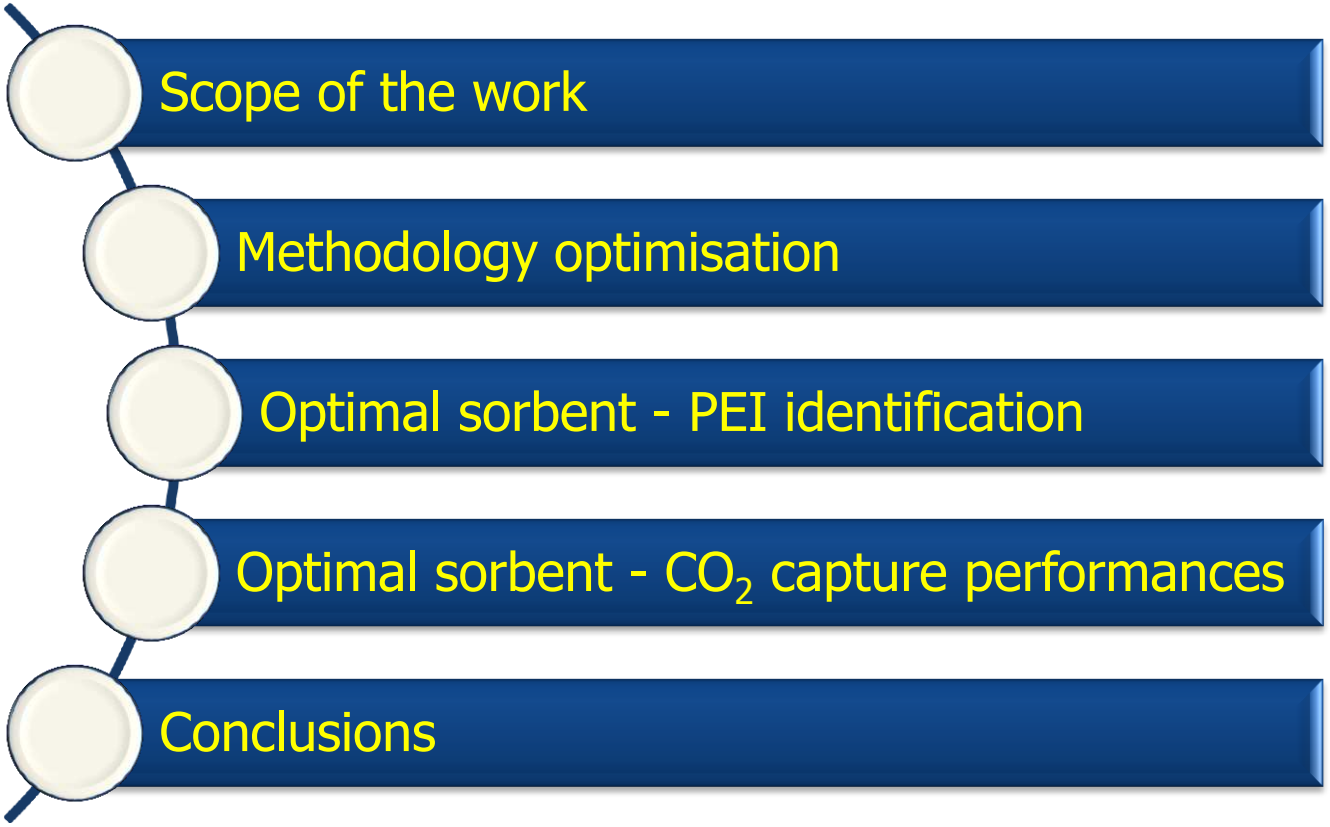
UNIVERSITY OF LEEDS

Optimised PEI impregnation of activated carbons - Enhancement of CO_2 capture under post-combustion conditions

Antonio Salituro, PhD student

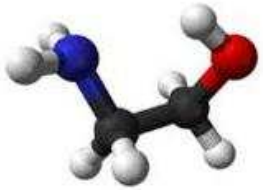
pmasal@leeds.ac.uk

Overview


Scope of the work
Methodology optimisation
Optimal sorbent - PEI identification
Optimal sorbent - CO_2 capture performances
Conclusions

Scope of the work

MEA
(Liquid solvent)



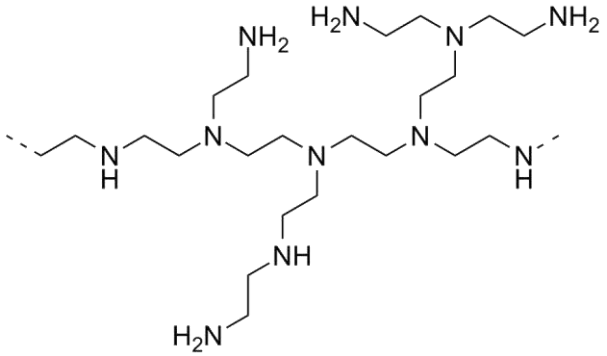
- Difficult handling
- Reactor Corrosion
- Degradation
- Energy demanding regeneration

Solid
Activated carbon

Amines incorporation

Methodology optimisation

Branched Polyethileneimine (PEI)



+

Solvent
(Methanol or Water)

15 min Stirring

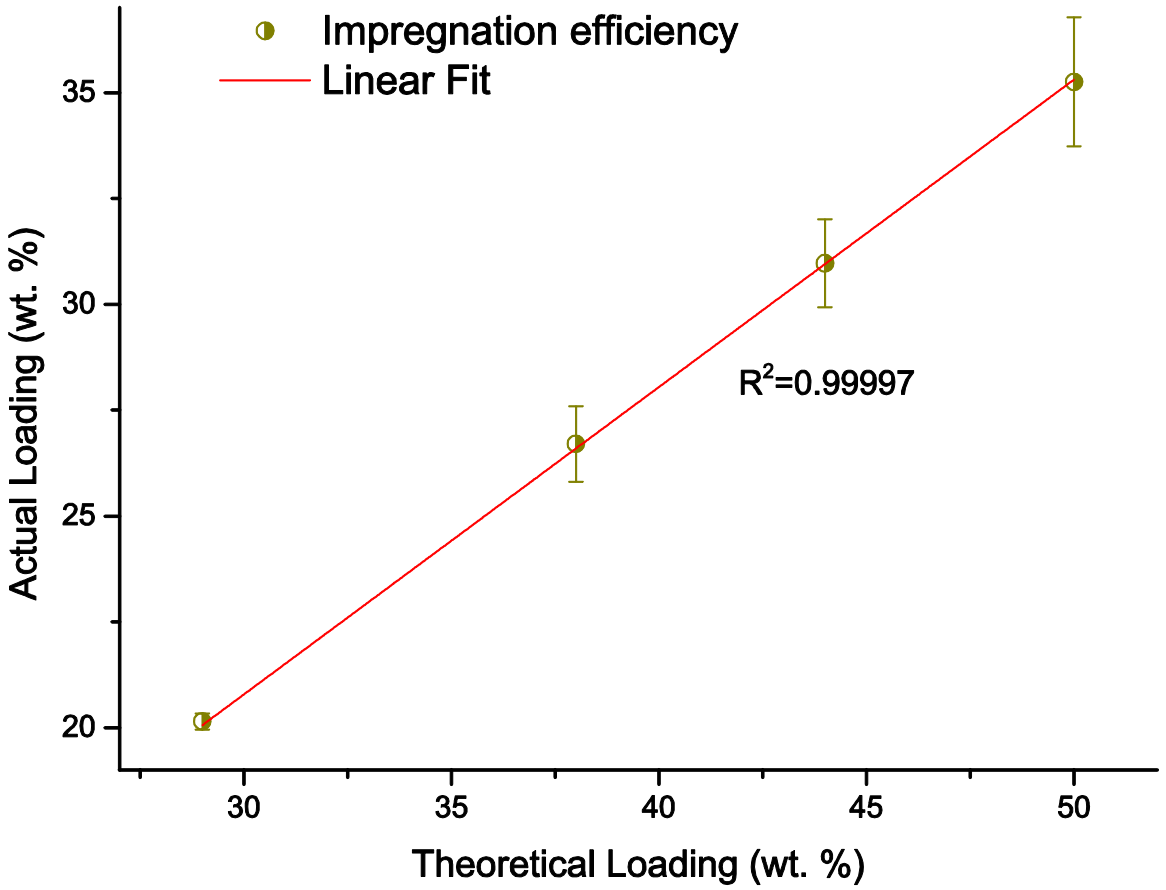
Activated carbon
(AR)

