BioMasse Canada

Supergen Bioenergy

Hydrogen from biowaste with in-situ CO2 capture and utilization

Presenter: Bharat Regmi
Supervisor: Dr. Animesh Dutta

Bio-Renewable Innovation Lab (BRIL)
School of Engineering, University of Guelph, Canada

University of Guelph

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Introduction

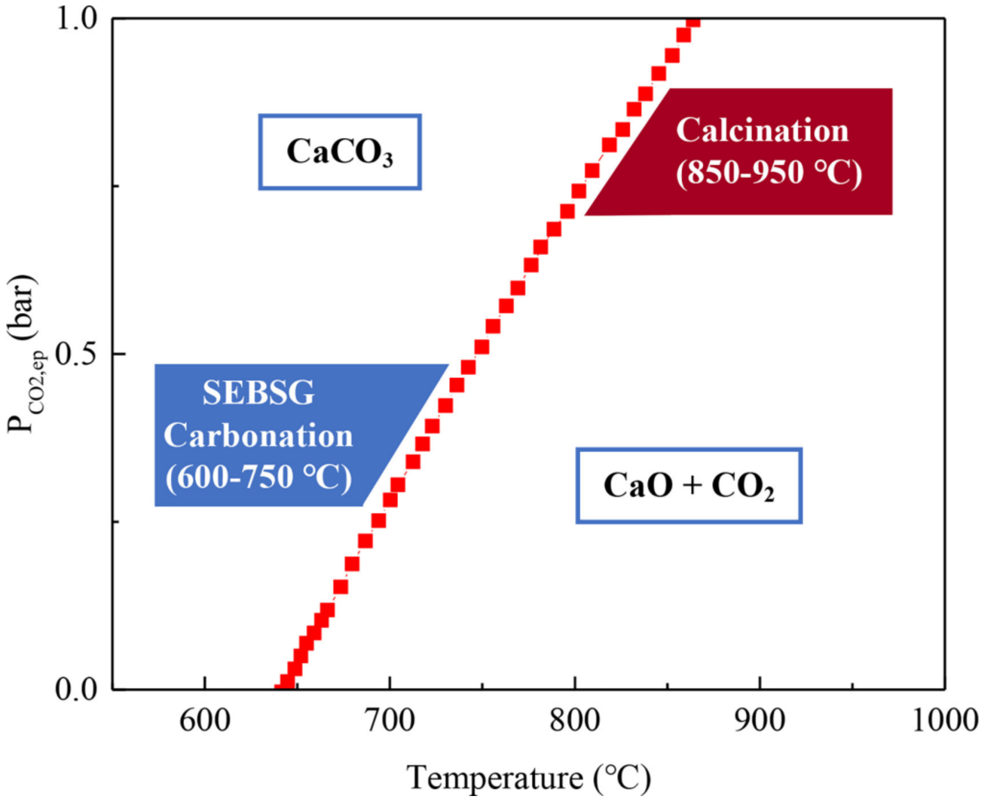
Biomass has better reactivity and is more suitable for hydrogen production by thermochemical methods compared to coal. Due to the low hydrogen content of biomass, a high H_2 yield cannot be obtained by its own hydrogen content.

Steam as the gasification agent undergoes for water gas shift reaction which exchange the H in the steam thereby increasing the hydrogen production. There are still a number of CO_2 and tar in the biomass gasification products and adding adsorbent and catalyst to the reaction process can reduce the concentration of by-products and obtain a higher hydrogen yield.

CaO is a basic alkaline earth metal oxide effective for CO_2 adsorption at moderate gasification.

- Enhances gas yield, reduces tar yield and enriches the hydrogen concentration in syn gas.
- Better thermodynamics and chemical properties, and its regeneration potential.
- Availability, low cost, safety, good adsorption and desorption kinetics, and adaptability for fluidized bed gasification.

- Researchers has reported a rise in hydrogen concentration from 43.69% to 63.07% and a reduction in CO_2 from 22.5% to 1.56% and reduction in tar from 81.28 g/Nm^3 to 26.71 g/Nm^3 using CaO as the bed material as sorbent (Udomsirichakorn et al., 2019)



Steam Gasification Chemistry:

Biomass + Heat $\rightarrow$ H_2 + CO + CO_2 + H_2O + CH_4 + C_nH_m + tar + char

Tar + H_2O $\rightarrow$ H_2 + CO_2 + CO + Hydrocarbons+ ...

