DESIGN OF A BIODIESEL PRODUCTION FROM ALGAE PLANT

PART 2.Upstream & Production

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3 BIOPROCESS: *Dunaliella tertiolecta*

WHY DO WE USE IT?

-Green sea alga: it doesn't need potable water to live.
-Non toxic alga: it solves the problem of a spill occurrence.
-Photosynthetic organisms which are able to grow in media containing an extremely wide range of salt concentrations, from 0.05 to 5.5 M NaCl.
- High quantity of oils produced.
-Environmental friendly: photosynthetic organism that reduces the quantity of CO_2 in the atmosphere.
- Non rigid cell wall: easily disrupted.
-Osmoregulation with its elastic citoplasmatic wall.
-High growth rate
-Its use for biodiesel production don't compete with alimentation

$$CH_{1.83}O_{0.48}N_{0.11}$$

Figure 4. *Dunaliella tertiolecta*

Microalgal species	Oil content(% dw)
Dunaliella tertiolecta	36-42

Figure 1 and 2. Algae oil production composition

Fatty acid	Chain length: no. of double bonds	Oil composition (w/total lipid)
Palmitic acid	16:0	12–21
Palmitoleic acid	16:1	55–57
Stearic acid	18:0	1–2
Oleic acid	18:1	58–60
Linoleic acid	18:2	4–20
Linolenic acid	18:3	14–30

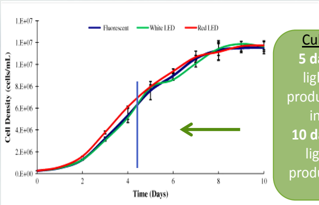
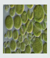


Figure 3. Cell density of *Dunaliella tertiolecta* in different light cultures

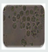
Culture time
5 days (24h of light for the production of the inoculum)
10 days (12 h of light during production time)

$T = 15h^{-1}$ d

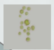
•OTHER OPTIONS



-*Chlorella protothecoides* → As It said in a paper of 2006, *Chlorella protothecoides* has a great potential for the production of liquid biofuels. Its lipid content is: 5-55 % of dry weight. Problem: few studies are published actually and its lipid content varies up to the conditions.



-*Schizochytrium* → Members of the genus produce significant amounts of docosahexaenoic acid and are now grown commercially as a source of oil for biofeeds and biomass. Lipid content: 33 % of dry weight.



-*Neochloris oleoabundans* → its lipid content: is 26% of dry weigh but this and its lipid productivity increases under stress conditions.

PHOTOBIOREACTOR

Photobioreactors offer a closed culture environment, which is protected from direct fallout, relatively safe from invading microorganisms and where temperatures are controlled with an enhanced CO_3^{2-} fixation that is bubbled through culture medium.

The algae use energy from the sun, carbon dioxide and nutrients from the sea water to produce biomass that can be converted into biofuels.

$$H_2CO_3 + 0.11NH_3 \rightarrow CH_{1.83}O_{0.48}N_{0.11} + 1.13\ O_2 + 0.25\ H_20$$

System consists of large flexible plastic bags floating on seawater
Because they are shallow, they achieve optimal light exposure with an outstanding productivity and because they float in a cushion of water, they can maintain optimum temperature at low cost and they don't need agitation.

If there's a storm:
The bag floats because its water inside is relatively less dense than the ocean where it is floating on. That density can be controlled in a number of ways, allowing the bags to be upended to facilitate harvesting, or lowered into the ocean in case of storm.
If the bags break:
Plastic bags can break. But as we are dealing with **biodegradable live organisms**, if a disaster happens we are **not going to ruin the whole coast line**.

