Sustainable Syngas Production via Sorption Enhanced Biomass Gasification

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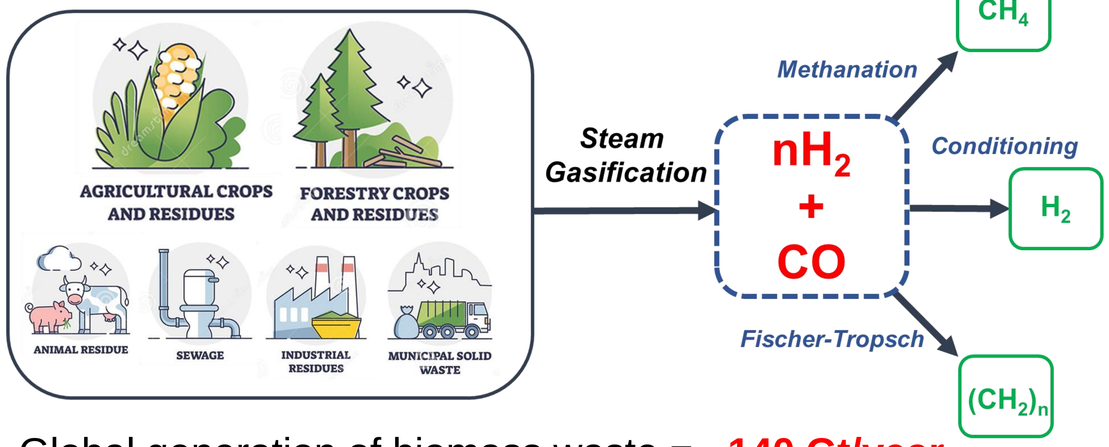
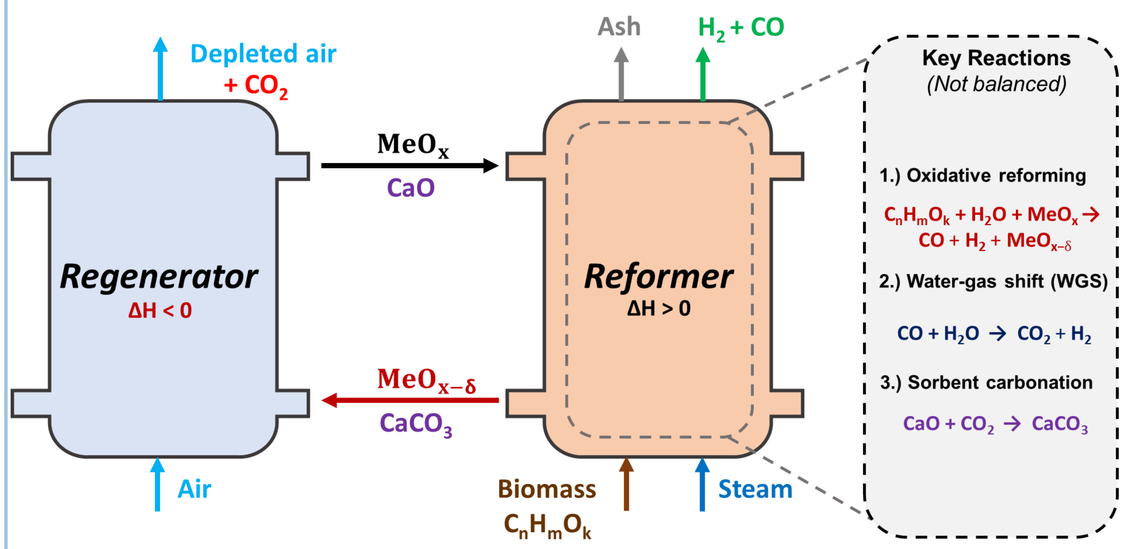
(1) Motivation: Trash to Treasure



Global generation of biomass waste = **~140 Gt/year**

The challenge: **low H_2:CO_x** with expensive downstream separations.

(2) Solution: Sorption Enhancement



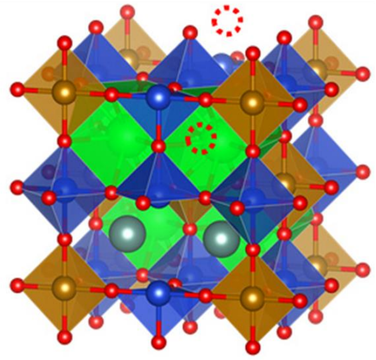
We desire reaction **(1)** to happen so that we can obtain **H_2 + CO**

But since we're co-feeding steam, reaction **(2)** can also occur and produce unwanted **CO_2**

By introducing a CO_2 sorbent such as **CaO**, we can capture the CO_2 in-situ which (i) avoids downstream separation and (ii) increases **H_2** yields.

