
CarbonPlus:
Catalyst Technology for
Biomass to Advanced Net Zero Fuels
pauloconnor@Yerrawa.com
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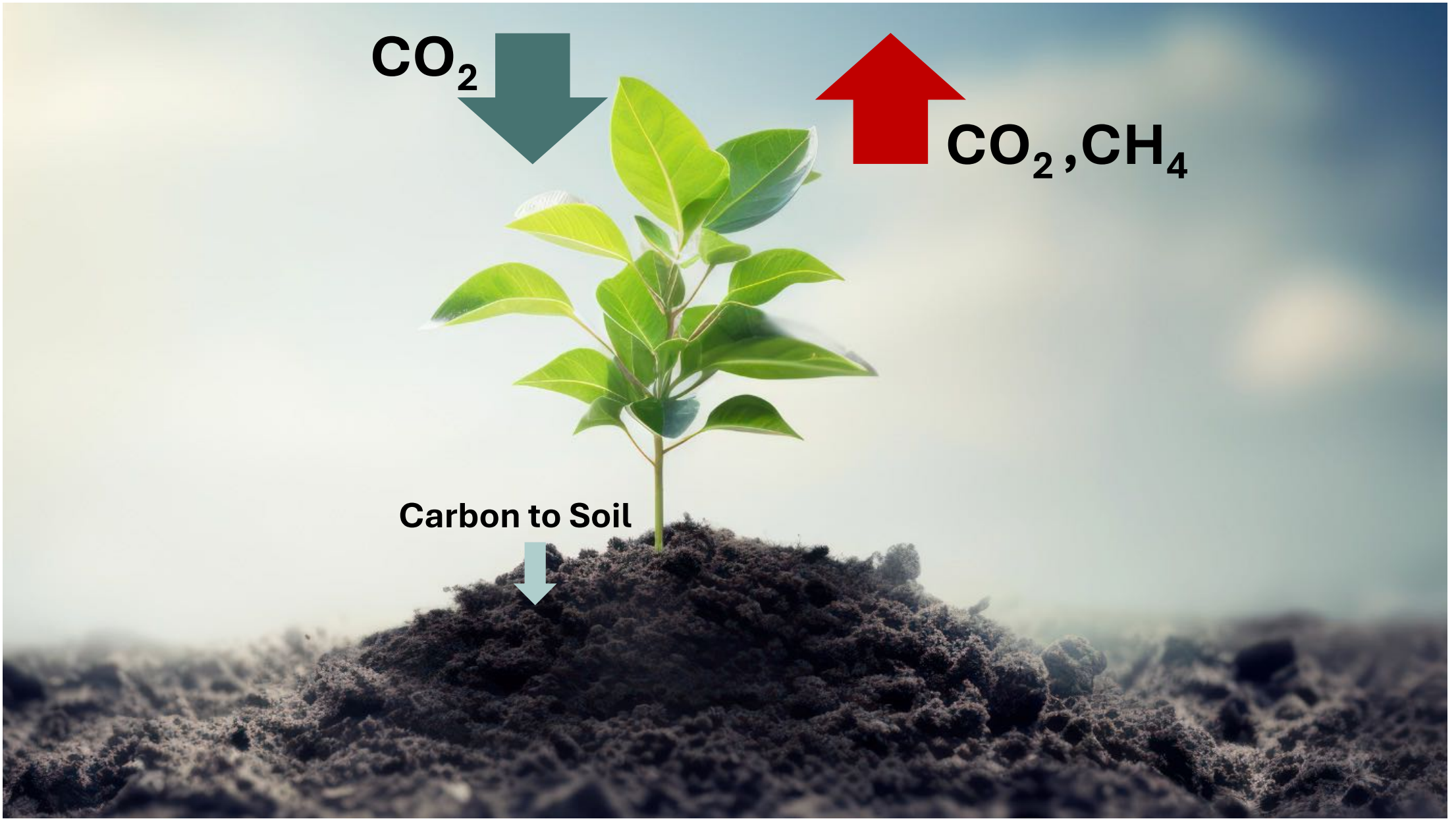
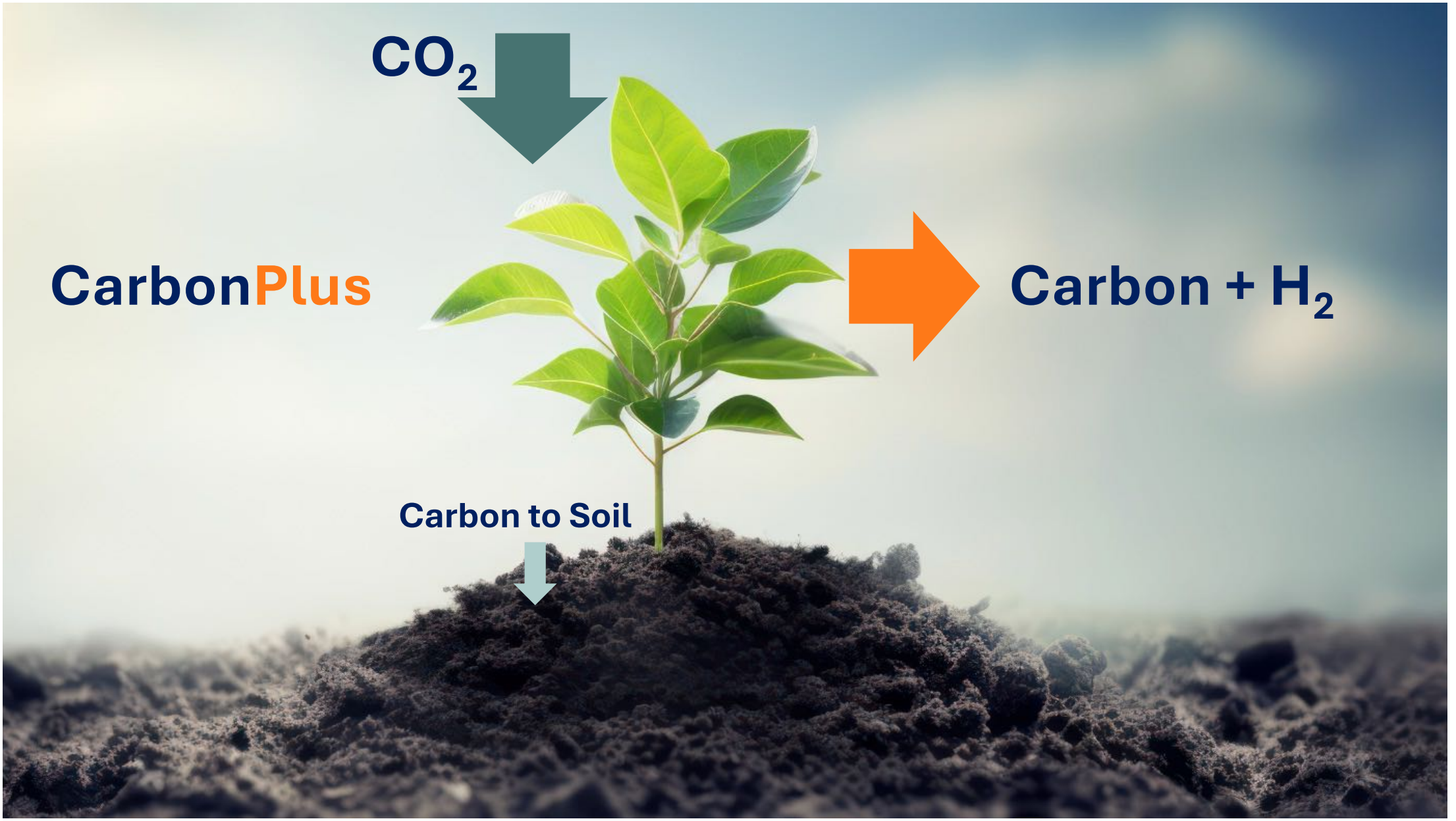
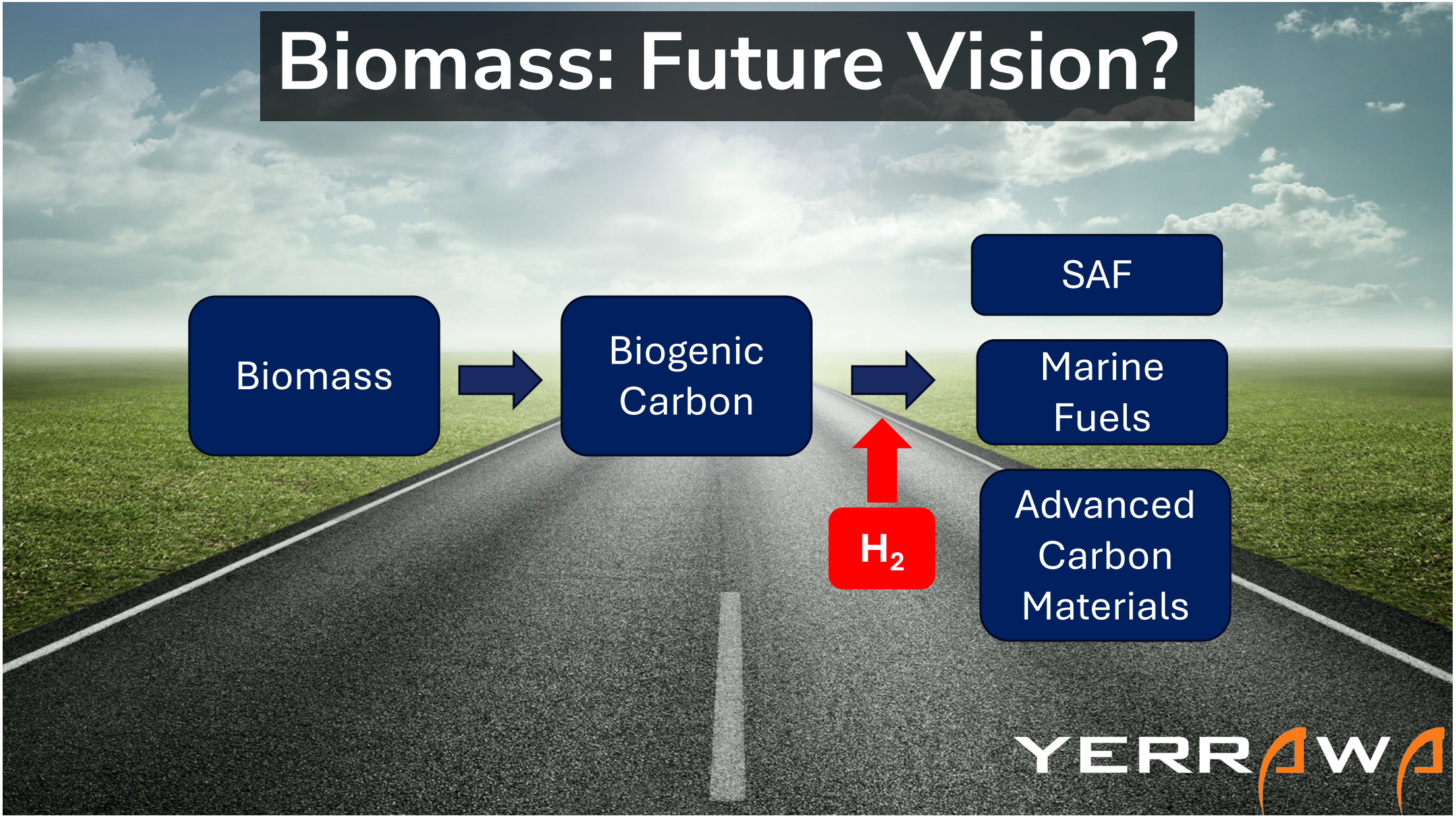

