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Effect of steam on the performance of Ca-based sorbents in calcium looping processes

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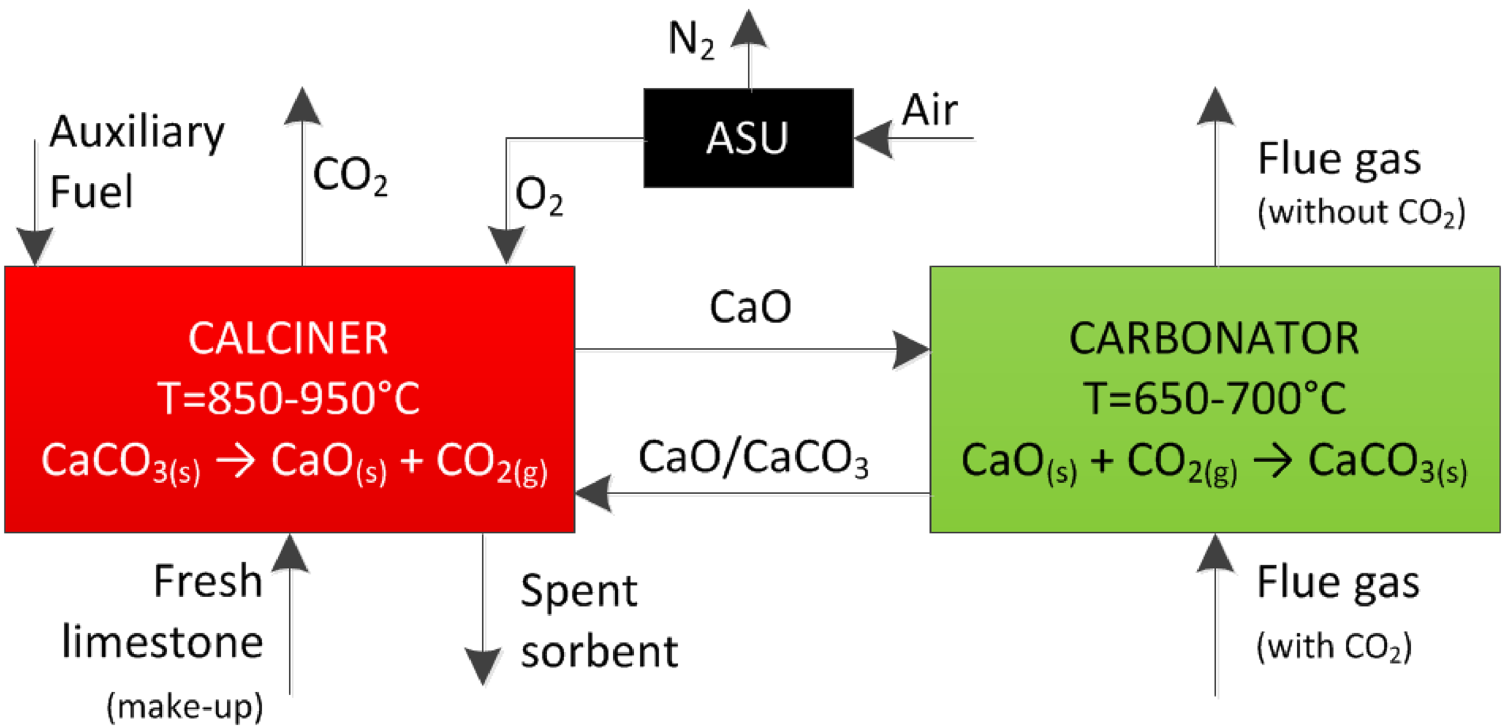
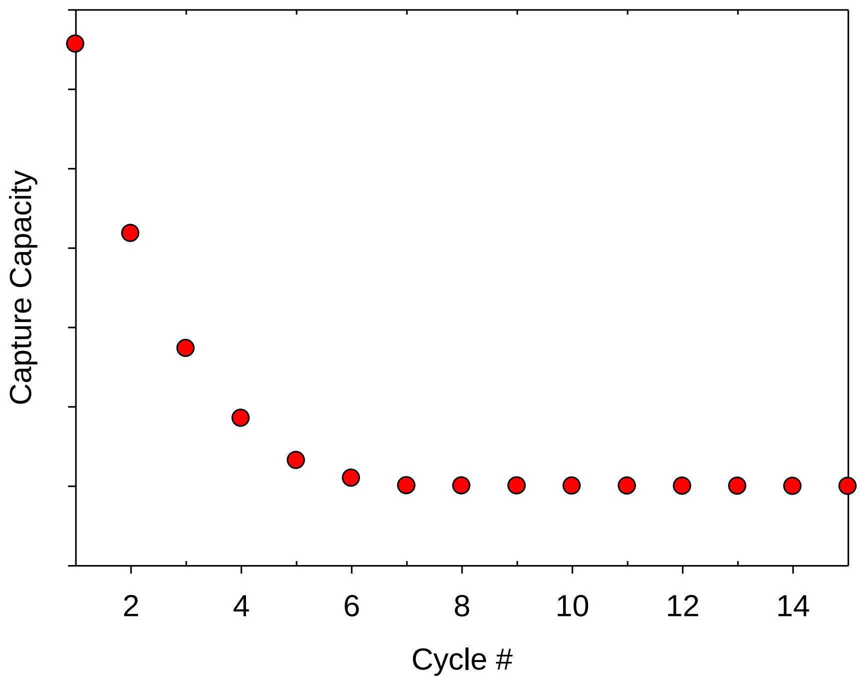
Overview: the Ca-looping concept