C + 2H_2O $\rightarrow$ CO_2 +2H_2-88 kJ/g.mole

C + H_2O $\rightarrow$ CO + H_2-131.4 kJ/g.mole

CH_4 + H_2O $\rightarrow$ CO + 3H_2+ 206 kJ/g.mole

CO + H_2O $\rightarrow$ CO_2 + H_2 + 42.3 kJ/g.mole

C + CO_2 $\rightarrow$ 2CO-172.6 kJ/g.mole

CaO + CO2 $\leftrightarrow$ CaCO3 -178kJ/g.mol

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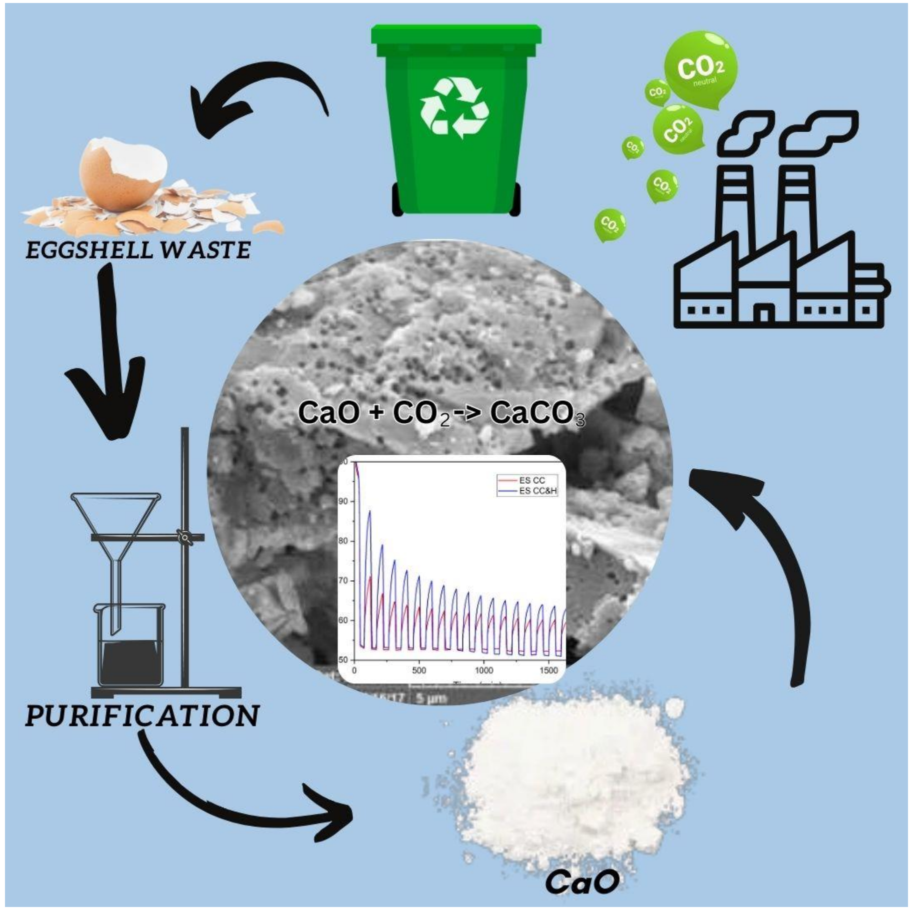
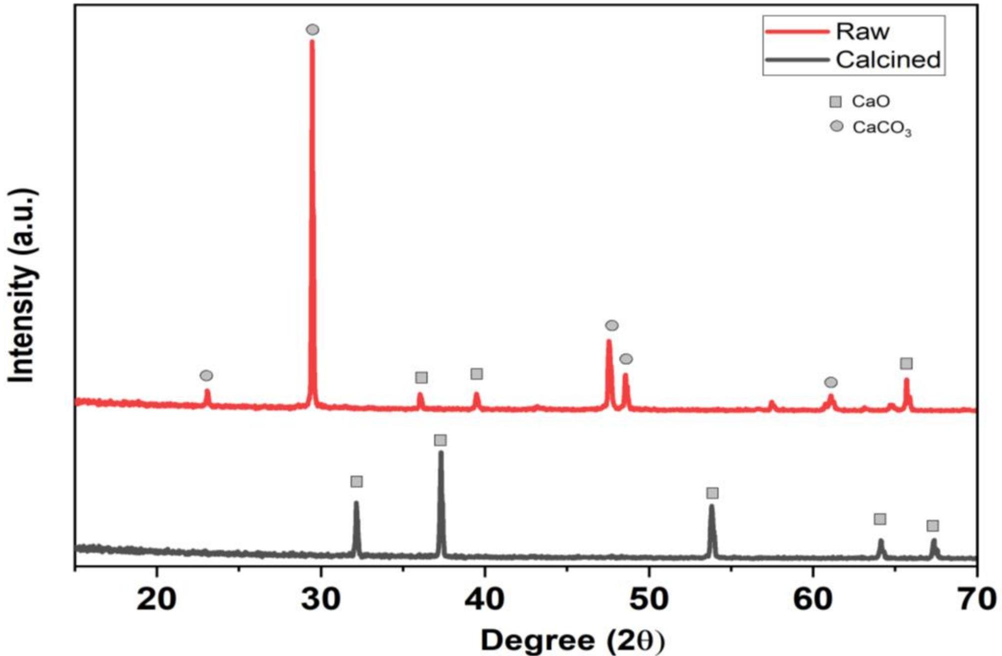
Research Objectives:

