Università degli Studi di Napoli Federico II

PhD in Biotechnology - 39th cycle

Dr. Alfonso Ferrara

Microalgae circular economy: carbon capture mediated by immobilized carbonic anyhdrases and biomass valorization

Tutor(s): Prof. Monti Daria Maria (BIO/10)

Department: Scienze Chimiche

Microalgae and cyanobacteria are autotrophic microorganisms able to fix CO_2 to synthesize all the biochemical compounds needed for cell growth. However, one of the main problems related to carbon fixation is the low CO_2 delivery efficiency, due to a low dissolution rate. Encapsulated or immobilized Carbonic Anhydrases (CAs) can represent a key enzyme to overcome the slow uptake of CO_2. CAs rapidly catalyze the conversion of CO_2 to HCO_3^- according to the following chemical reaction: $CO_2 + H_2O \rightleftarrows HCO_3^- + H^+$. Compared to the reversible spontaneous CO_2 hydration reaction, , CAs increase the velocity of the CO_2 hydration reaction from 100,000 to one million times per second (kcat in the range of 10^4–10^6 s^{-1}), making this superfamily among the fastest biocatalysts known in nature, they potentially represent a low-cost tool for improving large-scale microalgae production and favor natural direct air capture of CO_2. So the aim of the present project is the use of CAs to accelerate the slow diffusion of CO_2 from air into water. Different technologies will be evaluated to gain the maximum rate of CA encapsulation and floating. Then, selected microalgal strains will be grown in photobioreactors in the presence and absence of encapsulated CA. The biomass obtained, in the presence or absence of encapsulated CA, will be quantified and correlated to CA efficiency. Then, the obtained wet biomass will be extracted using a biorefinery approach, so that high-value molecules will be recovered in a cascade approach. The extracted molecules will be characterized, and their biological activity will be evaluated on cell based-models.

References

[1] B. Colman, I.E. Huertas, S. Bhatti, J.S. Dason, The diversity of inorganic carbon acquisition mechanisms in eukaryotic microalgae, Functional Plant Biology 29 (2002) 261. https://doi.org/10.1071/PP01184.

[2] J. Zeng, Z. Wang, G. Chen, Biological characteristics of energy conversion in carbon fixation by microalgae, Renewable and Sustainable Energy Reviews 152 (2021) 111661. https://doi.org/10.1016/j.rser.2021.111661.

[3] X. Xu, X. Gu, Z. Wang, W. Shatner, Z. Wang, Progress, challenges and solutions of research on photosynthetic carbon sequestration efficiency of microalgae, Renewable and Sustainable Energy Reviews 110 (2019) 65–82. https://doi.org/10.1016/j.rser.2019.04.050.

[4] V. Alterio, A. Di Fiore, K. D'Ambrosio, C.T. Supuran, G. De Simone, Multiple Binding Modes of Inhibitors to Carbonic Anhydrases: How to Design Specific Drugs Targeting 15 Different Isoforms?, Chemical Reviews 112 (2012) 4421–4468. https://doi.org/10.1021/cr200176r.