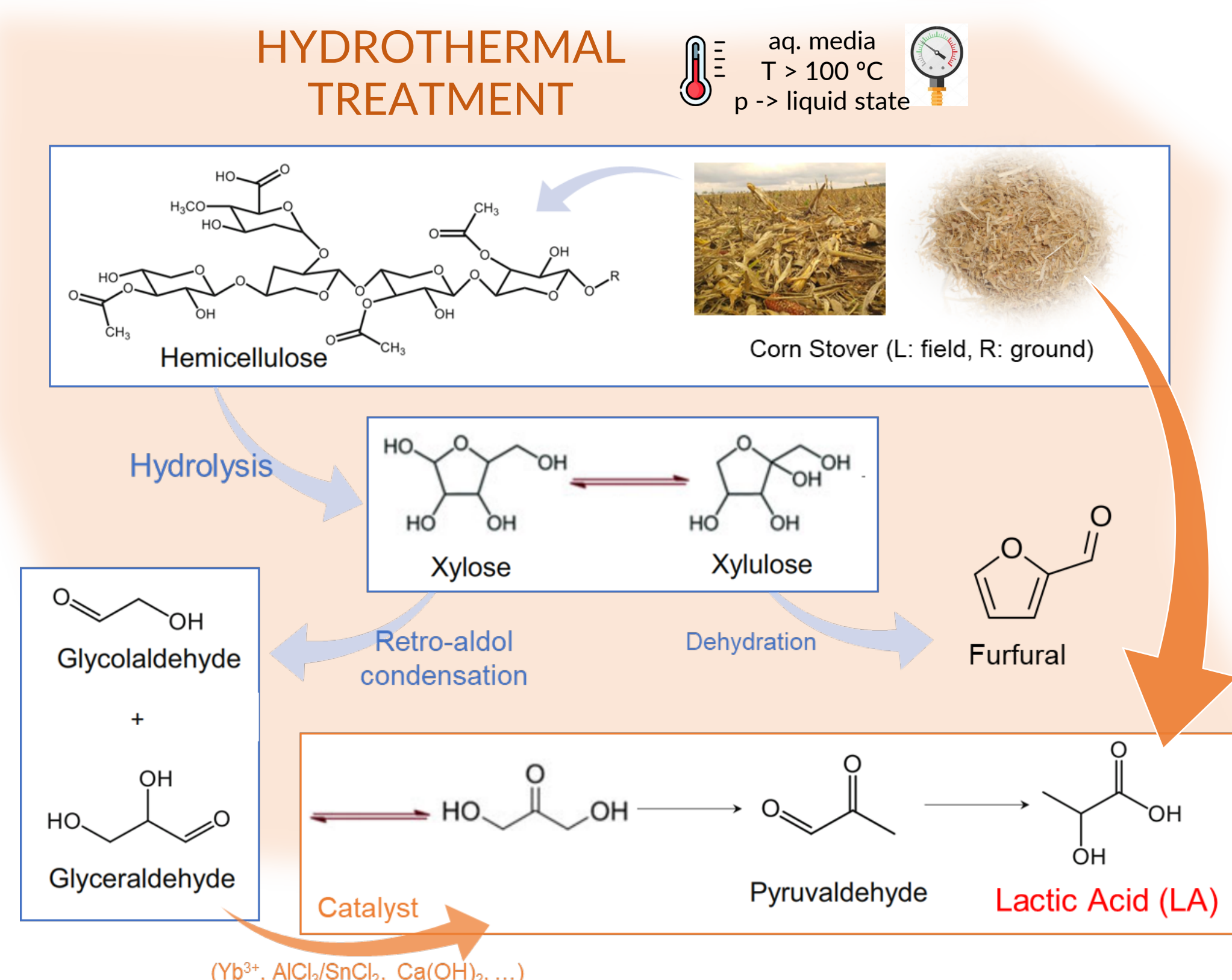


SUSTAINABLE LACTIC ACID PRODUCTION FROM AGRIFOOD RESIDUES VIA SUBCRITICAL WATER HYDROLYSIS AND NANOFILTRATION

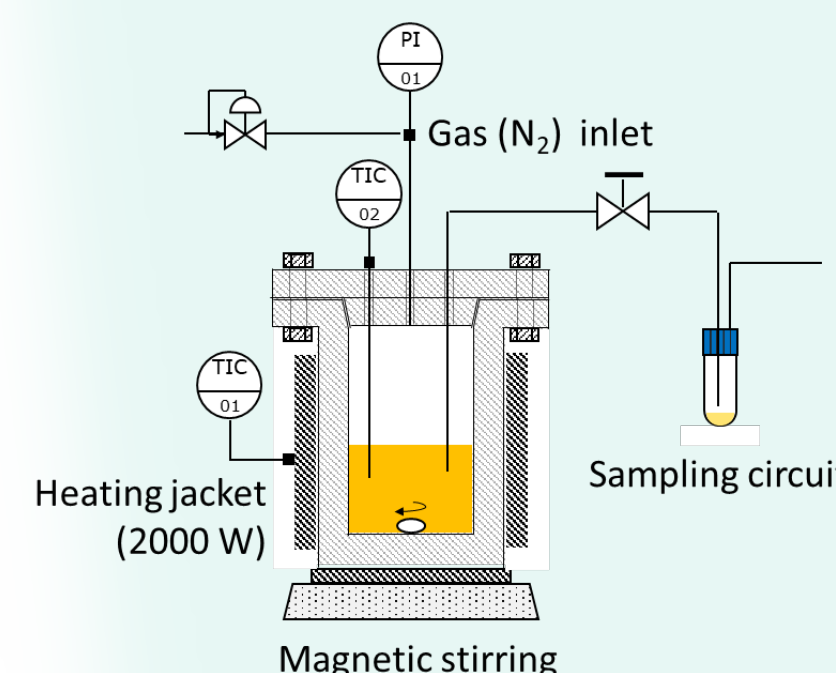
1. BACKGROUND

Agri-food residues rich in hemicelluloses, such as corn stover, were subjected to hydrothermal treatment in the presence of heterogeneous catalysts such as Yb^{3+} salts [1], and $\text{Ca}(\text{OH})_2$ to promote lactic acid (LA) production.



2. MATERIALS & METHODS

a) SUBCRITICAL WATER HYDROLYSIS (SWH)



Conventional **Stainless Steel batch reactor**

