Short ozonation of lignocellulosic wastes as effective pretreatment in bioethanol production

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Introduction

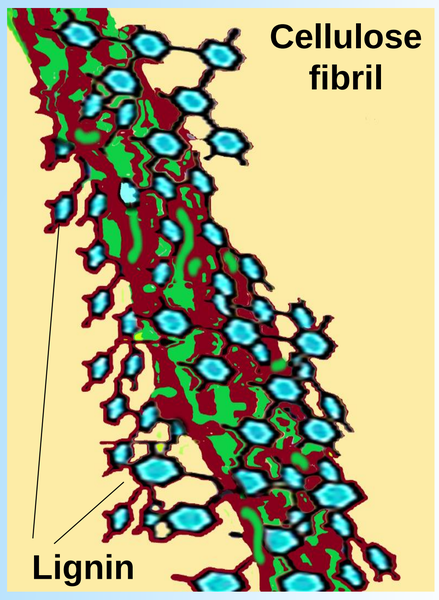

Figure 1: Lignin (blue) and Hemicellulose (brown) covering cellulose fibre (green)

- In bio-ethanol production from lingocellulosic wastes, the removal of lignin is an essential pretreatment process for making the cellulose accessible to hydrolysis.
- Lignin is a complex poly-phenolic polymer with an irregular 3D structure which varies among different plants, plant parts and seasons.
- Pretreatment methods used today suffer from many disadvantages but although ozonation pretreatment has high potential, it is rarely used because of high energy requirements in ozone production.

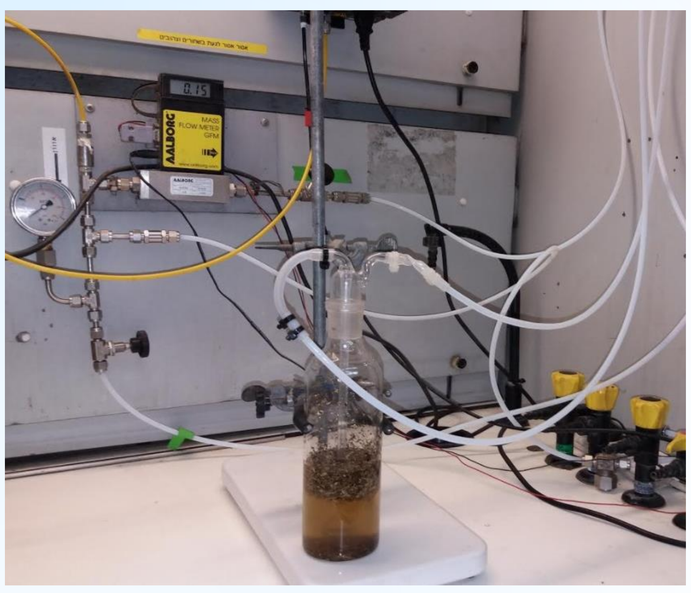

Figure 2: Ozonation system with a semi-batch reactor

- Ozone (O_3) can be produced on-demand, on-site, without need for dangerous chemicals.
- Ozonation, carried out at room temperature, avoids the formation of the inhibitory compounds known to be formed by other pretreatment methods (Furfural and HMF).
- Ozone dissolved in water has a short half life span of 20 minutes suggesting no harmful carryover.

