«Сейфуллин оқулары – 16: Жаңа формациядағы жастар ғылыми – Қазақстанның болашағы» атты халықаралық ғылыми-теориялық конференциясының материалдары = Материалы Международной научно-теоретической конференции «Сейфуллинские чтения – 16: Молодежная наука новой формации – будущее Казахстана». - 2020. - Т.I, Ч.2 - С.265-269

EVALUATION OF GROWTH AND BIO-OIL PRODUCTION AT ELEVEATED CO_2 CONCENTRATIONS

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Global demand and environmental pollution are the two inevitable issues which dictate the urge for finding the alternative energy. Developed countries tend to ensure uninterrupted power and eventual economic stability to increase the share of mechanization and automation of production, which in turn requires larger energy inputs. The energy demand well correlates with the population growth, as population directly increases the sophistication and eventual energy demand [1, 2]. Recently, microalgal biomass is attracting a great attention in energy research as a third-generation biofuel feedstock. Microalgae possess exceptional advantages which distinguished them from other generation feedstocks, such as high photosynthetic rate, growth rate/biomass productivity, and the ability to grow on waste liquids or seawater. However, the commercial feasibility of microalgal biofuels on comparing with conventional fuel market is the prevailing challenge to overcome [3, 4].

Scenedesmus obliquus SAG276-10 was chosen for further experiments due to relatively higher bio-oil yield [5]. The present experiment examined the effect of additional CO_2 supply on the growth and bio-oil yield of *S. obliquus* SAG276-10. The microalga was grown in lab scale at different concentrations of CO_2, then the growth was estimated. The optimum CO_2 concentration for maximum growth was chosen and applied in the photobioreactor in order to measure the bio-oil yield comparing to the control.

Scenedesmus obliquus SAG276-10 was grown in 1 L Erlenmeyer flasks containing 600 mL of Flory medium consisted of 2 g L^{-1} N-free Flory Basic Fertilizer-1 with 810 mg L^{-1} potassium nitrate as nitrogen source [6]. After a week, the culture was scaled up in the small reactor containing 16 tubes with 1.5 L working volume/each. The experimental set-up was consisted two stages. In the first stage, the small reactor was used for further experiments and to study the effect of CO_2 supply (0, 2, 5, and 10%) on growth. Culture was incubated at 25 ± 1.5 °C and aerated using an air pump at a constant rate of 0.2 vvm and illuminated with white light-emitting diodes (LEDs, T5 PAK4100110) at light intensity of 100 µmol m^{-2} s^{-1}. In the second stage, after getting the best CO_2 supply for maximum growth, the culture was scaled up in the tubular photobioreactor containing 140 L of the growth medium.

Growth in the PBR was daily monitored by measuring the dry weight gravimetrically. At intervals of 24 h, 10 mL of algal culture was filtrated through

0.45 μm pore size filter paper, then dried in oven at 80 °C. The biomass productivity (mg L^{-1} day^{-1}) was calculated using Eq. (1.1),

$$\text{Biomass productivity} = (DW_t - DW_0)/t \quad \textbf{(1.1)}$$

where DW_0 and DW_t represent the initial dry weight at the day of inoculation (g L^{-1}) and that at time (t), respectively.

The fixed bed reactor was used in this experiment [3]. The reactor was 140 mm height × 70 mm diameter. The temperature of the reactor was adjusted and monitored by a thermocouple in a heat resistant furnace. In addition, aluminum silicate fiber was used as insulation for the reactor in order to reduce the heat loss. Temperature and retention time were conducted at 600 °C and 60 min. Nitrogen was as a carrier gas and its flow rate was adjusted to 200 mL min^{-1} during the pyrolysis process. Bio-oil was collected in the condenser (ice trap), while biochar was left in the fixed bed reactor, but non-condensable gas was not collected. For the measuring of the weight of bio-oil and biochar the electronic balance was used. Pyrolysis products such as bio-oil, bio-char and gas yields were calculated using Eqs. 1.2-1.4.

$$Y_{bio-oil} = \frac{W_L}{DW} \times 100\% \quad \textbf{(1.2)}$$

$$Y_{biochar} = \frac{W_S}{DW} \times 100\% \quad \textbf{(1.3)}$$

$$Y_{gas} = 100\% - Y_{bio-oil} - Y_{biochar} \quad \textbf{(1.4)}$$

where W_L and W_S represent the weight of bio-oil and bio-char (g), respectively, while *DW* represents the dry weight of the injected biomass (g).