Overview: the Ca-looping concept

Sorbent-related Issues (1/2)



Decay of CO_2 Capture Capacity of the sorbent

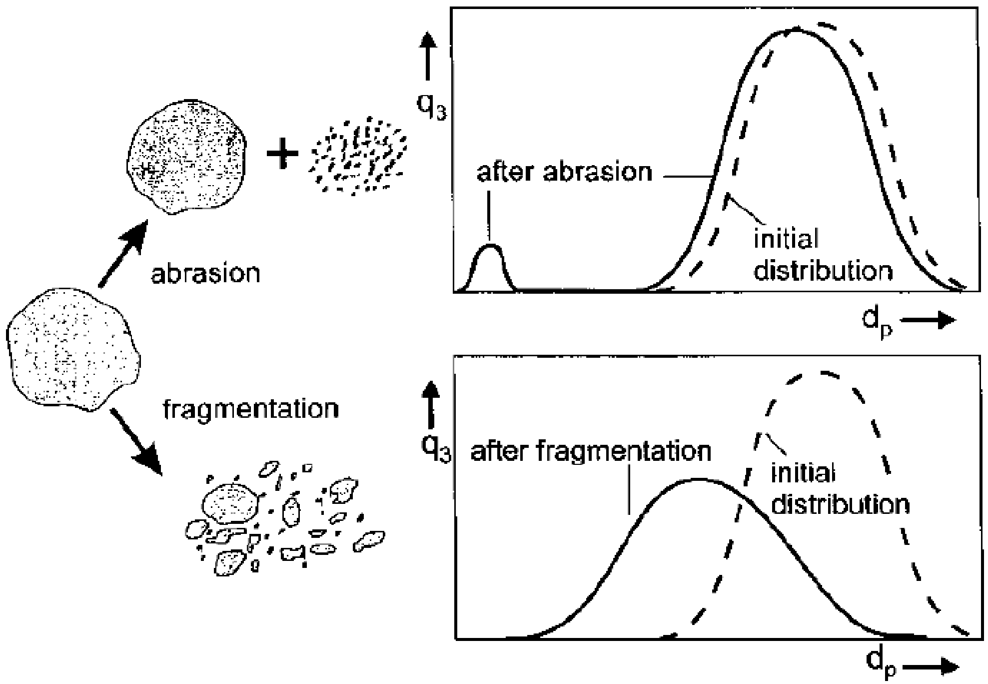
