The influence of liquid nanoparticles on photosynthetic biogas upgrading, biomass growth and pigments accumulation of *Coelastrella thermophila*

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Abstract

Biogas and biomethane play a crucial role in the energy system of many countries, as they seek to decrease reliance on fossil fuels while contributing to the achievement of the United Nations Sustainable Development Goals. Biogas is a renewable energy vector produced via the anaerobic digestion of the organic fraction of waste and wastewater [1]. However, the presence of contaminants, specifically CO_2, limits biogas application and requires different levels of removal, depending on the specific application. Among the different biogas upgrading processes, biological methods, particularly photosynthetic biogas upgrading, emerged as a promising technique for CO_2 removal while simultaneously generating valuable algal biomass [2]. In addition to its potential for CO_2 removal from biogas, microalgae can use wastewater for growth while simultaneously removing nutrients and producing valuable products such as carbohydrates, antioxidants, vitamins, lipids, and pigments, which have applications in the pharmaceutical, nutraceutical, cosmetics, and food industries [4]. In this context, this study evaluated the influence of the different fraction of carbon-coated iron nanoparticles on *Coelastrella thermophila var. globulina* metabolism during biogas upgrading. Additionally, pigments (chlorophyll and total carotenoids) and carbohydrates accumulation were also assessed. Two different series of experimental batch tests were performed in triplicate to evaluate: 1) the effects of NPs fraction type – total liquid fraction referred as "liquid nanoparticles" (R-NPs), solid form (S-NPs), and the resulting supernatant (SU-NPs) after

separation the solid NPs – and; 2) the concentration of R-NPs (1-3 ml L^{-1}) on *Coelastrella* metabolism during photosynthetic biogas upgrading. The batch tests were conducted at 25 °C under continuous agitation (300 rpm) and illumination (600 μE m^2s^{-1}), using synthetic urban wastewater (SWW) as culture media and synthetic biogas (70% methane and 30% carbon dioxide) as a carbon source. No significant differences were observed among the three fractions of NPs in terms of CO_2 removal performance when compared to the control tests. A slight increase of 6, 7 and 10 % on biomass productivity was observed in the photobioreactors supplemented with R-NPs, S-NPs and SU-NPs, respectively. The addition of SU-NPs supported a significant increase of 53% in carbohydrate accumulation compared to the control tests. Similarly, a substantial enhancement on pigments production, both chlorophyll and total carotenoids, was observed regardless of the NPs fraction tested. Further optimization of R-NPs dosage (1-, 2-, and 3-mL L^{-1}) revealed that the addition of 3 mL L^{-1} resulted in the highest pigment production, yielding 80% and 88% increase in chlorophyll and total carotenoids, respectively, compared to the control tests. Therefore, the supplementation of the total liquid fraction of the NPs positively influenced the production of carotenoids and chlorophyll in *Coelastrella thermophila* cultivated in synthetic wastewater and devoted to biogas upgrading.

References

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