- $V = 200\text{ mL}$
- Biomass load = 10 g
- $T = 260^\circ\text{C}$
- $t = 45\text{ min}$
- $p = 5\text{ MPa } (\text{N}_2)$
- [Catalyst]: 0.005 M

b) MICROWAVE (MW) APPARATUS

Microwave (MW)-heated **Teflon batch reactor**

- $V = 30\text{ mL}$
- Biomass load = 2.5 g
- $T = 260^\circ\text{C}$
- $t = 15\text{ min}$
- [Catalyst]: 0.005 M

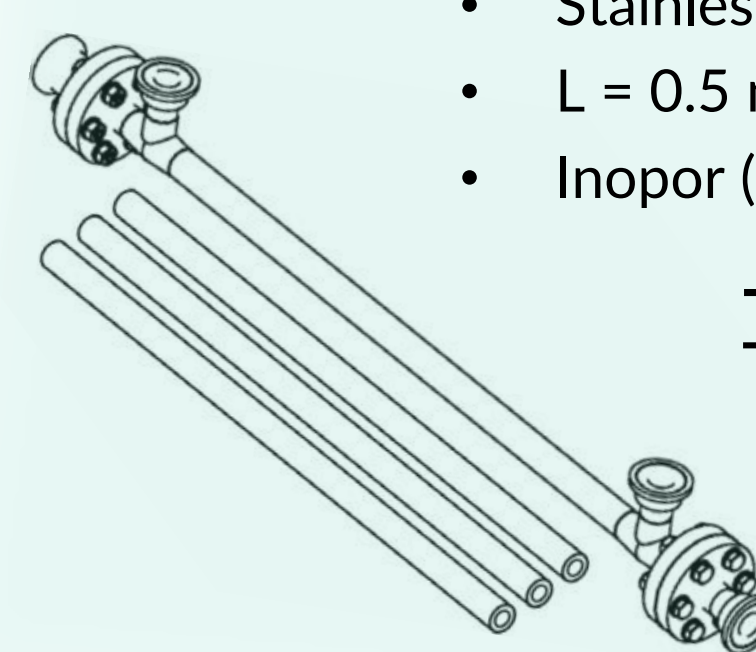


Milestone FlexiWAVE

c) NANOFILTRATION (NF) EXPERIMENTS

Nanofiltration membrane module

- Stainless Steel (MAWP = 4 MPa)
- $L = 0.5\text{ m}$, I.D. = 10 mm
- Inopor (Rauschert Distribution GmbH)