- Study of cyclic carbonation and calcination reaction kinetics, thermodynamics, and the sintering mechanism of calcium-based sorbent such as eggshell and dry wall.
- Experimental investigation of steam gasification with CO_2 capture using calcium-based waste sorbent such as eggshell and drywall.
- Impact of catalysts on improving carbonation stability for the reactivation of CaO-based sorbents through steam hydration during cyclic carbonation and calcination for CO_2 capture, utilizing CeO_2 and industrial waste as refractory additives.

Eggshell

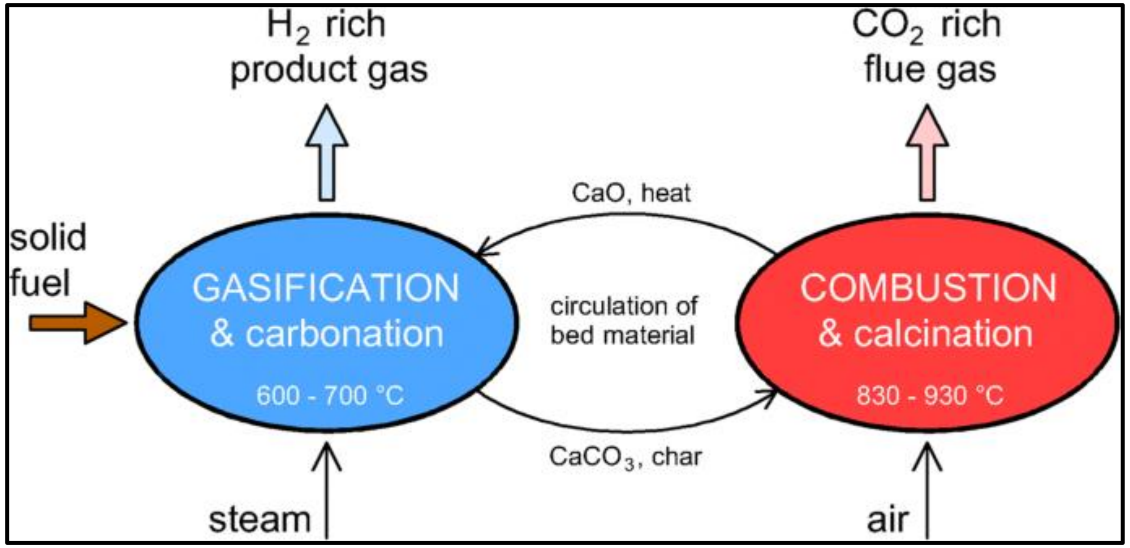
- Eggshells are comprised mainly of calcium carbonate (94 % weight), which makes it a promising candidate as a biomineralized Ca-based sorbent.
- Annual worldwide production of eggs was around 80 million tons in 2019 and is estimated that the yearly global egg consumption will upsurge to near 90 million tons by 2030 (A. Raheem, et al, 2019).
- 615 million dozen of egg per year accounting 45,000 tons of waste eggshell whose disposal cost around 1 million per year (A. Utioh et.al 2018) .

