OPTIMIZATION OF BIOGAS PRODUCTION FROM ALGAL BIOMASS

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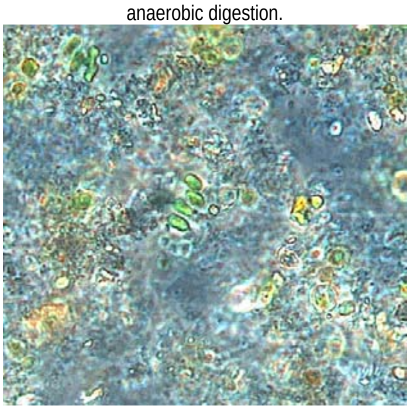
The ability of microalgae to fix CO_2, nutrients (N,P) and store the sun energy into their cells via photosynthesis renders them interesting as an alternative green energy (biofuel and biogas) and wastewater treatment technology. Compared with conventional plants, microalgae have higher growth rates and can be cultured in non-arable lands, and therefore, microalgae grown for biogas production will not compete with crops for human nutrition. The use of microalgae in wastewater treatment results in the generation of large amounts of biomass that need to be disposed. Likewise, the production of biodiesel from microalgae would generate large amounts of algal residues. One alternative to the landfill of this residual algal biomass is anaerobic digestion, which transforms these residues into CH_4, which itself can be converted into different kinds of energy (heat, electricity, etc).

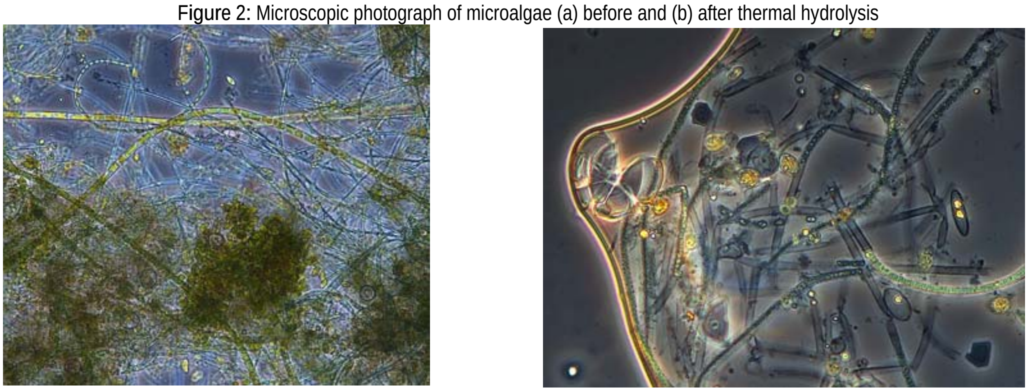
Studies determining the anaerobic biodegradability of microalgae have shown that this is a slow and incomplete process, and methane production is lower than that achieved for activated or primary sludge. The methanogenic potential of microalgae is related to their cellular composition, especially to the structure of their cell wall. Some microalgae have a strong cell wall, so the biodegradable organic material inside the cell is not available to the anaerobic bacteria. Many algal cells and cell walls remained often intact after anaerobic digestion (Figure 1). Likewise, microalgae without cell wall exhibited a higher degradation than those with cell walls with complex structures. In this context, the pretreatment of the algal biomass is necessary to render the intracellular organic matter accessible to anaerobic microorganisms, and therefore to improve methane production.

Figure 1: Microscopic photograph of microalgae after anaerobic digestion.



Different pretreatments have been successfully applied to activated and primary sludge to enhance methane productivities. These pretreatments can be classified as mechanical (ultrasonic, lysis – centrifuge, liquid shear, collision plate, grinding, etc.), biological, thermal hydrolysis and chemical (oxidation, alkali treatments, etc.). These pretreatments can be also used for microalgae. However, little information is available regarding the pretreatment of microalgal biomass for anaerobic digestion.

Figure 2: Microscopic photograph of microalgae (a) before and (b) after thermal hydrolysis



(a) (b)

In this project the potential of different pretreatments will be assessed in order to break-up microalgae cell walls and then increase the yields of methane production by anaerobic digestion (figure 2). For this purpose, different microalgae biomass (from wastewater treatment, oil extraction and pure cultures) will be tested. This project will also address the optimization of the co-digestion of algal biomass with agro-industrial residues in order to improve their digestion. This will also include the co-digestion in anaerobic digesters via dry digestion. Finally, a characterization of the effluent produced and a study of technical and economic feasibility of the process will be conducted.

Proyecto financiado por AQUALIA y el Ministerio de Ciencia e Innovación (Proyectos CENIT-VIDA y CONSOLIDER-CSD 2007-00055 y contrato RYC-2007-01667).

Relevant publications

Perez-Elvira SI., Fdz-Polanco M., Fdz-Polanco F. (2010) Increasing the performance of anaerobic digestion: Pilot scale experimental study for thermal hydrolysis of mixed sludge. Frontiers of environmental science and engineering in China. 4 (2) 135-141.

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Fdz-Polanco F, Velazquez R., Perez-Elvira SI., Casas C., del Barrio D., Cantero FJ., Fdz-Polanco M., Rodriguez P., Panizo L., Serrat J., Rouge P. (2008). Continuous thermal hydrolysis and energy integration in sludge anaerobic digestion plants. Water Science and Technology. 57 (8). 1221-1226.