Evaluation of a green pressurized reaction media (subW-CO_2) and pressurized microwave-assisted reaction for furfural production from corn stover and its derivatives sugars

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CORN STOVER AND ITS DERIVATIVES SUGARS

Corn stover is a **lignocellulosic biomass** with a valuable carbohydrates composition.

In corn production, residues constitute **50 %** of the total weight: **Corn rachis and corn stover**

Corn stover (leaves and stems)

CORN STOVER (CS) COMPOSITION

Component		g/100g dry-CS
Hemicellulose	**Xylans**	25 ± 3
	Arabinans	4.1 ± 0.5
	Acetyl	4.2 ± 0.2
Cellulose	Glucans	41.4 ± 4
	Total lignin	18.7 ± 3
	Protein	3.2 ± 0.2
	Ash	2.7 ± 0.4

FURFURAL FROM HEMICELLULOSE

- ✓ **Furfural** is considered one of the **top value-added chemicals** derived from biomass.
- ✓ It is the **dehydration product of pentoses** (xylose and arabinose in corn stover).
- ✓ C_5 polysaccharides are first **hydrolyzed from the hemicellulose** to then produce furfural.

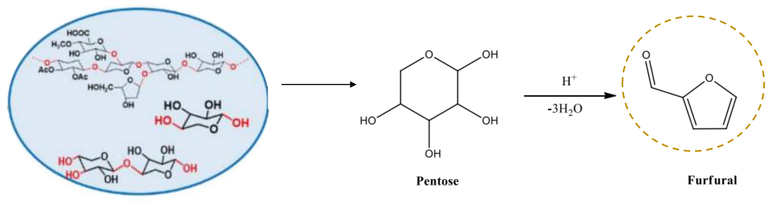


Figure 1. Furfural production from hemicellulose.

SubW-CO_2 SYSTEM

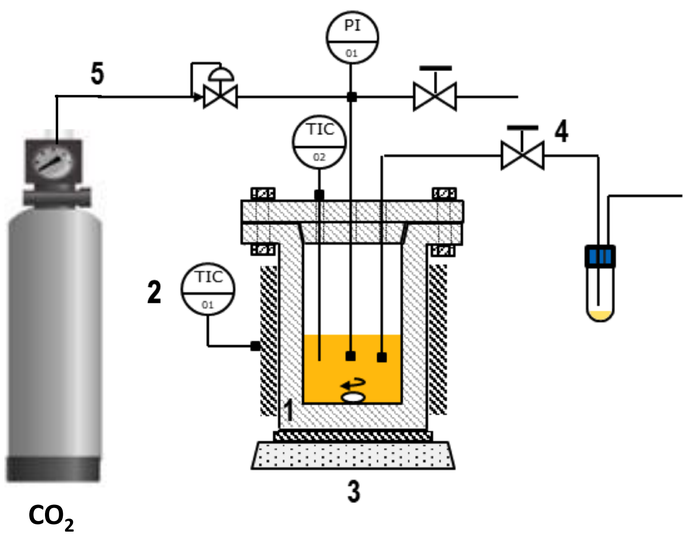


Figure 2. Diagram of the laboratory-scale subcritical water equipment. 1: pressure vessel; 2: heating jacket; 3: magnetic stirring; 4: sample valve; 5: pressurized gas system.

Two green technologies were proposed to **produce furfural** from **xylose and corn stover** with a **Lewis acid catalyst** only using **water as reaction medium**

Xylose load: 11g/L
Corn stover load: 5 % (w/w)
$CrCl_3$ as catalyst (2% w/xylose weight)

SubW-CO_2 SYSTEM	
Volume	**200 mL**
Pressure	**50 bar**
Temperature	**180 °C**
Time	**120 minutes**