Further Stirring
0.5, 2, 4, 6 or 8 h

PEI-impregnated AR
Theoretical Loading:
29, 38, 44 or 50 wt. %

Methodology optimisation

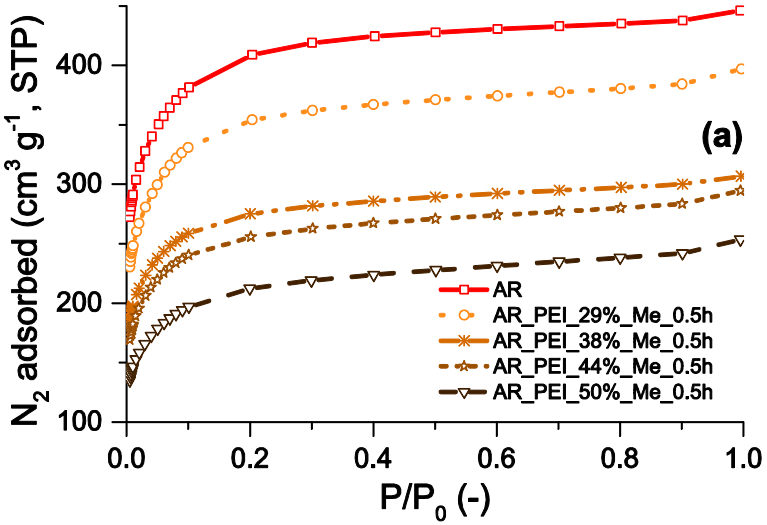
Effect of PEI loading (Stirring time=0.5 h; Solvent=methanol)

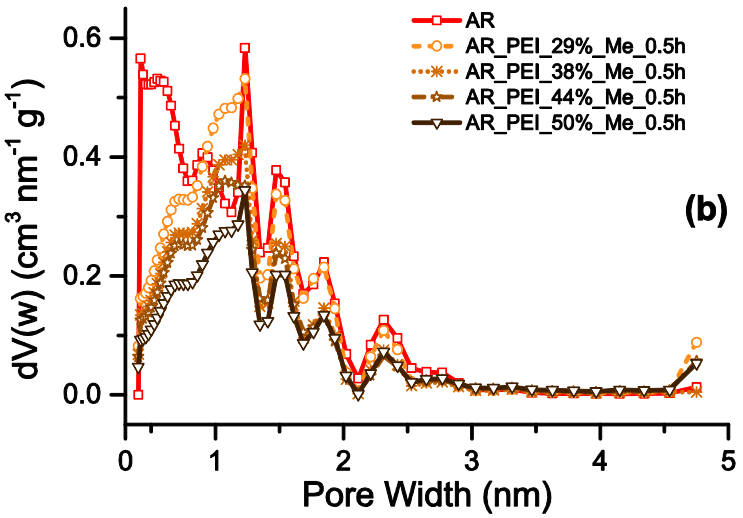


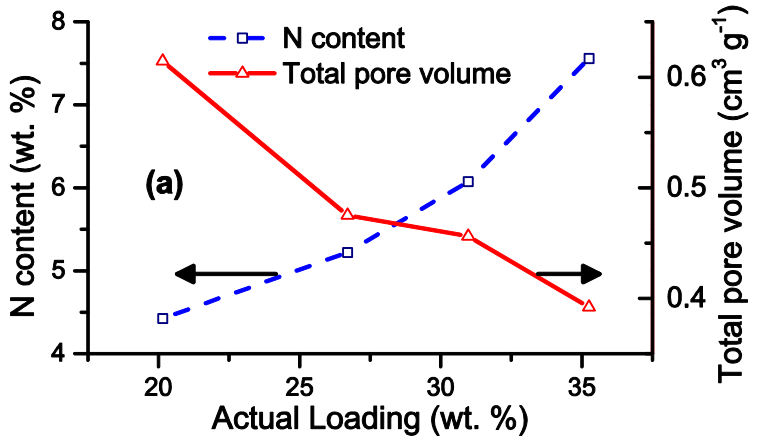
Constant Impregnation Efficiency = ca. 70%

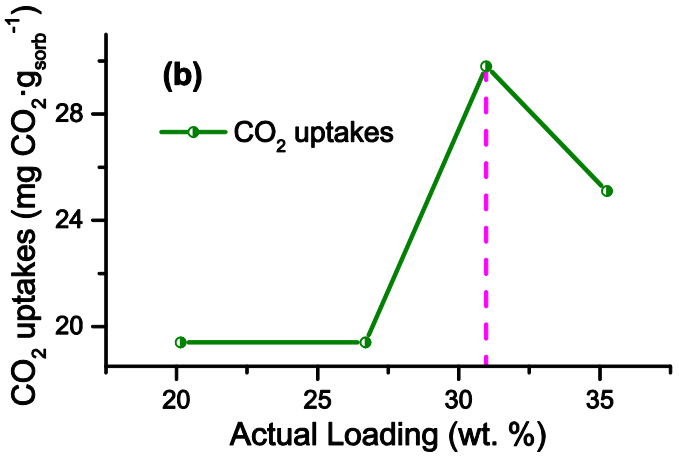
Methodology optimisation

Effect of PEI loading (Stirring time=0.5 h; Solvent=methanol)