Figure 1.1 shows the effect of different CO_2 ratios on the growth pattern of *S. obliquus* SAG276-10 for 9 days of incubation. By application of 2% of CO_2 ratio, the exponential phase started after 1 day and reached to late exponential phase (LEP) by the 4th day. For 5% and 10% of CO_2 ratio, the exponential phase started at the 2nd days and ended by 8th day of incubation. The dry weight and biomass productivity were higher using 5% of CO_2 with respect to 2% and 10% (Table 1.1). The results obtained from the present work were similar to that reported by Hanet al. [7], however in their results 2% CO_2 showed the highest growth rate and biomass productivity. According to the present results, 5% CO_2 was chosen for the next large-scale cultivation. As shown in Figure 1.2, growth pattern of *S. obliquus* SAG276-10 grown in the tubular photobioreactor with 5% of CO_2 aeration percent for 6 days of incubation was compared with the control

(aerated culture without CO_2 supplementation). Results showed enhanced growth in the presence of 5% of CO_2, which increased the dry weight and biomass productivity from 0.620 g L^{-1} and 0.103 g L^{-1} day^{-1} to 0.9 g L^{-1} and 0.113g L^{-1} day^{-1}, respectively (Table 1.2).

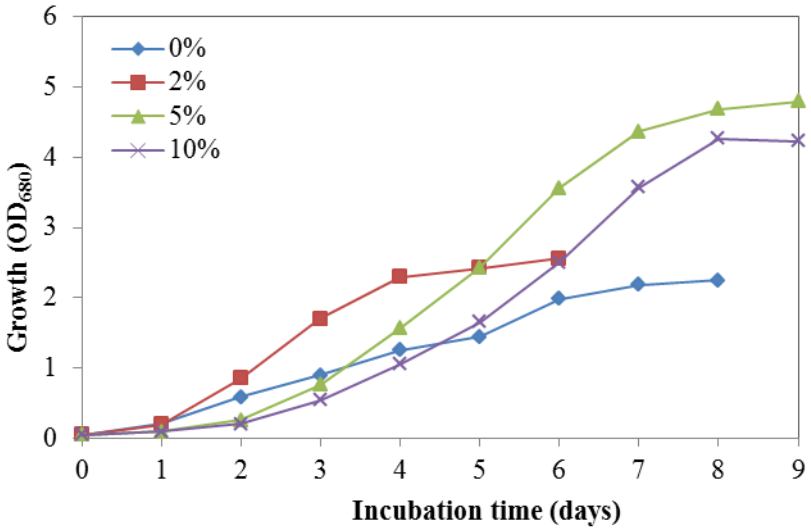

Fig. 1.1 Growth curve of *Scenedesmus obliquus* SAG276-10 cultivated in small reactor with different CO_2 aeration percent

Table 1.1 Dry weight and biomass productivity of *Scenedesmus obliquus* SAG276-10 grown with CO_2

CO_2 percent (%)	*Dry weight (g L-1)*	*Biomass productivity (g L^{-1} day^{-1})*	
0	0.42±0.072[a]	0.07±0.012[a]	
2	0.59±0.110[b]	0.016±0.018[b]	
5	1.34±0.087[c]	0.017±0.011[c]	
10	1.14±0.100[c]	0.014±0.013[c]	

Note:[a]At late exponential phase (day 6[th]) productivity calculated at late exponential phase

[b]At late exponential phase (day 4[th]) productivity calculated at late exponential phase

