Photoautotrophic ethylene production in high-density cyanobacterial cultivation

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INTRODUCTION

Ethylene (C_2H_4) is a gaseous hydrocarbon that is used as a raw material in the plastics industry. It is mainly produced from oil by steam cracking, which consumes a lot of energy and releases carbon dioxide into the atmosphere. Photosynthetic cyanobacteria are used in the development of new generation biotechnology applications, which aim to produce organic target chemicals directly from carbon dioxide using light energy. In this work, genetically modified *Synechocystis* sp. PCC 6803 cyanobacterial strain that produces ethylene by means of a heterologous EFE gene (EC 1.13.12.19) was used[1]. The aim was to test a special high-density cultivation equipment[2] for the first time for production of volatile end-products and use ethylene-producing cyanobacteria to evaluate the potential of ethylene production and to utilize new sensor technology in the product quantification.

MATERIALS & METHODS

Ethylene was produced using commercial equipment HD100 (CellDEG GmbH) designed for the cultivation of photosynthetic microbes (Figure 1). This equipment can be used to achieve a very high cell density (OD_{750} up to 40–50). A high carbon dioxide concentration (5–6 %) and high light intensities (max 780 µmol/m^2/s) were used for cultivation, which was possible with the help of a cultivation cabinet (Microbiosphere) custom made by Versa Elements. Cell growth and ethylene production were studied under different light conditions and at different stages of batch cultivation. Ethylene production was monitored directly from the gas phase of the growth chamber with GC-FID chromatography and a VOC-sensor developed for the quantification of volatile organic compounds.

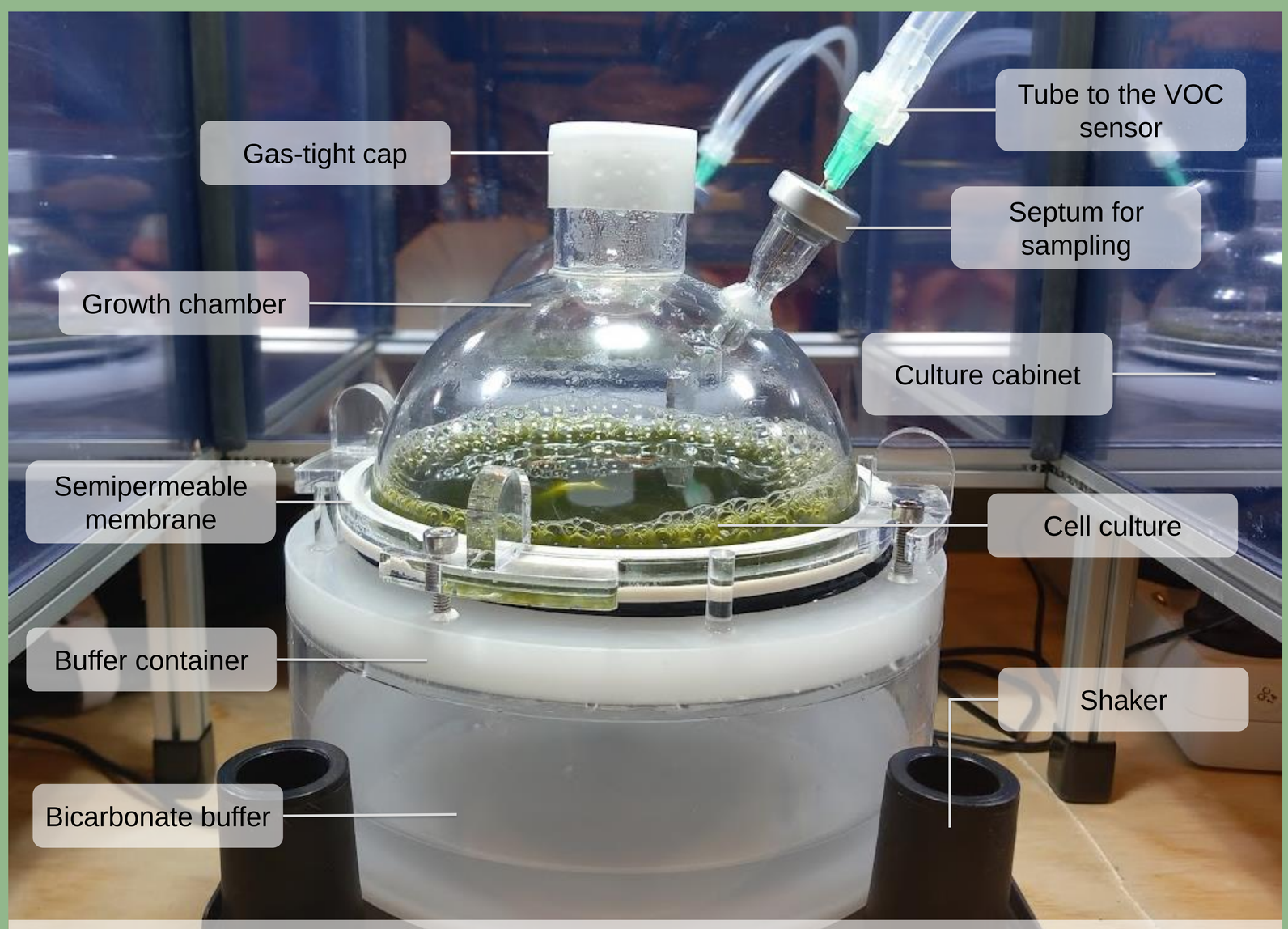

Figure 1: Overview of the HD100 high-density cultivation setup, which was used for analysing photoautotrophic ethylene production by engineered cyanobacteria under high CO_2 and high light.