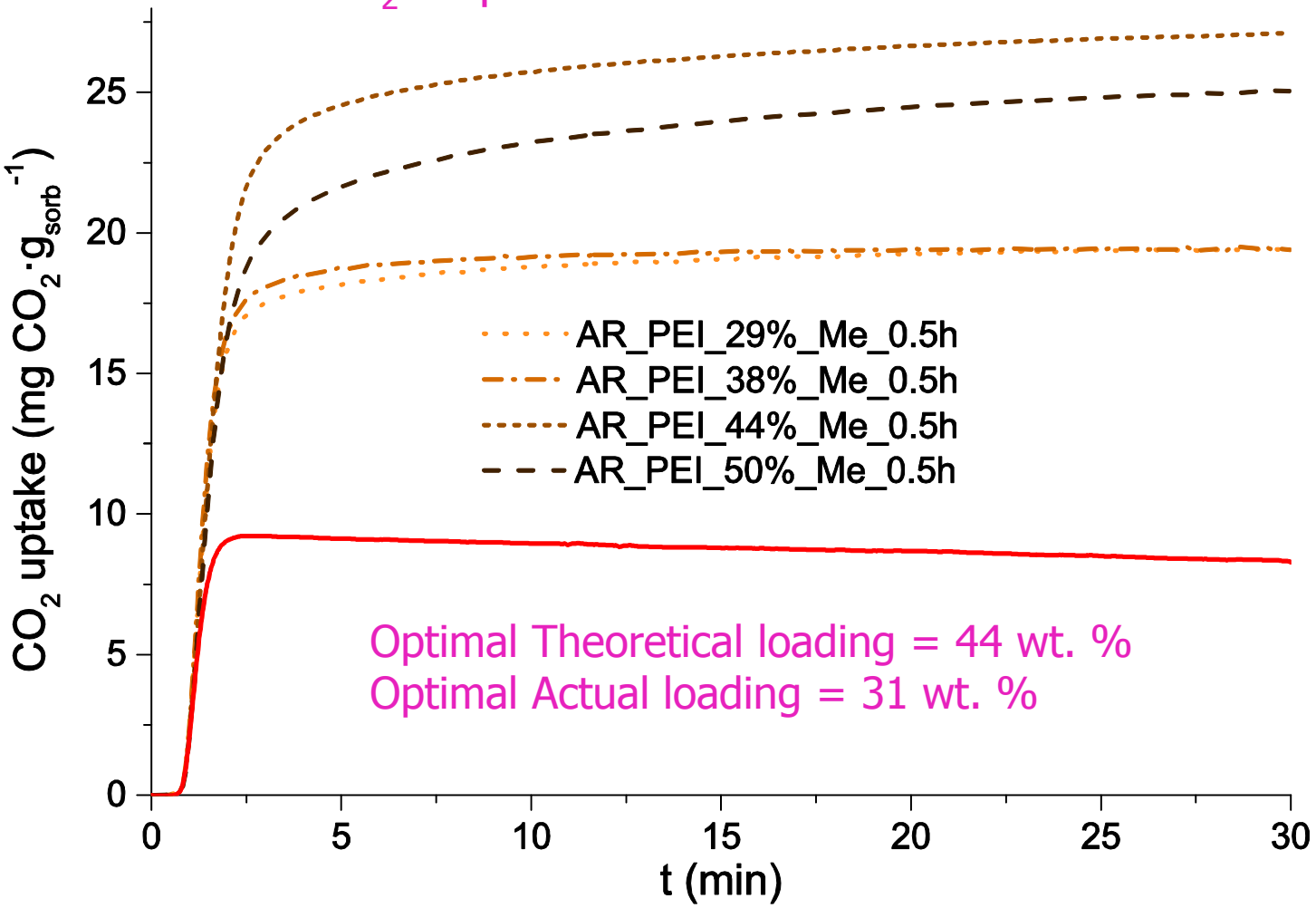




Trade-off Pore volume reduction/N incorporation

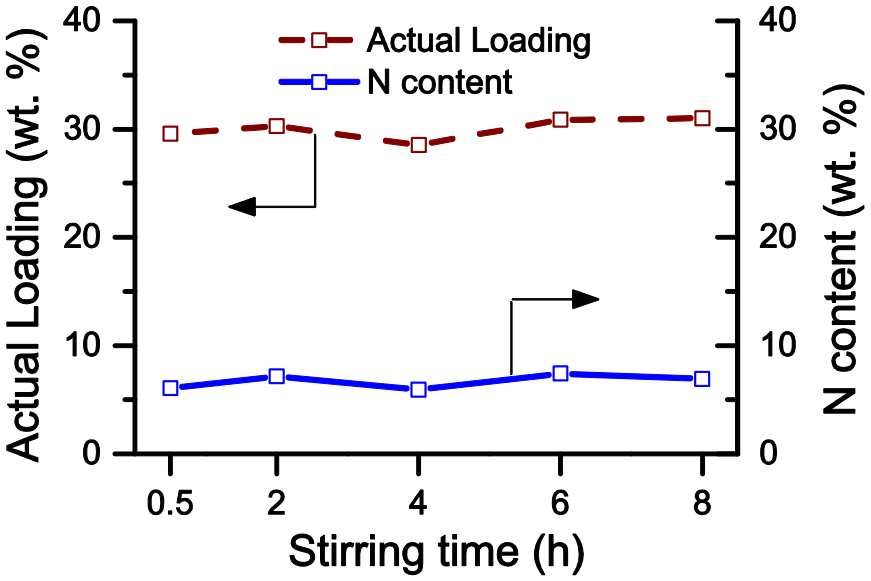
Methodology optimisation

Effect of PEI loading (Stirring time=0.5 h; Solvent=methanol)
15% CO_2 sorption kinetics at 53 °C and 1 bar



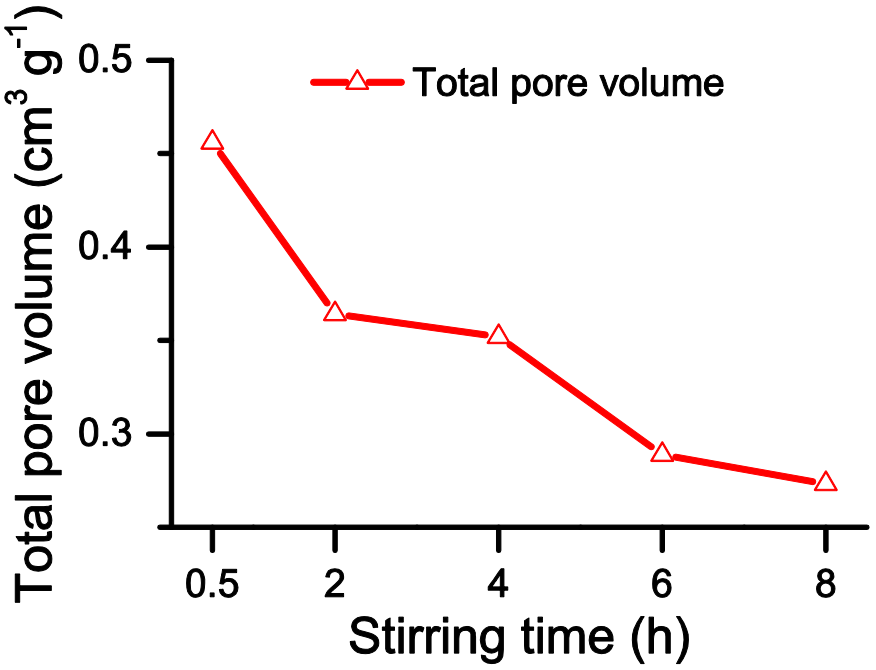
Methodology optimisation

Effect of stirring time (PEI loading = Optimal; Solvent=Methanol)



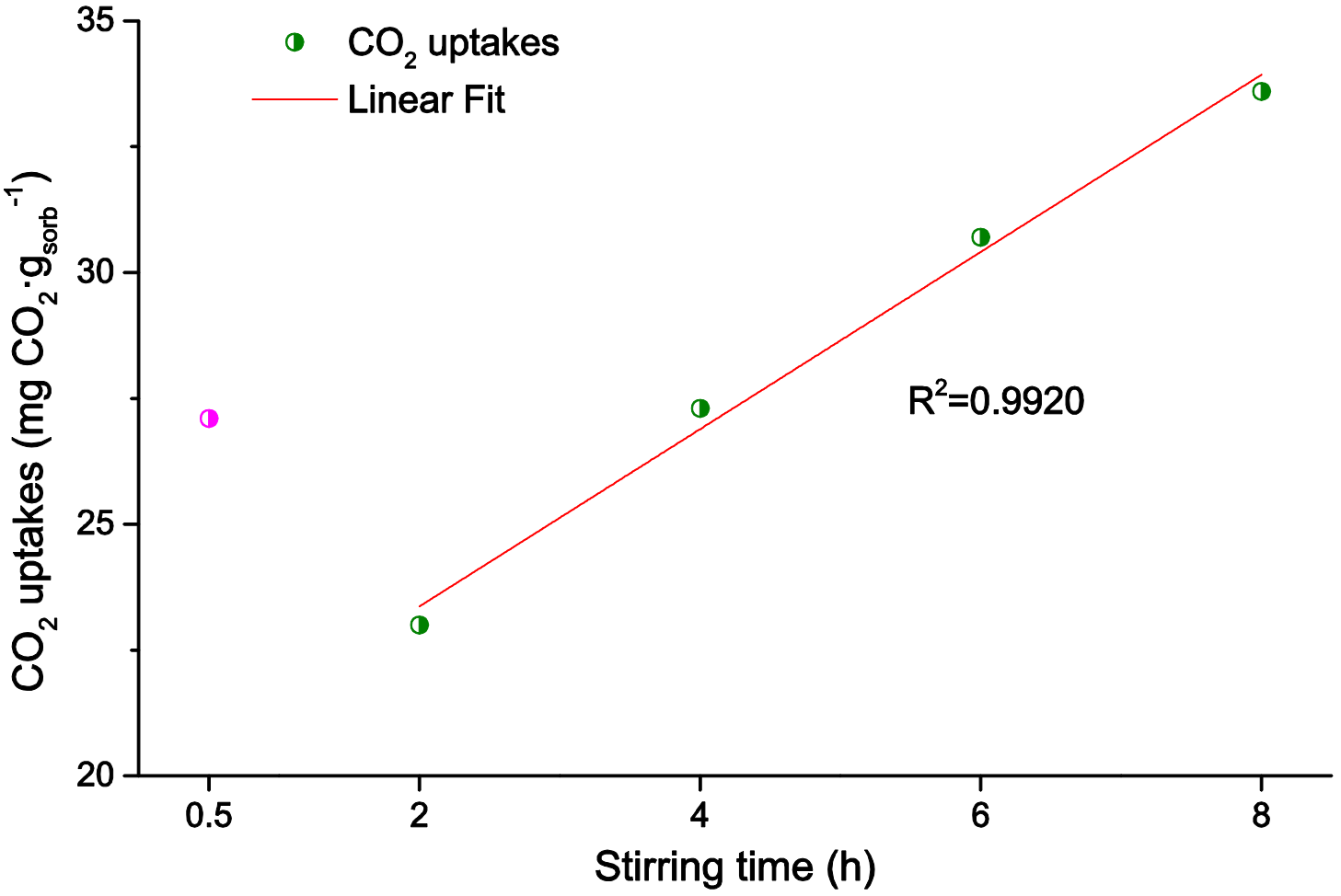
Constant
Actual loading and N content

Higher extent
Pore volume reduction
(Better dispersion of polymer)



Methodology optimisation

Effect of stirring time (PEI loading = Optimal; Solvent=Methanol)
15% CO_2 uptakes at 53 °C and 1 bar

