Carbonation of alkaline residues in the manufacture of lightweight aggregate

Dr Paula Carey

Chief Technical Officer,
Carbon8 Systems

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Carbonation & Mineralisation

- Carbonation can be accelerated by using increased concentration of CO_2
- Calcium and Magnesium silicates, oxides and hydroxides can react with CO_2 to form carbonates
- These minerals can be found in
  - Basic and ultrabasic rocks (basalts, serpentinites, dunites)
  - Industrial thermal residues (steel slags, ashes from EfWs, cement and concrete residues etc)
- Reaction is exothermic
- Does not require large amounts of energy for the transformation of the CO_2 molecule
- Permanent capture of CO_2
- Can use pure CO_2 or CO_2 directly captured from flue stacks or the air (DAC)

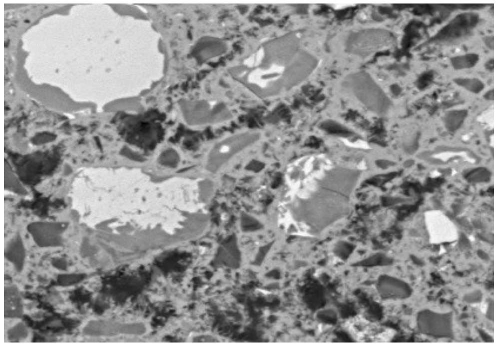
Conditions of Carbonation

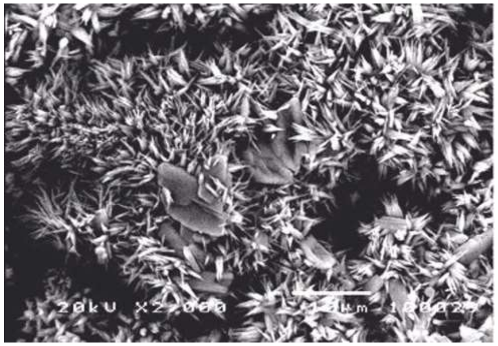
Two main conditions of carbonation

1. Wet water: solid ratios > 1:1 alkaline water leading to precipitation of carbonate in the water.

2. Semi-dry or thin film: Carbonate nucleates on the grains or replaces the grains of the residue and can help bind the grains together.

    - The reaction can be performed at atmospheric temperatures and pressures or at a range of elevated temperatures and pressures up to super critical CO_2 conditions





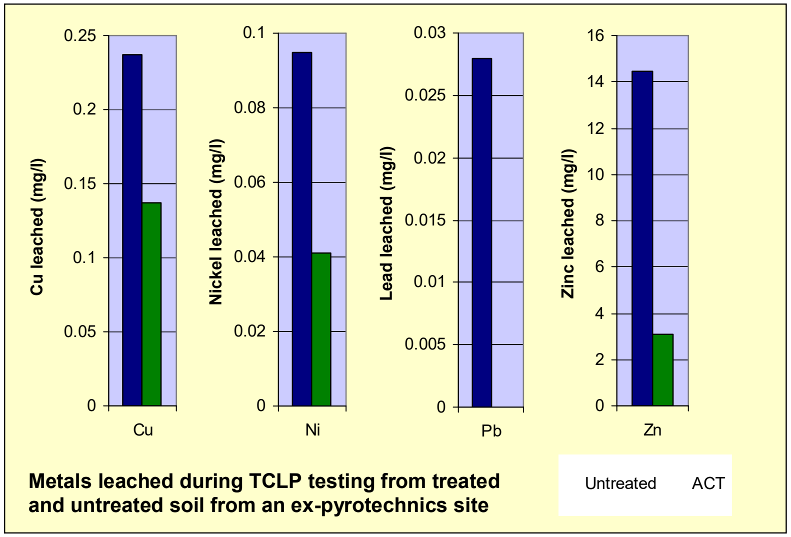
Carbon8 Systems

- Formed in 2006 after +10 years research into carbonation
- Particularly, treatment of contaminated soils with UK EA and USEPA
- Early patent using a modification of cement stabilization to treat hazardous wastes
- Use semi-dry carbonation, at atmospheric temperature and pressure conditions
- Commercialised the technology in 2010 via a license for the treatment of APCr from EfW
- Currently, three plants treating APCr in the UK using pure CO_2 delivered in a tanker
- From 2018, developed technology to use CO_2 directly from flue gas
- Two demonstration deployments in Ontario 2018 and UK 2019
- First commercial deployment with Vicat Cement Group in France 2021