CO_2
CO_2 ,CH_4
Carbon to Soil


CO_2
CarbonPlus
Carbon + H_2
Carbon to Soil


Biomass: Future Vision?
Biomass
Biogenic Carbon
H_2
SAF
Marine Fuels
Advanced Carbon Materials
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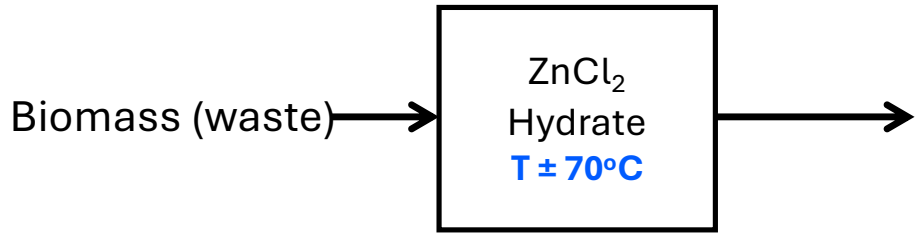
Development of Catalytic Biomass Carbonization

$ZnCl_2$ hydrate / Molten salt system

CELLiCON



Separation

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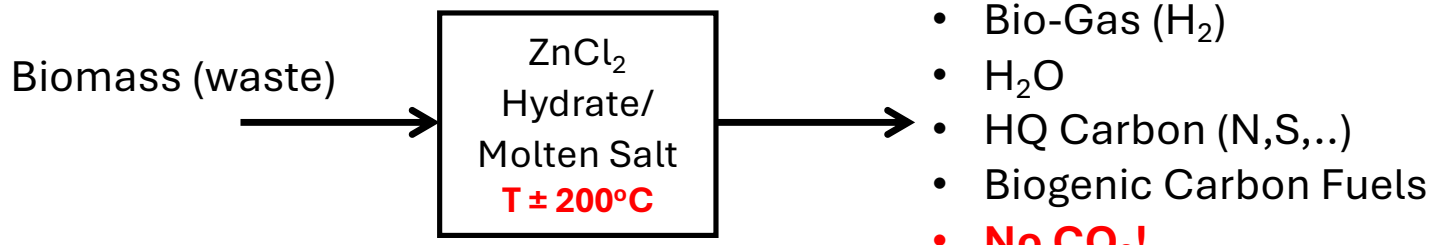

Conversion

Liquid Molten Salts Catalytic Cracking

McAffee – $AlCl_3$

~ 1920-1930

Patented Feb. 15, 1938 2,108,438

UNITED STATES PATENT OFFICE

2,108,438

PROCESS OF TREATING HYDROCARBON VAPORS WITH ZINC CHLORIDE

Franklin E. Kimball, Los Angeles, Calif.

No Drawing. Application July 21, 1936, Serial No. 91,788

9 Claims. (Cl. 196—36)

Patented Aug. 4, 1942 2,291,886

I claim as my invention:

1. A process for refining hydrocarbon distillate containing gasoline to improve the antiknock properties thereof which comprises adding to said distillate a suspension of a treating agent comprising essentially zinc chloride as the active constituent, heating the mixture to a desulfuriz-

55 temperature in the presence of z
fractionating the resultant products
gasoline and a condensate heavier t
heating said condensate in the pres
tional zinc chloride to a cracking te
60 excess of the first-mentioned temp
supplying the cracked products to s

