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INSIGHT INTO A STEAM EXPLOSION PRETREATMENT OF SUGARCANE BAGASSE FOR BIOETHANOL PRODUCTION

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1. INTRODUCTION: STEAM EXPLOSION (SE) AS LIGNOCELLULOSIC BIOMASS PRETREATMENT

Pretreatment is an essential technological step for the conversion of lignocellulose into fuels and biochemicals. The purpose of this preliminary step is **to reduce the lignin and/or hemicellulose content by modifying the cell wall structure of the biomass**, thus **increasing the surface area and accessibility to carbohydrates such as cellulose and thereby increasing the yield of fermentable sugars.**

The selection of a suitable pre-treatment will significantly increase the **efficiency of the hydrolysis process** by **helping to remove the lignin or hemicellulose and expose the cellulosic component.**

Steam explosion (SE) is one of the most attractive and uncomplicated pretreatment methods due to its low capital investment, high scalability, and lower hazard of the chemicals involved in the process, among other advantages **SE pretreatment,** as a physicochemical modification technology in food raw materials, is a method that presses steam at **high pressure (1–3.5 MPa) and temperature (180–240ºC) into cell walls and plant tissues for a few seconds (30 s) to several minutes (20 min),** combining the thermochemical action of high-temperature boiling coupled with the physical tearing action of instantaneous blasting. This leads to the decomposition of the lignocellulosic matrix as well as partial removal and/or redistribution of lignin which results in increased cellulose accessibility.

The hydrolysis of hemicellulose components results in the release of mono- and oligosaccharides, the alteration of the chemical structure of lignin, and an improvement in the cellulose crystallinity index and extractability of lignin polymer. SE couples autohydrolysis and biomass alteration through high temperature and explosive decompression.

The process is usually divided into two independent stages:

1. **An initial one where the vapor boiling, and explosion phase takes place.**
2. **The second phase is a process of adiabatic expansion and conversion of thermal energy into mechanical energy.**

Figure 1 shows the sequence of the basic steps of the SE method and its impact on the matrix.

Outstanding benefits of **SE pretreatment** are:

- The extensive hydrolysis of hemicelluloses polymers and the reduction of biomass particle size.
- The smaller particles have more available surface area, and the lignin droplets act as a binder, which improves particle-to-particle contact and binding capacity.
- SE has a high potential for energy efficiency, low capital investment, and lower environmental impact compared to other pretreatment technologies.