- *Sintering*
- *Presence of SO_2*

Overview: the Ca-looping concept

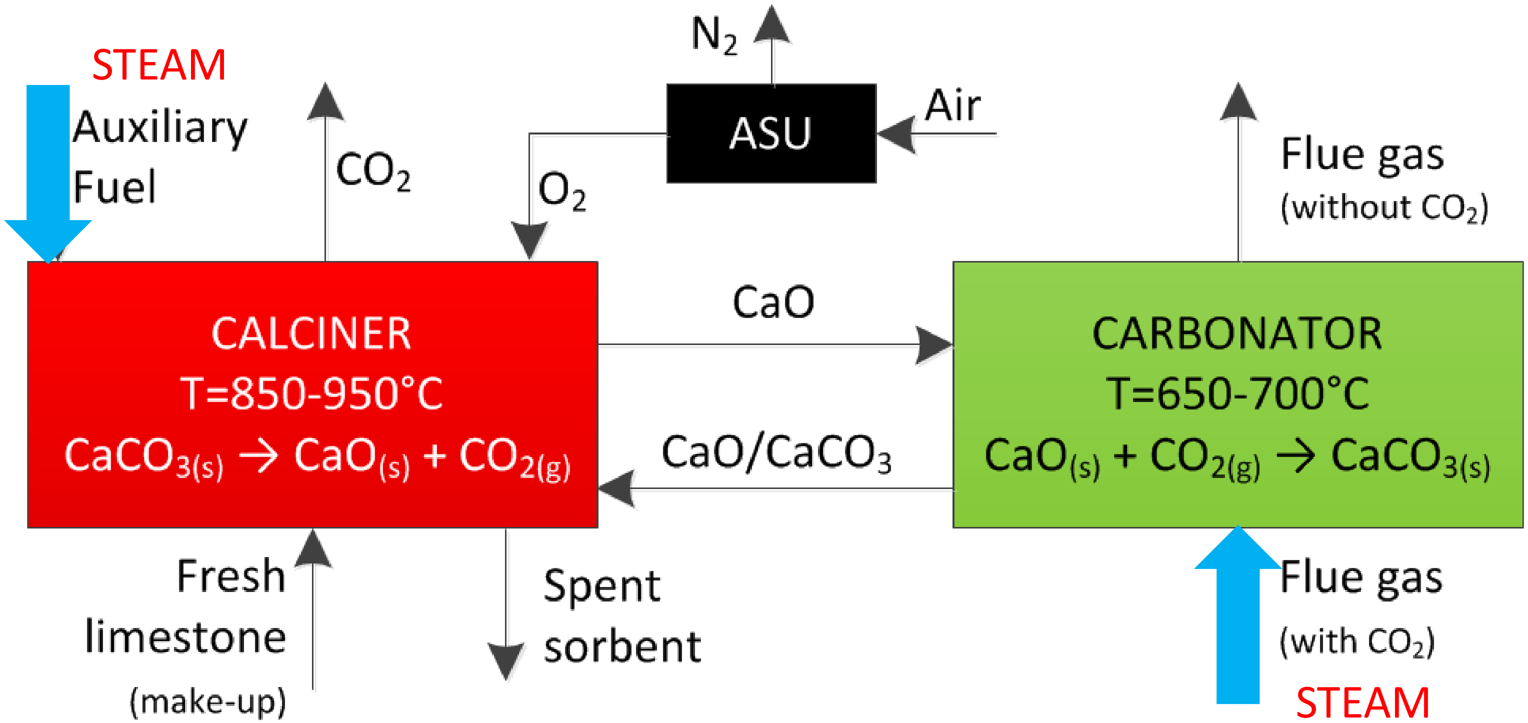
Sorbent-related Issues (2/2)

