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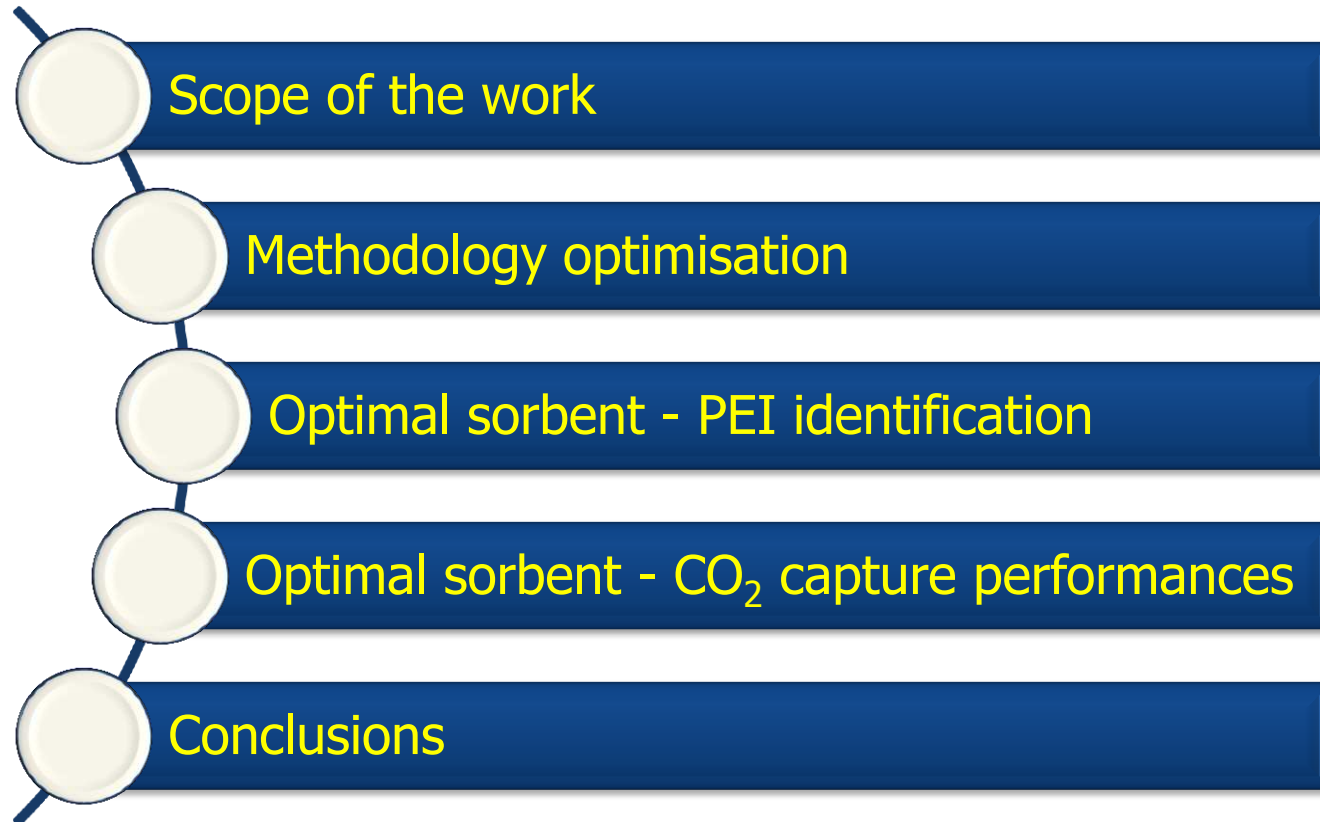
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# Optimised PEI impregnation of activated carbons - Enhancement of CO<sub>2</sub> capture under post-combustion conditions

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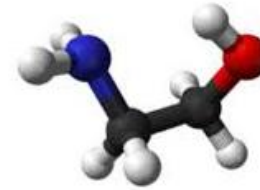
# Overview



# Scope of the work



**MEA**  
**(Liquid solvent)**

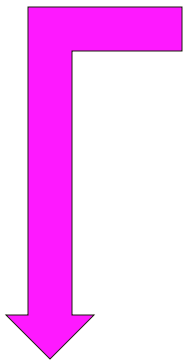


Difficult handling

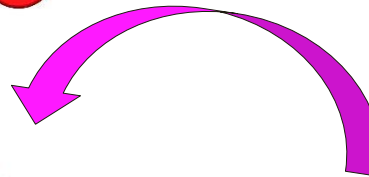
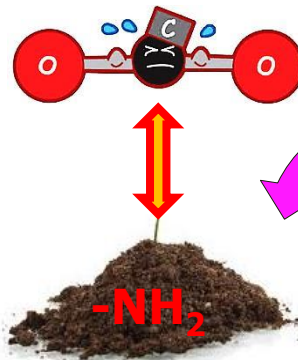
Reactor Corrosion

Degradation

Energy demanding regeneration



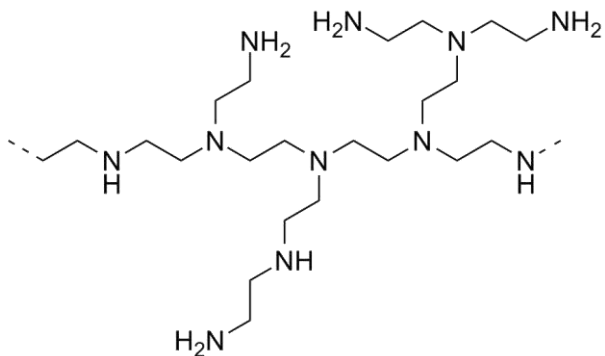
**Solid**  
**Activated carbon**



**Amines incorporation**

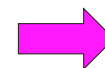
# Methodology optimisation

Branched Polyethileneimine (PEI)



+

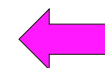
Solvent  
(Methanol or Water)



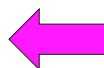
15 min Stirring



Activated carbon  
(AR)

