Synthetic Bioengineering of Microbial Consortia for Biomass-based Zero- and One- Carbon Gas Biofuels

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Abstract:

In different forms of biomass-based energy and chemicals, gas biofuels including methane and hydrogen are of importance, which can be produced by anaerobic fermentation. The anaerobic fermentation is an effective and feasible technology to recover energy from various biomasses, including organic wastes. Since hydrogen is an alternative clean energy carrier for the future, biohydrogen production is a potentially attractive way to utilize hydrogen, especially if organic wastes and other biomasses can be used as the renewable raw materials. Moreover, biomethane is a clean platform chemical, which can also be converted chemically or biologically (C1 biotechnology) to methanol or other chemicals. Therefore, production of the gas biofuels from biomass resources is of great importance to the utilization of low grade biomass for energy recovery. For developing this integrated process, systematic bioengineering of microbial consortia for biomass hydrolysis and co-production of hydrogen and methane is needed. In our study, the synthetic bioengineering of microbial consortia was studied by combining the manipulation and redesign of the metabolic networks and microbial consortia to maximize the energy from low grade biomass.

One of the key factors for affecting the energy recovery from the biomass and bioprocess efficiency is hydrogen productivity and stability. Therefore, manipulation of the metabolic networks and bioreactor development are indispensable to improving the hydrogen yield. Two typical hydrogen-producing strains, facultative anaerobic Enterobacter aerogenes and obligate anaerobic Clostridium paraputrificum, were studied as the model strains. There are two routes pertaining to the hydrogen evolution, including formate pathway and NADH-dependent pathway. Since up to now, few studies were focused on the NADH-dependent pathway, we systematically investigated the effects of newly introduced NADH regeneration on the hydrogen metabolisms of the two strains. It was found that the NADH regeneration can significantly perturb the global metabolic networks, which will further affect the hydrogen production. The tools for synthetic biology study on hydrogen metabolic network and microbial consortium were also developed, including the novel atmospheric and room temperature plasma microbial genome mutation, and systematic deletion and expression of multi genes in hydrogen producers, and microbial consortium design. These studies have provided the platform for constructing efficient bioprocess to produce biofuels.

Keywords:

Bioenergy, biofuels, biohydrogen, biomass, fermentation, methane, metabolic engineering, microbial consortium, mixed culture, synthetic biology