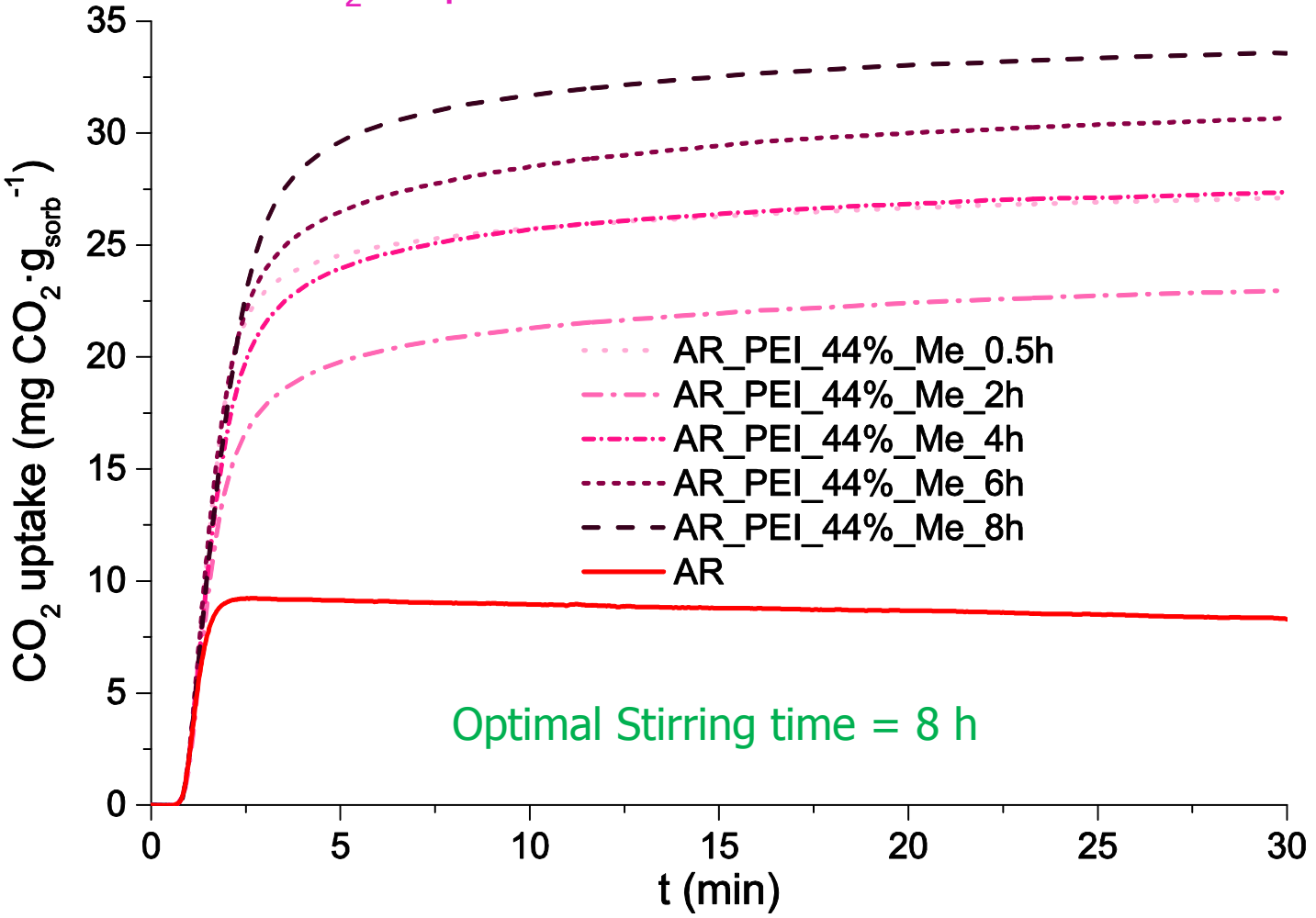


Methodology optimisation

UKCCS RESEARCH CENTRE

UNIVERSITY OF LEEDS

Effect of stirring time (PEI loading = Optimal; Solvent=Methanol)
15% CO_2 sorption kinetics at 53 °C and 1 bar



Methodology optimisation

Effect of Solvent type and Sorption temperature (Optimal PEI loading and Stirring time) 15% CO_2 sorption kinetics at 1 bar

Sample ID	Solvent	Stirring time	Theoretical Loading	Actual Loading	N	ΔVtot
-	-	h	wt. %	wt. %	wt. %	%
AR_PEI_44%_Me_8h	**Methanol**	8	44	**29**	**7.1**	**42**
AR_PEI_44%_W_8h	**Water**	8	44	**34**	**8.0**	**51**

53 °C

↓

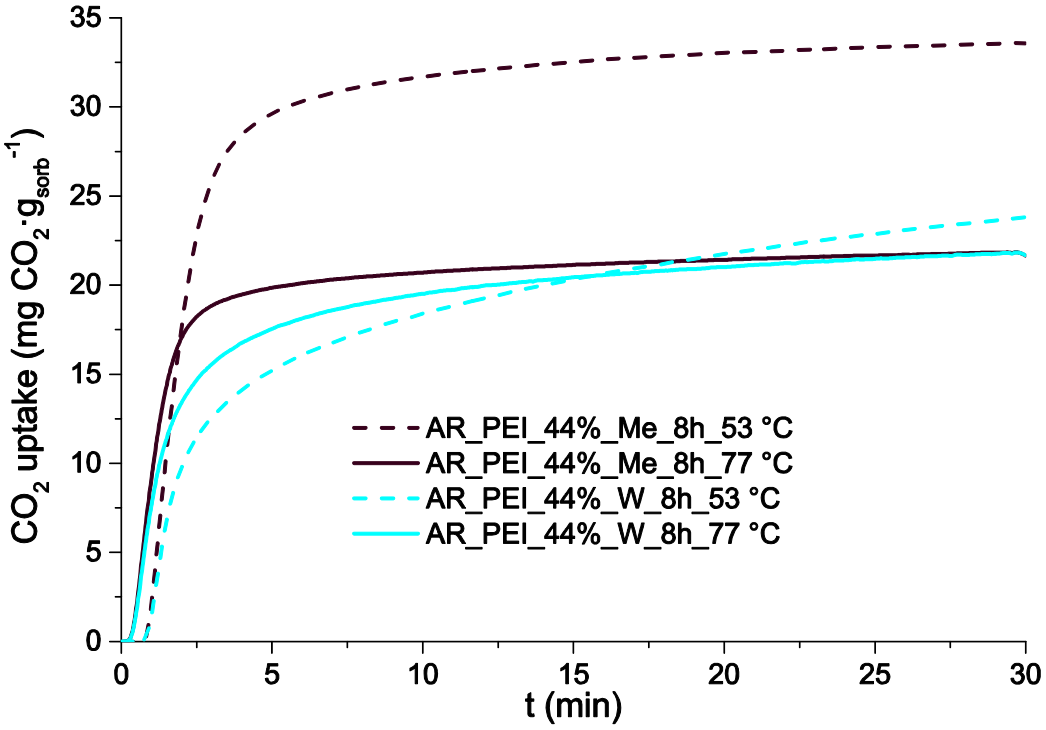
Methanol as optimal solvent

↓

Larger amount of polymer loaded when using water

↓

Slow kinetic
+
Lower uptakes
(diffusional limitations)



77 °C

↓

Water as optimal solvent

↓

Enhanced diffusion (more amines available)