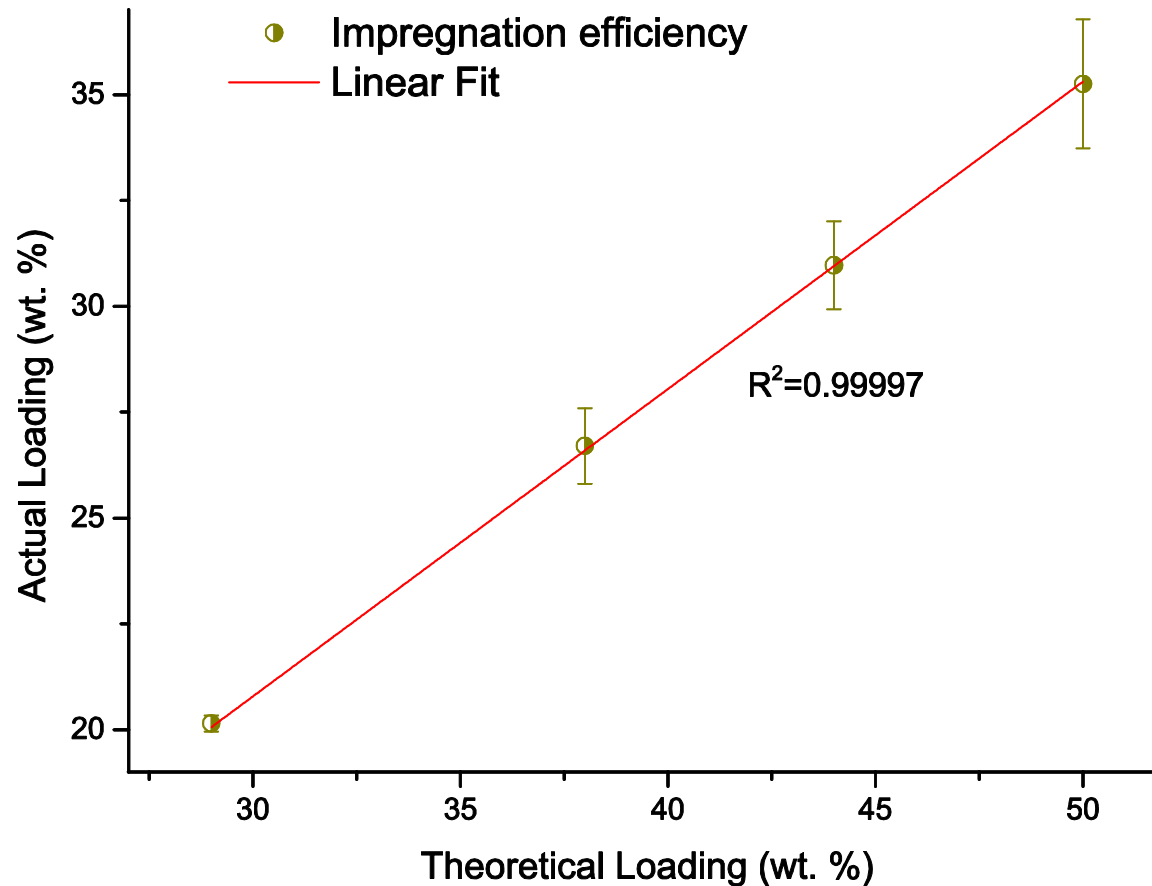


Further Stirring  
0.5, 2, 4, 6 or 8 h



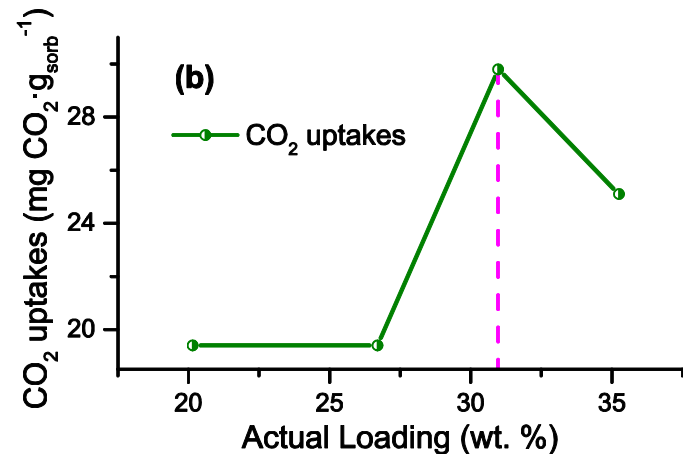
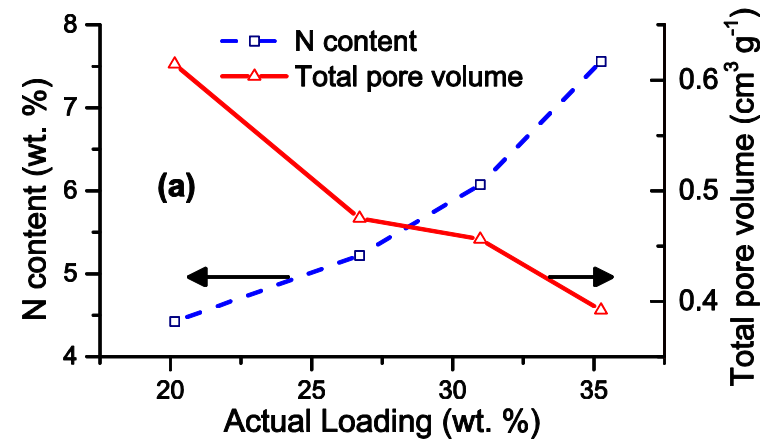
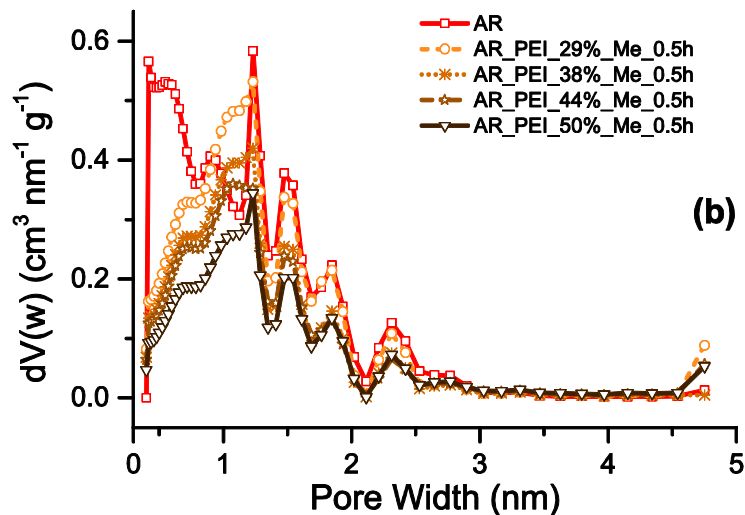
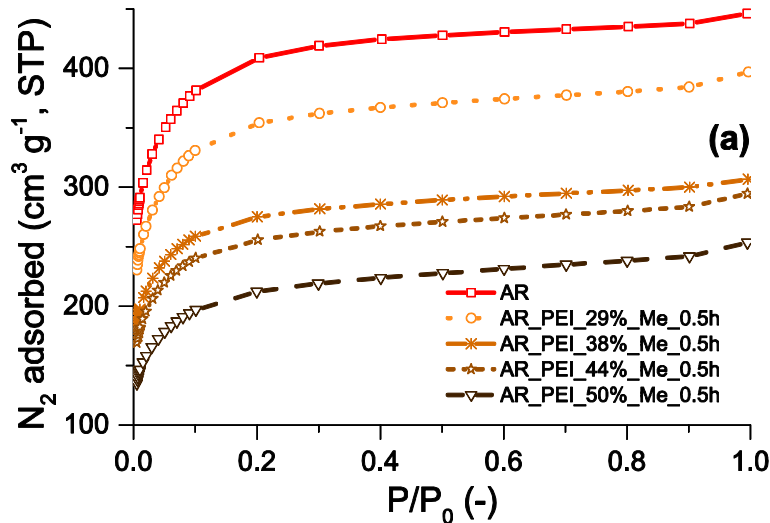
PEI-impregnated AR  
Theoretical Loading:  
29, 38, 44 or 50 wt. %

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



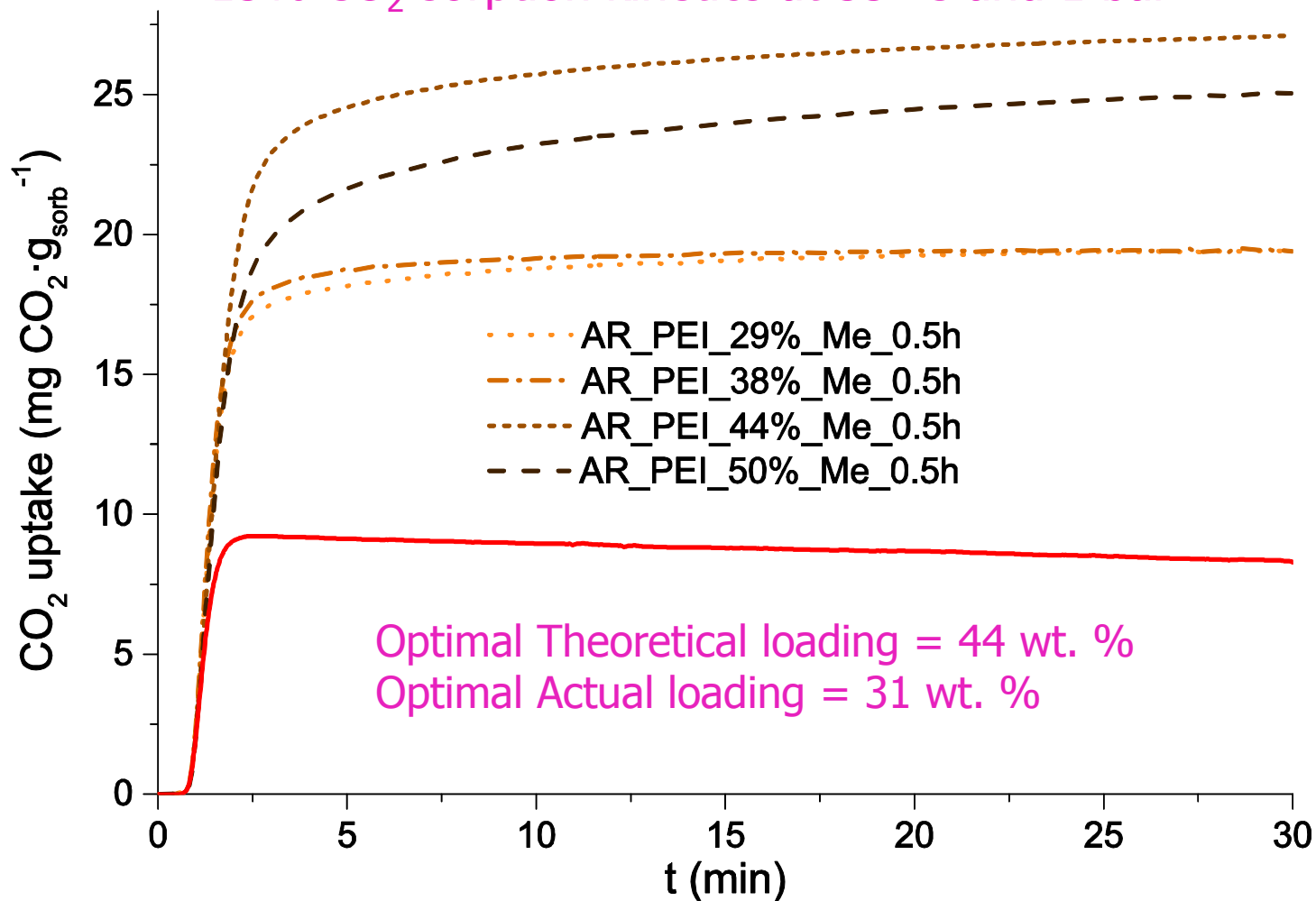
Constant Impregnation Efficiency = ca. 70%