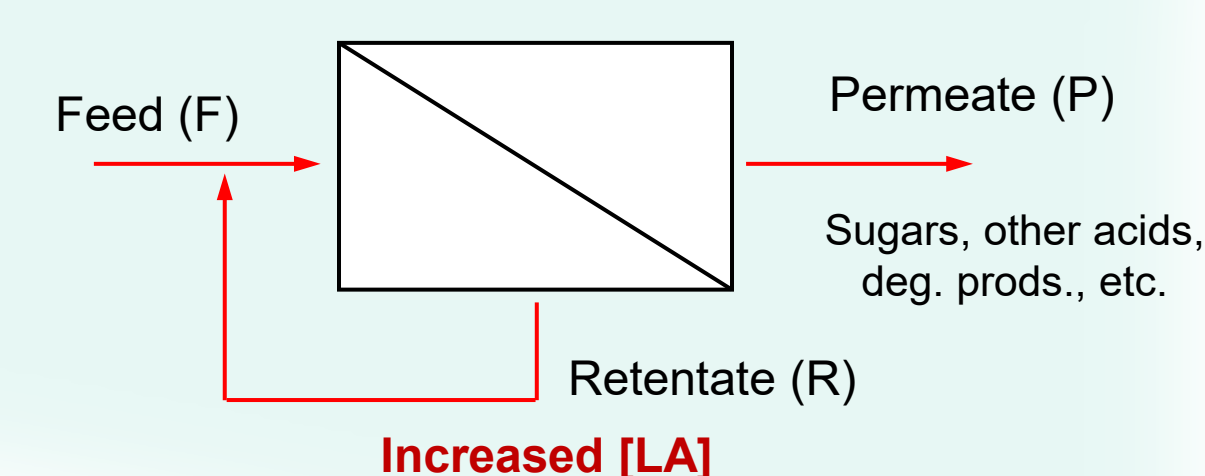


Tubular membrane LC1

- Al_2O_3 support with TiO_2 int. layer
- $L = 0.5\text{ m}$, I.D. = 7 mm
- $D_p = 0.9\text{ nm}$, MWCO $\leq 200\text{ Da}$