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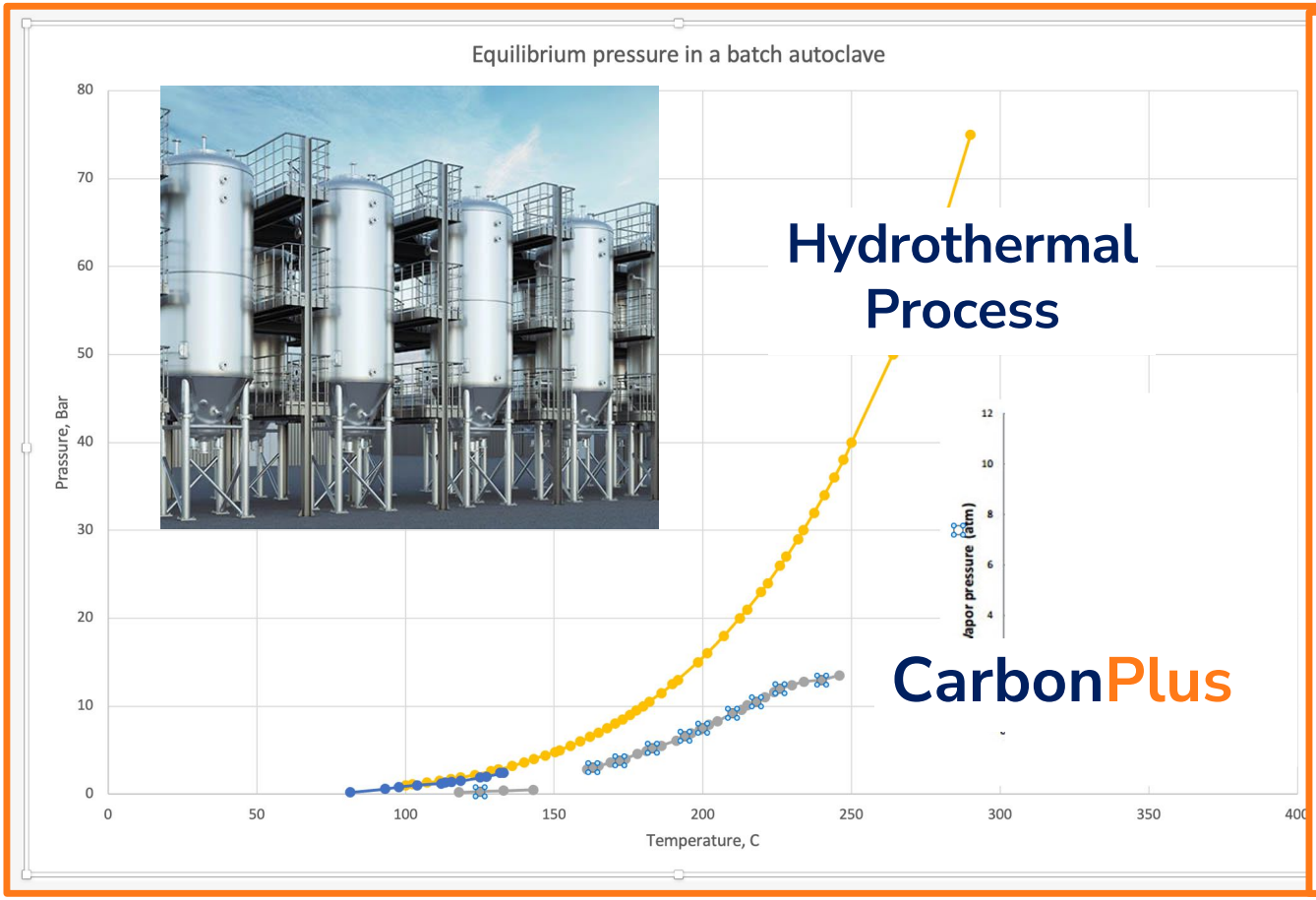
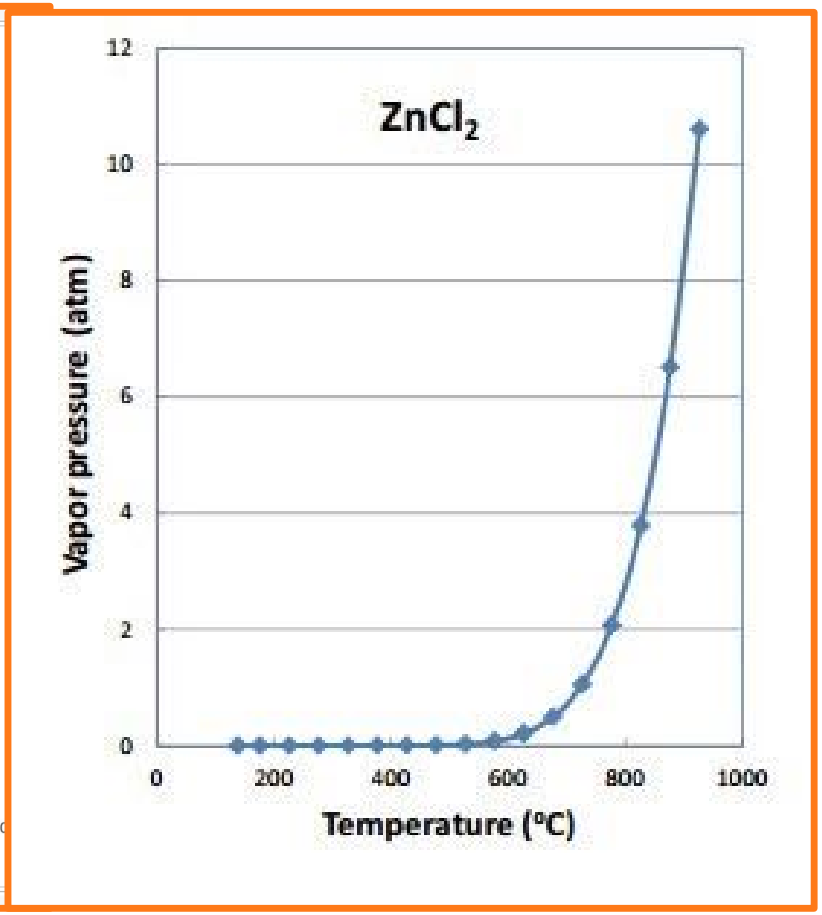
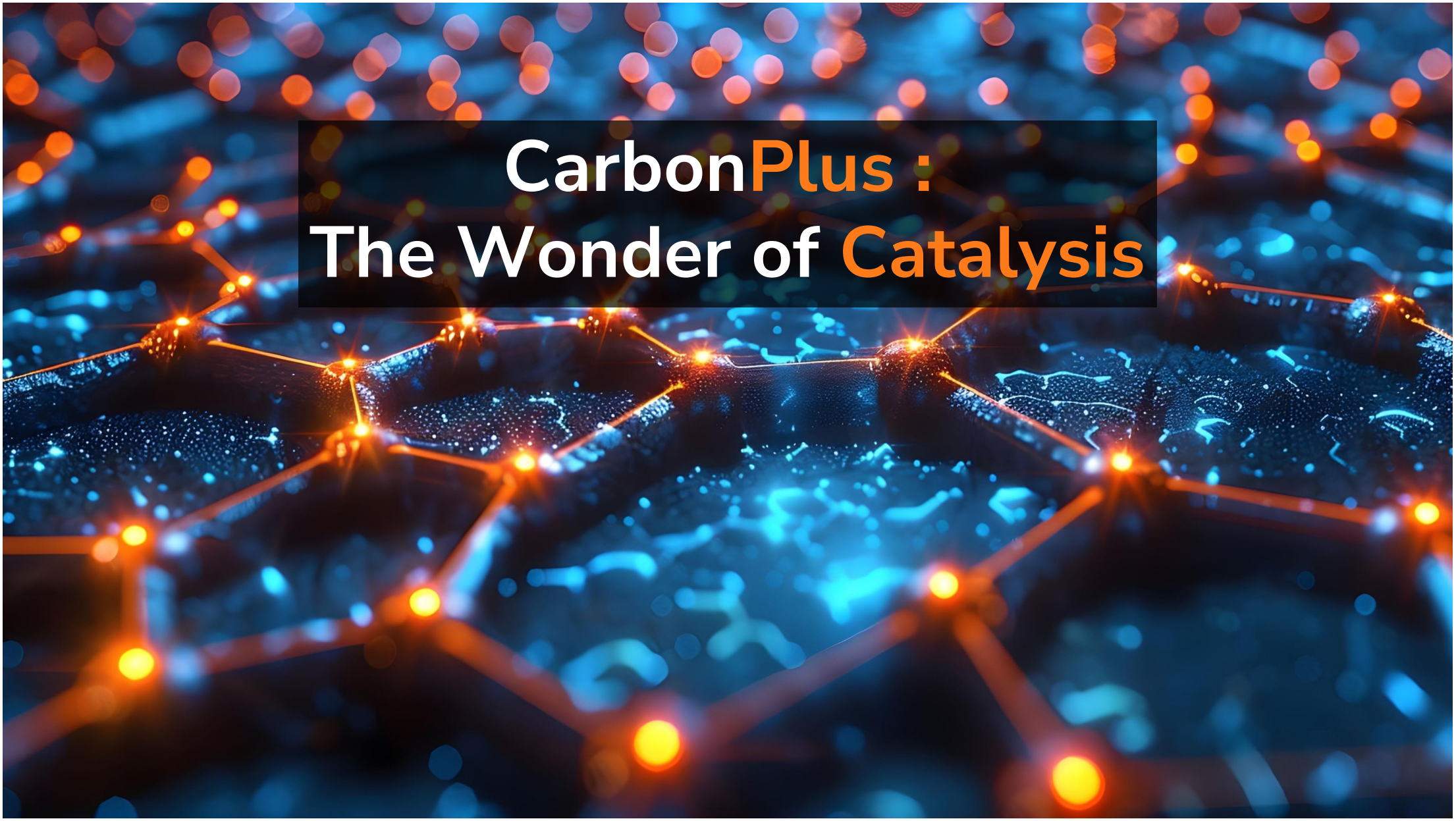
The Wonder of Catalysis