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



Trade-off Pore volume reduction/N incorporation

Effect of PEI loading (Stirring time=0.5 h; Solvent=methanol)  
15% CO<sub>2</sub> sorption kinetics at 53 °C and 1 bar

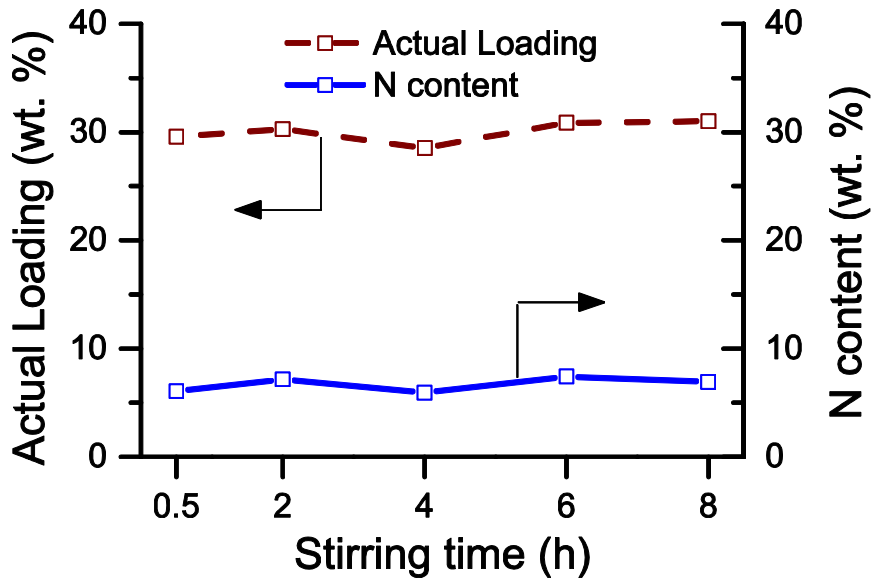




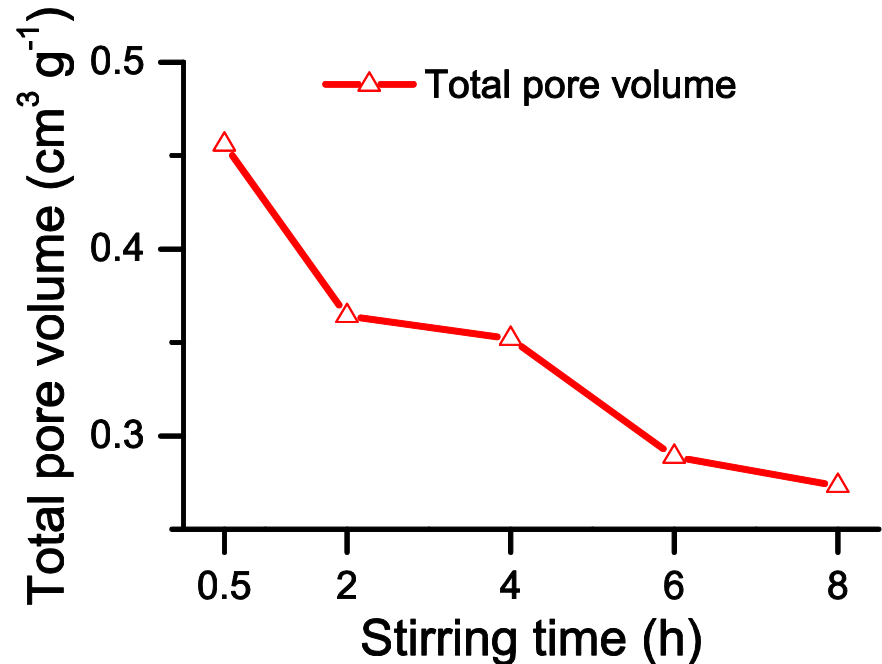
# Methodology optimisation

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

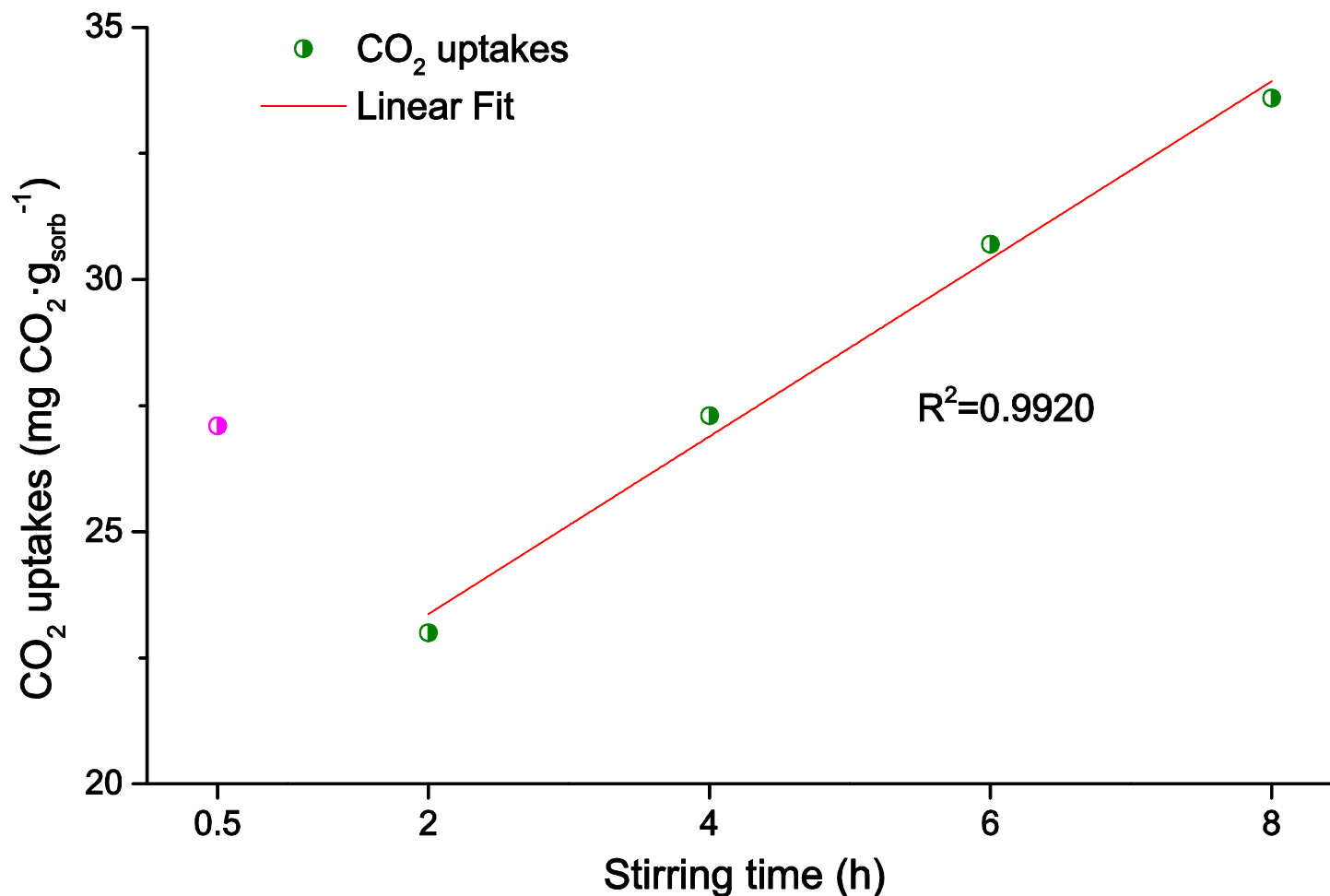


