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Aerobic metabolism of mixed carbon sources in sequencing batch reactor under pulse and continuous feeding

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HIGHLIGHTS

- Aerobic storage of PHB and glycogen from acetate/starch mixture was studied.
- ^{13}C NMR analysis was used to evaluate metabolic pathways of aerobic storage.
- Metabolism of glycogen from starch was not affected by the presence of acetate.
- Starch strongly affected acetate metabolism via anaplerotic and catabolic routes.
- PHB storage from acetate strongly decreased in the presence of starch.

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ABSTRACT

The aerobic metabolism of a mixture of acetate and starch was studied with main emphasis on their interaction and the effect on their storage as PHB and glycogen, respectively. Pulse feeding strongly increased the storage of both substrates; however, the presence of starch decreased PHB storage whereas the presence of acetate did not affect glycogen storage.

Indeed, ^{13}C NMR isotopomer analysis suggested an increase of acetate utilization towards TCA cycle, due to an increased request of ATP production for glycogen biosynthesis regulated by ADP-GlcPPase. This in turn influenced the partition flux for pyruvate synthesis between TCA cataplerosis and glyoxylate shunt. The corresponding reduction of PHB synthesis was in agreement with the competition for HS-CoA between KGDH activity and acetyl-CoA for PHB synthesis pathway.

As a practical consequence, bioprocesses for PHA production from volatile fatty acids could be negatively affected from other carbon sources, such as unfermented carbohydrates.

1. Introduction

The comprehension of storage phenomena under aerobic conditions is relevant for their effect of microbial population dynamics in activated sludge processes and related bulking control (Majone et al., 1996) as well as for production of biodegradable polymers by using microbial mixed cultures and volatile fatty acids as carbon source (Dionisi et al., 2004). Due to the time- or space-dependent substrate profile in the biological tanks in wastewater treatment plants (WWTPs), microorganisms frequently face with transient conditions and tend to convert the substrate into storage polymers whenever the substrate uptake rate can be higher than its direct utilization for growth and related energy needs (Majone et al., 1996). The balance between the direct growth and storage may be regulated through appropriate choice of operating conditions, e.g. organic load rate and feeding pattern (e.g. continuous vs. sequential).

The presence and relative magnitude of the storage phenomena are dependent on the type of the carbon source. Glycogen is mostly formed when the primary substrate is a compound that can be easily converted into pyruvate and reducing power, e.g. glucose, other carbohydrates, glycerol or proteins. On the other hand, polyhydroxyalkanoates (PHAs) are directly formed from the central metabolite acetyl-Coenzyme A (acetyl-CoA) (Anderson and Dawes, 1990; Doi, 1990), as in the metabolism of acetic acid and other volatile fatty acids (VFAs).

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