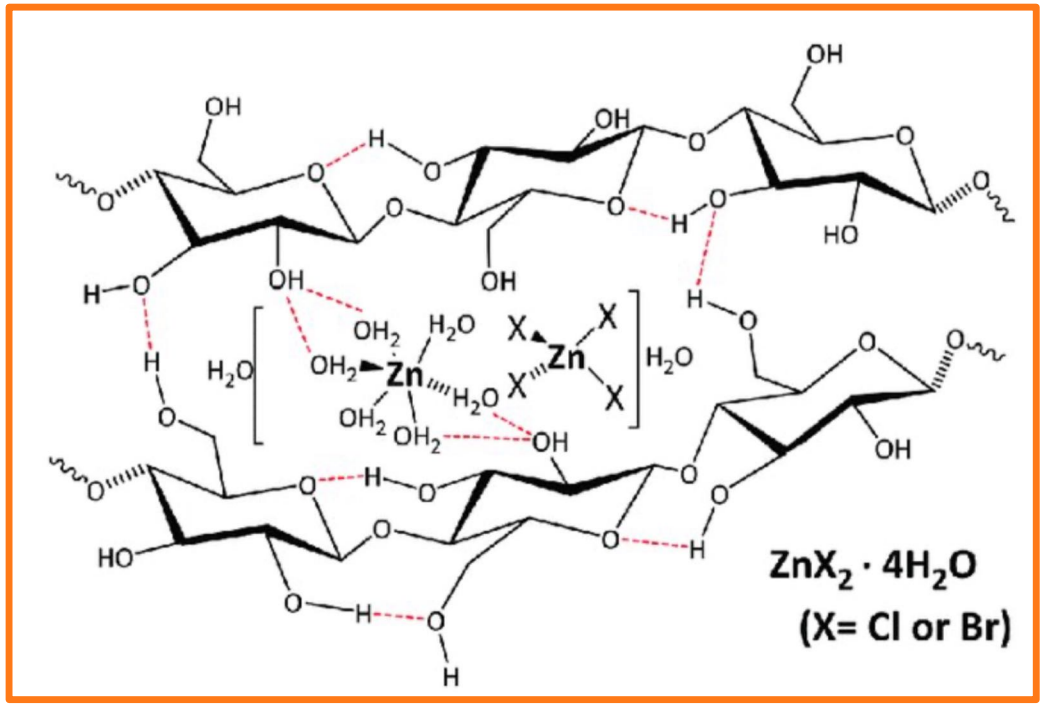


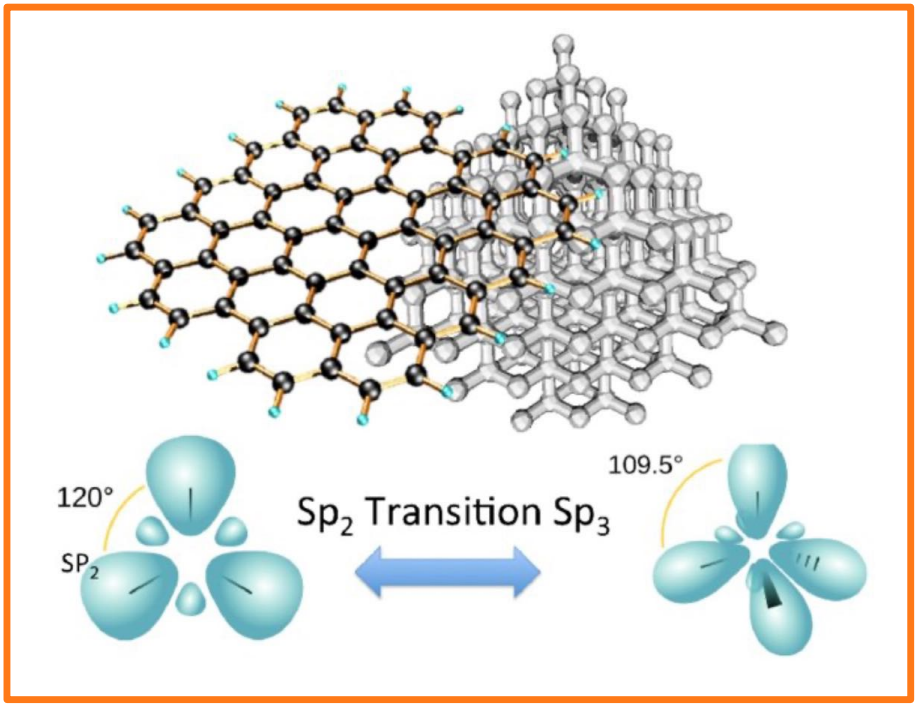
Innovative Molten Salt Homogeneous Catalyst:

A solid (No vapor Pressure), which behaves as a liquid!


CarbonPlus :
The Wonder of Catalysis

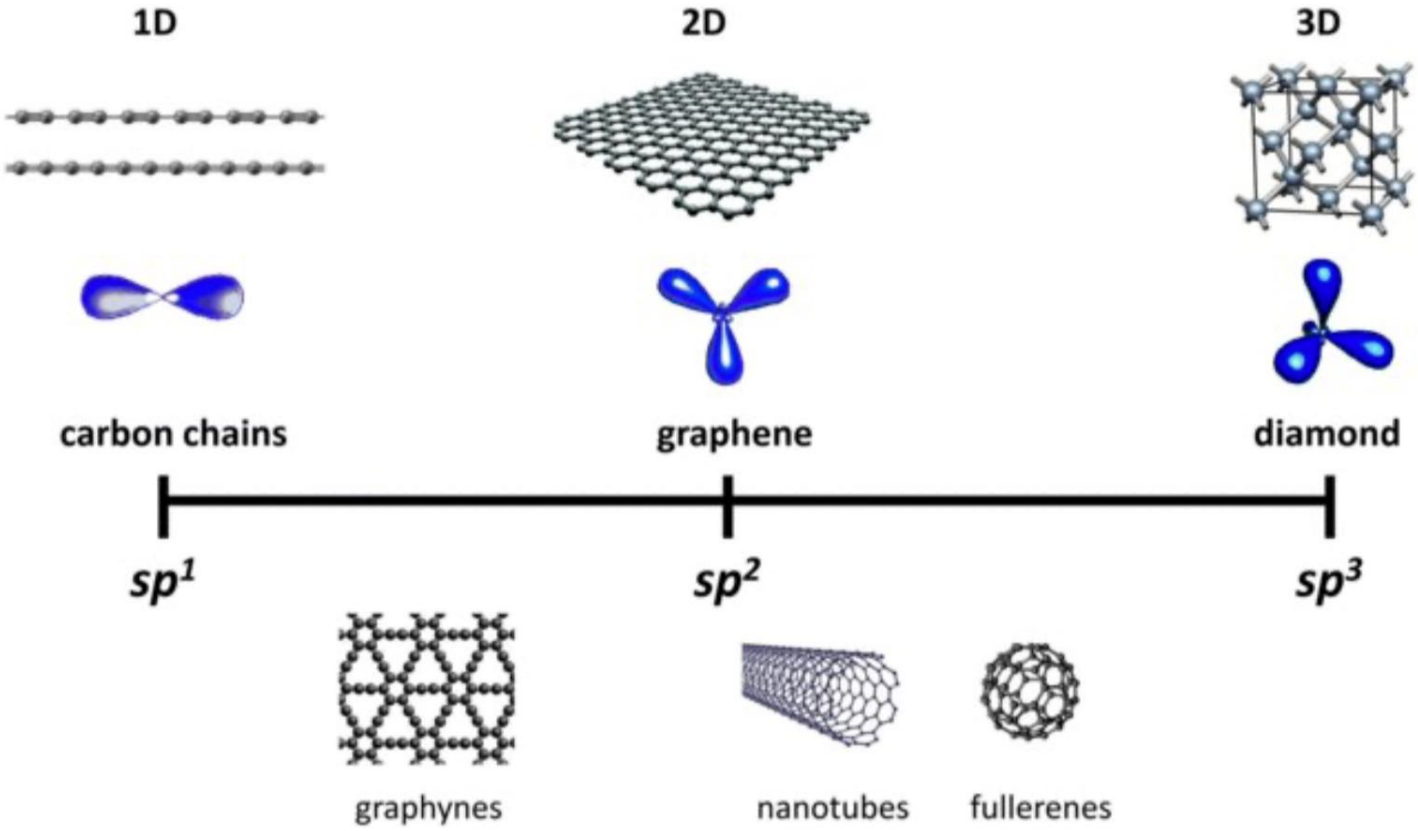
The Wonder of Catalysis





Catalysis vs Thermal Conversion:
Faster (> 2000x) Reaction rates @ Higher Sp_2/Sp_3 selectivity

Carbon: Sp^3 vs Sp^2 Hybridization



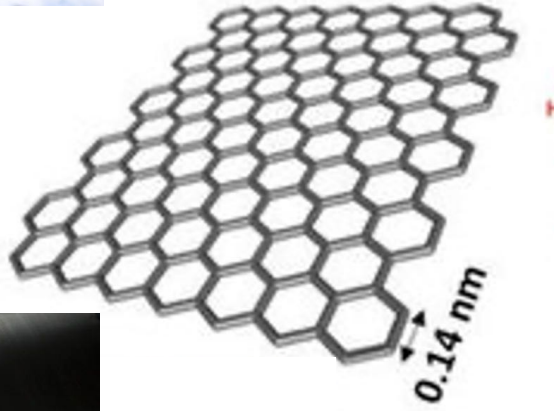
Potential Applications

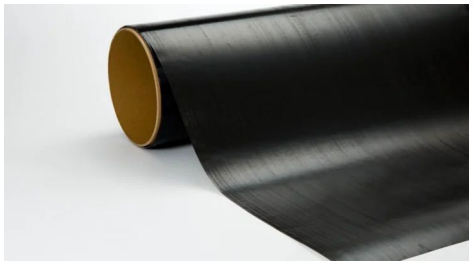
Bio-Char/Bio-Soil

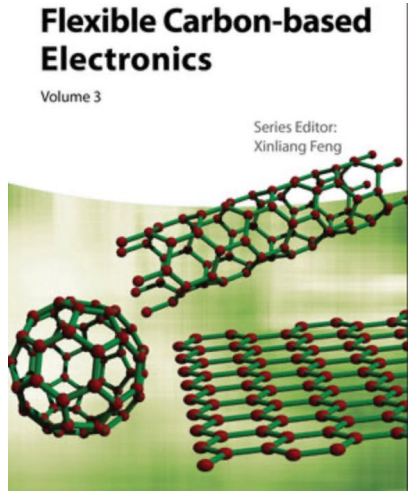
Asphalt & Cement Construction Materials
Carbon fibers

Graphene/GO precursors

Electronic Materials







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Routes to Carbonization

Process	T °C	P bar	Carbon Quality* Raman –Sp_2	Solid Carbon Yield %
Torrefaction	±200	±1-2	Low /Charcoal +H_2O	> 80
HydroThermal	>200	> 20	Low + Oil +H_2O + CO,CO_2	< 50
Pyrolysis	>600	< 10	Low C + Oil +H_2O + CO,CO_2	< 50
Catalytic Pyrolysis	>600	< 10	High C + Oil +H_2O + CO,CO_2	< 20
CarbonPlus	±200	< 10	High C +H_2O + CO,CO_2	± 80