Constant  
Actual loading and N content

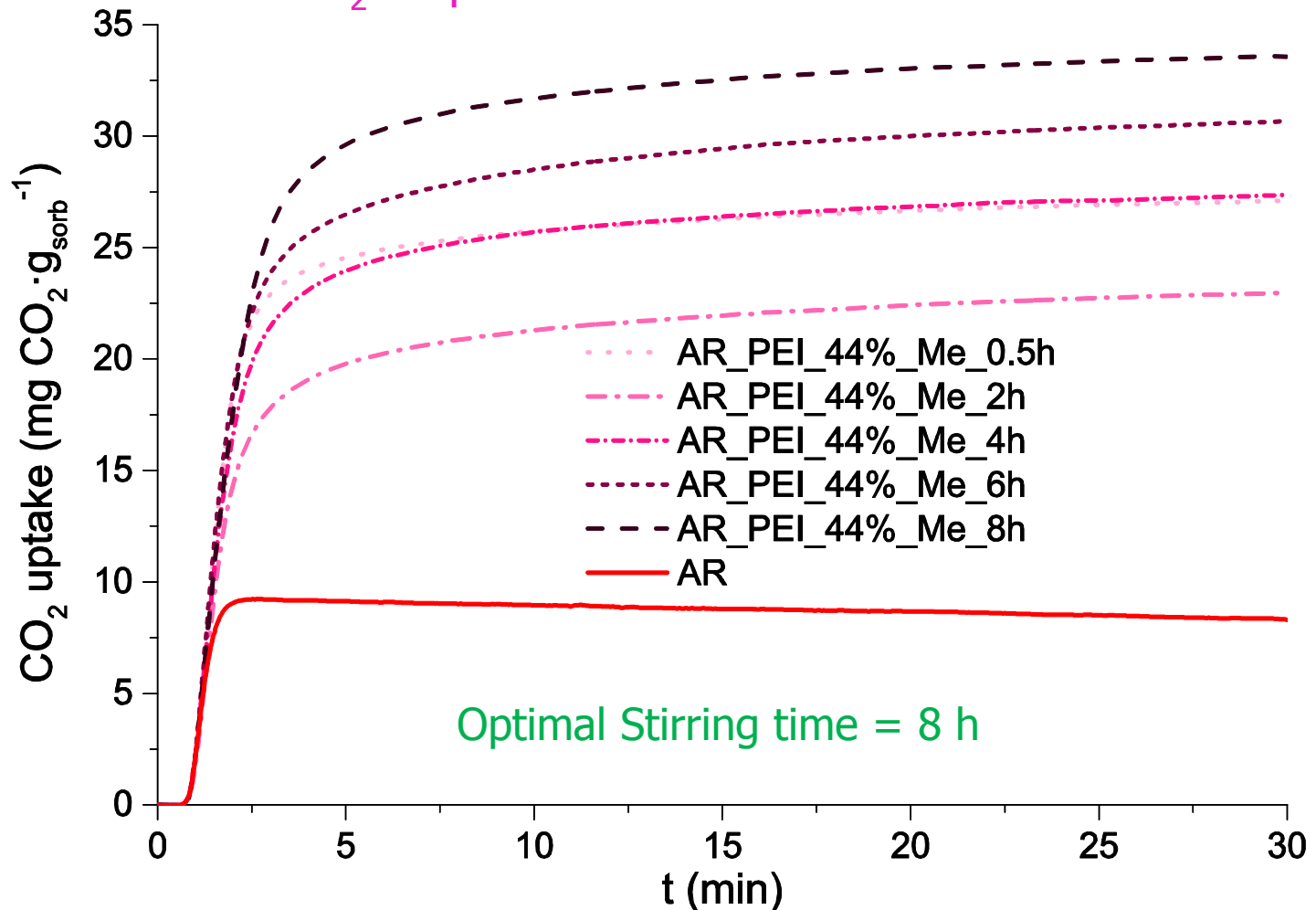


Higher extent  
Pore volume reduction  
(Better dispersion of polymer)

Effect of stirring time (PEI loading = Optimal; Solvent=Methanol)  
15% CO<sub>2</sub> uptakes at 53 °C and 1 bar

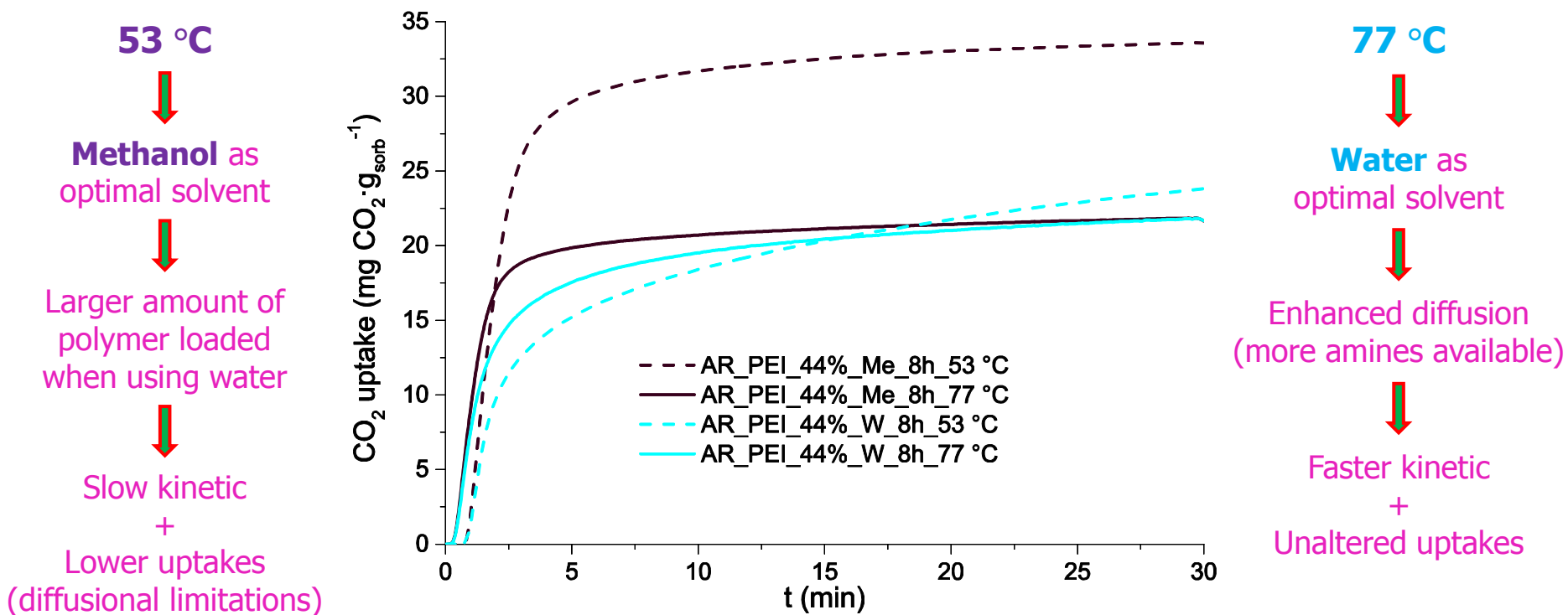


Effect of stirring time (PEI loading = Optimal; Solvent=Methanol)  
15% CO<sub>2</sub> sorption kinetics at 53 °C and 1 bar



