MICRO-ALGAE PRE-TREATMENT: A SUPERSTRUCTURE OPTIMIZATION PROBLEM

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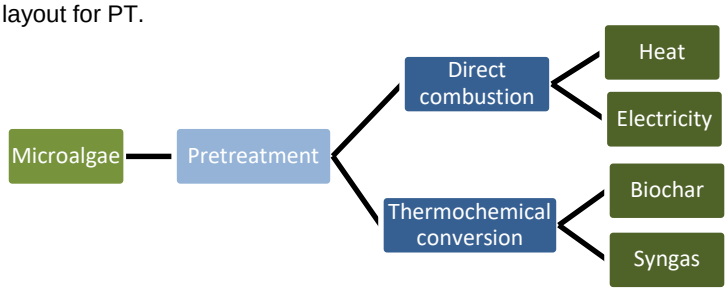
INTRODUCTION

Nowadays, biofuels or energy production from microalgae biomass (MA) have been widely studied. However, some of MA characteristics - moisture and ash content and nitrogen presence - can be drawbacks in the contexts of valorization through thermochemical processes or direct combustion.

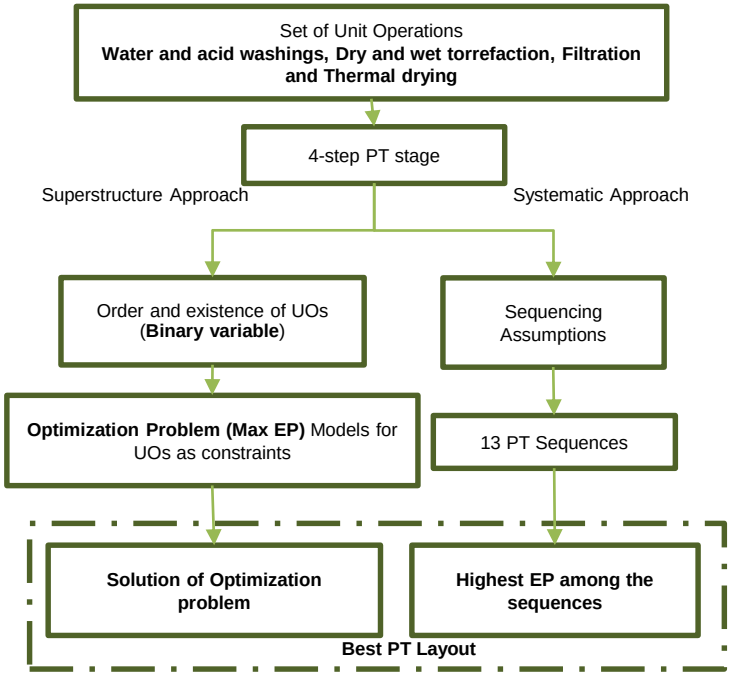
Thus, the goal of this work is to study a **multi-step pretreatment (PT) stage**. The novelty of this study is the set of pretreatment unit operations (UO) considered and the use of two different approaches to combine those UOs and find the best layout for PT.



METHODOLOGY

Criteria for selecting PT layouts - Energetic Potential (EP)

$$EP = \frac{Useful\ heat\ in\ final\ MA(kWh)\ -\ Energy\ consumption\ of\ PT(kWh)}{Dry\ MA\ initial\ mass\ (kg)}$$



RESULTS

Biomass : MA (Chlorella V.)

Cases:

I. Initial moisture fraction = 73% wt (73%M)

II. Initial moisture fraction = 90% wt (90%M)

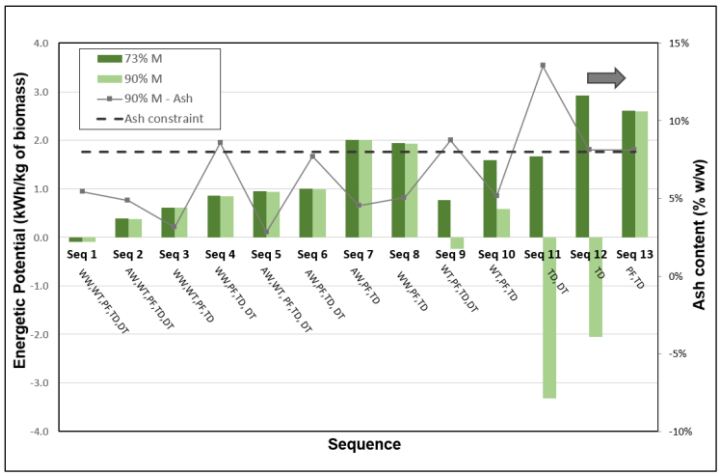
III. II + Final Ash fraction < 8% wt (90%M-Ash)

For all cases, Final moisture fraction < 10% wt

Operations:

Water Washing(WW), Acid Washing (AW), Filtration (PF), Thermal drying (TD), Dry torrefaction (DT), Wet Torrefaction(WT)

SYSTEMATIC APPROACH



BEST PRETREATMENT LAYOUTS

CASE	SEQUENCE	U. OPERATIONS	EP kWh/kg
I – 73%M	12	Thermal Drying	2.92
II – 90%M	13	Filtration+ Thermal Drying	2.59
III – 90%M -Ash	7	Acid Washing+ Filtration+ Thermal Drying	2.00

SUPERSTRUCTURE APPROACH

OPTIMIZATION VARIABLES → Binary variables (y) indicating which unit operation (UO) is present in each step (st)

GAMS

CASE	Optimization variables	EP kWh/kg
I – 73%M	y ('TD',1) = 1	2.92
II – 90%M	y ('PF',1) = 1; y ('TD',2) = 1	2.59
III – 90%M -Ash	y ('AW',1) = 1; y ('PF',2) = 1; y ('TD',3) = 1	2.00

CONCLUSION

In a nutshell, this study compared two approaches for determining best layout for pretreatment of microalgae. Results obtained from both were in good agreement in terms of unit operations arrangement and evaluation criteria (EP).

For the future, the optimization-based approach will be use and the next steps are:

- Addition of upstream (MA production) and downstream (Thermochemical valorization) processes;
- Use of more detailed models for PT unit operations;
- Addition of economics and life-cycle analyses is also considered.

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