*) High means high degree of graphene-like layered structures

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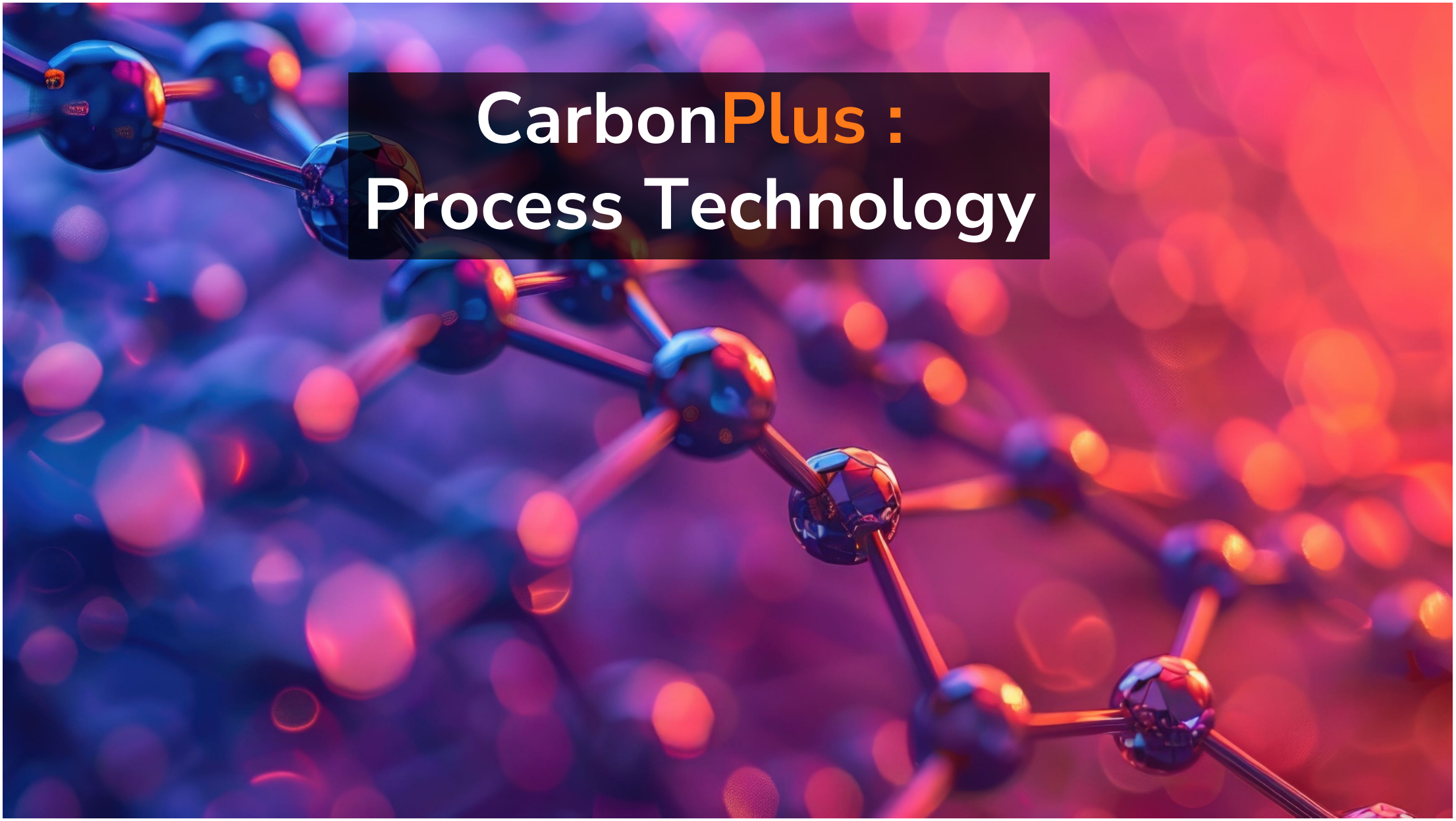
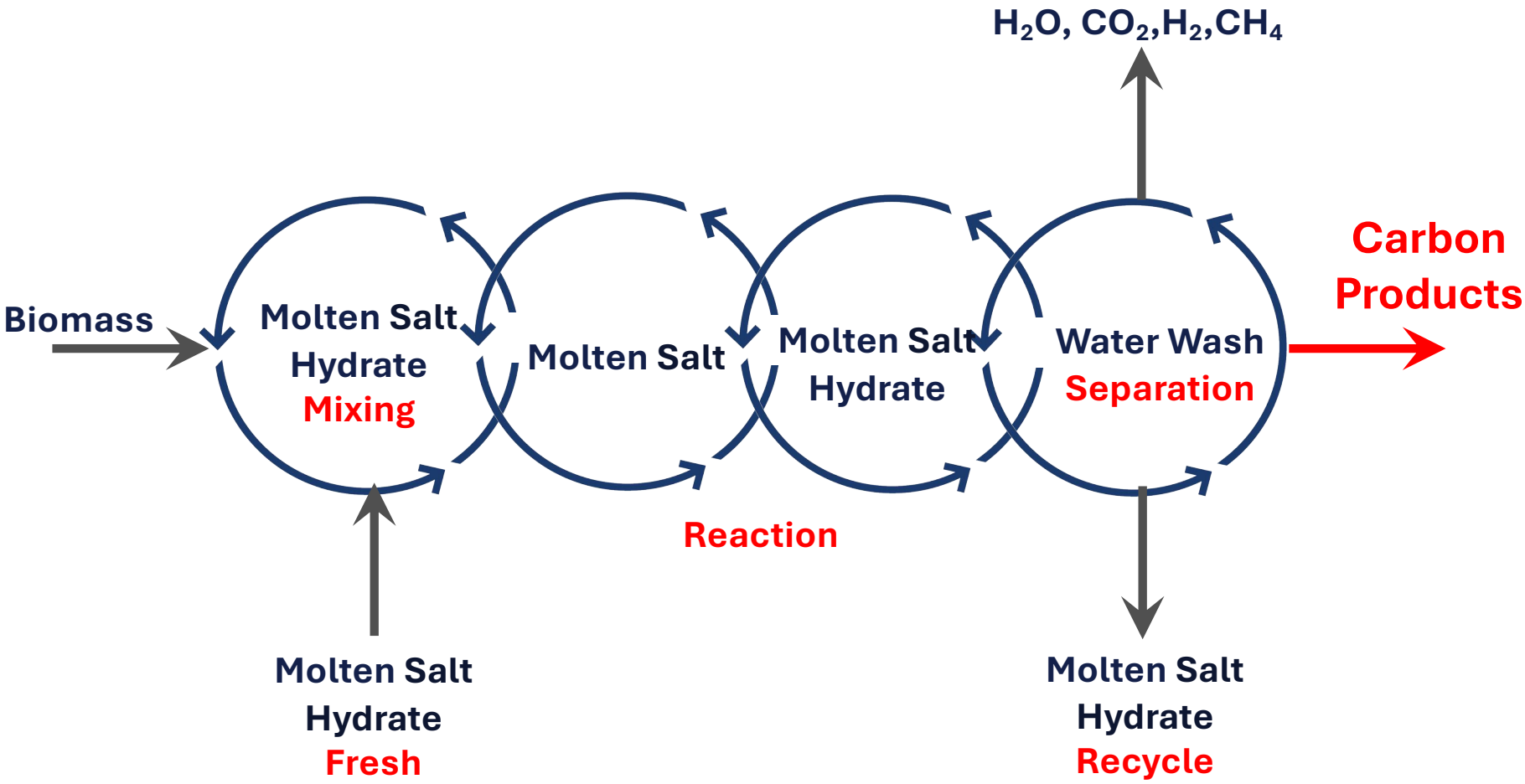

CarbonPlus :
Process Technology

CarbonPlus: Biomass to HQ Carbon



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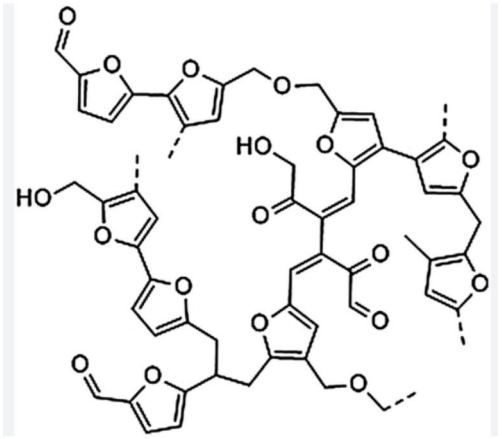
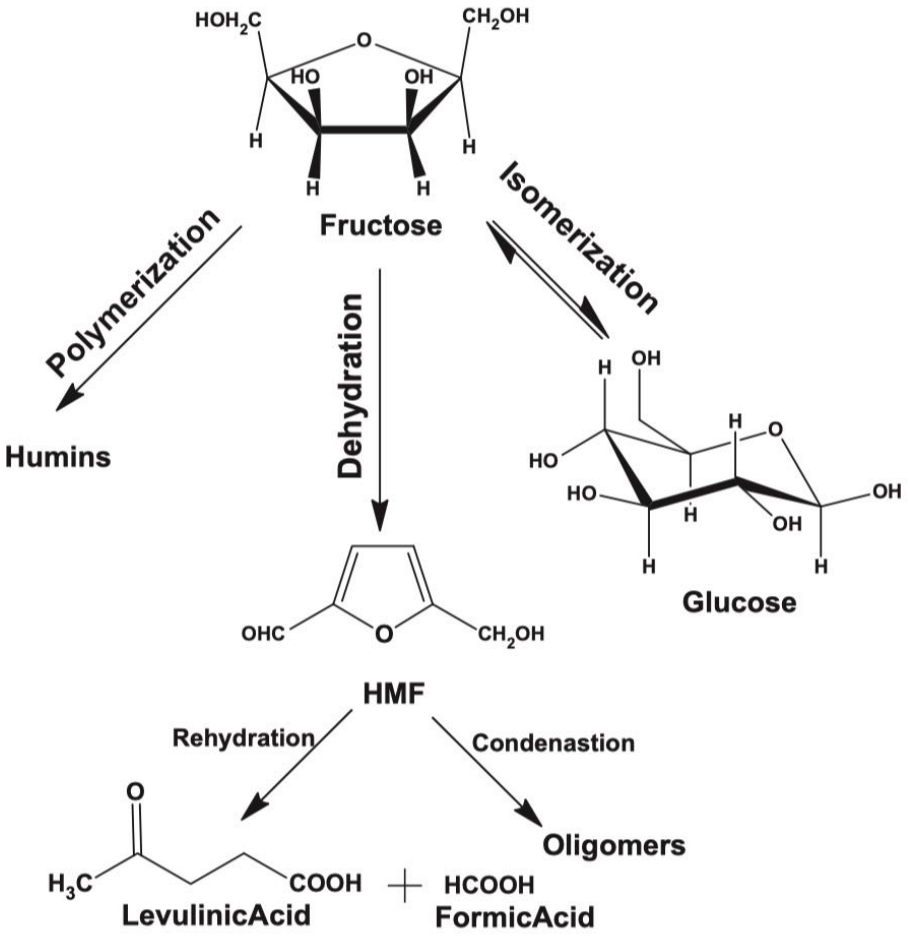
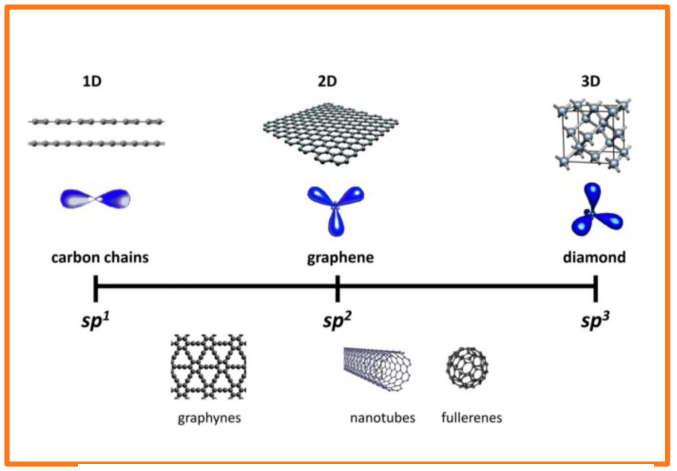
Cellulose / Glucose ‘Cracking’ - Dehydration