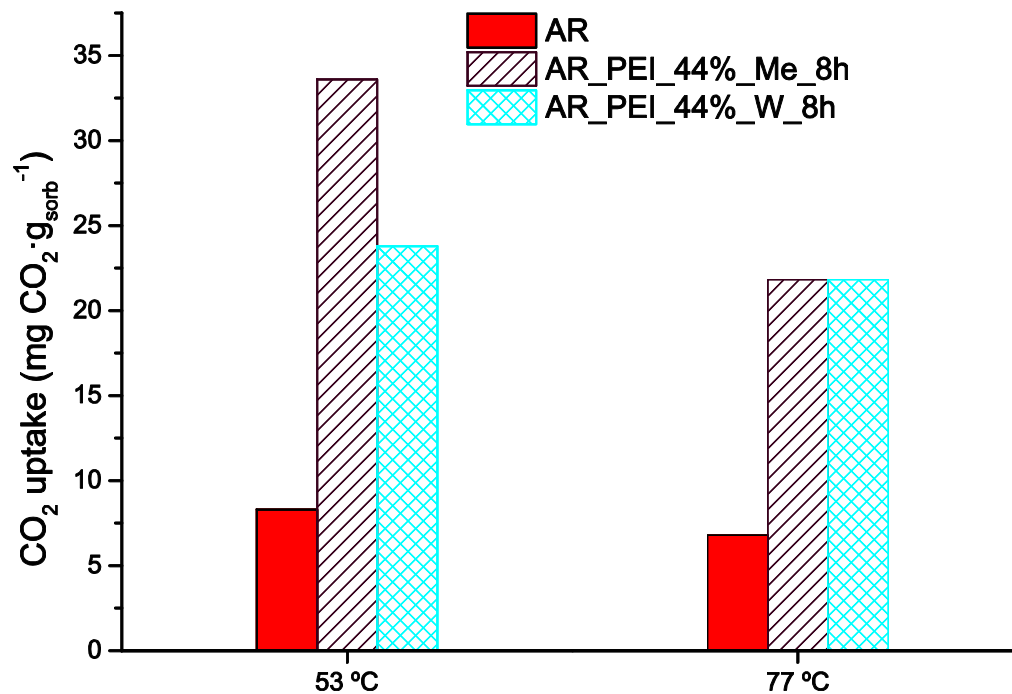
## Effect of Solvent type and Sorption temperature (Optimal PEI loading and Stirring time) 15% CO<sub>2</sub> sorption kinetics at 1 bar

Sample ID	Solvent	Stirring time	Theoretical Loading	Actual Loading	N	$\Delta V_{tot}$
-	-	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

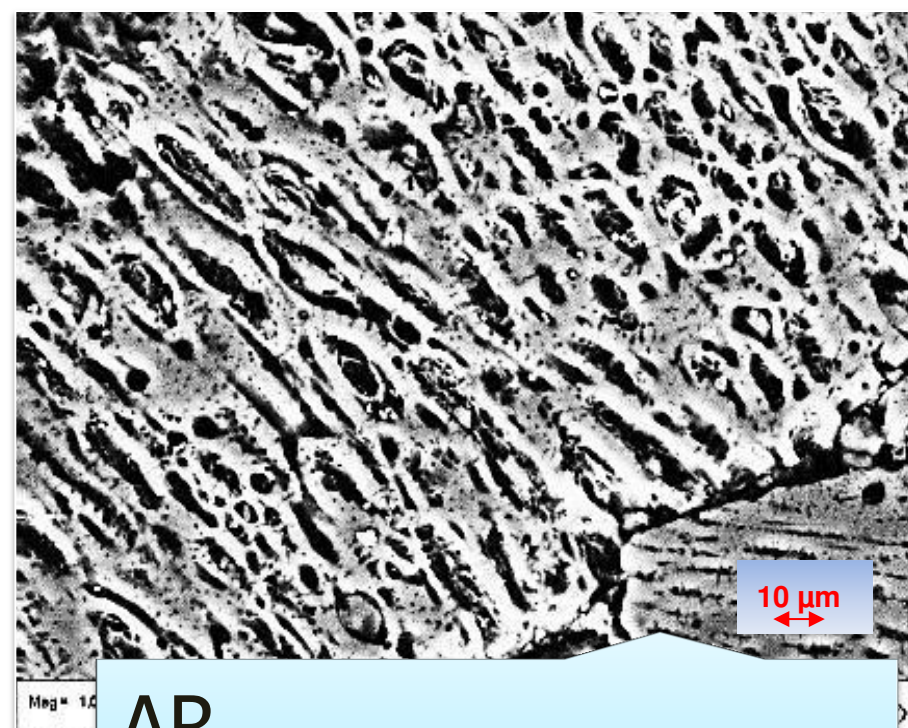


## Effect of Solvent type and Sorption temperature (Optimal PEI loading and stirring time) 15% CO<sub>2</sub> uptakes at 1 bar

Sample ID	15% CO <sub>2</sub> uptake (mg CO <sub>2</sub> ·g <sub>sorb</sub> <sup>-1</sup> ) at 1 bar		
	53 °C	77 °C	CO <sub>2</sub> 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