Results

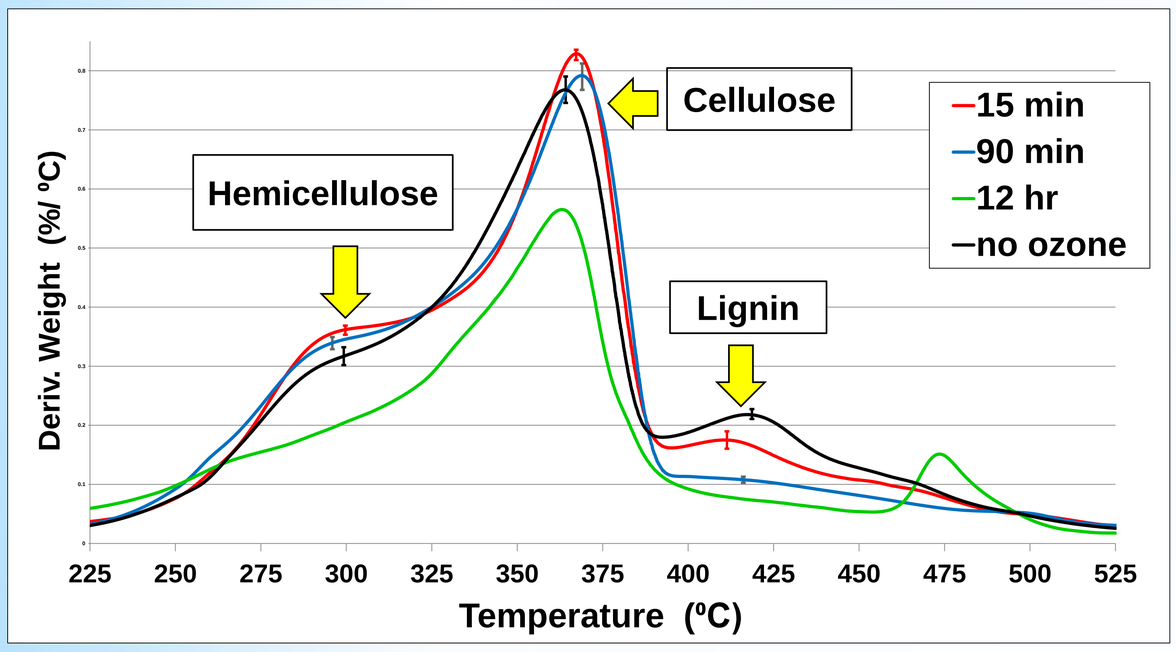

Figure 3: Thermo-Gravimetric Analysis (TGA) results showing lignin reduction accompanied with the appearance of hemicellulose. The amount of the three substances is calculated as the area (∫) under the substances specific curve

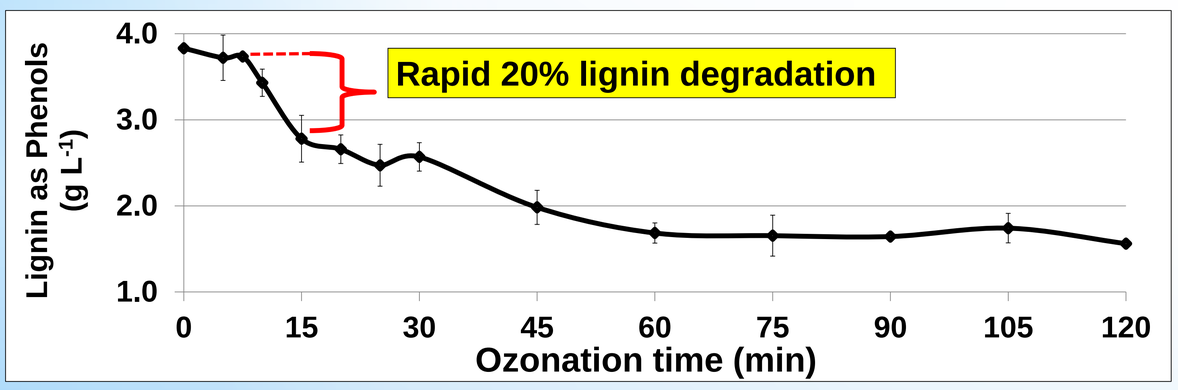

Figure 4: Lignin alkali (4 gL^{-1}) degradation as determined by phenol content via Folin- Ciocalteu (F-C) assay