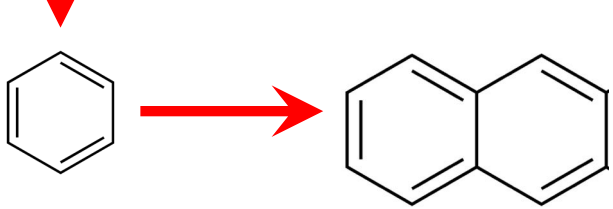
Scheme 1. Dehydration of C-6 sugars to HMF.

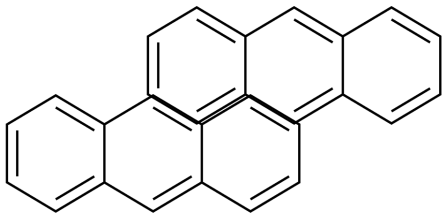
High ‘Aromatics’ (sp^2) selectivity



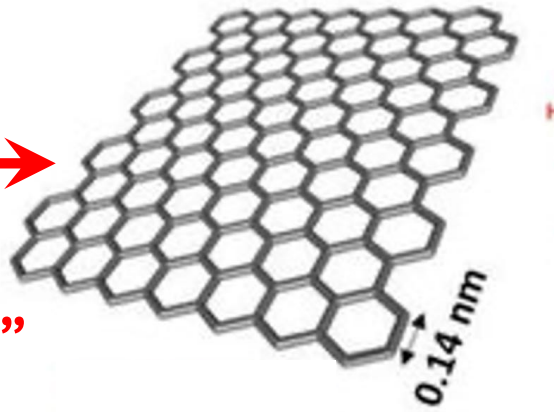
Cellulose
+
Lignin

> 80% Selectivity





“Alhambra effect”

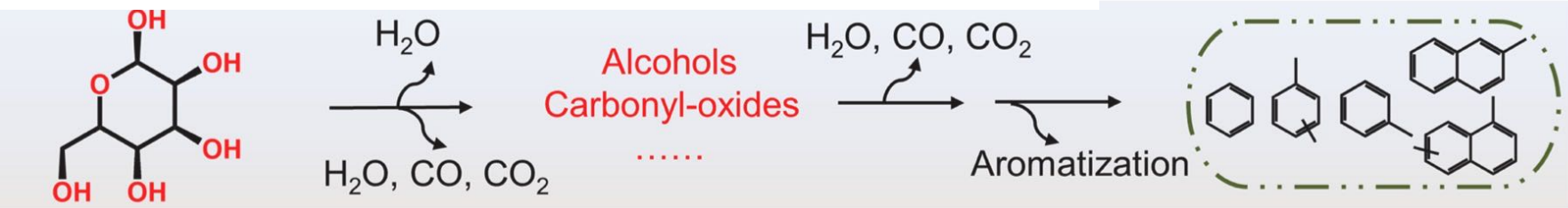


+ H_2 - Hydrotreat to SAF

Graphene-like Materials

Catalysis ➔ Very High Selective Aromatization

Low temperature upgrading glucose to aromatics via a H_2-free melting-catalysis strategy



We demonstrate that the melting of glucose promotes the accessibility to catalytic sites and enhances subsequent catalytic processes. The introduction of inter-crystalline mesopores facilitates diffusion of molecules, and the moderate acidity favors the deoxygenation of oxygenated intermediates, both of which promote aromatics formation. Consequently, 10ZSM-5–80 with abundant inter-crystalline mesopores and optimum acidity achieves a maximum aromatics selectivity of 95.4% at 280 ◦C, of which 70.2% are monocyclic aromatic hydrocarbons.

Our findings provide a new pathway for the selective generation of aromatics from glucose, which is expected to advance next-generation biomass utilization.

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Low temperature upgrading glucose to aromatics via a H_2-free melting-catalysis strategy

Zhe Zhang [a,1], Huan Chen [a,1], Helin Pan [a], Dengle Duan [c,*], Yayun Zhang [a,b,**], Donghui Long [a,b]

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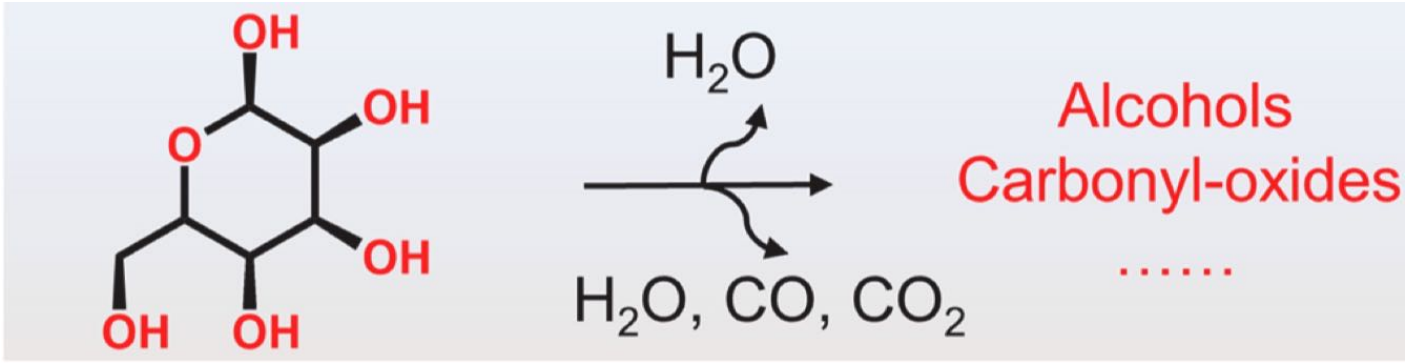
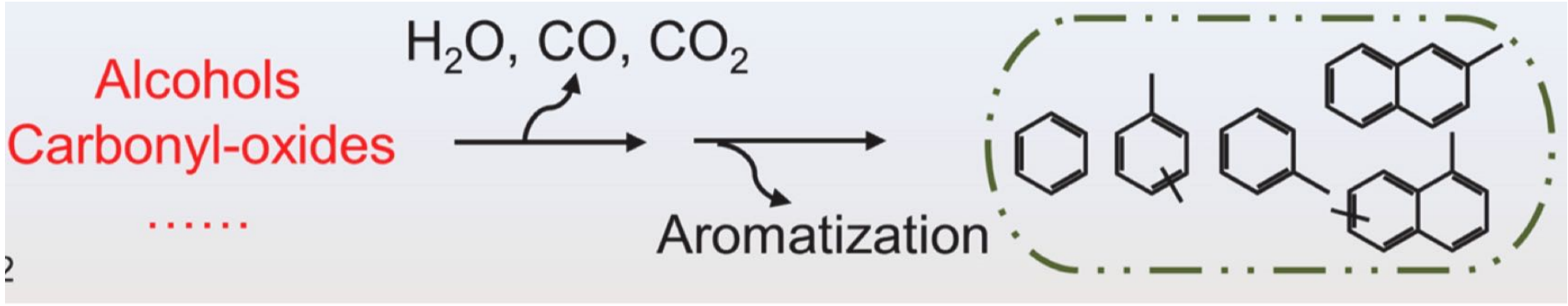
[b] Key Laboratory of Specially Functional Polymeric Materials and Related Technology (Ministry of Education), School of Chemical Engineering, East China University of Science and Technology, Shanghai 200237, China
[c] Guangdong Provincial Key Laboratory of Lingnan Specialty Food Science and Technology, Zhongkai University of Agriculture and Engineering, Guangzhou, 510000, China

C6-C12 Aromatics ➔ SAF!