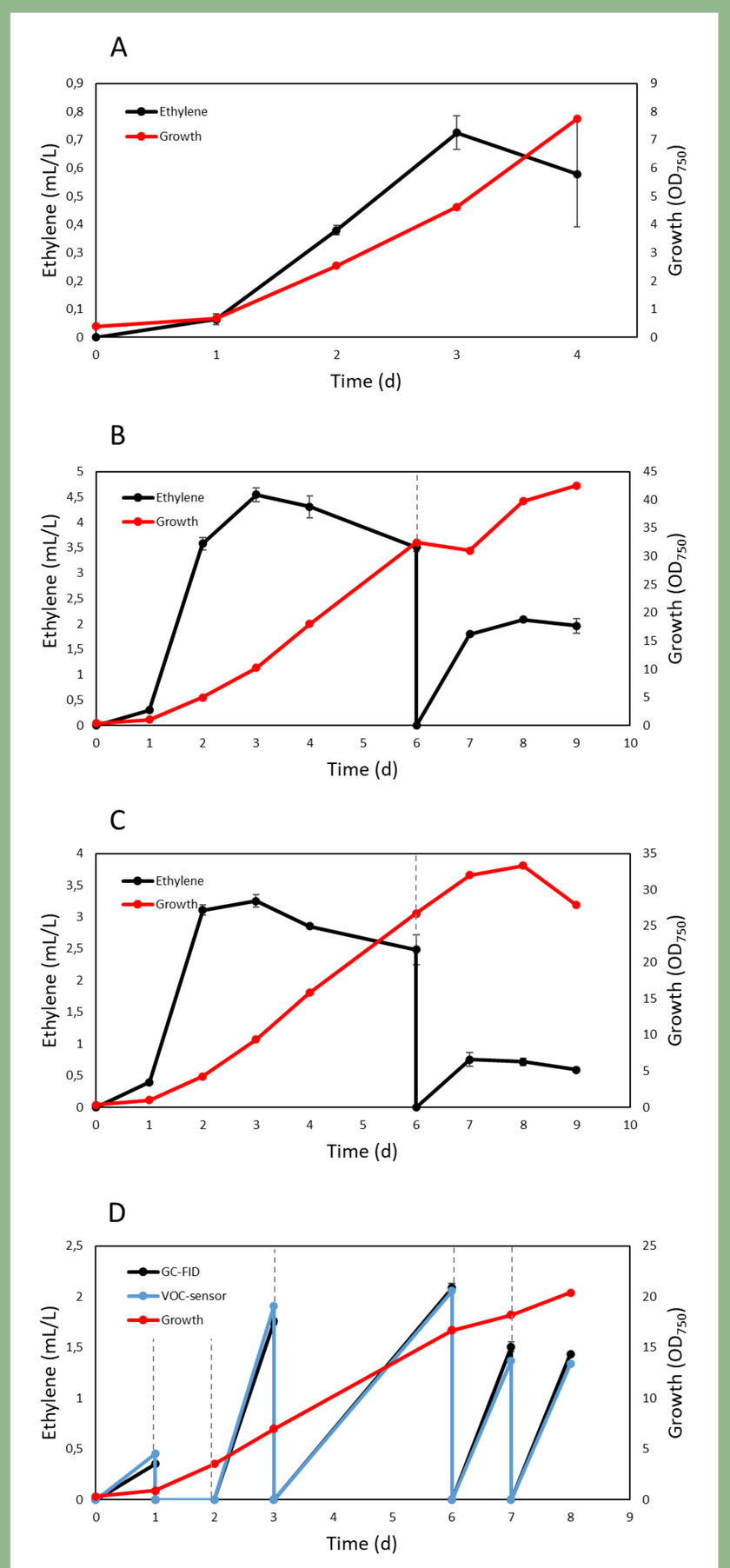

Figure 2: Photoautotrophic **e**thylene production and growth of *Synechocystis* sp. PCC 6803 cells in HD100 high-density cultivation equpment with three-step increase of light intensities. Light intensities in different cultivations were **A** 30 µmol/m^2/s (0-1 d), 80 µmol/m^2/s (1-3 d), 160 µmol/m^2/s (3-4 d), **B** and **D** 290 µmol/m^2/s (0-1 d), 460 µmol/m^2/s (1-2 d), 620 µmol/m^2/s (2-9 d) and **C** 290 µmol/m^2/s (0-1 d), 460 µmol/m^2/s (1-2 d), 780 µmol/m^2/s (2-9 d). Standard deviations were calculated from three technical replicates which were taken at the same time from gas phase of the cultivation. Time points of gas phase emptying are marked with dashed line.

RESULTS & CONCLUSIONS

The results show that the cultivation equipment is suitable for the photoautotrophic production of ethylene at high light intensities. The highest measured ethylene concentration was about 4.5 mL/L of cell culture and the highest yield per day was about 3.3 mL/L of cell culture (Figure 2B), which are in the same order of magnitude as the best values published in the literature[3]. The sensor was shown to be sensitive enough to detect ethylene directly from the gas phase, enabling real-time measurement of the product (Figure 2D). The results of the work can be used, for example, in the development of growth condition optimization based on artificial intelligence, which supports the development of photoautotrophic biotechnologies towards larger-scale applications.

REFERENCES

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