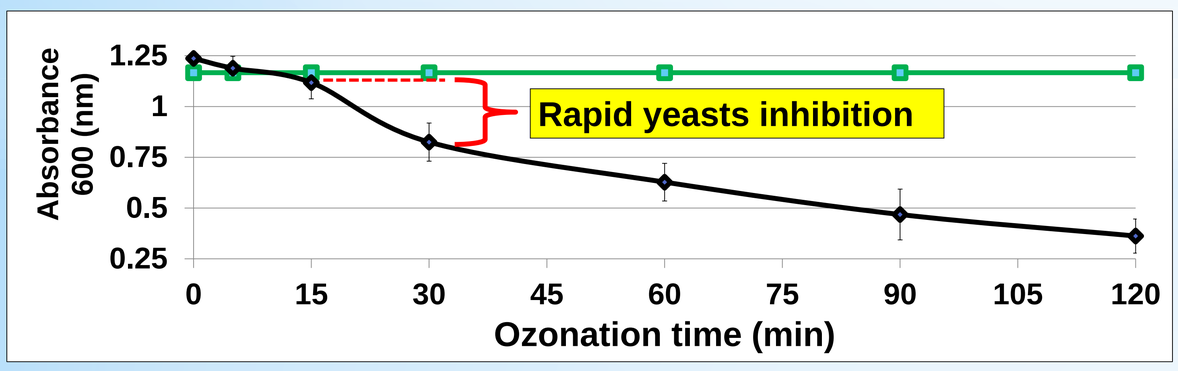

Figure 5: Inhibition to yeasts growth by suspended substances produced via ozonation (black), compared to growth in 2% YPD medium (green)

Figure 6: Changes in color waste solubles through ozonation from brown (left, untreated) till milky white (right, 240 min)

Figure 7: Before ozonation (left) and after 90 min ozonation (right)

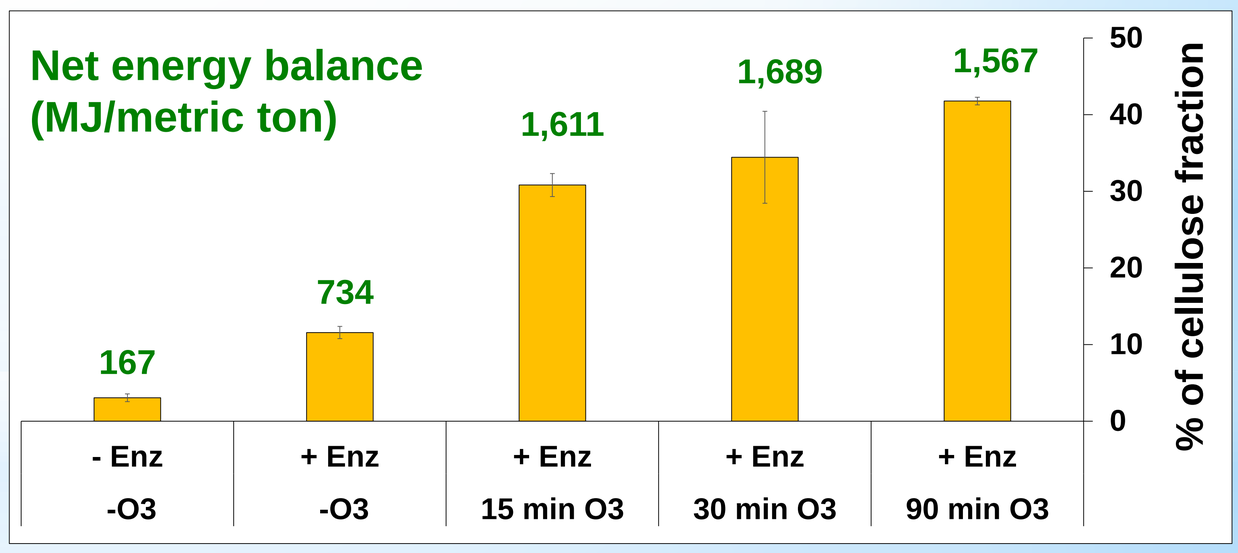

Figure 8: Sugar release after ozonation followed 72 hr Saccharification (black) showing that reducing 75% of ozonation time (15 min instead of 90 min) yielded in 25% less sugar conversion (30% instead of 40%). The net energy balance (green) is showing a reduction at higher ozone dose, demonstrating increased process efficiency at lower ozone doses

Conclusions

- **Short ozonation (15 min), although removed only 20% of the lignin, was enough to improve saccharification efficiency 3-folds.**
- **Longer ozonation improve saccharification but have lower net energy balance.**
- **These results suggest that long ozonation is unnecessary, making ozonation pretreatment more economical and energy favored.**
- **The benefits of ozone (simple infrastructure, on-situ on-demand production and no toxic compounds) make it highly suitable for decentralized pretreatment facilities, reducing transport costs of biomass.**

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