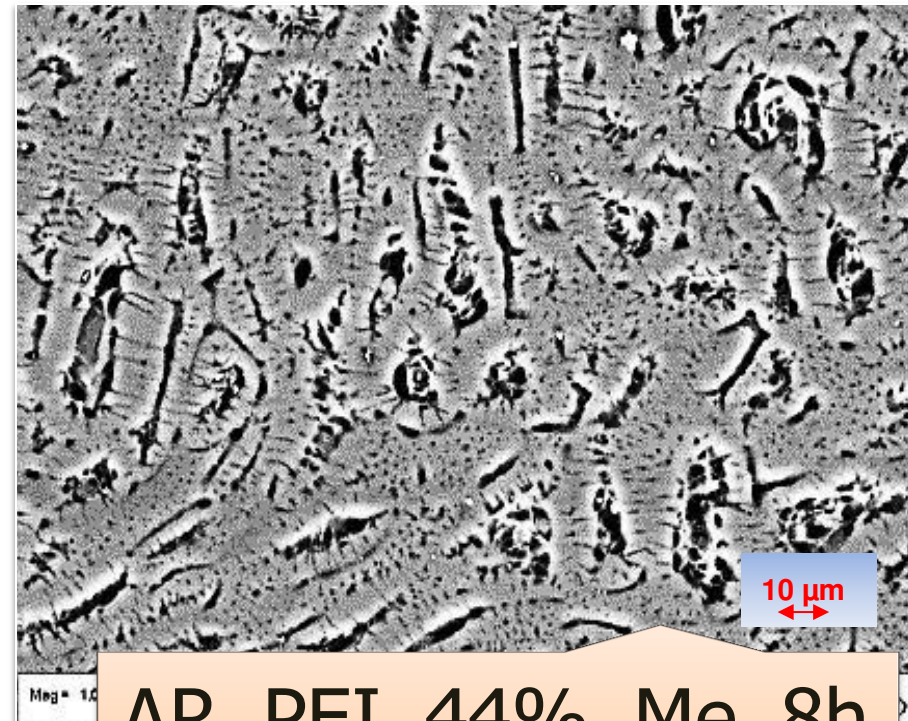


## SEM micrographs of samples' cross section



AR

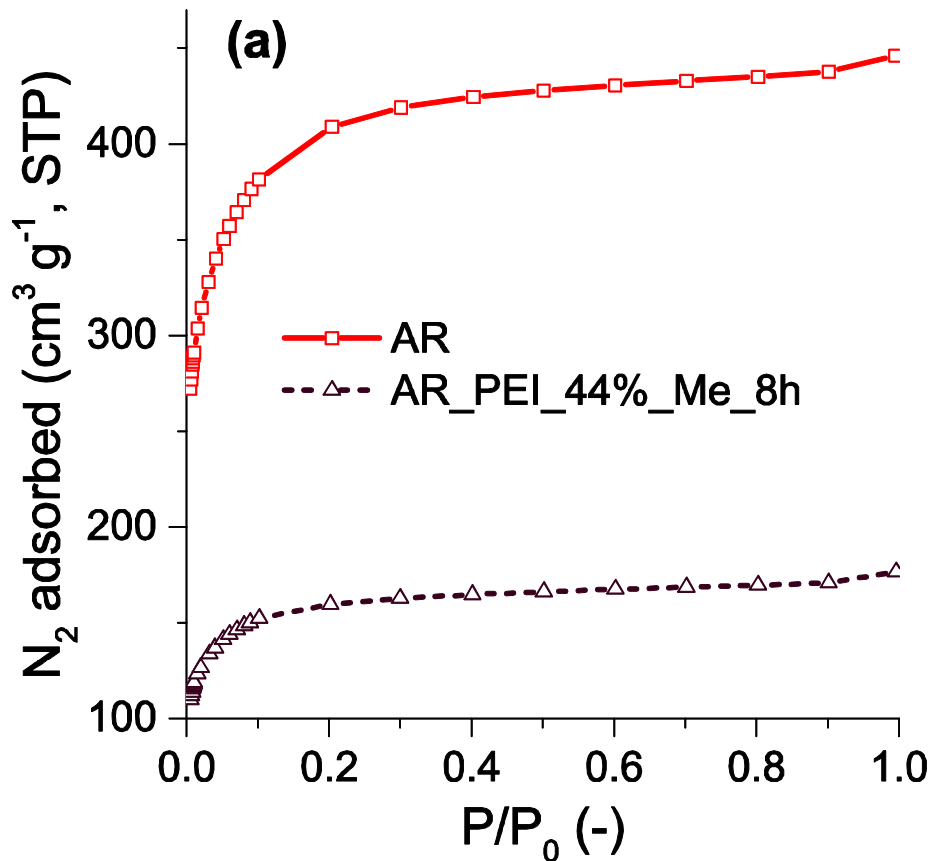
- Virgin carbon



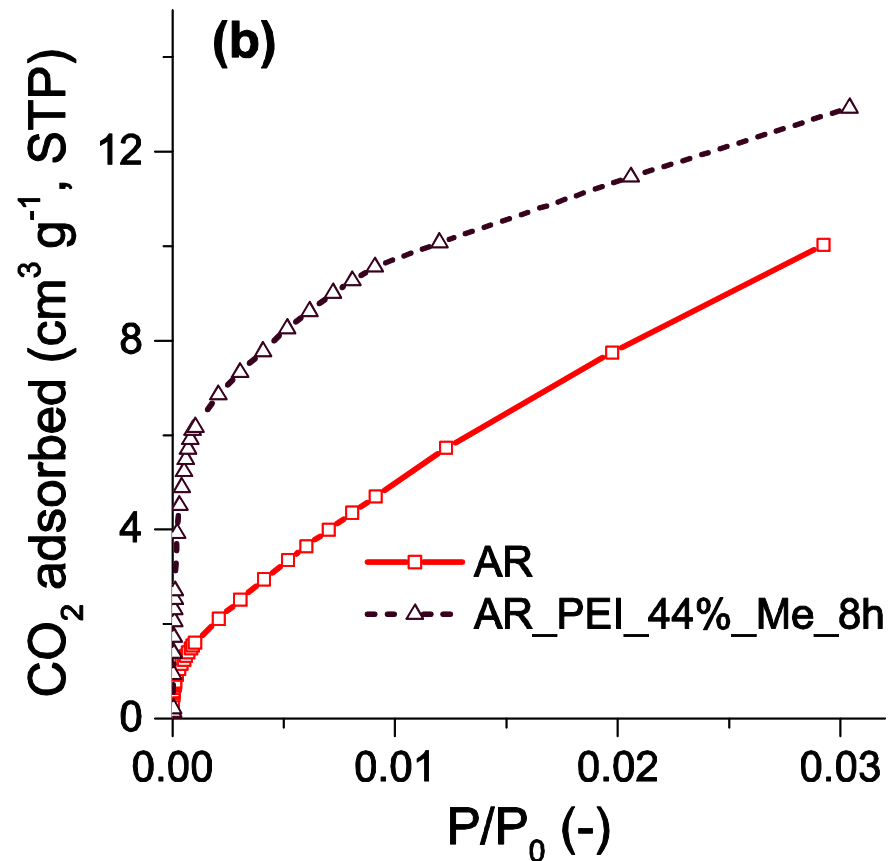
AR\_PEI\_44%\_Me\_8h

- PEI-loaded carbon

## Gas adsorption isotherms

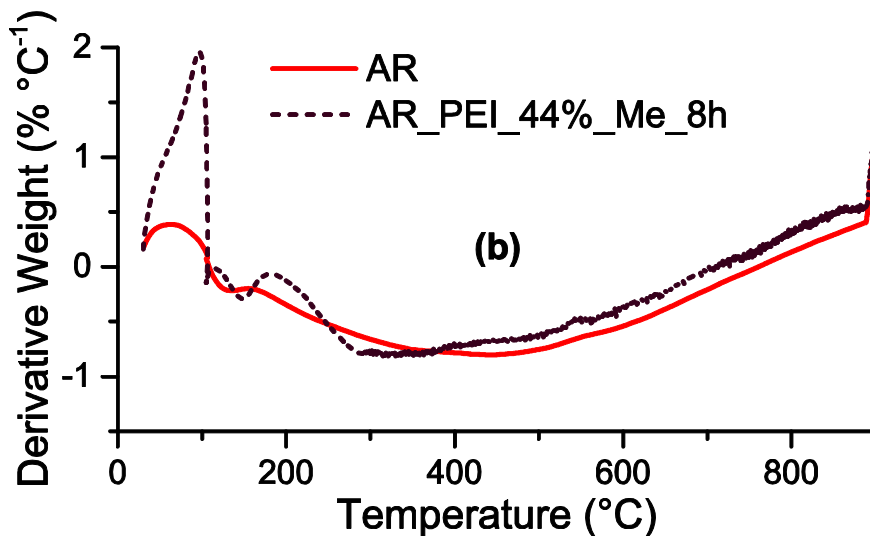
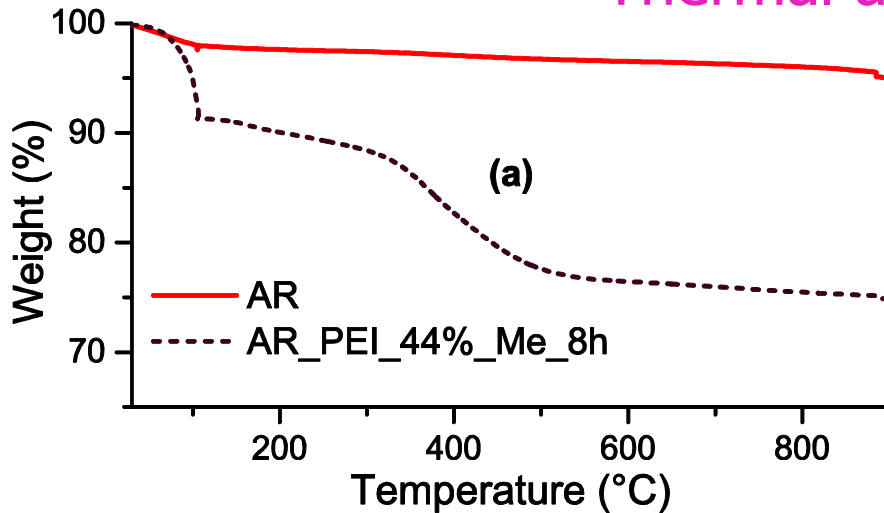


Dramatic porosity reduction



Higher  $CO_2$  uptakes at  $0^\circ C$   
in particular at lower partial pressure