NF as a clean strategy for LA separation and purification

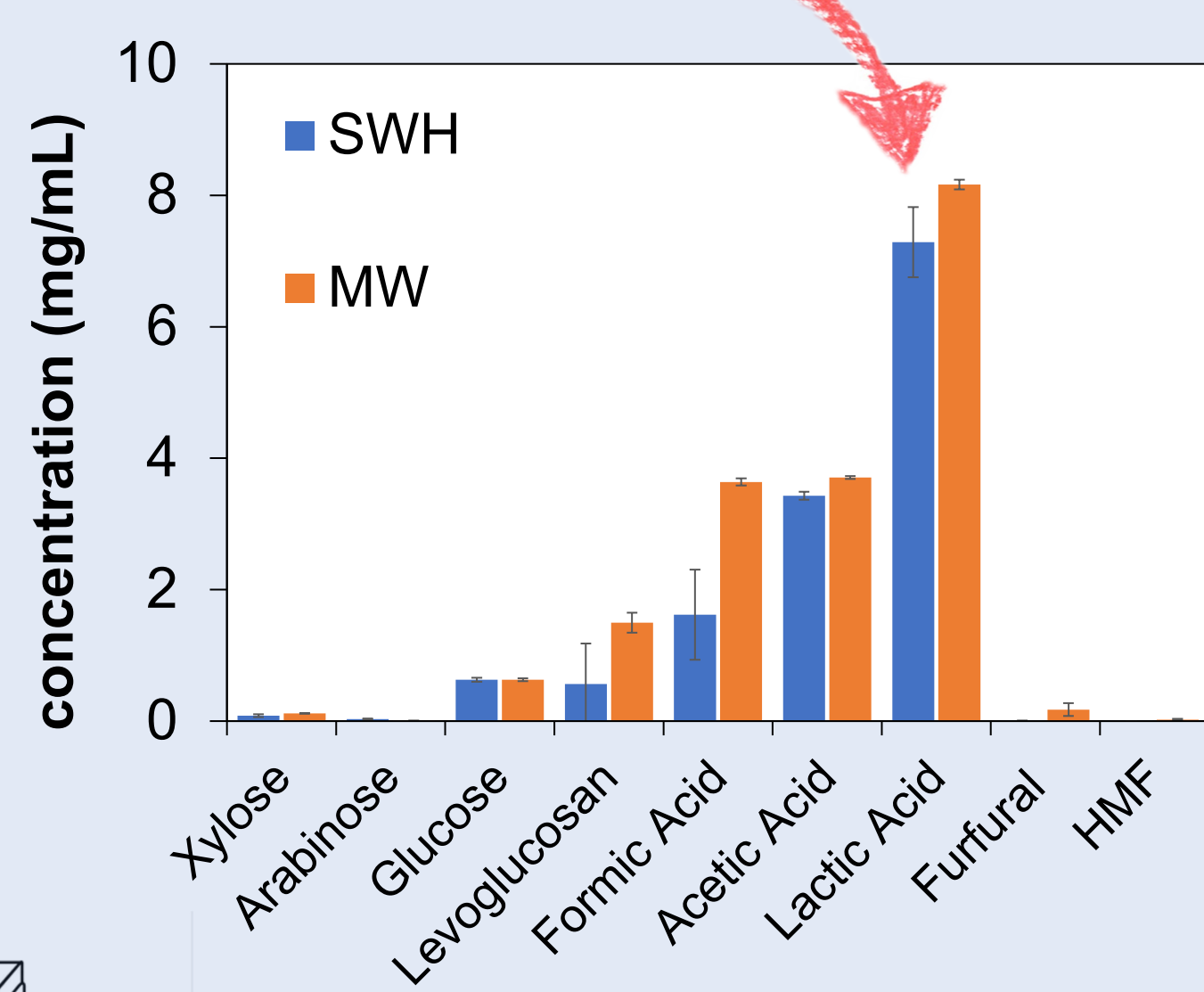
Synthetic solutions with LA and other acids were used as Feed



3. RESULTS

Hydrolysis products were rich in LA

Presence of sugars, other organic acids and degradation products



HPLC analysis [2]

Agilent 1260 Infinity II system
Bio-Rad Aminex-HPX-87H column, 40°C
VWD and RID detectors.
0.005 M sulfuric acid 0.6 mL/min

3.1. MEMBRANE CHARACTERIZATION

Boundary Flux Theory [3]