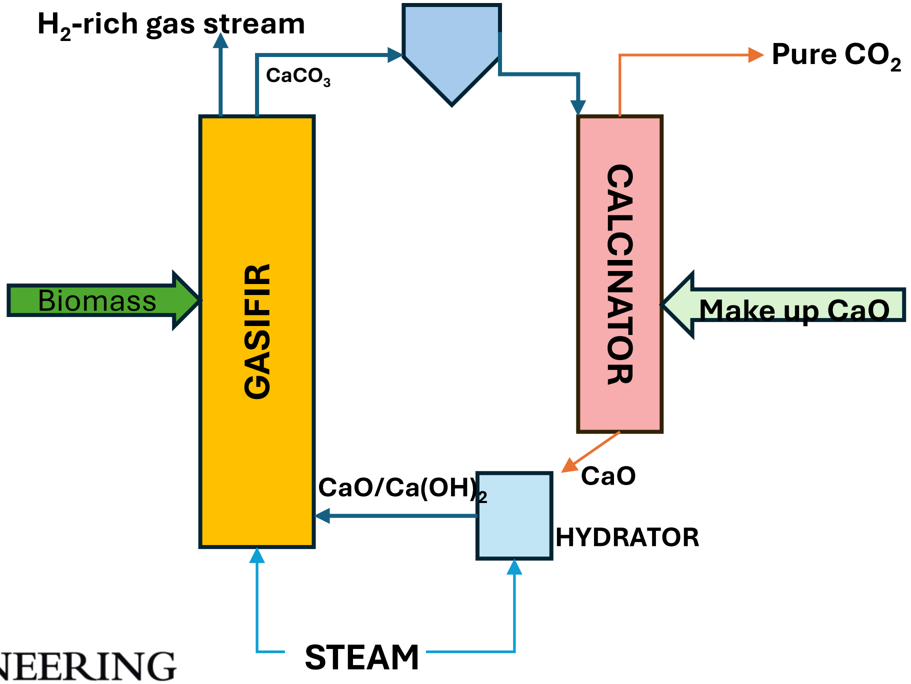


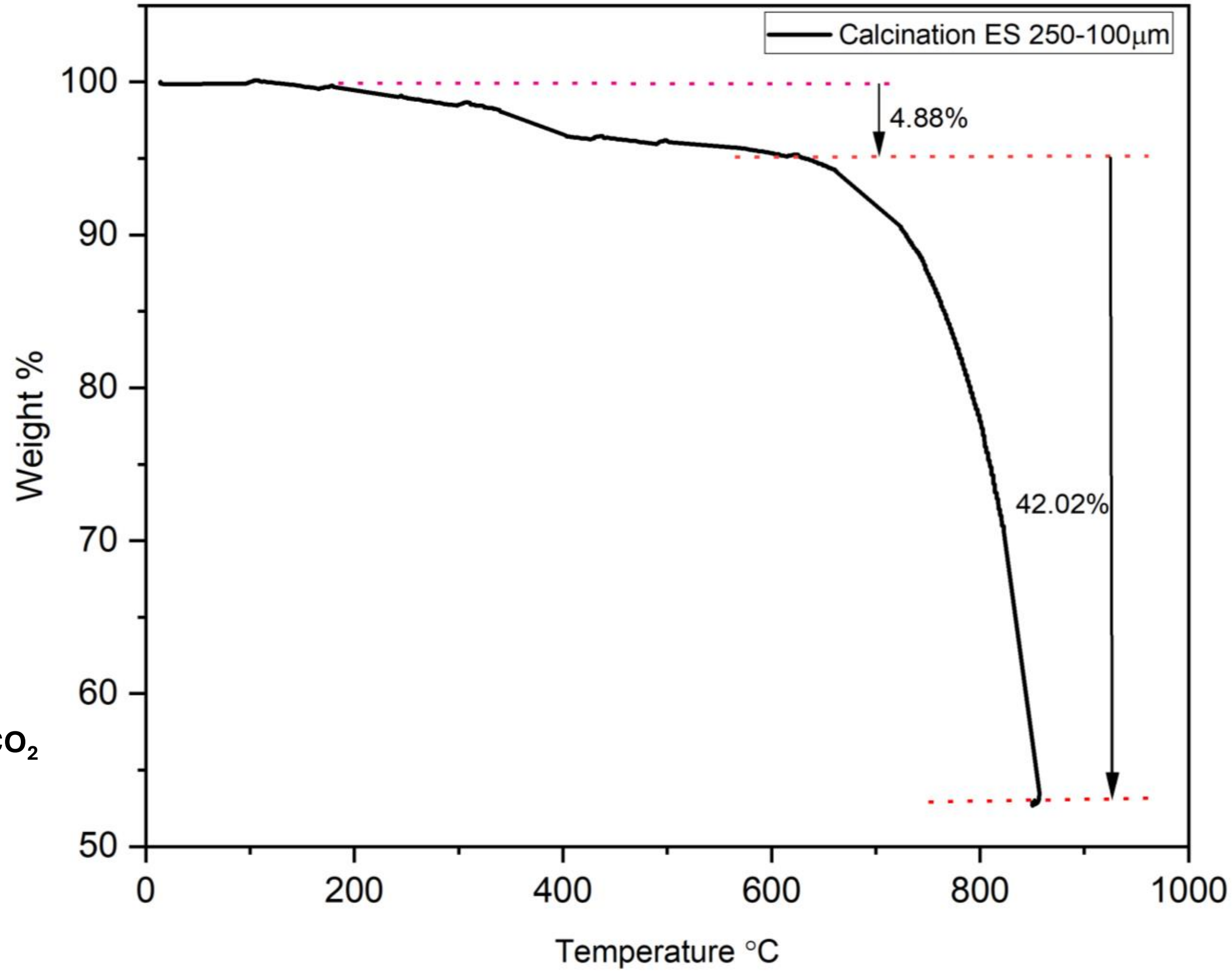


Material	Na_2O (mass%)	MgO (mass%)	SiO_2 (mass%)	K_2O (mass%)	CaO (mass%)
Raw Eggshell	0.152	0.53	0.176	0.053	53.05
Calcined Eggshell	0.166	0.99	0.205	0.072	94.81

Cyclic CO2 capture of Eggshell







The decomposition curve of eggshells is widely known with the decomposition of organic material present in the membrane is decomposed from 200 °C to 400 °C and from 600 °C calcination starts to occur at a very rapid rate typically found in Ca-based materials