## Thermal analysis



Higher Volatiles loss



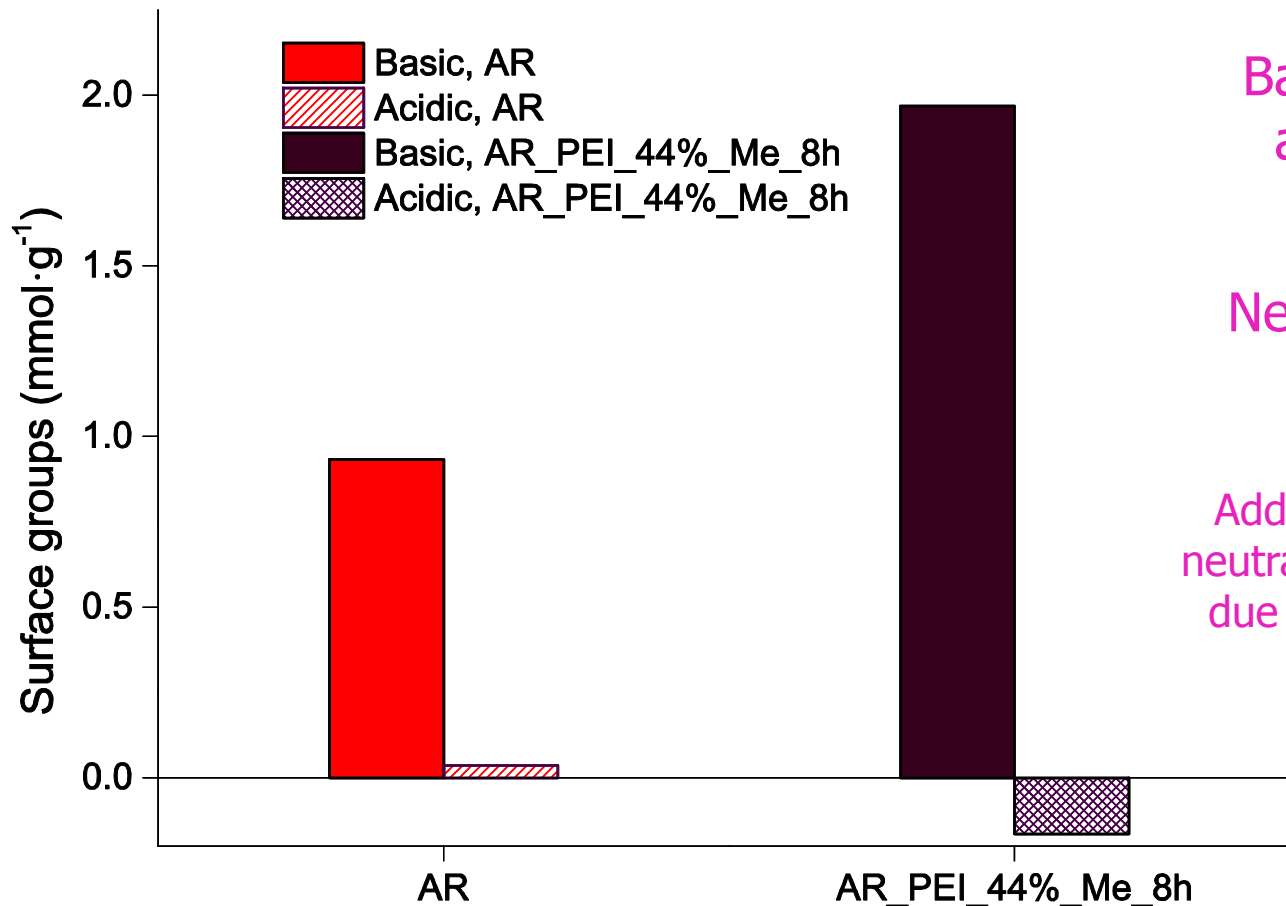
PEI decomposition



Additional endothermic peak



## Boehm's titrations



Basic groups doubled  
after impregnation

Negative acidic groups

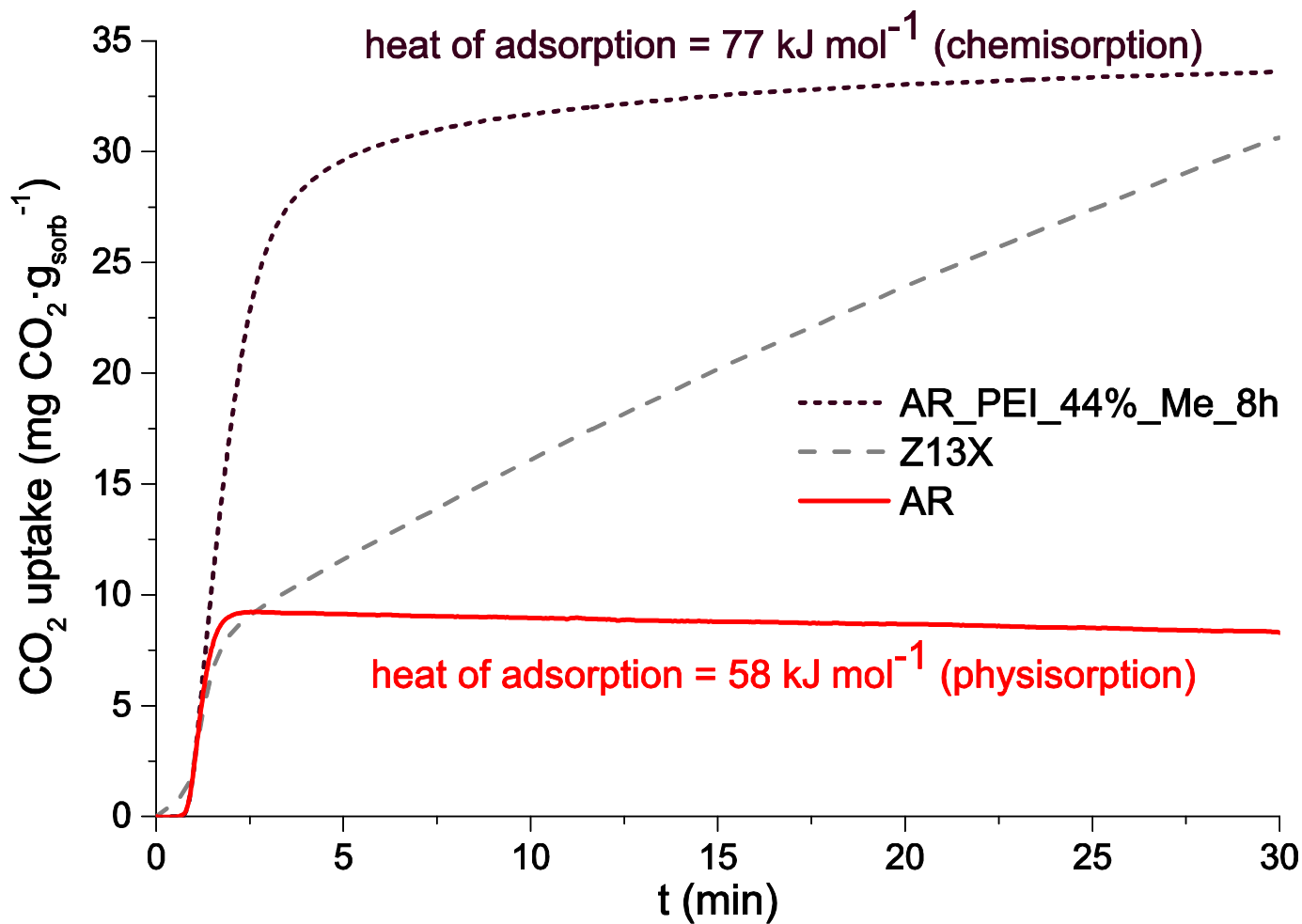


Additional  
neutralisation  
due to PEI

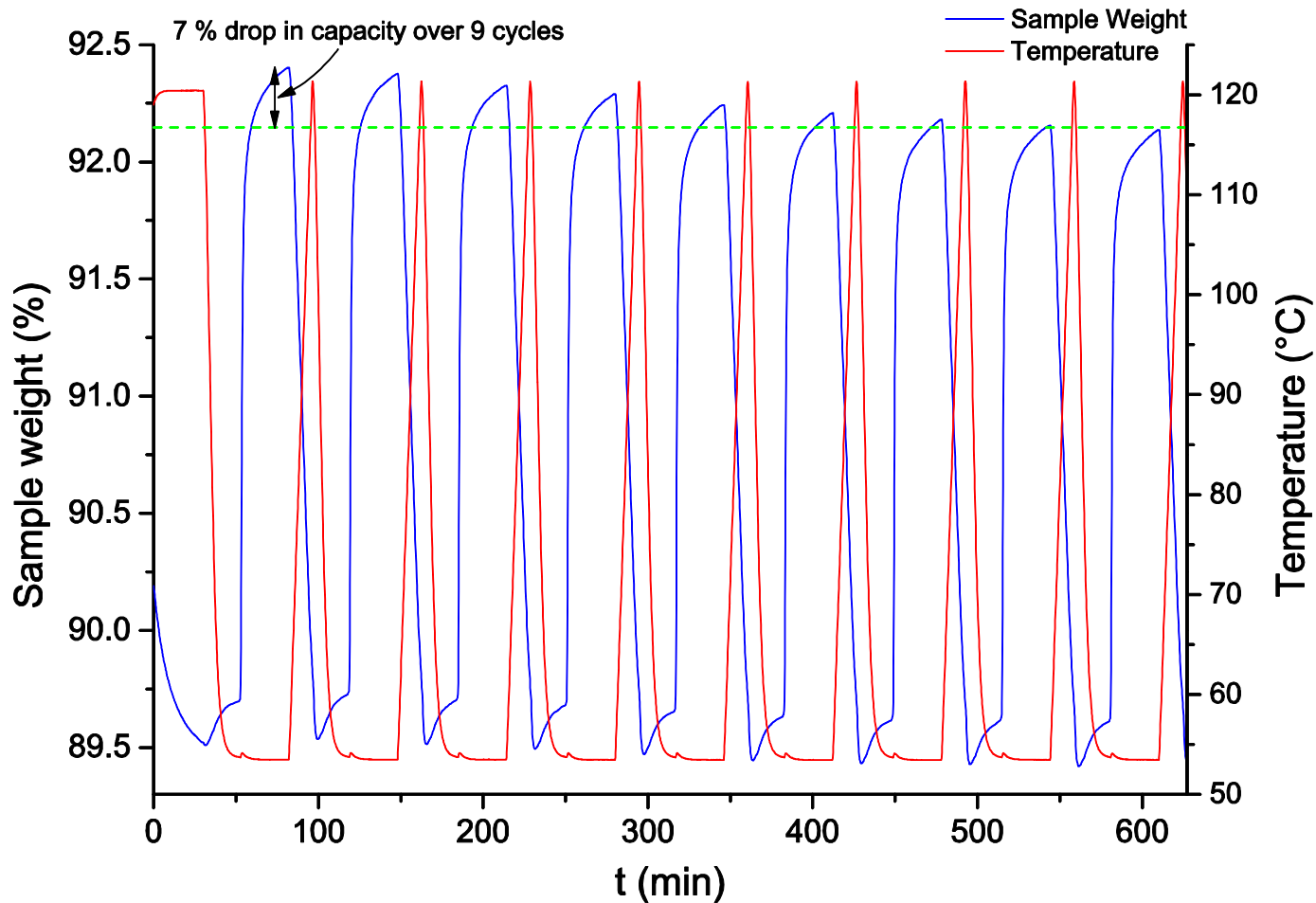


Release of polymer  
in the alkaline  
supernatant

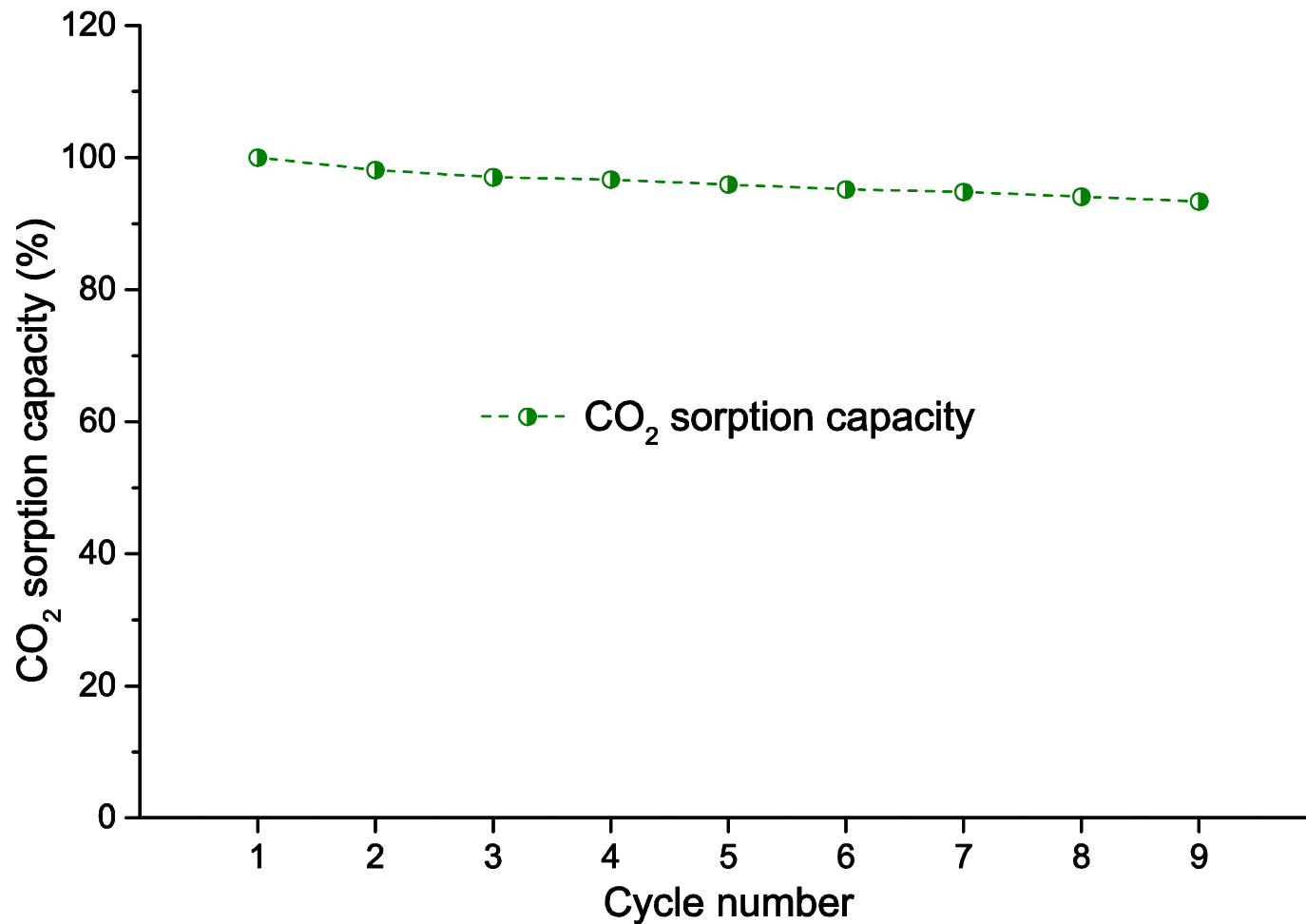
## 15% CO<sub>2</sub> sorption kinetics at 53 °C and 1 bar - Comparison with benchmark



## 15% CO<sub>2</sub> sorption kinetics at 53 °C