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Mixotrophic Growth as a Tool for Increasing Polyhydroxyalkanoates (PHA) Production in Cyanobacteria

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Abstract : Cyanobacteria are ecologically extremely important phototrophic gram-negative bacteria capable of oxygenic photosynthesis. They synthesize many interesting metabolites such as glycogen, carotenoids, but the most interesting metabolites are polyhydroxyalkanoates (PHA). The main advantage of cyanobacteria is the fact they do not require costly organic substrate and, oppositely, cyanobacteria can fix CO_2. PHA serves primarily as a carbon and energy source and occurs in the form of intracellular granules in bacterial cells. It is possible, PHA helps cyanobacteria to survive stress conditions since increased PHA synthesis was observed during cultivation in stress conditions. PHA is microbial biopolymers that are biodegradable with similar properties as petrochemical synthetic plastics. Production of PHA by heterotrophic bacteria is expensive; for price reduction waste materials as input, materials are used. Positively, cyanobacteria principally do not require organic carbon substrate since they are capable of CO_2 fixation. In this work, we demonstrated that stress conditions lead to the highest obtained yields of PHA in cyanobacterial cultures. Two cyanobacterial cultures from genera Synechocystis were used in this work. Cultivations were performed either in Erlenmayer flask or in tube multicultivator. Multiple stressors were applied on cyanobacterial cultures, and stressors include PHA precursors. PHA precursors are chemical substances and some of them do not occur naturally in the environment. Cultivation with the same PHA precursors in the same concentration led to a 1,6x higher amount of PHA when a multicultivator was used. The highest amount of PHA reached 25 % of PHA in dry cyanobacterial biomass. Both strains are capable of co-polymer synthesis in the presence of their structural precursor. The composition of co-polymer differs in Synechocystis sp. PCC 6803 and Synechocystis salina CCALA 192. Synechocystis sp. PCC 6803 cultivated with γ-butyrolakton accumulated co-polymer of 3-hydroxybutyrate (3HB) and 4-hydroxybutyrate (4HB) the composition of the copolymer was 56 % of 4HB and 44 % of 3HB. The total amount of PHA, as well as yield of biomass, was lower than in control due to the toxic properties of γ-butyrolakton. Funding: This study was partly funded by the project GA19-19-29651L of the Czech Science Foundation (GACR) and partly funded by the Austrian Science Fund (FWF), a project I 4082-B25. This work was supported by Brno, Ph.D. Talent – Funded by the Brno City Municipality.
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