Attrition/Fragmentation Phenomena

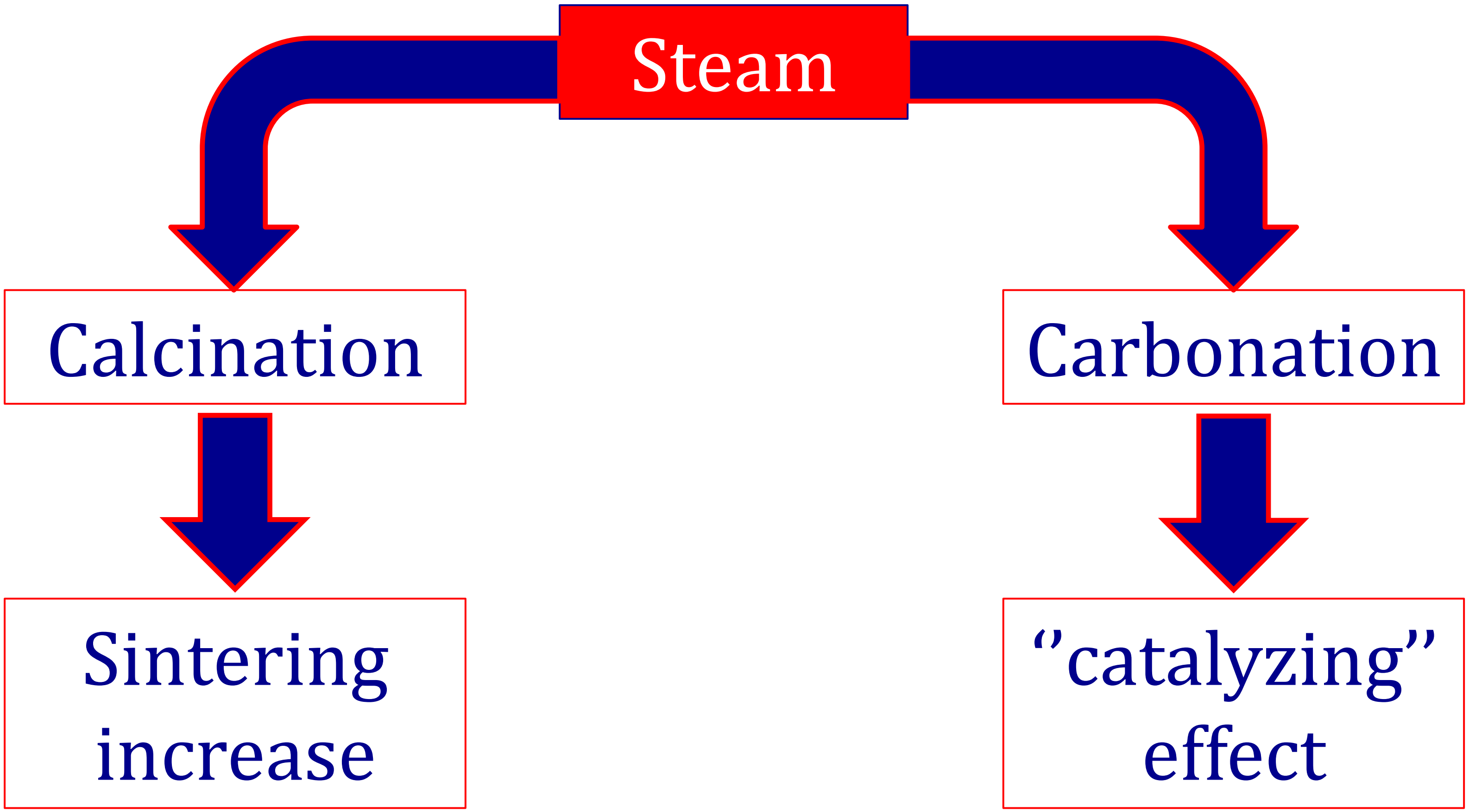
- Primary Fragmentation
- Secondary Fragmentation
- Attrition by Abrasion



Overview: effect of steam



Overview: effect of steam



Experimental

Lab-scale Fluidized bed (40mm-ID)

German Limestone (EnBW) (0.4-0.6 μm)