Glucose Catalytic ‘Cracking’ - Dehydration





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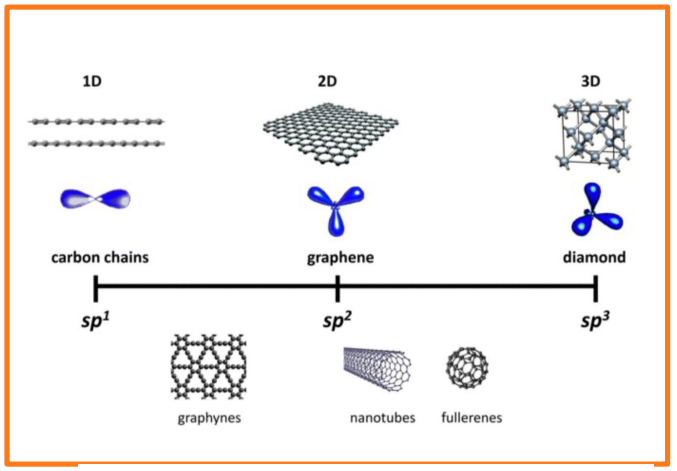

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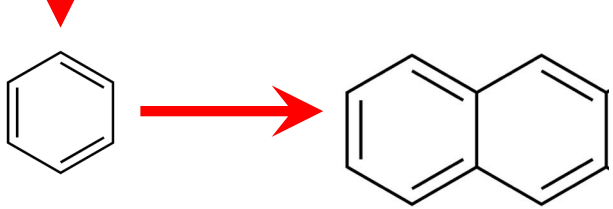

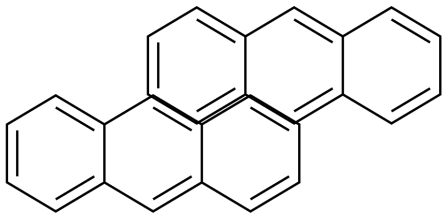

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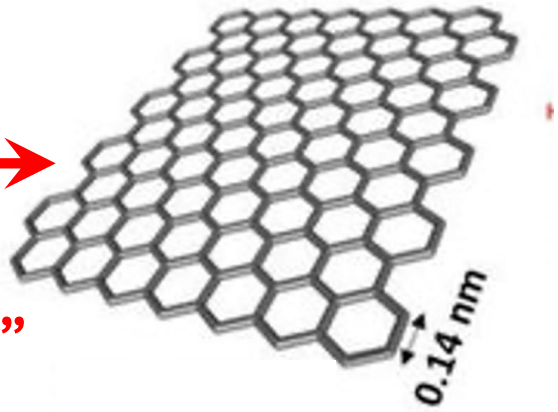
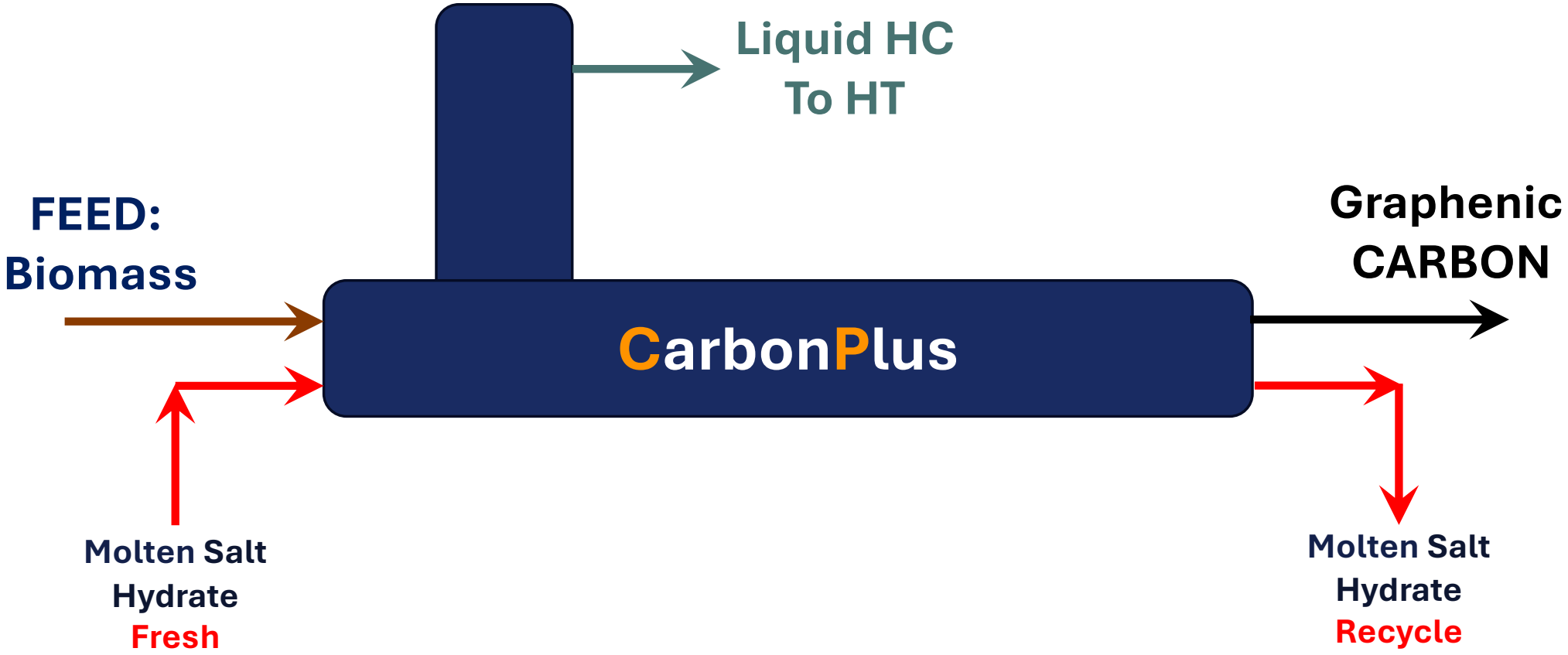