Contaminated Land Remediation

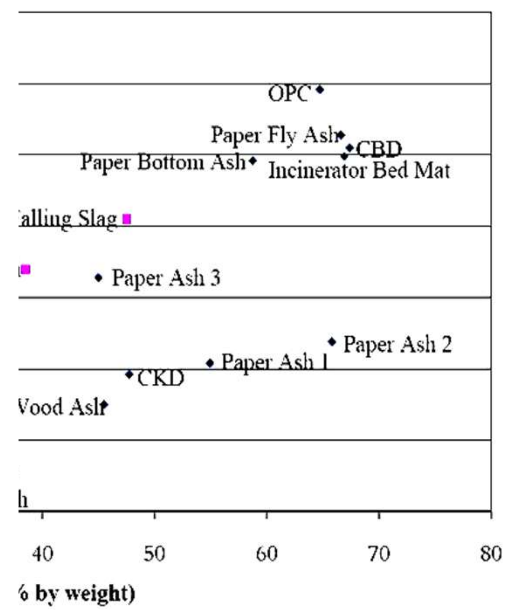
- ACT can be applied to contaminated soils – through the addition of a carbonatable binder
- Modified form of cement stabilisation/solidification (S/S)
- Reduced pH
- Final granular product generated in minutes rather than hours for traditional S/S

Treatment of soil washing residues, Olympic Park



Treatment of heavy metal contaminated soil.

Applicable residues



Carbon Sequestration Potential

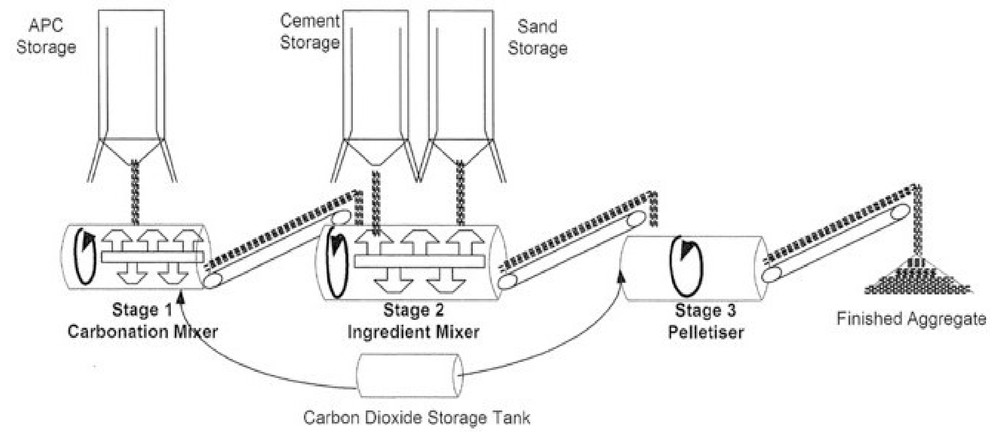
The total amount of CO_2 that could be sequestered globally through C8S Accelerated Carbonation Technology processes is theoretically 1,045Mt per year but 500 Mt per year more realistic

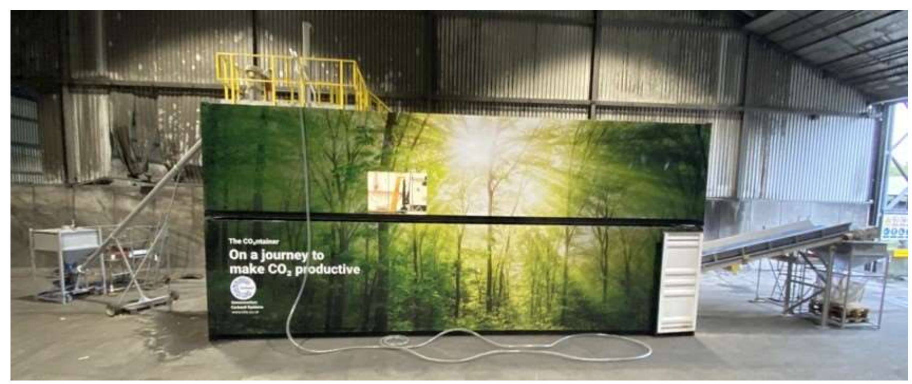
Coal	Cement	CDW	Biomass	Steel	Oil shale	EfW	Paper & pulp
411Mt	192Mt	178Mt	174Mt	79Mt	5Mt	4Mt	1Mt

All figures based on annual production of residues, excluding legacy wastes
This information is based on external academic papers as well as internal know how

Air Pollution Control Residues

- Thermal residues from Energy from Waste Plants: Air Pollution Control residues (APCr)
- APCr treated using Accelerated Carbonation Technology
- Treated APCr mixed with binders and fillers and then pelletised with further carbonation.
- 3 plants in the UK treating APCr under licence
  - Use pure CO_2 delivered in tanker
  - Treating 40,000 t APCr /year
  - End of Waste acceptance by Environment Agency
- Demonstration of CO_2ntainer for treatment of APCr in 2020 at AVR in Netherlands