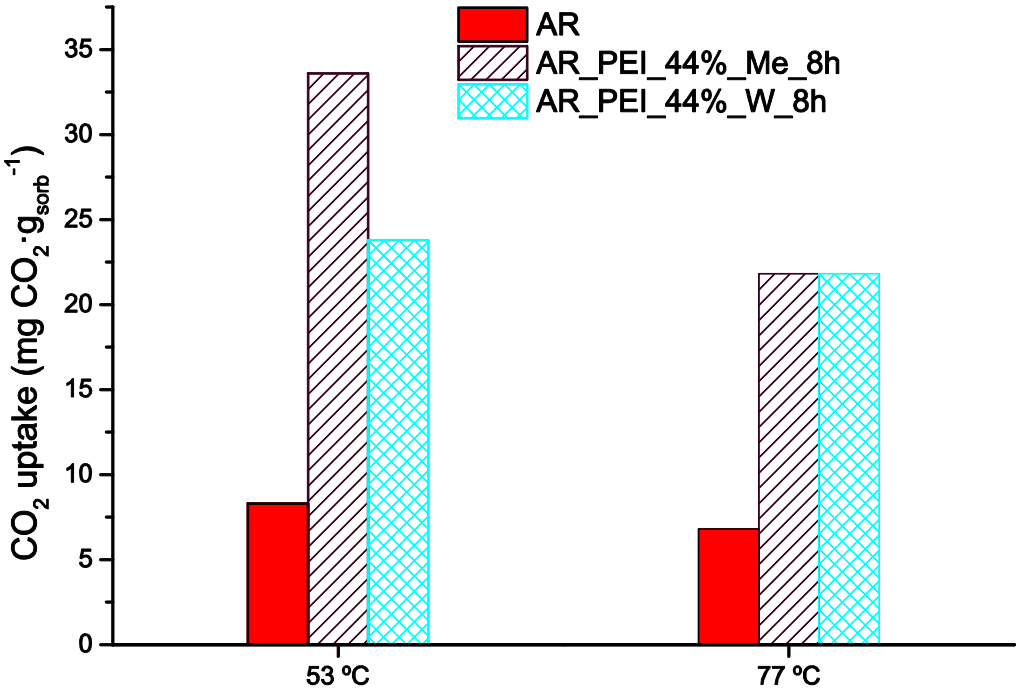
↓

Faster kinetic
+
Unaltered uptakes

Methodology optimisation

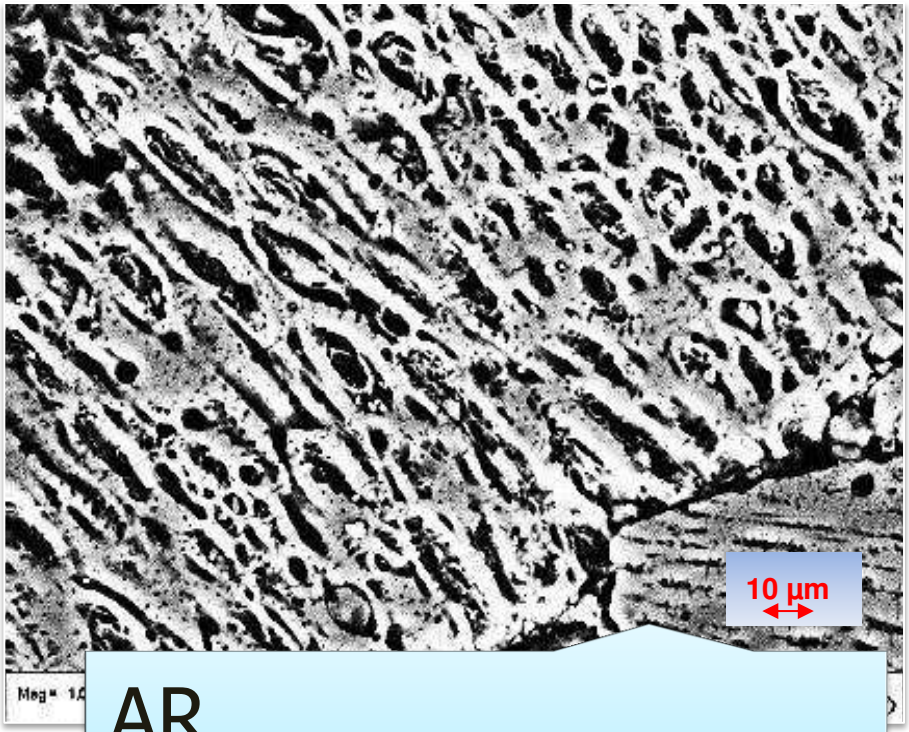
Effect of Solvent type and Sorption temperature (Optimal PEI loading and stirring time) 15% CO_2 uptakes at 1 bar

	15% CO_2 uptake (mg $CO_2 \cdot gsorb^{-1}$) at 1 bar		
Sample ID	**53 °C**	**77 °C**	**CO_2 capacity drop (%)**
AR	8.3	6.8	18
AR_PEI_44%_Me_8h	33.6	21.8	35
AR_PEI_44%_W_8h	23.8	21.8	8