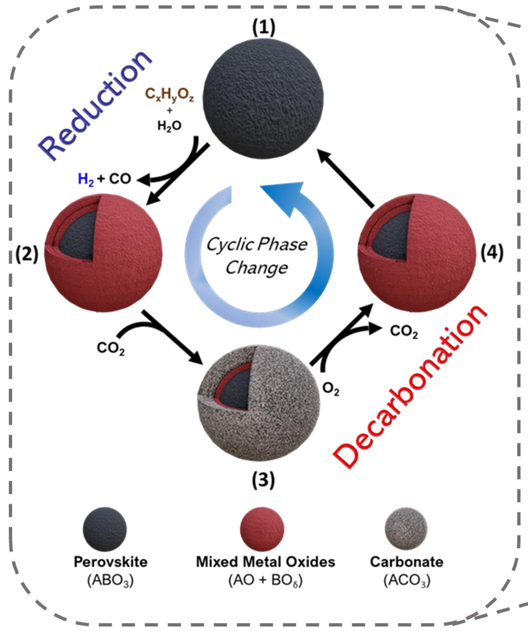
Unfortunately, **CaO** is not recyclable at gasification temperatures because the pores sinter close and inhibits further carbonation

(3) Redox-Activated Perovskite Phase Transition Sorbents



$$A_xA'_{1-x}B_yB'_{1-y}O_{3-\delta}$$

A,A' = Ca, Sr, Ba…
B,B' = Mn, Fe, Co, Ni…
$0 \leq \delta \leq 0.5$



Key Reactions *(Not balanced)*

1.) Reduction/WGS
$C_nH_mO_k + H_2O + ABO_x \rightarrow CO + H_2 + CO_2 + AO + BO_{x-\delta}$

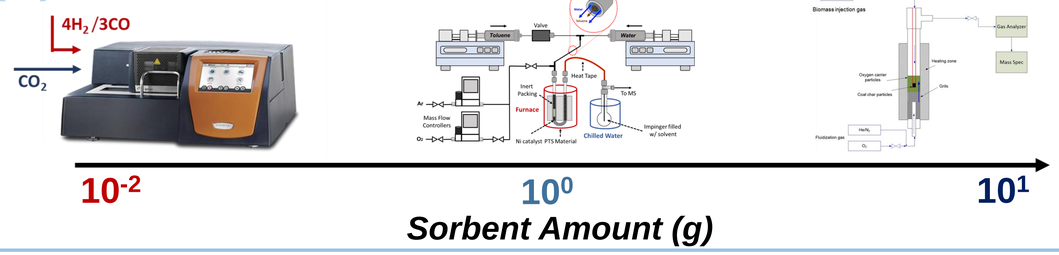
2.) Carbonation
$AO + CO_2 \rightarrow ACO_3$

3.) Decarbonation/ Regeneration
$ACO_3 + BO_{x-\delta} + O_2 \rightarrow ABO_x + CO_2$

…the cycle restarts

We propose to use **Perovskite Oxides** as recyclable CO_2 sorbents

(4) Demonstration at Different Scales



Thermogravimetric Analysis: smallest Scale, used for initial sorbent screening;

Bench-scale: used for more elaborate feeds like methane, glycerol, and toluene;

Sub-pilot scale: used for genuine woody biomass steam gasification

(5) Sorption-Enhanced Steam Reforming of…

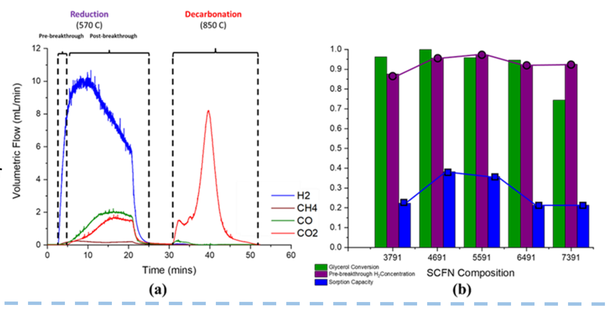
…glycerol:

Sorbent: $Sr_xCa_{1-x}Fe_{0.9}Ni_{0.1}O_{3-\delta}$ (SCFN-x(1-x)91)

Feedstock: 30 wt% **Glycerol** in water

Sorption Capacity:

$$\left(\frac{moles\ of\ CO_2\ released}{moles\ of\ A-site\ metal}\right) \times 100\%$$

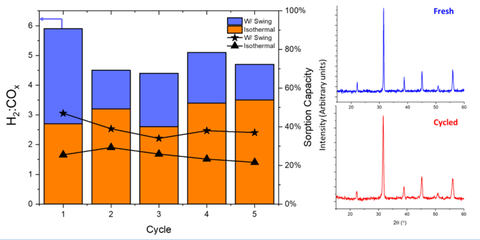


…toluene:

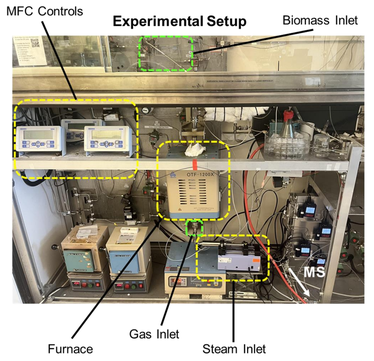
Sorbent: $Sr_xBa_{1-x}Fe_yCo_{1-y}O_{3-\delta}$ (SBFC-x(1-x)y(1-y))

Feedstock: **Toluene** co-fed with steam at S/C of 1.5-2.5

Configuration: Dual-bed with 0.3g of **Ni/γ-Al_2O_3** with and without temperature swing



Woody Biomass Gasification



Torrefied Southern pine chips were used as a feedstock to test the perovskite sorbents. The sorbent **$SrMnO_3$** demonstrated excellent sorption capacity (60-70%) and was cycled >100 times.