**CO2 and SO2 removal from cement plant flue gases by *Scenedesmus dimorphus* cultivation - Impact on cell growth and biochemical content**

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**Highlights**

* Microalgal cultivation is a promising source of bio-based energy
* Industrial flue gases are a propitious source of carbon and sulfur for the cultures
* Sulphites formed by the flue gas dissolution inhibit growth at high concentration
* *S. dimorphus* composition is slightly impacted by the sulfite content of the medium

**1. Introduction**

Microalgae are considered as a promising source of bio-based energy thanks to their high photosynthetic rates and their rapid growth compared to terrestrial plants, high lipid content, low surface area demand and year-round cultivation. Nevertheless, life-cycle assessment for production of interesting products like biodiesel from microalgae cultivation have shown that the production of biomass needs to be coupled with some other aspects: the valorisation of microalgal high-value-added by-products (antioxidants, protein and/or polysaccharide contents), the CO2 mitigation and the use of other industrial waste streams1.

This is why industrial flue gases are a propitious source of carbon and other nutrients for the microorganisms2,3. In such an industrial process, some components of the flue gas (mainly CO2 and SO2) are transferred into the culture medium and form dissolved CO2 and SO2 as well as (hydrogen)-carbonates and (hydrogen)-sulphites. The latter are then oxidised by oxygen to form sulphates. Sulphates and (hydrogen)-carbonates are nutrients for the culture, but some authors have shown that hydrogen sulphites can inhibit microalgal growth4,5.

The first objective of this work was to determine the composition of *Scenedesmus dimorphus*’s culture medium (3N-BBM medium) at equilibrium with a synthetic cement plant flue gas. According with the equilibrium compositions, three sulphite stresses were performed on *S. dimorphus* cultures in order to evaluate the impact of the sulphite anions on cell growth and biochemical composition (proteins, polysaccharides and lipids).

**2. Methods**

Absorption equilibrium between the synthetic flue gas and the 3N-BBM culture medium

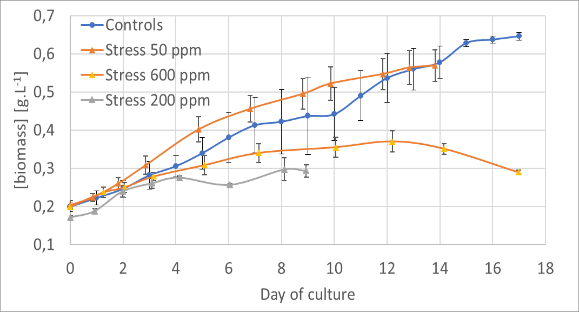
The 3N-BBM medium is a fresh autotrophic medium6. The synthetic flue gas composition is: 300 ppm SO2, 33 ppm NO2, 430 ppm NO, 5% O2, 20% CO2, balance N2. The liquid phase was analysed by ionic liquid chromatography associated with a conductivity detector (SO32- and SO42- contents) and by a total organic carbon analyser (NDIR) for the determination of the carbon species content.

*Scenedesmus dimorphus* stock culture and stressed cultures

*S. dimorphus* (CCAP 276/48) stock culture was performed in a 2L sterile bottle placed on an agitated platform, at 25°C, under a 70 µmol PAR photon.m-2.s-1 illumination (12h dark/12h light) provided by fluorescent lamps. The culture medium was the 3N-BBM medium at pH 7 (CO2 supply regulation). Stressed and control cultures were performed in duplicates in 3L airlift flat panel photobioreactors, at 25°C, under a 100 µmol PAR photon.m-2.s-1 illumination (12h dark/12h light) provided by fluorescent lamps. The culture medium was the 3N-BBM medium at pH 7 (CO2 supply regulation). Biomass density was measured by UV-Vis spectrophotometer at 680 nm. Biomass was harvested by centrifugation and freeze-dried. The lipid content was measured by gravimetric method after solvent extraction (methanol, chloroform, water); (poly)saccharides were quantified by the phenol sulphuric method; finally, total proteins were quantified by the BCA test.

**3. Results and discussion**

The first part of this study showed that the NO/NO2 are (practically) insoluble in the 3N-BBM culture medium. The S(IV)-containing anions reached a maximal concentration of 250 mgSO32-.L-1(figure not shown). The second part of this study investigated the impact of three sulphite concentrations on the microalgal growth and on the biochemical composition of the biomass. Figure 1 shows a growth inhibition at 200 and 600 mgSO32-.L-1. No inhibition is observed at 50 mgSO32-.L-1. Both the 50 and 600 ppm stresses did not induce significant changes in the biomass composition in comparison with controls: 20-27% lipids, 30-35% proteins, 30-37% (poly)saccharides. Regarding the 200 ppm stress, a 10% drop and a 7% rise have been found respectively for the protein and the (poly)saccharide contents. These contradictory behaviours can be explained by the variability of the culture duration.



**Figure 1.** *S. dimorphus* growth under different sulphite stress

**4. Conclusions**

This study has shown that *S. dimorphus* can grow in a 3N-BBM medium containing 50 ppm of sulphites (related to the solubilization of SO2) with no significant changes in its biochemical composition. In the future, tests will be done with the *Chlorella vulgaris* and *Cyanidium caldarium* strains. All the cultures will be stopped after 14 days to prevent undesirable differences in the biochemical composition of the biomass due to the culture duration.

**References**

1. M.K. Lam, K.T. Lee, A.R. Mohamed, International Journal of Greenhouse Gas Control 10 (2012) 456-469.
2. J.R. Benemann, Energy Conversion and Management 34 (1993) 999–1004.
3. D. Hess, K. Napan, B.T. McNeil, E. Torres, T. Guy, J. Mclean, L.C. Quinn², Algal Res. 25 (2017) 68–75.
4. S. Yang, J. Wang, W. Cong, Z. Cai, F. Ouyang, Enzyme Microb. Technol*.* 35 (2004) 46–50.
5. J.A Lara-Gil, M.M. Alvarez, A. Pacheco, J. Appl. Phycol. 26 (2014) 357–368.
6. CCAP. Bold Basal Medium with 3­fold Nitrogen and Vitamins. at <https://www.ccap.ac.uk/media/documents/3N\_BBM\_V.pdf>