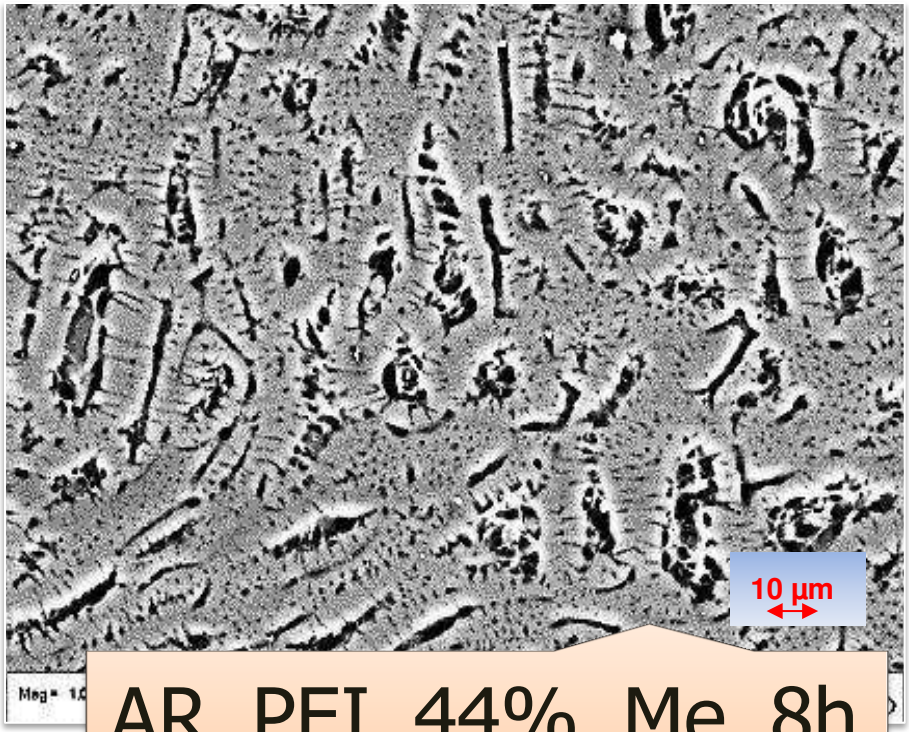
Optimal sorbent - PEI identification

SEM micrographs of samples' cross section



AR

- Virgin carbon

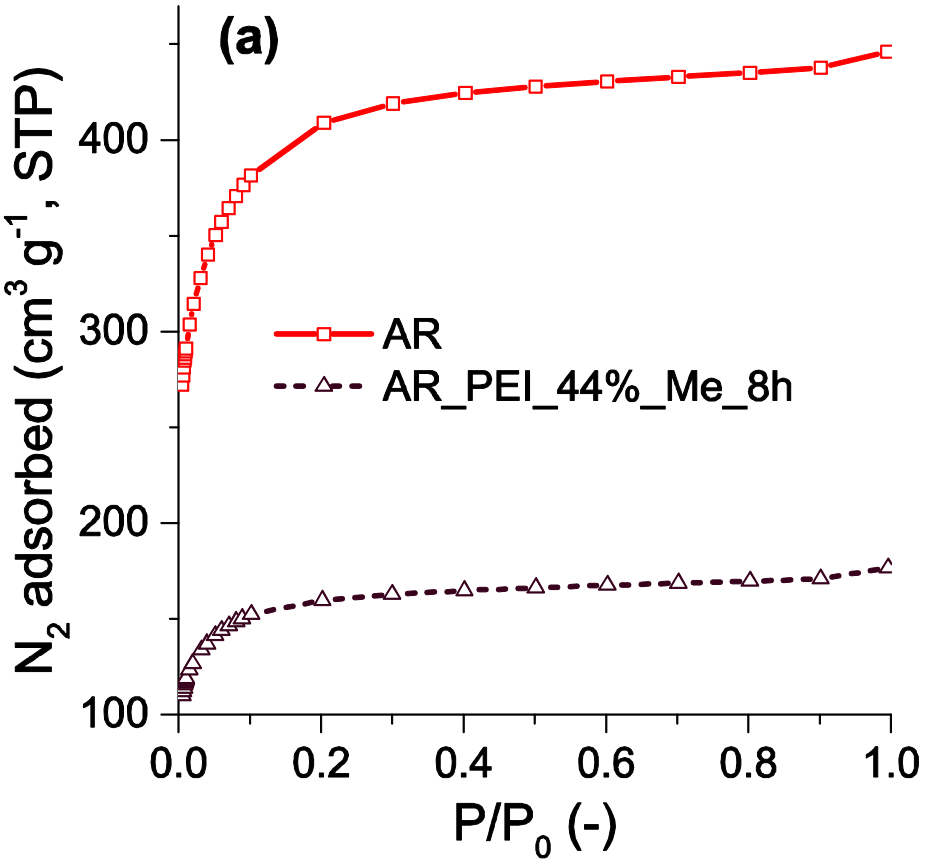


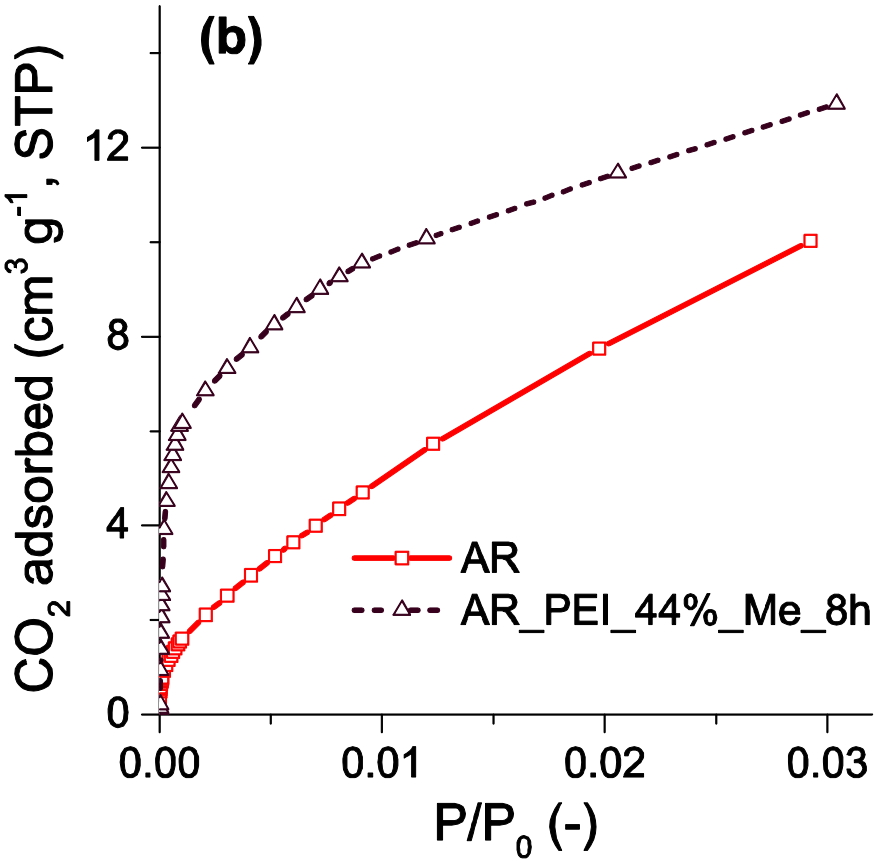
AR_PEI_44%_Me_8h

- PEI-loaded carbon

Optimal sorbent - PEI identification

Gas adsorption isotherms



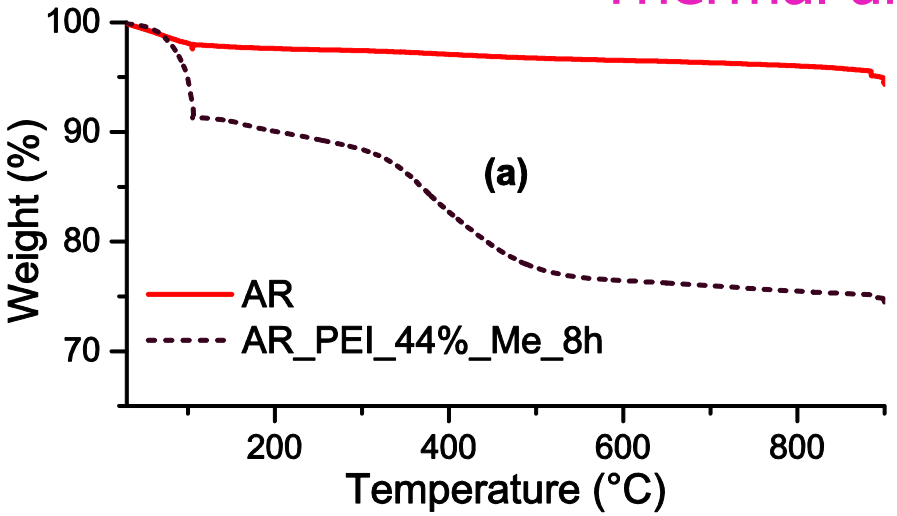


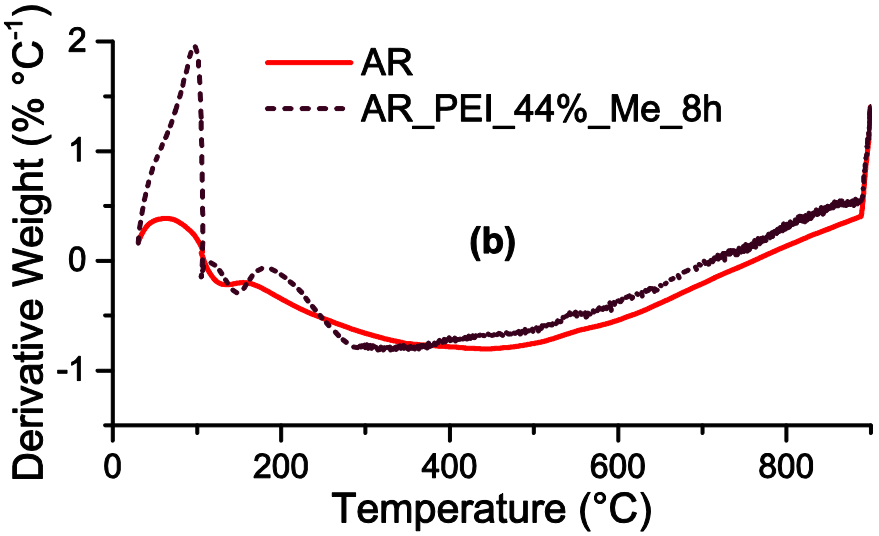
Dramatic porosity reduction

Higher CO_2 uptakes at 0 °C
in particular at lower partial pressure

Optimal sorbent - PEI identification

Thermal analysis





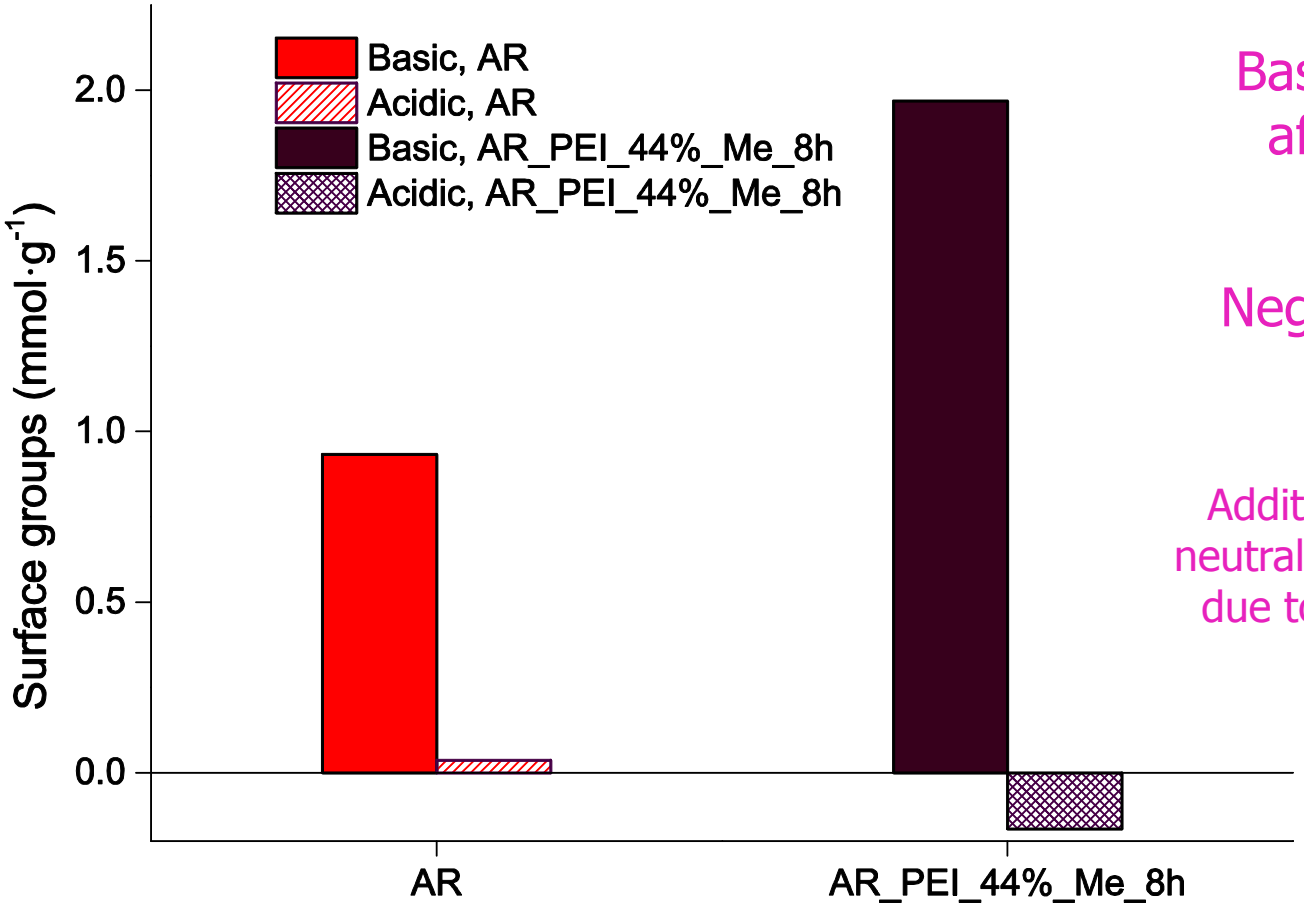
Higher Volatiles loss

PEI decomposition

Additional endothermic peak

Optimal sorbent - PEI identification

Boehm's titrations