4 complete cycles + 5° Calcination

→

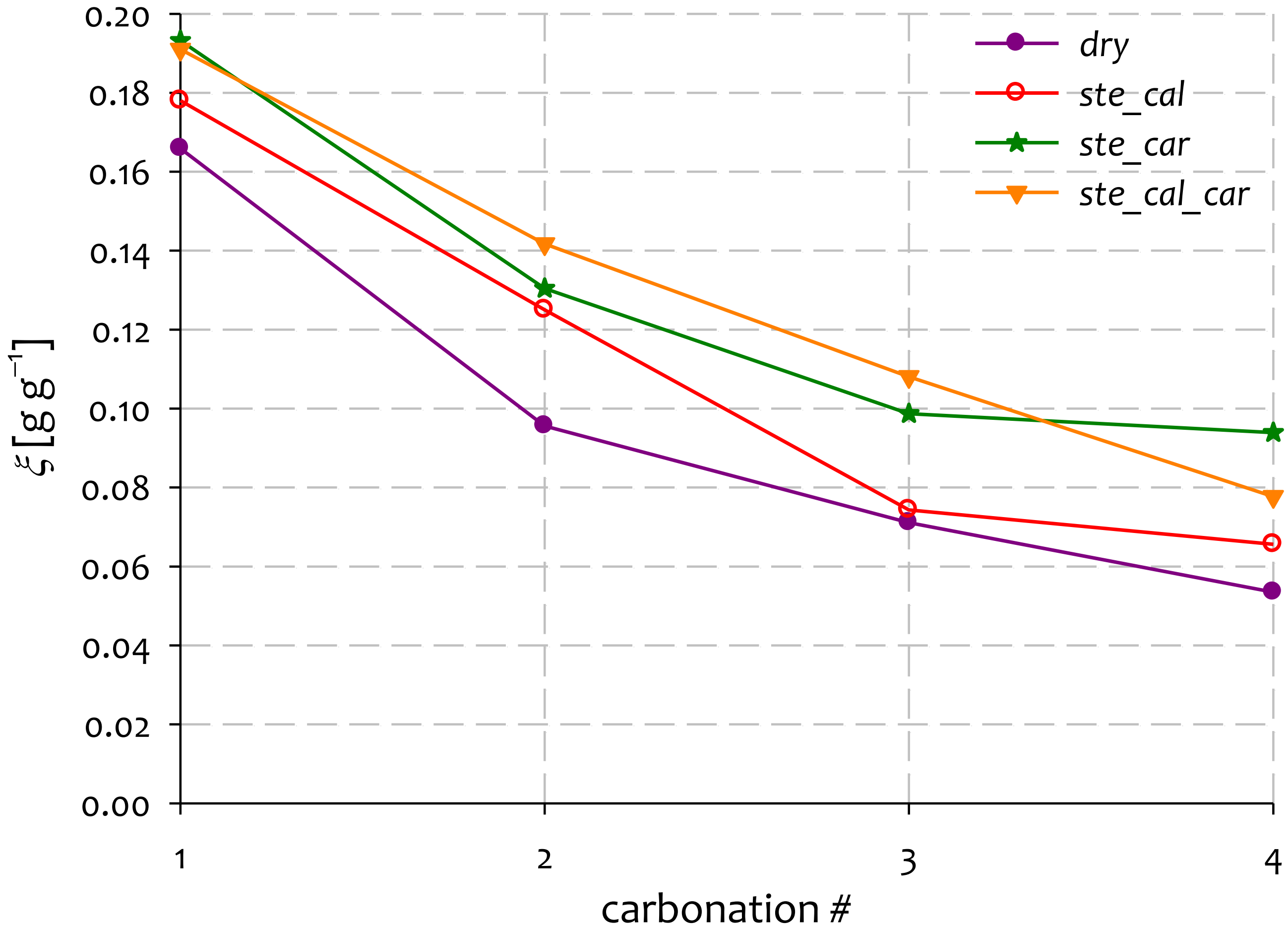
CO_2 Capture Capacity (ξ)