Use of Flue Gas derived CO_2

- Work with UCL in 2006 showed that higher concentrations of CO_2 resulted in lower conversion rates
- Thus, there were benefits to using flue gas derived CO_2 directly
- This was supported by our work in 2010 using landfill derived CO_2
- Pure CO_2 is expensive and can be in short supply
- In 2018, returned to using point sources of CO_2

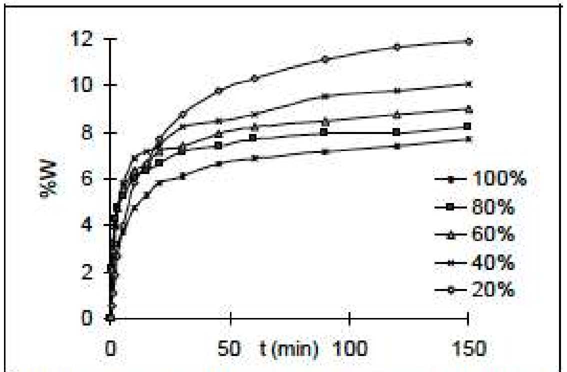
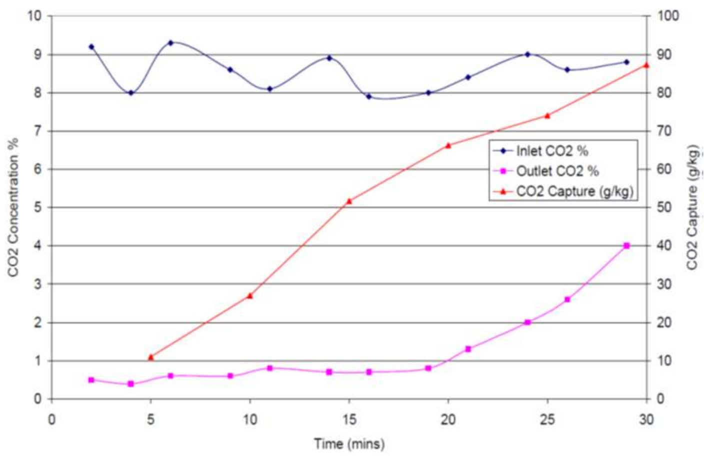
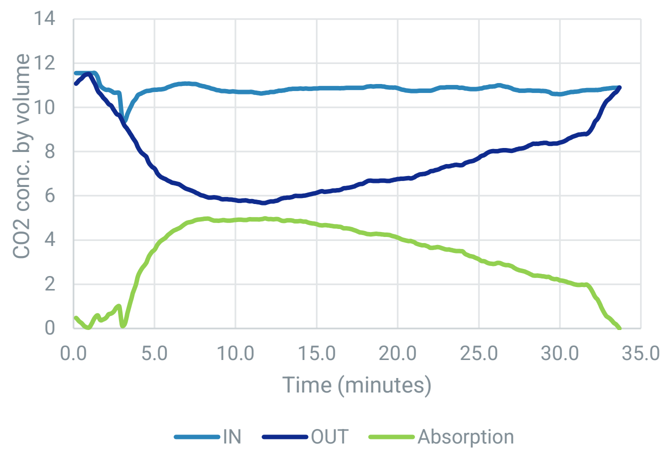
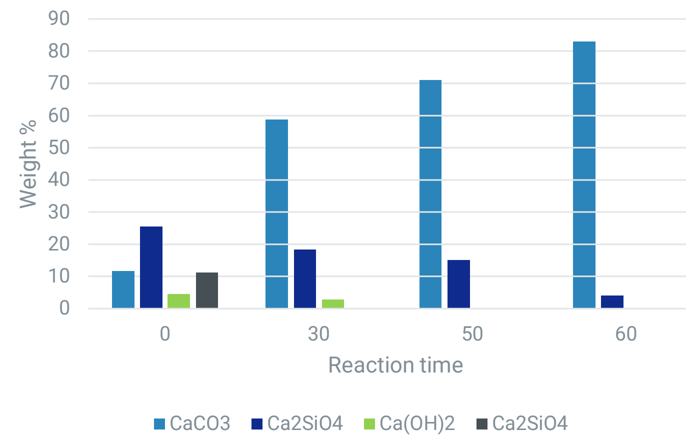


Figure 2 (a). Evolution of reaction with time for different concentrations of CO_2, w/s=0.3, T=20ºC.