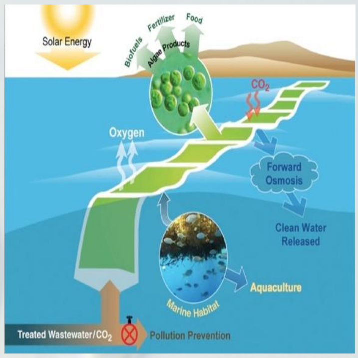


Figure 5. Algae bags on the sea: nutrient and gases exchange

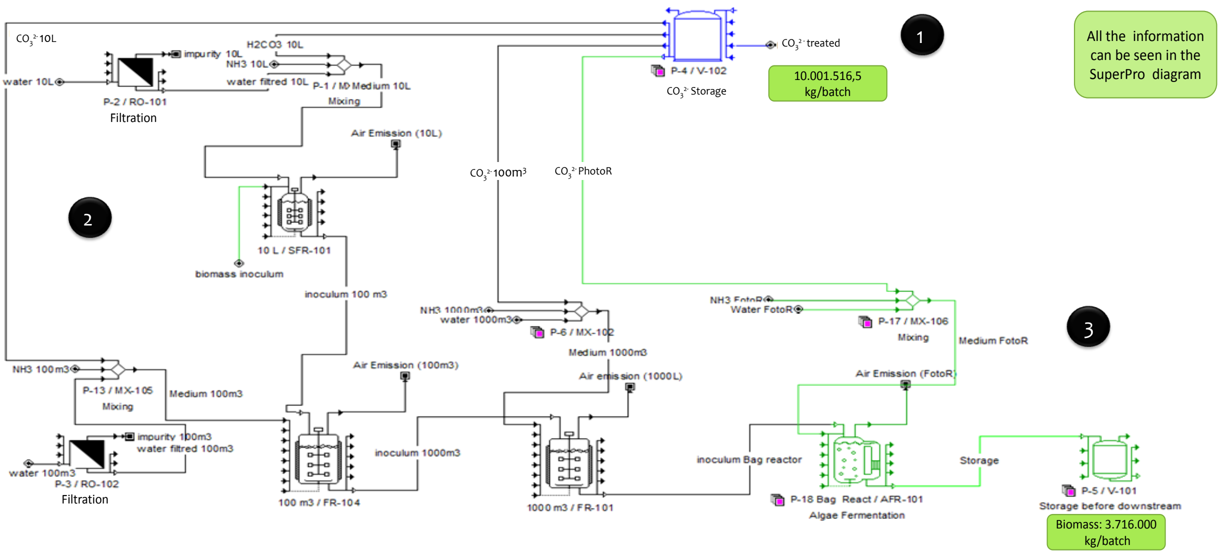
In order to ensure a correct light exposure for the algae, the maximum concentration of the algae in each bag is between 2.5-3 g/L

Figure 6. Algae bags

ALGAE PRODUCTIVITY
100 g^{-1} dry weight m^{-2} d^{-1}
was achieved in 300 l culture systems

The bags are made of a thin and flexible polymer, in which algae can grow. It allows the pass of saline water and float on the sea

FLUX DIAGRAM OF UPSTREAM AND BIOPROCESS



2 SCALING ITERATIONS

Real Scaling		
Total Volume (useful)	Scaling	Unit number
10 (9.26) L	x10⁴	1
100 (99.19) m³	x10	1
1000 (992.39) m³	x10	1
1 m³	x10⁴ *	1.709.880

Figure 7. Table with the scaling process applied. * This scaling value refers the pass from a 1000m³ reactor to the total volume of the 1709880 bags.

Why do we scale up?

-It's not possible to make all the investigations in a large scale because of the cost of these and because the experimentation will be much more difficult.
-The ideal scale up is x10-1000 each time in order to ensure that between reactors the physical and chemical constants are maintained.
-Scaling up is necessary to find the correct values of the experiment variables in each reactor. For example, the oxygen rate can differ between the 10L and the 100m³ or the agitation rate required.

STAGE'S Summary:

Productivity
(Kg Biomass/batch):
3.716.000

Installation Price ($):
1.222.000

Space required:
2.000 hm²

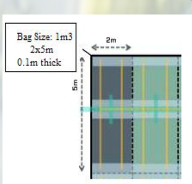


Figure 8. Bag size

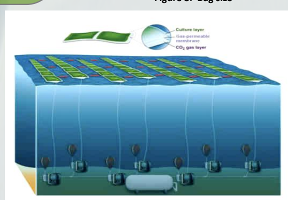


Figure 9. Bag layout on the sea

1 QUANTITY OF CO_3^{2-} REQUIRED

Figure 10. CO_3^{2-} storage tank

Quantity CO_3^{2-} required
1,00 x 10⁷
Kg/batch

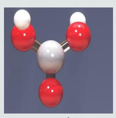


Figure 11 .CO_3^{2-} molecule

Cost of CO_3^{2-} storage

The idea is to **produce it continuously** in order to spare money.

(The tank it's not real it's a way to explain better the process)

Selected References

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