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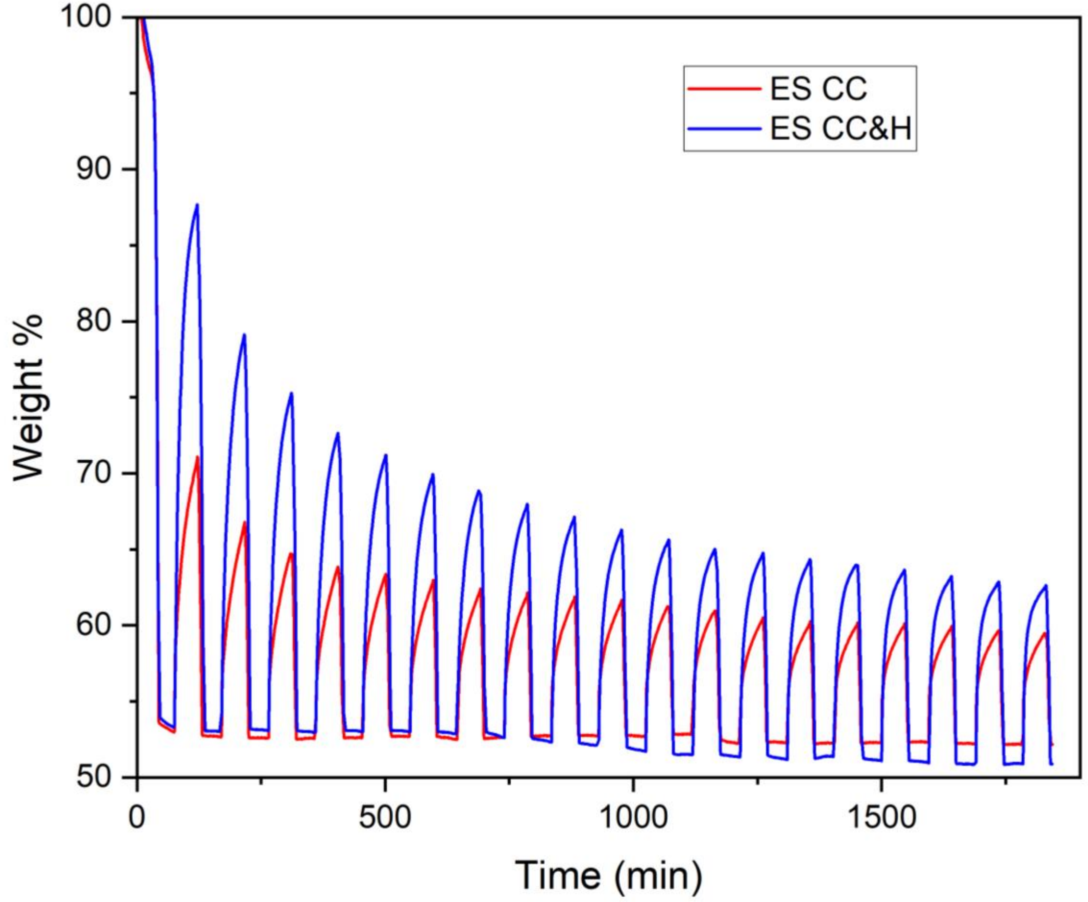
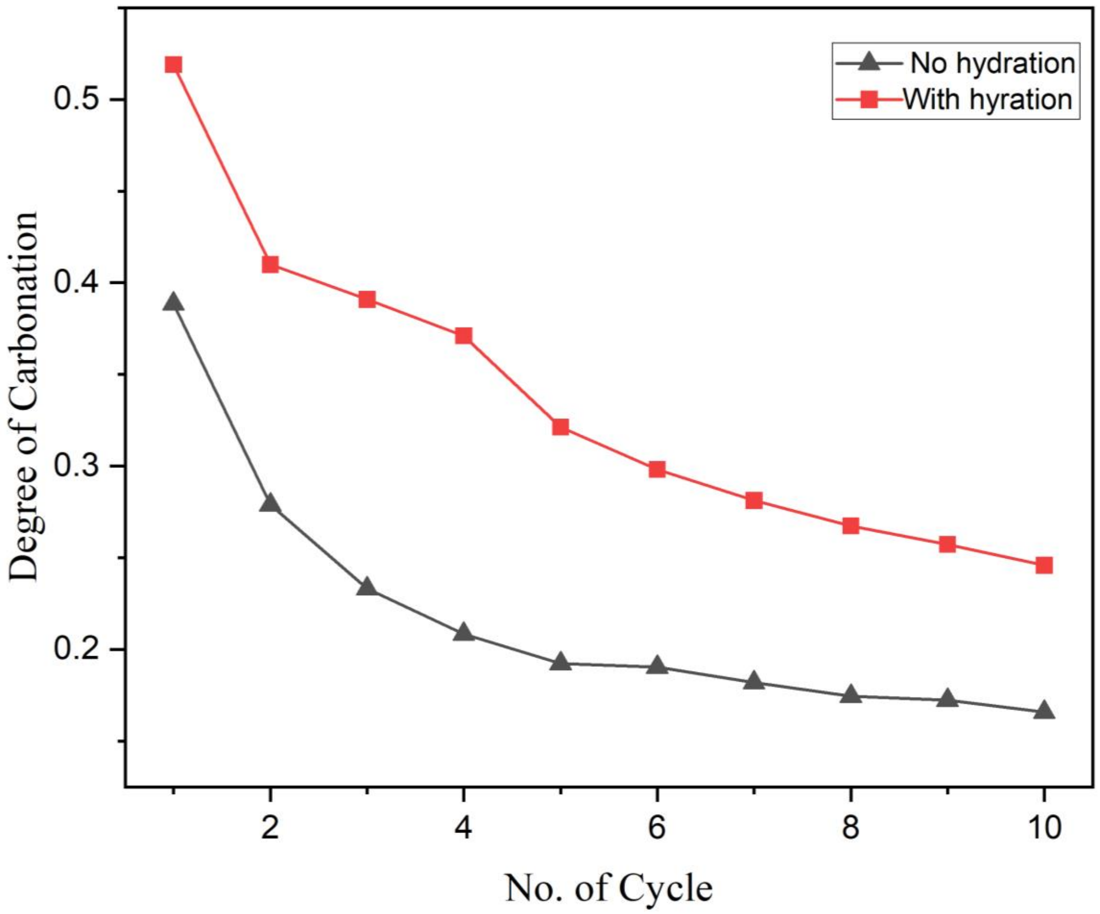
Hydration reactivation





- Effect of simultaneous carbonation and hydration
- There is an average 10% increment in the CO_2 capture capacity of sorbent for simultaneous carbonation and hydration