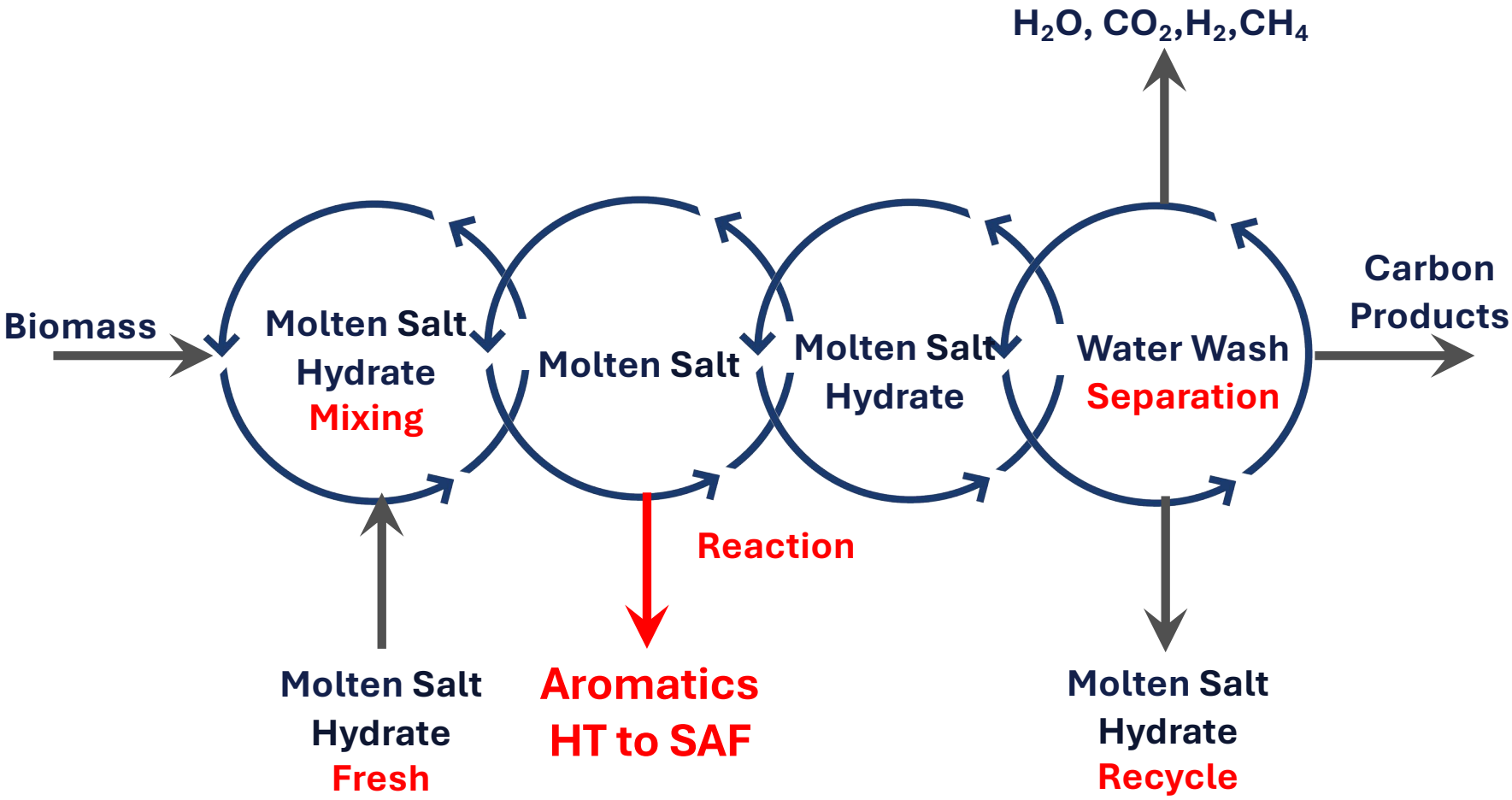
+ H_2 - Hydrotreat to SAF

Graphene-like Materials

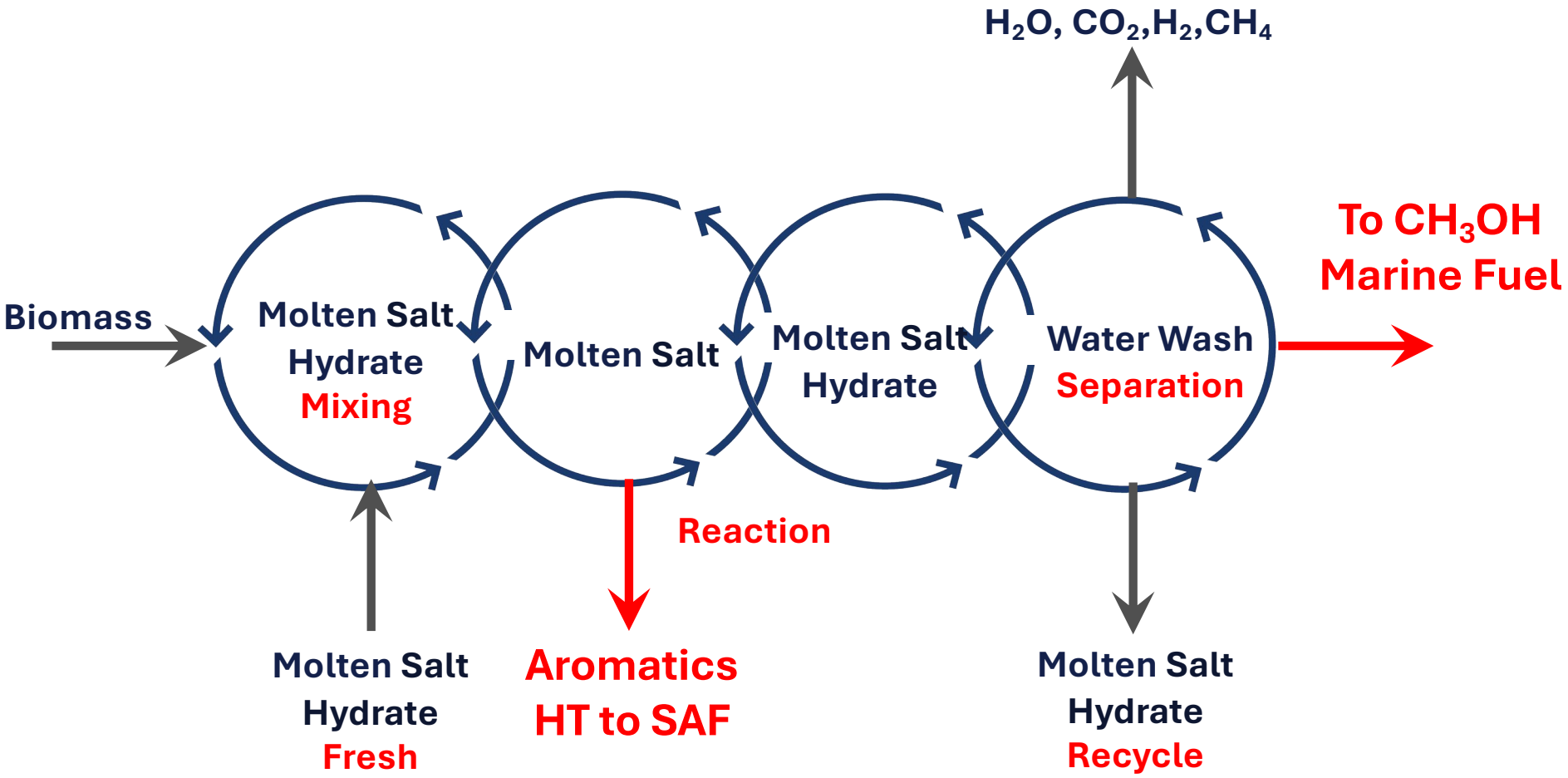
CarbonPlus ➔ Liquid Carbon + Carbon



CarbonPlus: Biomass to Zero CO_2 Fuels



CarbonPlus: Biomass to Zero CO_2 Fuels



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Unique Technology

- Catalytic Carbonization
- Unique homogeneous catalyst
- Low temperature / pressure operating conditions
- Easy separation & recovery of Carbon products
- Very high Carbon yield & recovery
- High Selectivity (“Aromatics”)
- Advanced Carbons and/or Biogenic Fuels
- Scalable technology

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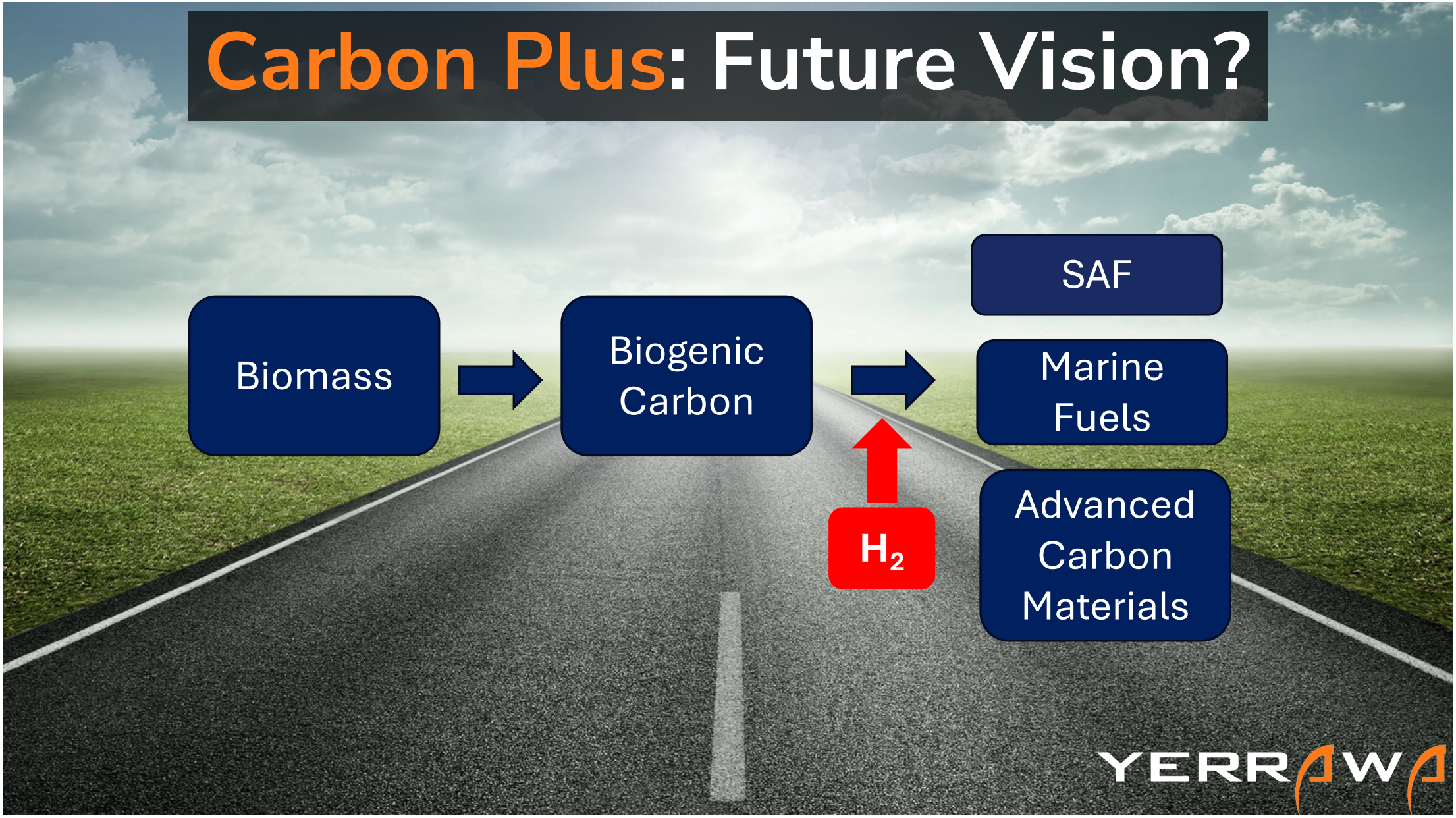
Carbon Plus: Future Vision?
Biomass
Biogenic Carbon
H_2
SAF
Marine Fuels
Advanced Carbon Materials
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Q&A
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