Role of Knallgas Bacterium in Waste Management

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Abstract

In the aftermath of the Industrial Revolution, atmospheric concentrations of carbon dioxide (CO2) have persistently surged, setting annual records. This underscores the imperative of transitioning from conventional industrial infrastructures to an eco-friendly economy and society. This shift hinges on key priorities: (i) harnessing renewable resources, (ii) advancing carbon-neutral processes, and (iii) embracing waste recovery and recycling, all aimed at mitigating the global average temperature rise. Cupriavidus necator, a versatile microorganism thriving in both soil and water, particularly stands out among knallgas bacteria, demonstrating both heterotrophic and lithoautotrophic metabolism based on environmental conditions (Sohn et al., 2021). Extensively studied for its prowess in producing Polyhydroxyalkanoates (PHAs) from diverse renewable resources, including sugarcane vinasse, molasses, and carob pods, C. Necator assumes a pivotal role in the development of metabolically engineered strains (Ewering et al., 2006). These strains have shown promise in synthesizing biopolymers, biofuels, and biochemicals like ethanol, isobutanol, and higher alcohols. Notably, bio-based processes involving recombinant C. necator have made substantial strides in producing high-value products from biomass waste, plastic debris, and waste gases. Given its remarkable substrate flexibility, spanning sugars, aromatic compounds, plastic waste fragments, and C1 gases, the focus is on developing superior C. necator strains capable of utilizing carbon sources from renewable resources, waste, and even greenhouse gases. This necessitates a targeted approach involving metabolic engineering, coupled with the further development of efficient bioconversion and integrated biomass pretreatment processes.

Key Words: Renewable resources, Metabolism, Bioconversion, Carbon-neutral processes.

Aerobic hydrogen oxidizing bacteria, sometimes called Knallgas bacteria, these are bacteria that oxidize hydrogen with oxygen as final electron acceptor and source of energy. Examples: Hydrogenobacter thermophilus, Cupriavidus necator,Hydrogenovibrio marinus. Cupriavidu snecator, commonly known as “knallgas bacterium”, is a gram-negative bacterium belonging in the family of Burkholdariaceae that can live in both heterotrophic and lithoautotrophic metabolism (Sohn et al., 2021). Furthermore, the metabolic engineering for C. necator with the heterologous expression of necessary genes or manipulation of its genomic DNA along with the optimization of culture conditions provides an efficient strategy for the transformation of wastes into value added products such as PHA, PHB, ethanol, isobutanol, methylcitric acid, isopropanol, acetone (Ewering et al., 2006). Therefore, C. Nectar is a versatile microbe that ferments a variety of carbon sources, including sugars, aromatic compounds, plastic waste pieces, and C1 gases, to produce value-added compounds ranging from polymers to chemicals and fuels.

There have been considerable efforts to use underutilized resources, the scattered wastes around the globe from various industrial sectors, and to convert them into industrially important compounds by C.necator (Lee et al., 2016). Therefore, the development of a superior C. necator strain able to use carbon sources from renewable resources, wastes and even greenhouse gases via metabolic engineering combined with further development of the efficient bioconversion and biomass pre-treatment integrated process is important to produce compounds in economically feasible titers, yields, and productivities(Ewering et al., 2006). Although C. necator can provide a solution, in part, to the plastic wastes problems by utilizing PE and PP waste fragments and by producing PHAs as one of the promising biodegradable polymers, there still remains the challenges in tackling various kinds of piled-up plastic wastes (Kim et al., 2016). Thus, the design of integrated processes using C. necator as a biocatalyst can provide clues to (i) the realization of carbon neutrality using biomassderived wastes and C1 gases as fermentation feedstocks and (ii) the resolution of plastic wastes problems by producing biodegradable polymers and the upcycling of plastic wastes. In this regard, C. necator can be truly considered a potential game-changer in global challenges, including the climate crisis and the plastic wastes problems.

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