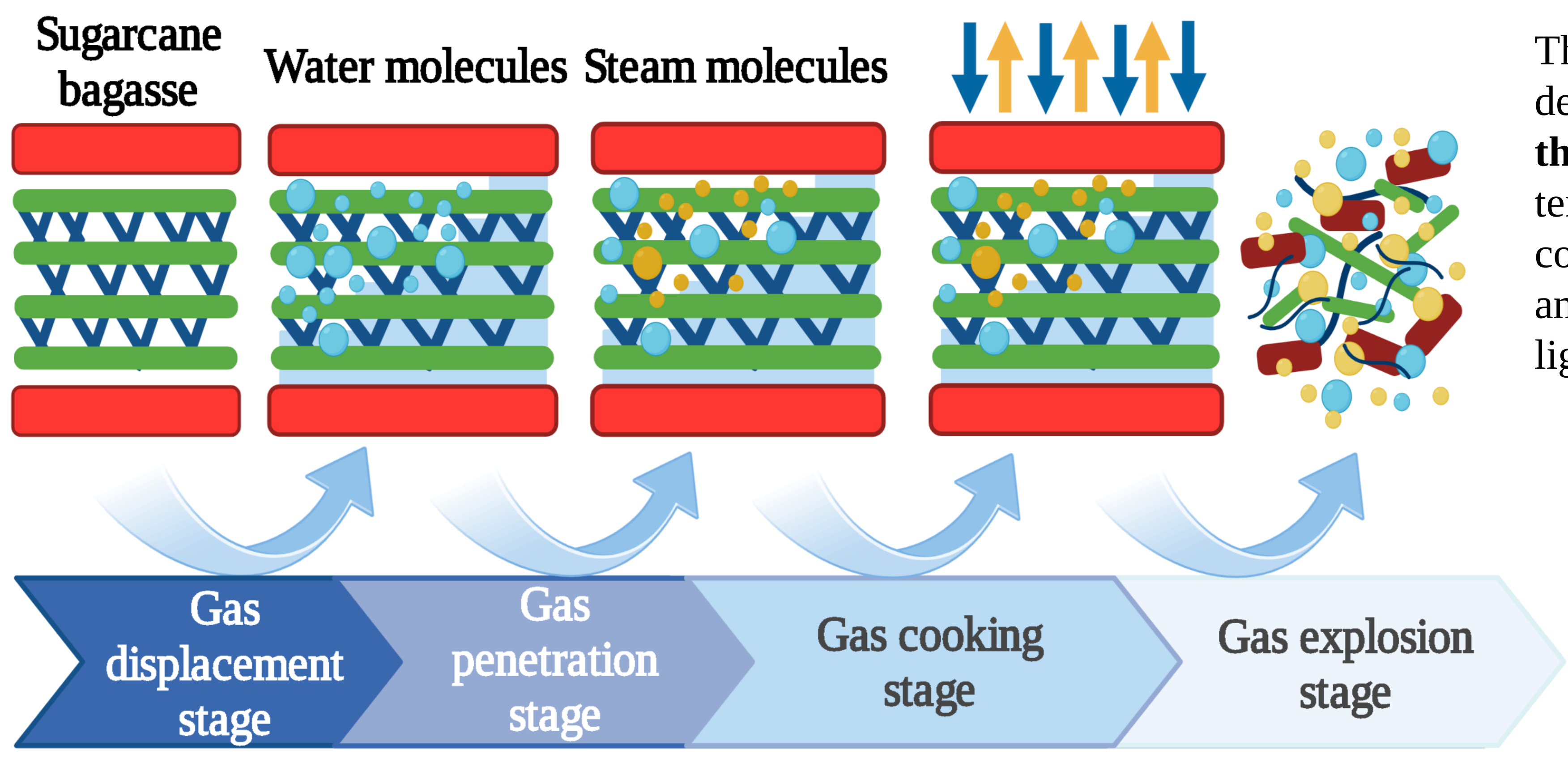


Figure 1 . Illustration on the process of lignocellulosic material disruption and molecules released.

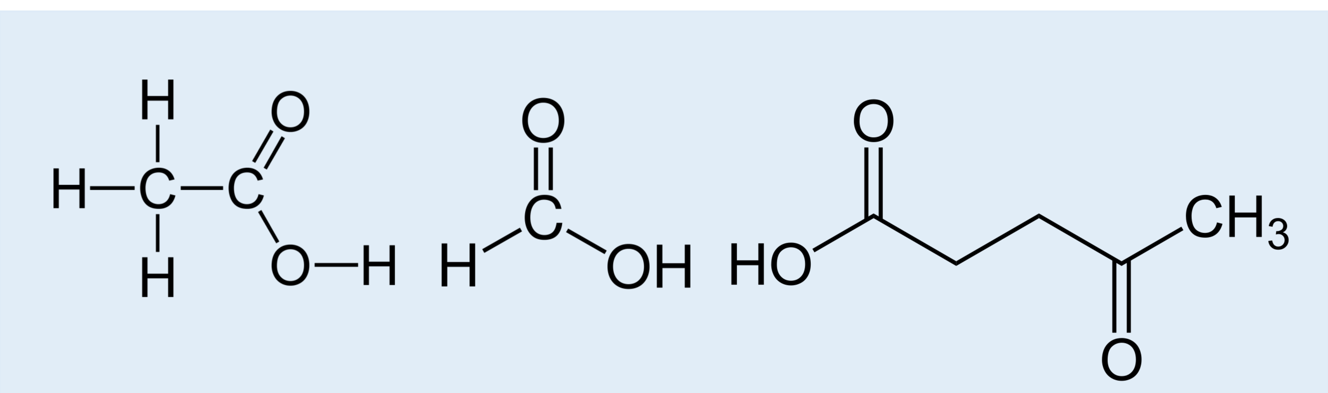
The **effectiveness of SE** pretreatment differs depending on factors such as the **toughness of the pretreatment conditions** (e.g., the temperature and residence time are known as the combined pretreatment **severity factor (SF)**) and/or the recalcitrance of the biomass (e.g., lignin content) to hydrolysis.

$$\text{SF } (R_0 = e^{T_{exp} - 100/14.75})$$

SF is **an influential parameter that defines the relationship between hydrothermal severity** (operating conditions and physicochemical changes) and lignocellulosic biomass

