trans algae INFOSHEET

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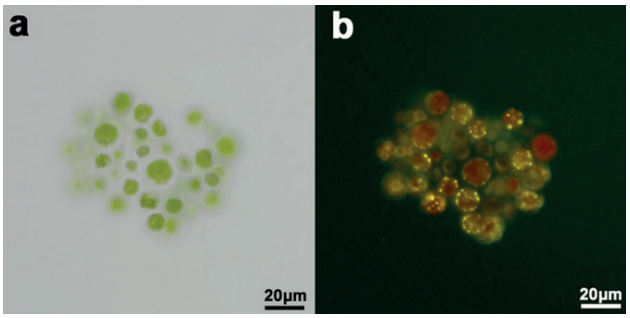
Microalgal lipids can be smartly enhanced

In response to the energy crisis, global warming and climate changes, microalgae have received a great deal of attention as a biofuel feedstock. Due to a high lipid content in microalgal cells, microalgae present as a promising alternative source for the production of biodiesel. Environmental and culturing condition variations can alter lipid production as well as chemical compositions of microalgae.

LIPID OVER-PRODUCTION

The application of suitable strategies to activate lipid accumulation opens the door for lipid over-production in microalgae.



Before (a) and after (b) lipid over-accumulation

LIGHT INTENSITY

Microalgal growth needs the input of light during the photosynthesis. As one of the key factors, light affects the performances of microalgal growth and the compositions. Adequate light intensity favors the overproduction of microalgal lipids. Either limited or saturated light intensity cannot favor the growth of microalgae.

TEMPERATURE

The effect of temperature on microalgal growth and lipid production is similar to that of light intensity. Microalgal growth as well as lipid production exponentially increases to a certain extent as the temperature increases, and reaches an optimal level. The optimal value of temperature where the highest biomass and lipid production is achieved varies from species to species. For example, microalgae *Chlorella vulgaris* and *Scenedesmus* sp. accumulated maximum lipids at 25 and 20 °C, respectively.

CARBON DIOXIDE

As for phototrophic microalgae, CO_2 ensures carbon supply for photosynthesis. Optimal growth of microalgae needs adequate amount of dissolved CO_2. In general, as the quantity of CO_2 increases to an optimal level, the growth of microalgae and production of lipids increase. The optimal amount of CO_2 also varies among microalgal species. For example, when microalga *C. vulgaris* was cultivated under 8% (v/v) CO_2, the maximum amount of saturated fatty acids and lipid productivity of 29.5 mg L^{-1} day^{-1} were achieved, while the microalga *Chlamydomonas* sp. produced maximum lipid content (65.3%) and productivity (169.1 mg L^{-1} day^{-1}) under 4% (v/v) CO_2.

NUTRIENT STARVATION

Nutrient starvation or limitation is thought to be a feasible and environmentally friendly approach for the control of the cell cycle to enhance lipid productivity. So far, nutrient starvation is recognized as the most successful strategy and most widely used. In an attempt to improve lipid productivity, it is important to obtain both substantial biomass yield and high lipid content of microalgal cells. In practice, algae are grown in media with sufficient nutrients in early stages to obtain higher biomass concentration as quickly as possible, while nutrient starvation is introduced in later stages for the overproduction of lipids.

Nitrogen, phosphorus and/or sulfur starvation is widely recognized as a main lipid inducer for green microalgal species (Table 1).

Table 1: Lipid content of microalgae under the cultivation with nutrient stress factor. Data from references.

Microalgae	Stress factor	Temperature (°C)	Culture time (d)	Metabolic type	Lipid content (%)
Chlorella vulgaris	Nitrogen starvation	25	10	Autotrophic	53
Monoraphidium sp.	Nitrogen starvation	25	5	Autotrophic	44.4
Scenedesmus sp.	Nitrogen starvation	25	10	Mixotrophic	31
Chlorella zofingiensis	Nitrogen and phosphorus starvation	25	8	Mixotrophic	46.2
Ankistrodesmus falcatus	Nitrogen starvation; Phosphorus starvation	20	16	Autotrophic	34.4; 45.9
Chlorella protothecoides	Phosphorus starvation	28	7	Mixotrophic	32.8
Parachlorella kessleri	Sulfur deprivation	20	14	Autotrophic	50.7
Chlorella lobophora	Sulfur deprivation	20	21	Autotrophic	50.0
Parachlorella kessleri	Depletion of diluted nutrient media	30	4	Autotrophic	60.0

SALINITY STRESS

To resist osmotic pressure due to salinity stress, some metabolites in algal cells can be produced. Surrounding salinity can affect the physiological and biochemical properties of microalgae. The salinity stress created inside the cells results in increment in the lipid content. Many microalgal species have been found to be subjected to the salinity stress. It is reported that the highest total fatty acid content of 47.0% dried weight was achieved at 13 g L^{-1} NaCl. However, too high salinity introduced can inhibit the cell growth and change the shape and structure of microalgal cells, due to the water pressure between media and cells. Thus, an optimal range for salinity level is supposed to be determined.

METAL STRESS

Metal ions can also affect the growth of microalgae and lipid production. It is reported that the iron, magnesium and calcium stress could contribute to the increase of the total lipid content up to 43.2, 35.0 and 47.4%, respectively, when heterotrophic microalga *Scenedesmus* sp. R-16 was cultivated in a dark environment. A study was carried out using Chlorella species under copper exposure to evaluate the metal stress on lipid contents, and it is found that much higher lipid concentrations were observed in *C. vulgaris*, *C. protothecoides* and *C. pyrenoidosa* in the presence of copper concentration at 4.0 mg L^{-1}. However, too high metal concentration will also damage the microalgal cells. Thus, an optimal range should be applied.

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