[c]At late exponential phase (day 8[th]) productivity calculated at late exponential phase

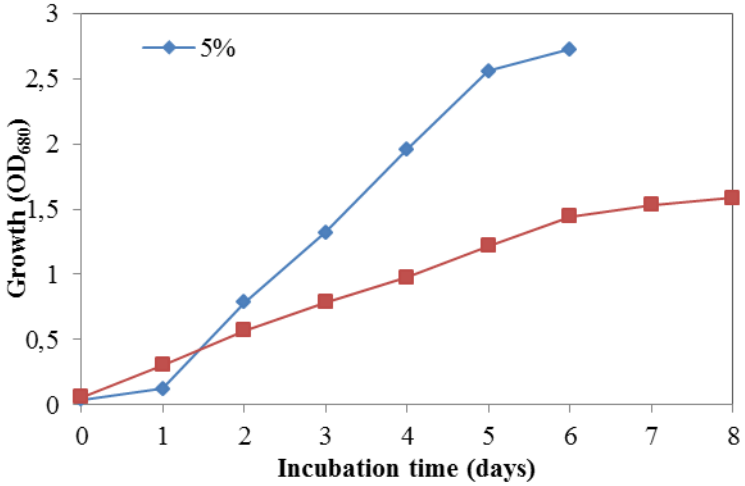

Fig. 1.2 Growth pattern of *Scenedesmus obliquus* SAG276-10 grown in the tubular photobioreactor with 5% CO_2 and 0% CO_2 as a control

Table 1.2 Dry weight and biomass productivity of *Scenedesmus obliquus* SAG276-10 cultivated in PBR and harvested at late exponential phase grown with 0% and 5% of CO_2

CO_2 percent (%)	*Dry weight ($g\ L^{-1}$)*	*Biomass productivity ($g\ L^{-1}\ day^{-1}$)*
0 (control)	0.620±0.020	0.103±0.003
5	0.9±0.087	0.113±0.011

As shown in Figure 1.3, the *S. obliquus* SAG276-10 biomass grown with 5% CO_2 ratio showed 8.28% higher bio-char content compared to the cells grown with 0% CO_2 (control), and significant reduction in the bio-oil yield by 15.4% at the temperature of 600 ℃. The highest gas portion generated from *S. obliquus* SAG276-10 cells grown with 0% CO_2 (control) in this investigation was equaled to 16.2 %.

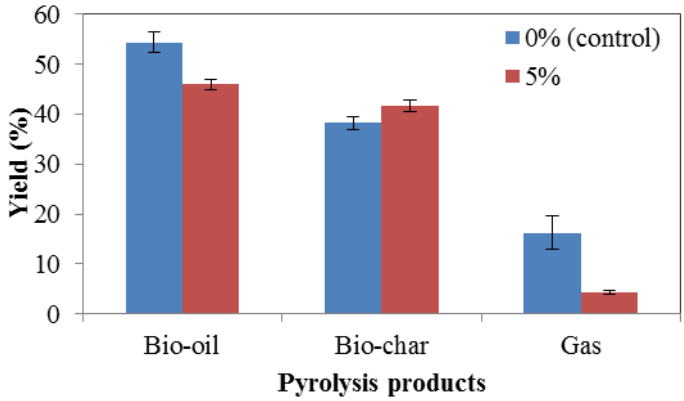

Fig. 1.3 Pyrolysis products of *S. obliquus* SAG276-10 grown with 0% and 5% CO_2.

Results confirmed that 5% CO_2 enhanced the growth and biomass production of *S. obliquus* SAG276-10 with maximum recorded biomass productivity of 0.113 g L^{-1} d^{-1}. However, on the other hand, results of pyrolysis products showed that the highest yield of bio-oil of 54.4 wt% was recorded for *S. obliquus* SAG276-10 cells grown with 0% CO_2 (control), while the bio-oil yield of *S. obliquus* cells grown with 5% CO_2 was significantly reduced to 46.0 wt% at the 600℃.

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