Fragmentation tendency

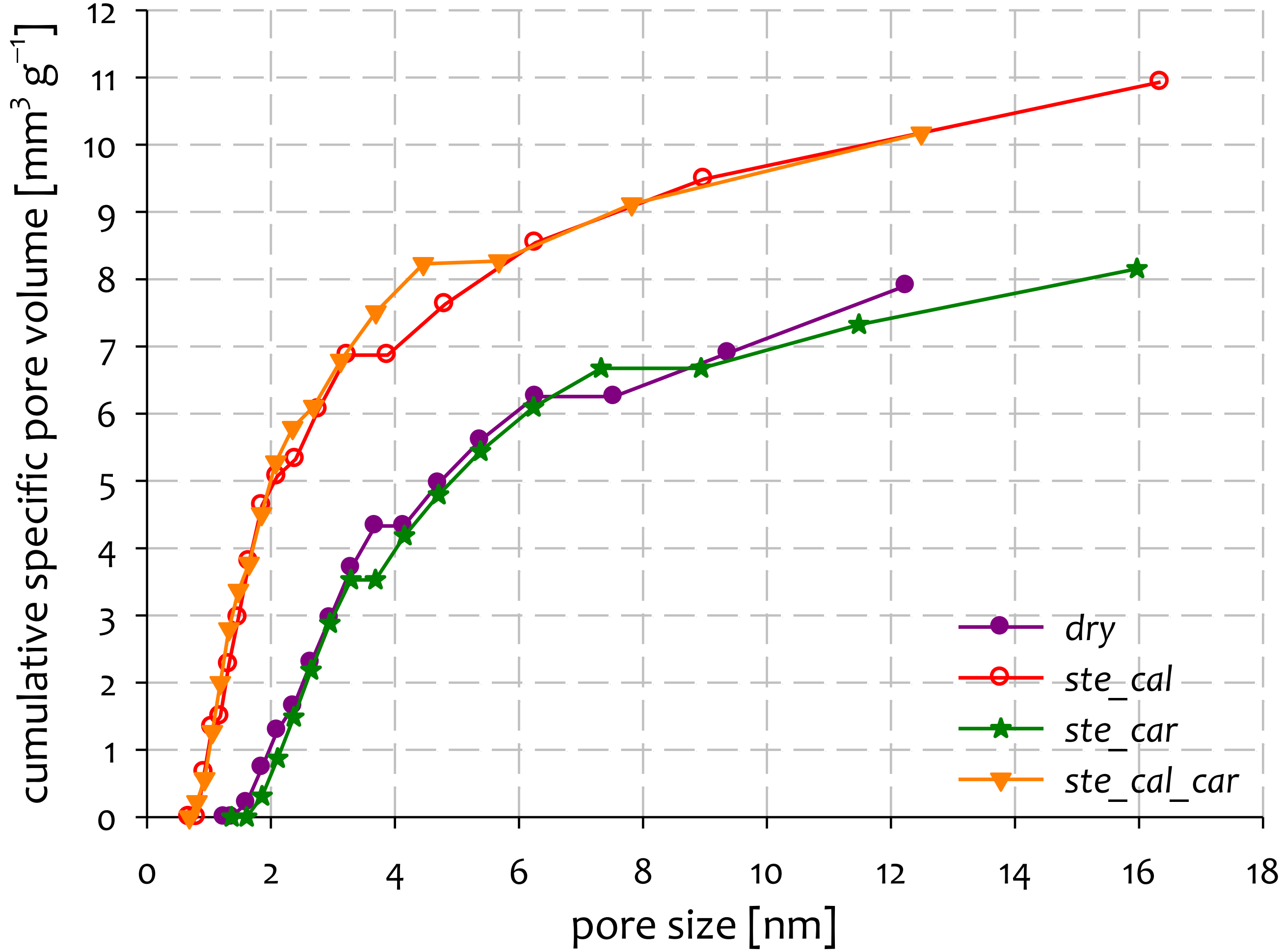
N_2 porosimetry + SEM

	calcination stages	carbonation stages
dry		
Temperature	940°C	650°C
Test duration	20 min	15 min
Fluidization superficial velocity	0.7 m s^{-1}	0.6 m s^{-1}
Fluidizing gas composition (vol.)	70% CO_2+30% air	15% CO_2+85% air
ste_cal		
Fluidizing gas composition (vol.)	10% steam+70% CO_2+20% air	15% CO_2+85% air
ste_car		
Fluidizing gas composition (vol.)	70% CO_2+30% air	10% steam+15% CO_2+75% air
ste_cal_car		
Fluidizing gas composition (vol.)	10% steam+70% CO_2+20% air	10% steam+15% CO_2+75% air