Catalysts for sorbent reactivation

Egg Shell+ CeO_2/Fly-ash

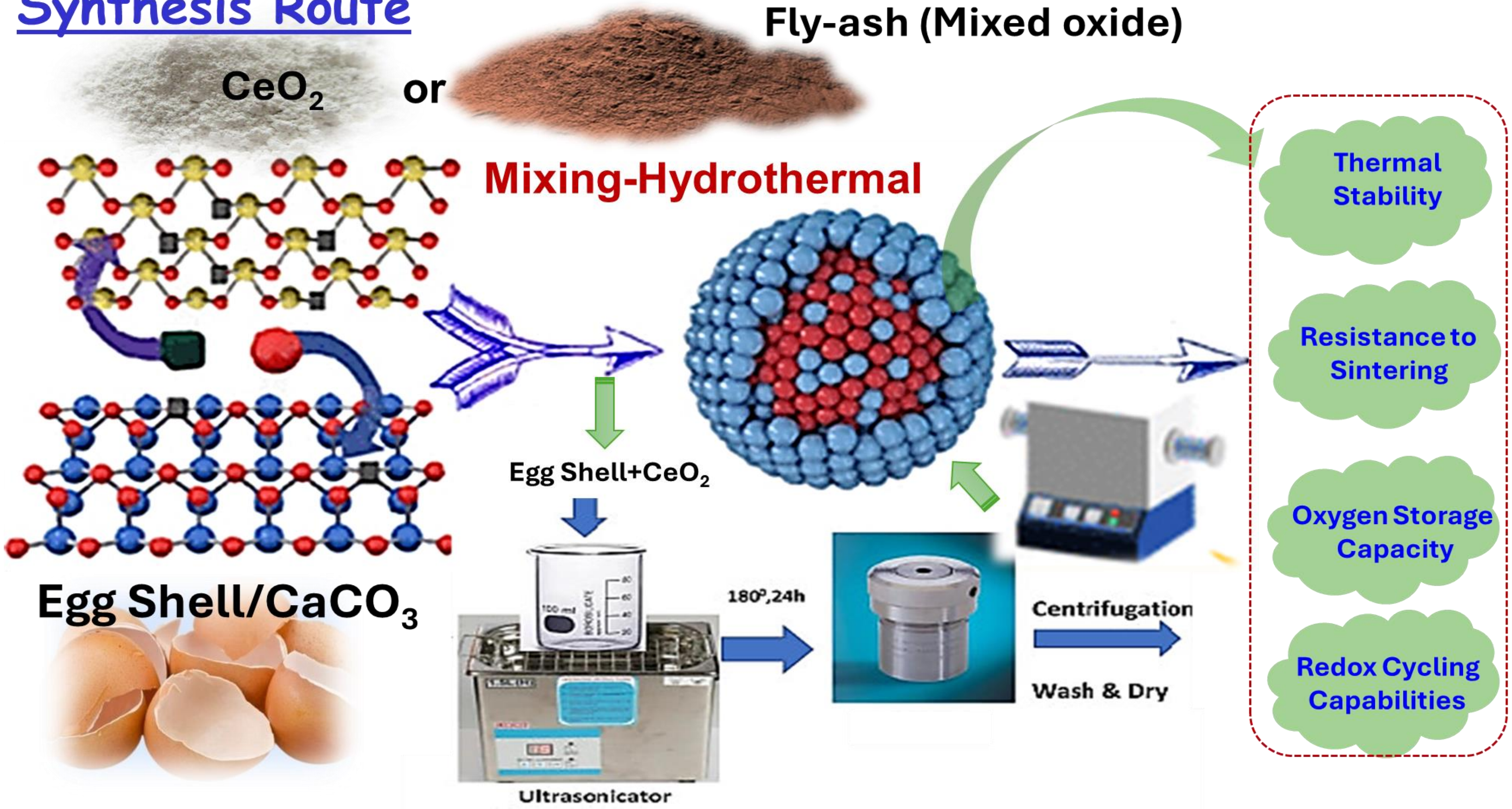
➤ **Why CeO_2??**

❖ CeO_2 (cerium oxide) is an excellent catalyst : **redox cycles between Ce^{4+} and Ce^{3+}**
❖ This redox flexibility allows **CeO_2 to act as an effective oxygen carrier**
❖ Additionally, CeO_2 has strong interactions with metals, making it an ideal support material for metal-based catalysts in CLG. These interactions **stabilize metal particles and promote dispersion, which enhances the overall catalytic performance**.