and 1 bar - TSA cycles



15% CO<sub>2</sub> sorption capacity at 53 °C and 1 bar - Durability



## Conclusions

### 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<sub>2</sub> uptakes  
under simulated  
**post-combustion**  
conditions

### CO<sub>2</sub> sorption performances

**Larger uptakes** and  
**Faster sorption kinetics**  
than Z13X

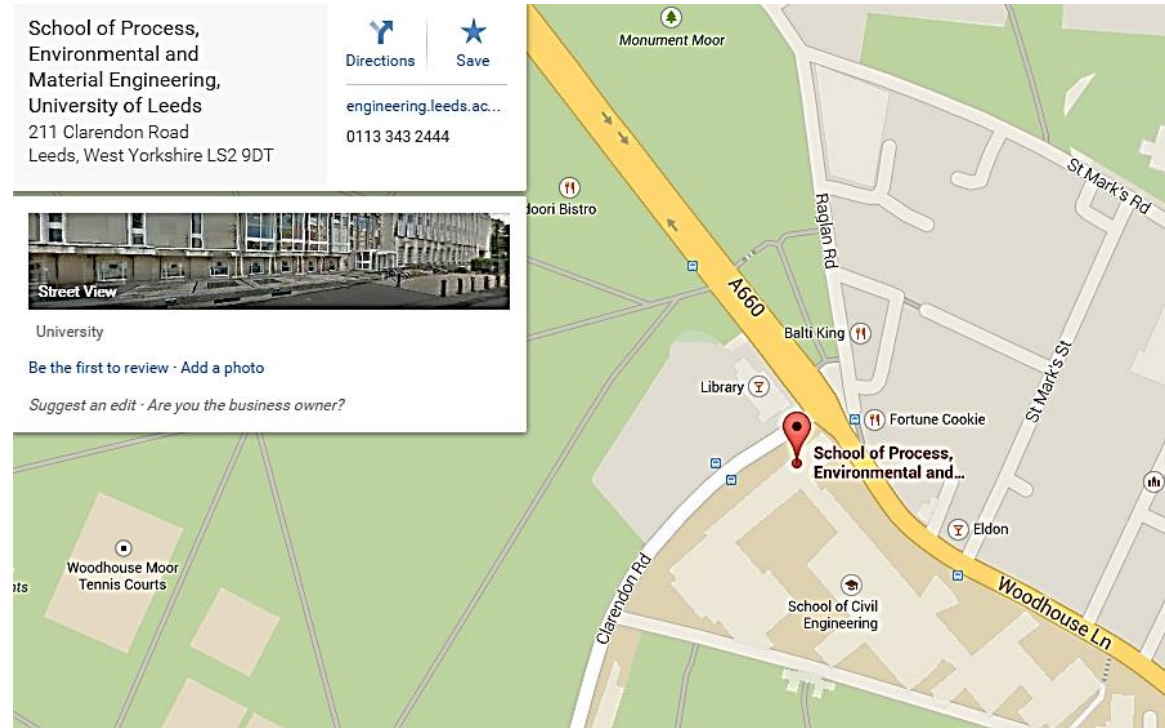
**Easy regeneration**  
through TSA cycles

**Good durability**  
over time  
(9 working cycles)

Thanks for listening...  
...Any questions?

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