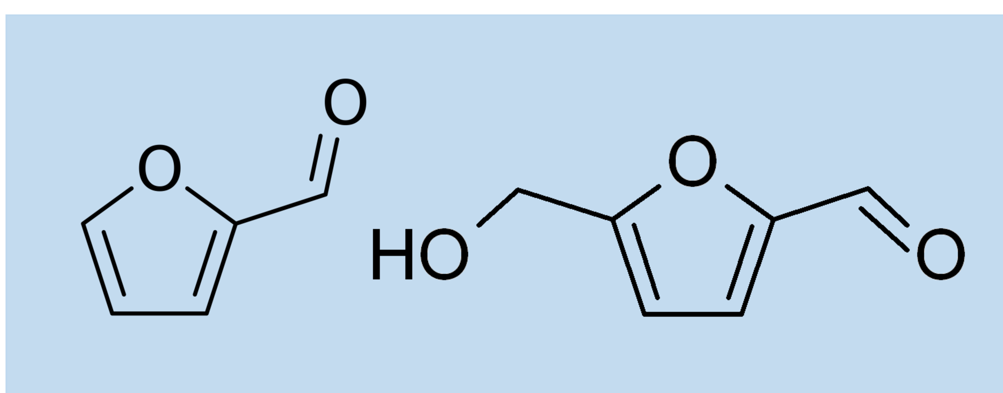
It should also be noted that the by-products that are likely to be generated during the SE process are basically divided **into three groups:**

WEAK ACIDS



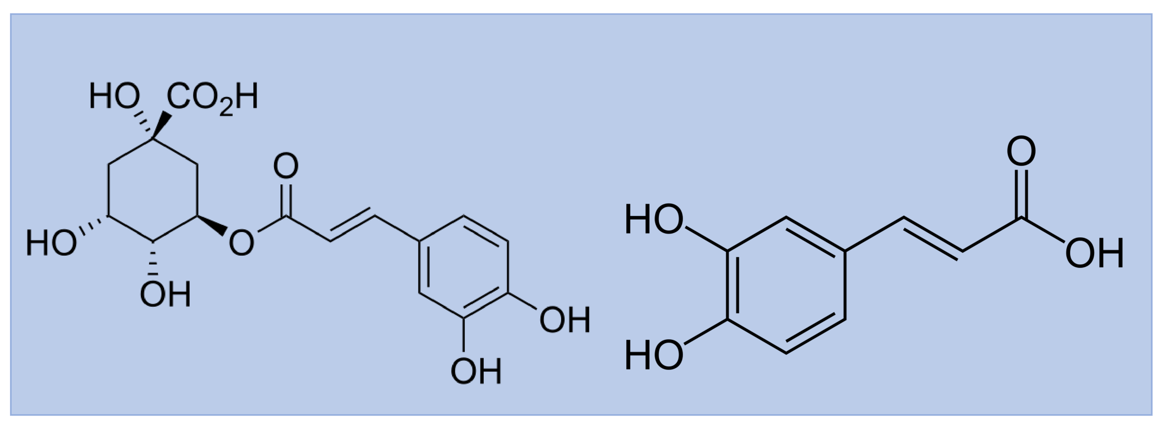
Acetic acid | Formic acid | Levulinic acid

FURANIC DERIVATIVES



Furfural | Hidroximetilfurfural

PHENOLIC COMPOUNDS



Chlorogenic acid | Caffeic acid

2. SUGARCANE BAGASSE (SCB) AS A POTENTIAL MATRIX FOR BIOETHANOL PRODUCTION

Sugarcane (*Saccharum oficinarum* L.) is a tropical grass characterized for being large and perennial, that belongs to the ***Gramineae*** family and the ***Saccharum*** genus **Sucrose** is the main product of sugarcane, **which is accumulated in the internodes of the stalk.** Sugar cane production generates a percentage of waste, which ranges between 25-30%, so the reuse of by-products is key from a circular economy point of view.

These residues produced by the sugarcane industry can be classified in straw, which is the harvest residue, and bagasse, which is the fibrous fraction that follows the juice extraction. These two by-products are characterized for their lignocellulosic composition**, being cellulose, lignin and hemicellulose the major components, having also extractants and ashes in their composition.**

SCB is defined as the waste obtained after the collection of the sugarcane stem juice.

The SCB is composed by 45-50% of cellulose, 25-30% of hemicellulose, 25% of lignin, and 2.4-9% of ash, approximately.

From an economic point of view, it is necessary to consider the scaling-up feasibility of bioethanol production using SCB and SE pretreatment. In this way, the industrial pro-duction of bioethanol has been examined in some studies. **It is important to notice that the techno-economic feasibility of bioethanol production also includes the enzymatic hydrolysis of sugars, where the bioethanol is obtained, although this work has not highlighted this step.**

3. CONCLUSION

A new era of biofuels production has been promoted in recent years due to the current carbon emissions generated by conventional fuels. In this way, alternative pathways have been developed being bioethanol production using **lignocellulosic biomass one of the options to be considered.**

SE has been extensively studied as a potential thermo-mechanical pre-treatment to be incorporated in this process. The use of SCB is of particular interest as sugar production generates large quantities of this by-product, the disposal of which is currently a problem.

Studies have shown positive results obtained in terms of both sugar conversion and cellulose, hemicellulose, and lignin content reduction when SE was applied in SCB, so the bioethanol production using this methodology **seems to be a promising new pathway.**

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