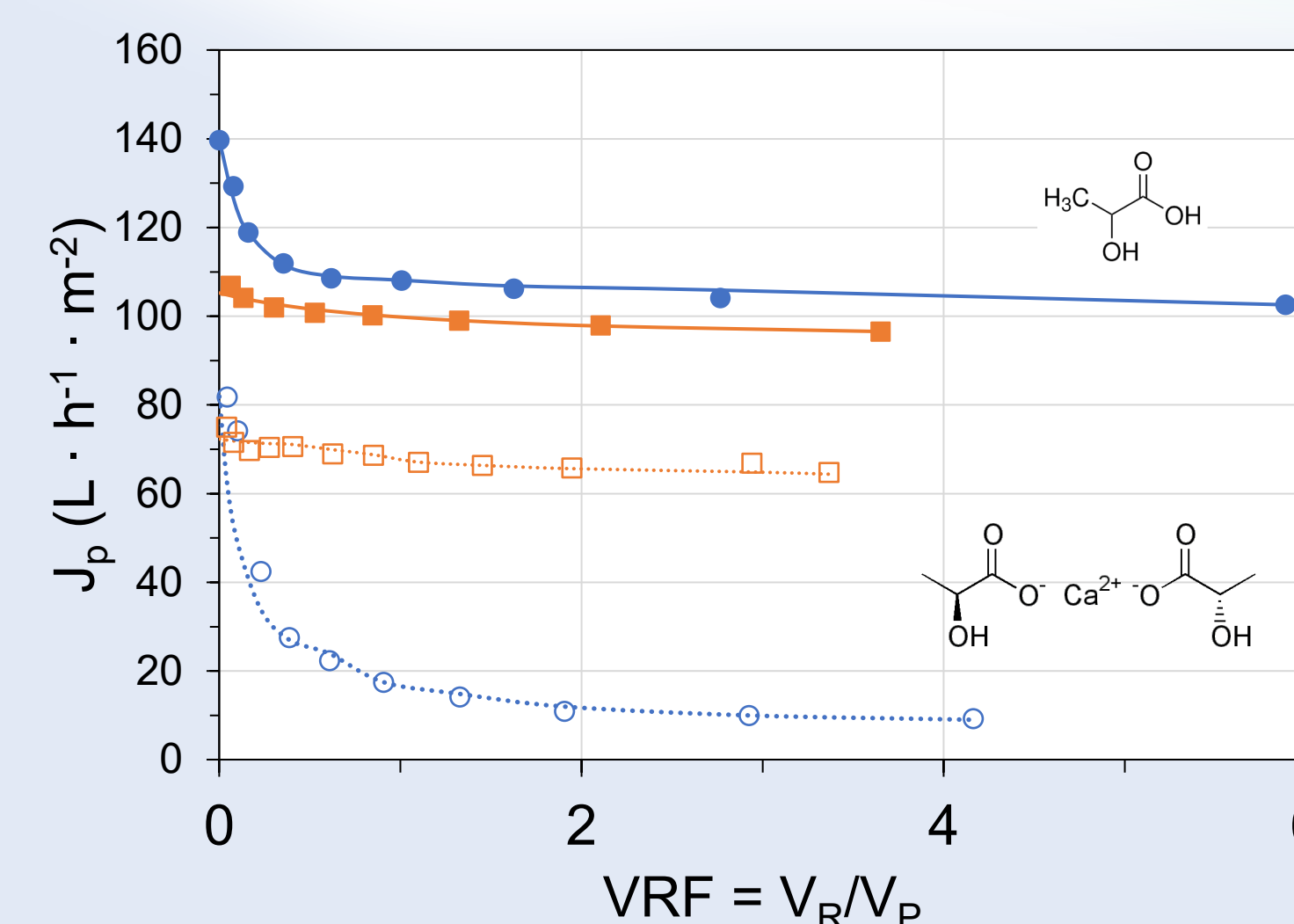
$$J_p(t) = J_p(t_1) - \alpha P_{TM}(t - t_1); \quad J_p(t) \leq J_b(t)$$

$$J_p(t) = J_p(t_1) - \frac{\alpha - \beta J_p(t_1) + \beta J_b}{\beta} (e^{-\beta P_{TM}(t - t_1)}); \quad J_p(t) > J_b(t)$$

J_b is the boundary flux

α is the sub-boundary fouling rate index, which indicates the constant permeability reduction rate of the membrane

β is the supra-boundary fouling rate index, determining the fouling pattern in the exponential fouling regime of the membrane system. It is a function of the applied transmembrane pressure (PTM)

