Conversion of waste CO_2 into green gold microalgae

From micro- to macro-scale approaches

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Various carbon capture, utilization and storage (CCUS) technologies have recently been proposed to reduce anthropogenic carbon dioxide (CO_2) emissions. Unfortunately, practical application of the previously proposed CCUS systems has been hampered by the low economic feasibility and the CO_2 reduction efficiency. In this regard, microalgae-based conversion of CO_2 into sustainable resources has garnered considerable attention because its photosynthetic and CO_2 conversion efficiency outperforms other terrestrial crops. Despite the remarkable potential of microalgal systems, their practical utilization is still limited by their insufficient productivity. Here we present promising multilateral approaches to enhance CO_2 sequestration and productivity of microalgae systems. First, we developed microfluidic-based high-throughput screening platforms for selection of highly productive microalgal strains. We found for the first time that phototactic and photo-chemotactic (to HCO_3^-) responses are closely related to photosynthetic efficiency and CO_2 fixation rate of microalgae, respectively. Subsequently, high-performing strains were facilely isolated from a mutant library using tactic-based screening methods. We also devised a novel microdroplet-based microalgal screening systems capable of rapid selection of excellent microalgal strains, resulting in successful isolation of fast-growing strains. Second, besides the exploitation of microsystem, we developed contamination control protocol, economical buffer system, and 1-ton scale single module photobioreactor with infinite scalability. These macro-scale approaches allowed the direct utilization of liquefied natural gas (LNG) and coal-fired flue gases to cultivate the superior microalgal strains up to 10 tons. Thus, we expect that our abovementioned multilateral strategies can play a key role in the realization of biological conversion of CO_2 by providing effective solutions for enhancing photosynthetic CO_2 fixation of microalgae.

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Research Interests:

Photosynthesis of microalgae for carbon dioxide utilization

Bio-chip development and nanobiotechnology

Bio-micro electro mechanical systems (Bio-MEMS)

Selected publications

1. Sim et al., *Nature Communications*. 2019, published.
2. Sim et al., *Small*, 2019, published.
3. Sim et al., *Nature Communications*. 2016, published.
4. Sim et al., *Advanced Materials*. 2013, published.
5. Sim et al., *Nature Biotechnology*. 1997, published.