Early deployments of the CO_2ntainer





The CO_2ntainer – Carbon Capture in a Box

Introducing the Plug 'n Play CCUS solution: retrofittable into any existing industry plants

CO_2ntainer at Vicat Group in Montalieu, France

CO_2 capture
Direct capture solution,
1,500tonnes– 4,000tonnes CO_2 per annum

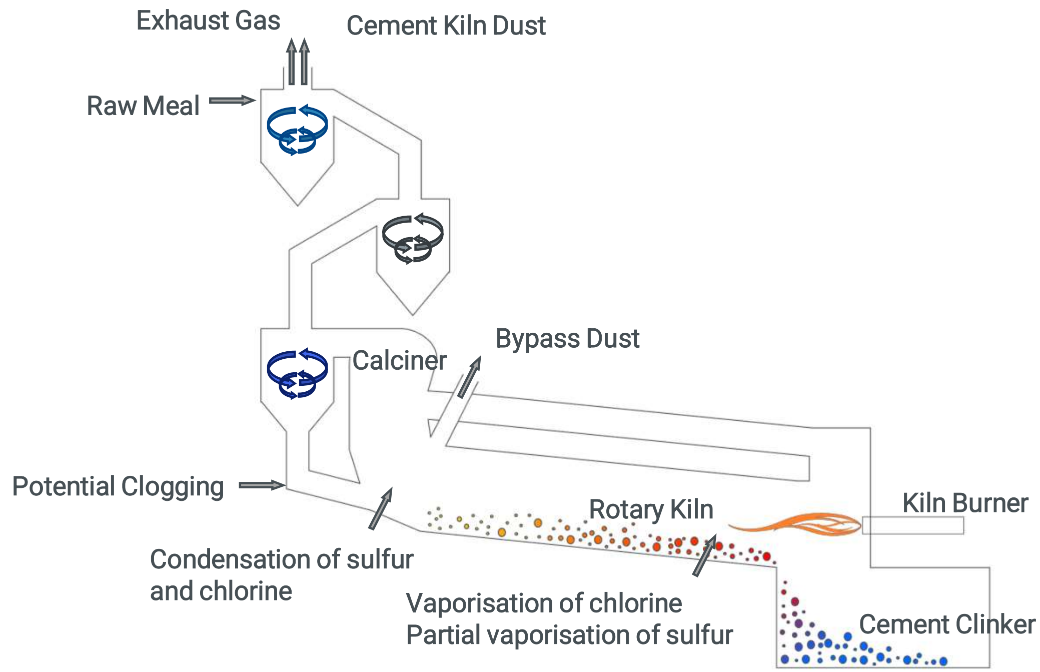
12,000 tonnes
Waste treated per annum

100% automation
Manual or automatic operation

Seamless integration
No interference with production

Cement By Pass Dust

- By-pass dust produced primarily as a result of change to alternative fuels
  - Chlorides etc in the refuse derived fuel need to be prevented from getting into the clinker
  - Can cause clogging in the kiln
- Annual global cement production is 4100 Mt (2020)
- Production of CKD and CBD between 250 and 400 Mt per year.
- >40 Mt of CO2 could be captured per year.
  - Assuming an average of 15%_CO_2 reactivity
- Compared with using natural aggregate the use CBD aggregate in concrete can lower its the overall carbon footprint by >10%.



Properties of By-pass Dust

	min	max	average
CO_2 uptake (wt%)	7	33	18
Loose bulk density (kg/m3)	276	910	625
Chloride content (wt%)	2	23	10

- By-pass dust variable between plants and within a plant
    - Variable composition of fuel and amount burnt
- Undertake “mix design development” project for each new plant
    - Assessment of technological and economic viability of CO_2ntainer deployment

Properties of Aggregate

	Vicat ACT aggregate	Leca
CO_2 uptake (weight %)	10-15%	-
Strength (Mpa)	>1.0	0.9
Los Angeles Abrasion (%)	<40	Not tested
Loose Bulk Density (kg/m^3)	<1100	350
Water absorption (%)	<25	<30
Water soluble chloride (%)	<2.0	<0.04
Acid soluble sulfate (%)	<0.5	<0.5

Applications in Construction

- Concrete blocks
- Ready-mix Concrete
- Asphalt
- Pipe bedding
- Floor screeds






Benefits – Economic sustainability

A circular solution to industrial waste and CO_2 capture

1

Direct cost savings

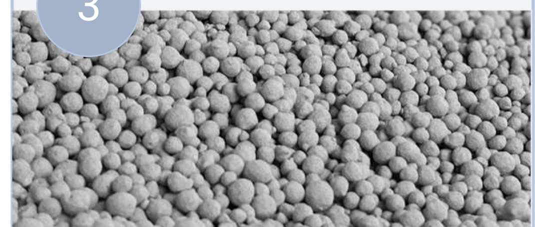
Divert residues from landfill with sustainable waste management and offset associated costs

2

Carbon footprint reduction

Permanently and safely store CO2 from point source

3



High-value manufactured products

Enable circularity through implementing sustainable alternative building materials in production or market them for a profit

Carbon8

www.c8s.co.uk