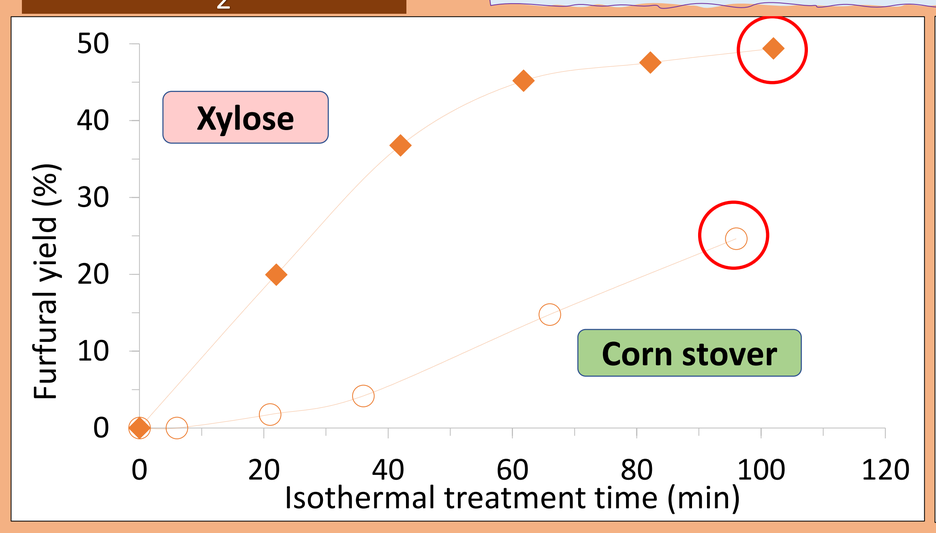
MW SYSTEM	
Volume	**30 mL**
Pressure	**10 bar**
Temperature	**180 °C**
Time	**5-90 minutes**

PRESSURIZED MW SYSTEM

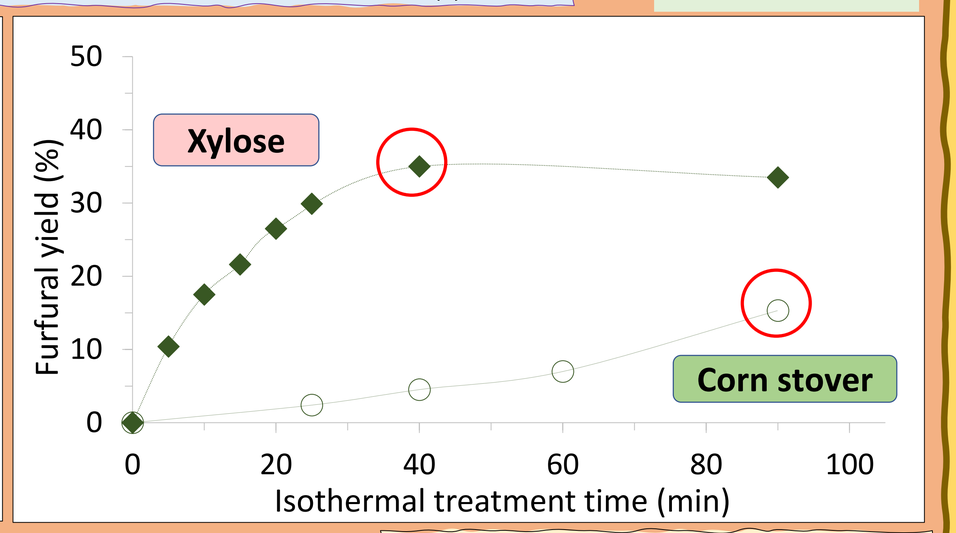
Figure 3. Microwave (MW) equipment.

$$\textbf{Furfural yield}\ (\%) = \frac{\text{moles of C in furfural}_{(t)}}{\text{moles of C in pentoses monomers}_{(0)}} \cdot 100$$

SubW-CO_2 SYSTEM



MW SYSTEM



- ❖ **Xylose** yielded **more furfural** than corn stover.
- ❖ **Corn stover** required **more time** than xylose to produce furfural.
- ❖ In **corn stover**, hemicellulose needs to first be **hydrolyzed into pentoses** to then produce furfural.

Highest furfural yield values

Substrate	MW	subW
Xylose	**35 %**	**50 %**
Corn stover	**15 %**	**25 %**

MW technology produced lower furfural yield than subW-CO_2

- ❖ The main difference between the two technologies is the use of **CO_2** as pressurizing agent **in the subW system.**
- ❖ **Dissolved CO_2 formed carbonic acid** in water, which acted as a **Brønsted acid**, favouring furfural production.

CONCLUSIONS

- **Both technologies** showed their **viability to produce furfural**.
- **Corn stover produced less furfural** than xylose due to its **more complex matrix.**
- **subW-CO_2** produced the **highest furfural yield** from xylose (**50 %**) and corn stover (**25 %**) when **compared to MW.**
- The **presence of CO_2** was a **key parameter** for furfural production, acting as a **Brønsted acid.**
- **subW-CO_2** produced **less degradation products** than MW.

Subcritical water pressurized by CO_2 showed to be an effective combination for the production of furfural from xylose and corn stover.

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