Results

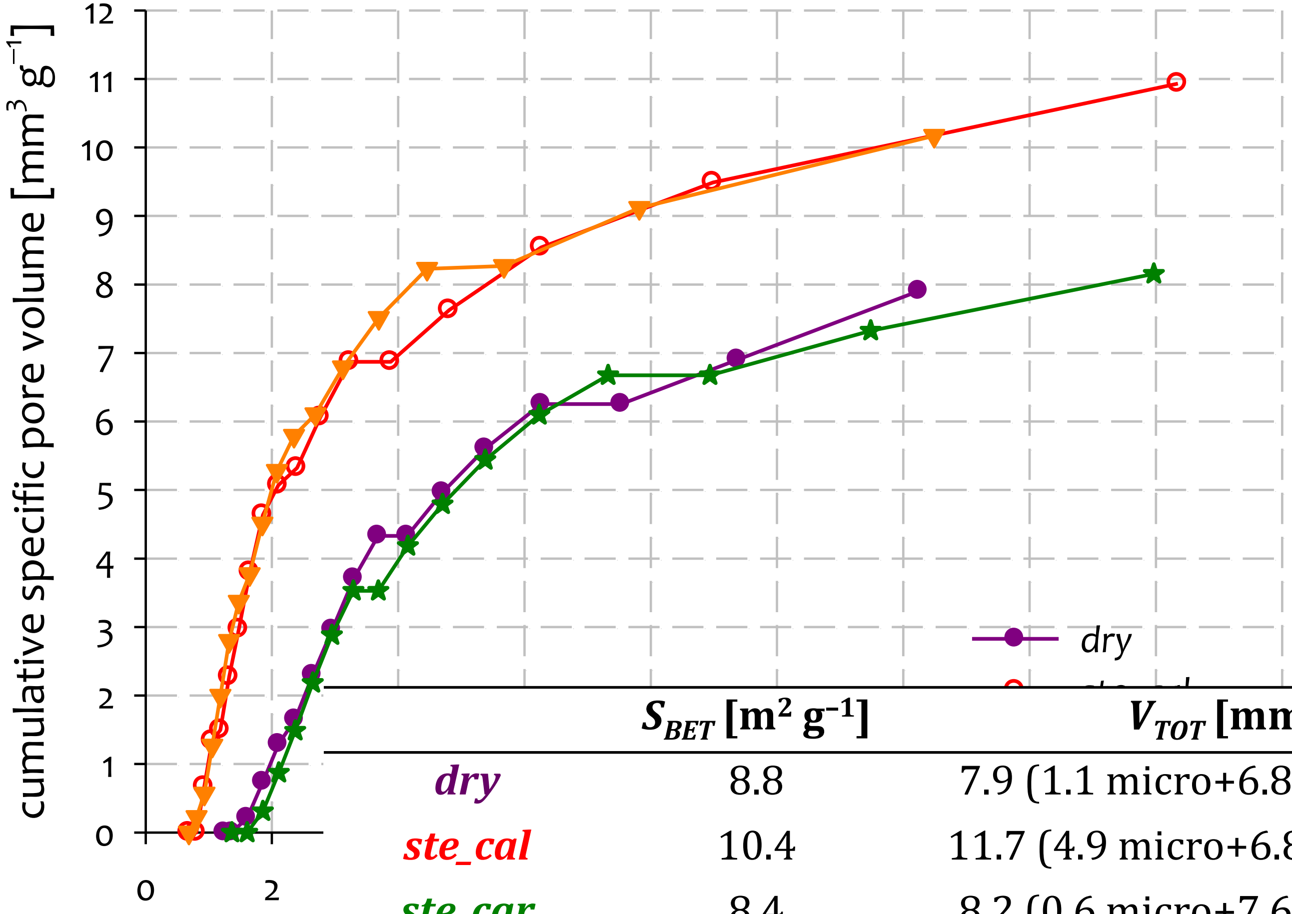

0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
ξ [g g⁻¹]
1
2
3
4
carbonation #
dry
ste_cal
ste_car
ste_cal_car