Basic groups doubled after impregnation

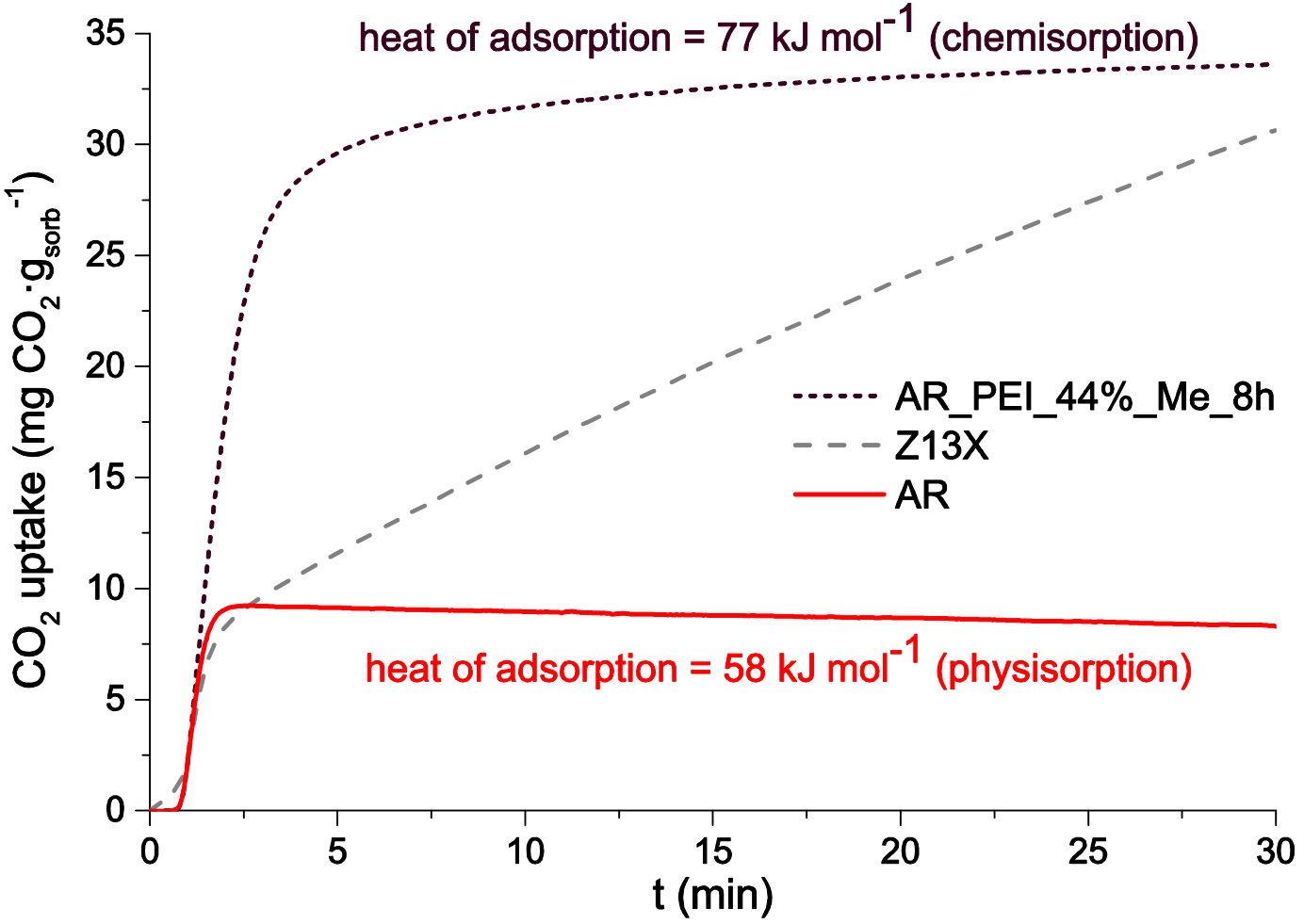
Negative acidic groups

Additional neutralisation due to PEI

Release of polymer in the alkaline supernatant

Optimal sorbent - CO_2 capture performances

15% CO_2 sorption kinetics at 53 °C and 1 bar - Comparison with benchmark

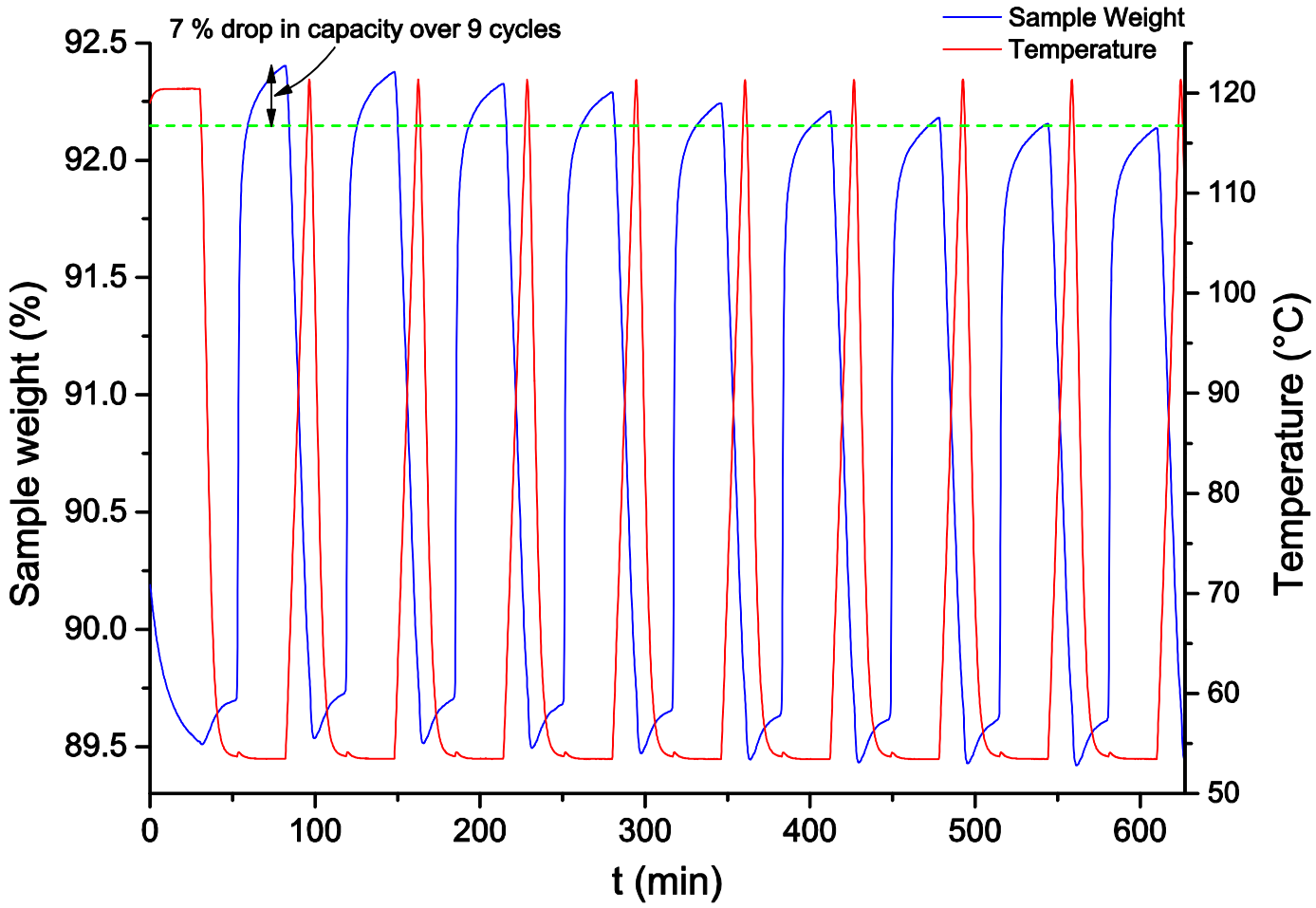


UKCCS RESEARCH CENTRE

UNIVERSITY OF LEEDS

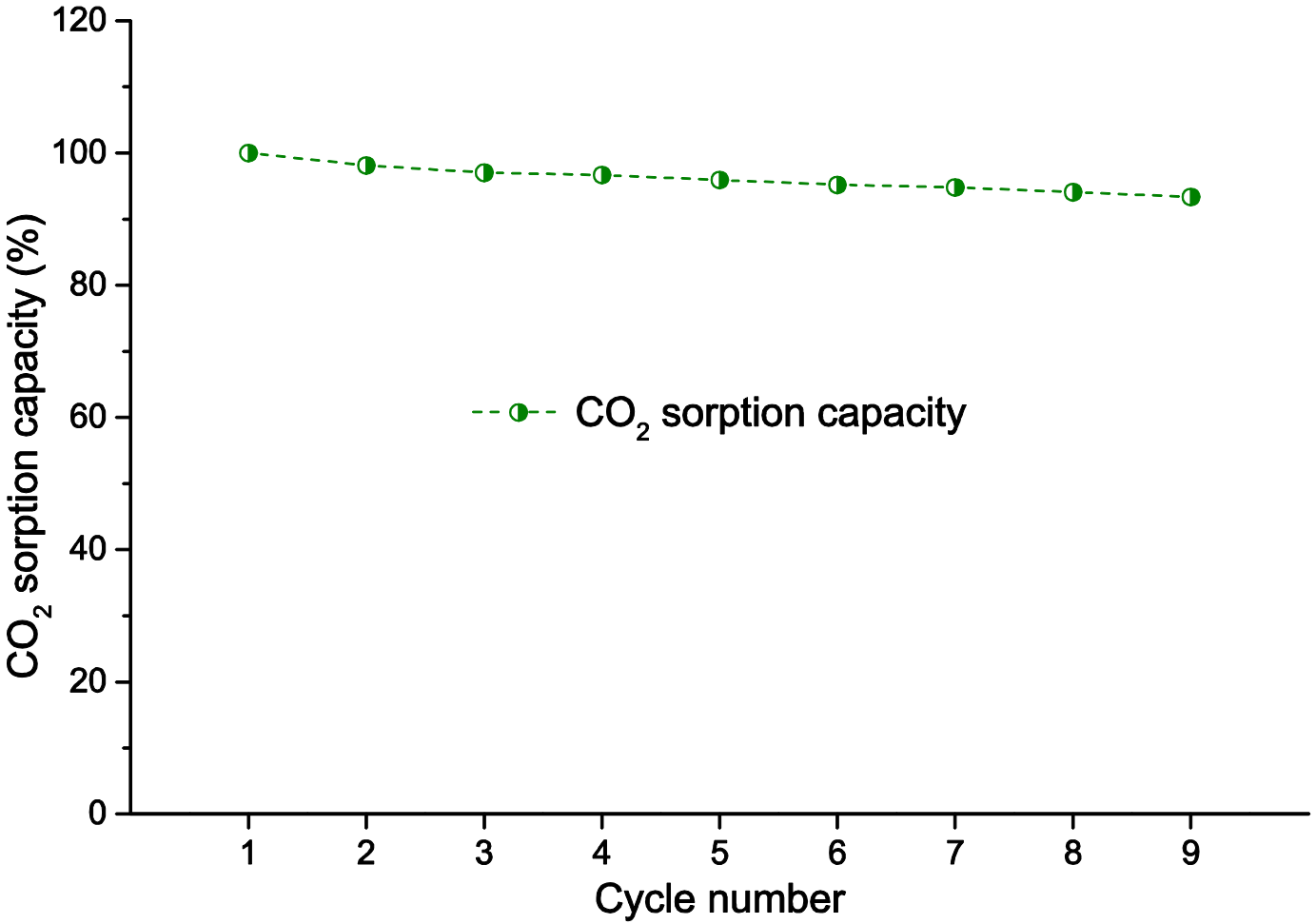
Optimal sorbent - CO_2 capture performances

15% CO_2 sorption kinetics at 53 °C and 1 bar - TSA cycles



Optimal sorbent - CO_2 capture performances

15% CO_2 sorption capacity at 53 °C and 1 bar - Durability



Conclusions

UKCCS RESEARCH CENTRE

UNIVERSITY OF LEEDS

Optimised route

Actual PEI loading: 31 wt. %

Longer stirring time: 8 h

