Recent Advances in Outdoor High-Density Cultivation of Novelty Micro-Algae Strain with High Content of Lipids

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The objective of the study was the pilot plant examination of a newly developed integrated process for autotrophic cultivation of useful micro-algae. The process utilizes waste carbon dioxide as a source of carbon and yields simultaneously products that can be utilized in food and cosmetic industries, turned into biodiesel and/or used as a supplement in animal feed.

At present, the cultivation of micro-algae merely for the production of biofuels is not economically viable. In the proposed process, the economy is improved by complex utilization of the micro-algae for simultaneous integrated manufacturing of several products that may be priced at different levels. In this way, the overall economy of the process is positive.

Needed carbon dioxide can be obtained both from the waste industrial flue gases and from the flue gases leaving the co-generation units that turn biofuel into energy and heat.

In the latter case, nitrogen and phosphorus from the flue gas are utilized in the proposed integrated process as nutrients for micro-algae.

The necessary prerequisite for achieving a positive economic balance in a process that integrates production of several different products is the existence of a suitable strain of micro-algae.

Recently discovered special Czech strain of micro- algae classified as *Trachydiscus minutus* seems a good choice. The strain has high content of lipids with both unsaturated and saturated fatty acids and high content of proteins and carotenes. The strain may be cultivated in both the closed and the open photo-bioreactors. Unsaturated fatty acids are selectively extracted from lipids and subsequently turned into high value added products for food and cosmetic industries. The extracted saturated fatty acids can be later turned into biodiesel via transesterification. The residual biomass with its high content of proteins and carotenes is utilized as an animal feed supplement. Unsaturated EPA (eicosanpentaeonic acid) forms approximately up to 44% of all fatty acids contained in the algae, saturated myristic acid forms approximately 8%-30%, depending on the cultivation conditions. Further biotechnological processing is relatively simple and the unsaturated and saturated acids can be easily separated. The profile of fatty acids can be manipulated by selecting particular cultivation conditions. Pilot plant cultivation was done in two different types of equipment:

a) A closed, flat-plate vertical bubble photobioreactor, the height of algae suspension 1500 mm, width 2000 mm, thickness 50-130 mm. Carbon dioxide was distributed from a perforated tube distributor that was located in the bottom of the reactor. The photobioreactor was also operated in field conditions as a part of an integrated cogeneration station that used biogas from agricultural waste.
b) An open inclined flat plate photobioreactor with high rates of algae suspension on the top of the plates (the suspension was pumped on the plates at high rates). The thickness of the layer of the algae suspension on the plates was 9 mm, the total area of the plate was 12 m^2. Carbon dioxide was fed into the pump that circulated the algae suspension.

The growth rate of the micro-algae was measured in both photobioreactors under various conditions. Geometrical and hydrodynamical parameters were optimized for several ratios of the fatty acids. The growth rate of micro-algae mass depends heavily on the height of the illuminated layer of the suspension. The highest growth rates were measured in the inclined plate reactor (about 20g of dry matter/m^2/day including at night).
The construction of both photobioreactors is not complicated and their scale-up does not pose problems. Artificial illumination can be installed in both reactors. Available ways to harvest the obtained biomass and optimal utilization of the biomass in the industry are also discussed in the paper.