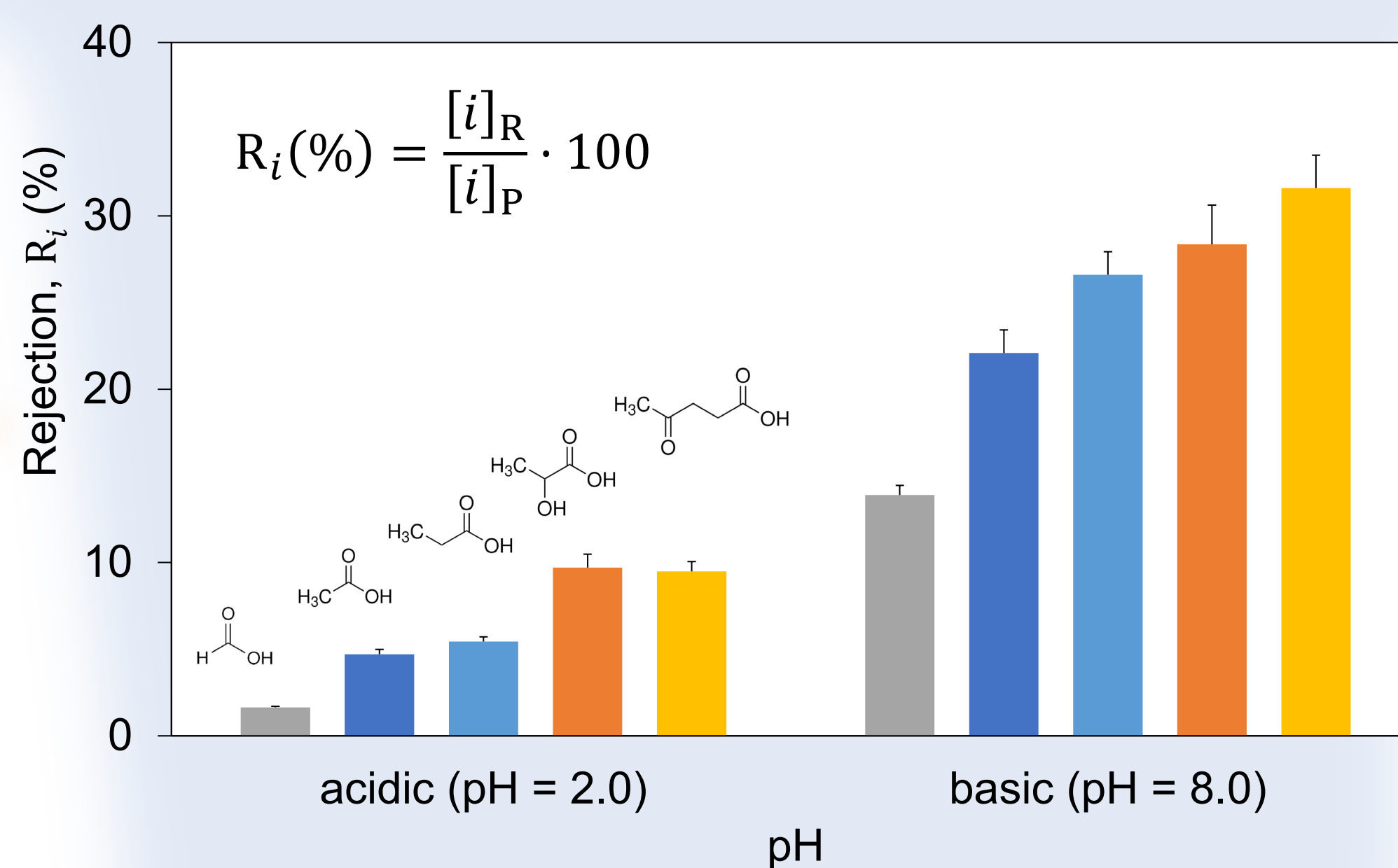


Permeate flux vs. VRF for lactic acid and calcium lactate solutions.
Feed flow = 2 L/min; solute concentration = 8 g/L; PTM = 2.5 MPa, $T = 25^\circ\text{C}$.

●: acidic pH (2.0-3.0), ■: basic pH (8.0-9.0).

Full symbols: lactic acid, hollow symbols: calcium lactate
Lines are from the fitting of the boundary flux model

3.2. REJECTION OF ORGANIC ACIDS



Rejection of organic acids by the LC1 membrane (Inopor) at different pH.
Feed flow = 2 L/min; PTM = 2.5 MPa, $T = 25^\circ\text{C}$.

■: formic acid (3 g/L), ■: acetic acid (3 g/L) ■: propionic acid (0.5 g/L),
■: lactic acid (8 g/L), ■: levulinic acid (0.5 g/L).

CONCLUSIONS

- ✓ The **boundary flux theory** satisfactorily explains the behavior of LC1 membrane for lactic acid and calcium lactate solutions. Parameters α and β account for the **permeability reduction** and the **fouling rate** of the membrane, respectively.
- ✓ The **presence of Ca^{2+}** from the catalyst $\text{Ca}(\text{OH})_2$ reduces permeability, especially at acidic pH
- ✓ **Basic pH** reduces fouling rate and improves rejection of the tested organic acids, although lower permeability is observed.
- ✓ Rejection of organic acids by LC1 membrane seems related to MW, although certain selectivity for LA is observed at acidic pH.

REFERENCES

- [1] Bermejo-López, A., Illera, A.E., Melgosa, R., Beltrán, S., Sanz, M.T. (2024), *Food Bioproc Technol* 17, 4851 – 4867.
- [2] Alonso-Riaño, P., Sanz, M.T., Benito-Román, O., Beltrán, S., Trigueros, E. (2021), *Food Chem* 351, 129264,
- [3] Ochando-Pulido, J., Martínez-Férez, A., Stoller, M. (2019) *Membranes* 9, 2

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