Results



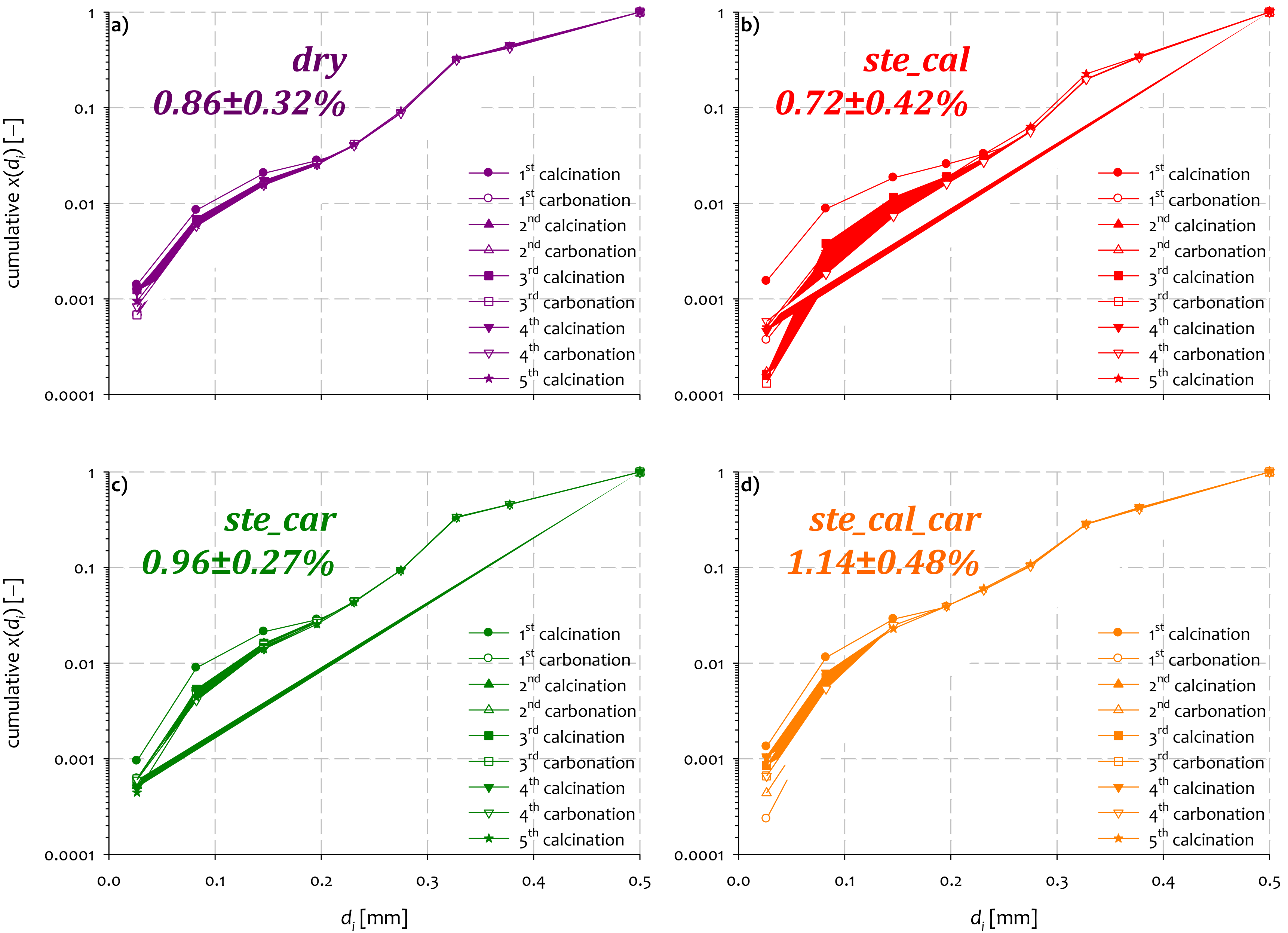
cumulative specific pore volume [mm^3 g^{-1}]
pore size [nm]
0
1
2
3
4
5
6
7
8
9
10
11
12
0
2
4
6
8
10
12
14
16
18
dry
ste_cal
ste_car
ste_cal_car

Results



	S_{BET} [m² g⁻¹]	V_{TOT} [mm³ g⁻¹]
dry	8.8	7.9 (1.1 micro+6.8 mesoporosity)
ste_cal	10.4	11.7 (4.9 micro+6.8 mesoporosity)
ste_car	8.4	8.2 (0.6 micro+7.6 mesoporosity)
ste_cal_car	10.1	10.2 (5.0 micro+5.2 mesoporosity)

Results



a)
dry
0.86±0.32%
b)
ste_cal
0.72±0.42%
c)
ste_car
0.96±0.27%
d)
ste_cal_car
1.14±0.48%
cumulative x(d_i) [–]
d_i [mm]
1st calcination
1st carbonation
2nd calcination
2nd carbonation
3rd calcination
3rd carbonation
4th calcination
4th carbonation
5th calcination
1
0.1
0.01
0.001
0.0001
0.0
0.1
0.2
0.3
0.4
0.5

Conclusions

- **steam is beneficial (CO_2 uptake)**
- **calcination development of accessible porosity CO_2 uptake in the order of 10%**
- **carbonation positive role of steam as a "catalyst" of CO_2 diffusion through the sorbent $CaCO_3$-based product layer.**
- **calcination + carbonation: synergistic effects**
- **fragmentation propensity: during calcination induces a more resistant external particle structure.**
- **results highlight the positive role that the presence of steam in realistic calcium looping conditions**

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Thank you for your attention

Acknowledgments

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