Microalgae as a sustainable raw material for biofuels production and high added value compounds extraction by an integrated biorefinery concept

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Abstract:

In this work, the authors propose a microalga-based integrated system, where optimization of all energy vectors (biodiesel, bioethanol and biohydrogen) is highlighted under the concept of biorefinery (Project PTDC/AAC-AMB/100354/2008). This involves the integration of different processes such as oil and starch extraction from microalgae for biodiesel and bioethanol production, respectively, and biohydrogen production from the biomass left-overs. The extraction of high value added compounds, such as carotenoids, contributes to the economic viability of the overall process.
Scenedesmus obliquus, Spirogyra sp. and Nannochloropsis sp. microalgae were studied, being grown autotrophically (CO_2 sequestration) in different bioreactors (e.g. raceway ponds, plastic bags), under different conditions (e.g. light, photoperiod).
Biomass harvesting was performed by centrifugation and by innovative electrochemical methods. Cell disruption was carried out by different chemical (e.g. acid hydrolysis) and physical (e.g. bead mill, ultra-sound) methods, and compared in terms of oil, sugar and pigments extraction yields.
Microalgae lipids were obtained by conventional soxhlet and supercritical extraction, for further transesterification to biodiesel and carotenoid purification.
Bioethanol was produced by different yeasts (e.g. Saccharomyces bayanus, Kluyveromyces marxianus) from microalgae sugar extracts.
The whole microalgal biomass and the biomass left-over after oil extraction were used for hydrogen production by fermentation with Enterobacter aerogenes and Clostridium butyricum.
The proposed integrated system brought about important technological and economic improvements to the process of biofuels production from microalgae.