Solvent as a f(T):
a) Methanol at 53 °C;
b) Water at 77 °C.
Environmentally friendly
+
Less energy demanding

The importance of stirring time

Better dispersion of PEI within porous network

4 times increase CO_2 uptakes under simulated post-combustion conditions

CO_2 sorption performances

Larger uptakes and Faster sorption kinetics than Z13X

Easy regeneration through TSA cycles

Good durability over time (9 working cycles)

Thanks for listening…
…Any questions?

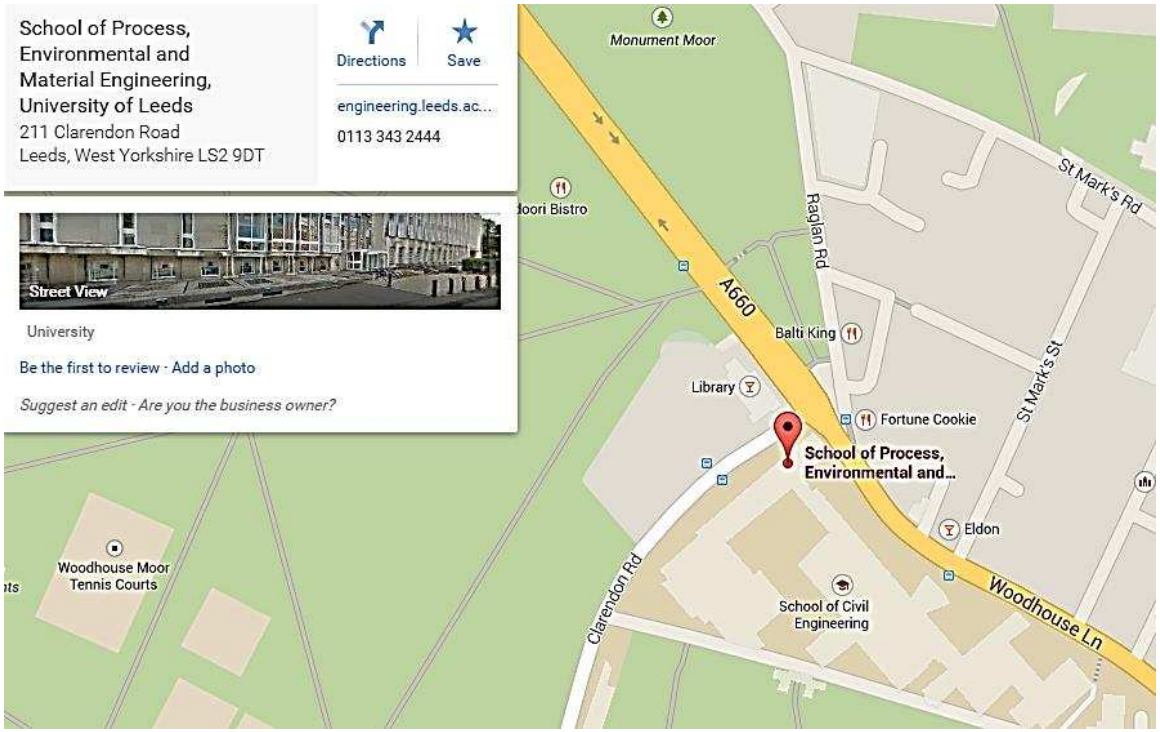
UKCCS RESEARCH CENTRE

UNIVERSITY OF LEEDS

Antonio Salituro

PhD student

pmasal@leeds.ac.uk



*Institute for Material Research (**IMR**)*

*School of Chemical and Process Engineering (**SCAPE**)*

Faculty of Engineering, University of Leeds, LS2 9TJ