➤ **Why Fly-ash??**

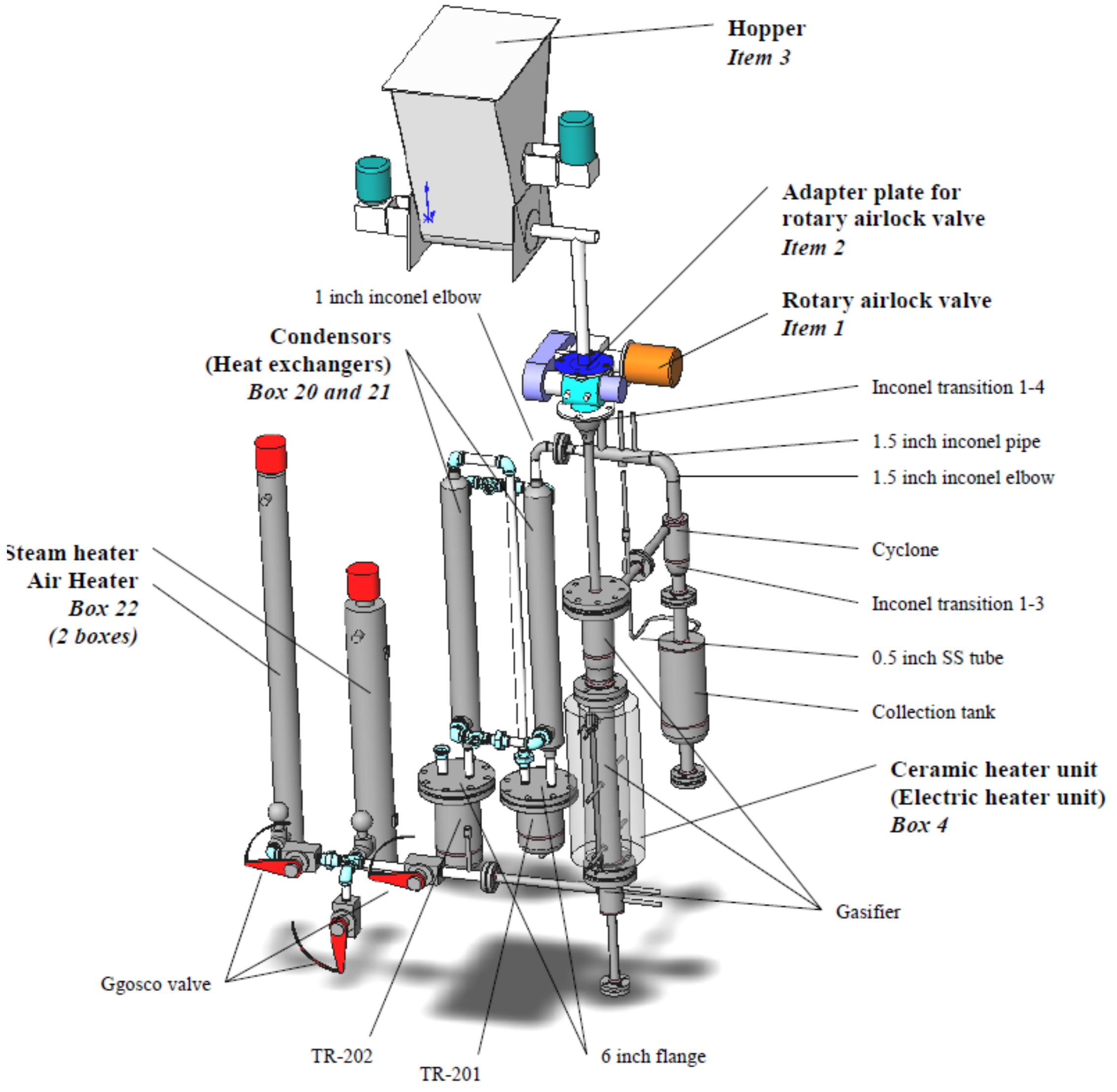
❑ Rich content of metal oxides, such as iron oxides (Fe_2O_3), and its **exceptional thermal stability**
❑ **Metal oxides** act as **oxygen carriers**, facilitating the conversion of carbonaceous fuels into syngas (a mixture of hydrogen and carbon monoxide) without direct contact with air.
❑ The iron oxides in fly ash can serve as **effective oxygen carriers, aiding in the oxidation and reduction cycles**

Synthesis Route



Scope of Future Work and Plan:

- Sorbent preparation with appropriate catalyst as support material.
- Sorbent characterization using HPTGA, SEM, XRD & XPS.
- Performing the gasification experiments
  - ✓ Steam gasification without carbon capturing
  - ✓ Steam Gasification simultaneous with Carbon Capture
    - ➢ Using Sorbent as the bed material for Gasification
    - ➢ Feeding sorbent along with biomass as feed into the reactor



Gasification Pilot Plant, Zentek Ltd., Guelph

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Thank You