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Nannochloropsis oceanica biomass enriched by electrocoagulation harvesting with promising agricultural applications

Daniel Figueiredo [a], Alice Ferreira [b], Florinda Gama [a], Luisa Gouveia [a,b,*]

[a] GreenCoLab - Green Ocean Technologies and Products Collaborative Laboratory, CCMAR, University of Algarve, Campus de Gambelas, 8005-139 Faro, Portugal
[b] LNEG, National Laboratory of Energy and Geology I.P., Bioenergy and Biorefineries Unit, Estrada do Paço do Lumiar 22, 1649-038 Lisbon, Portugal

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ABSTRACT

Electrocoagulation is a promising technology to harvest and concentrate microalgae while saving costs on secondary dewatering steps. However, the sacrificial electrodes release salts that impact the media and the harvested biomass. This study evaluated the effects of Fe, Zn, and Mg electrodes on *Nannochloropsis oceanica* harvesting and elementary composition of biomass and supernatants. Moreover, plant bioavailability of electrocoagulation minerals attached to biomass was assessed in the tomato plant model *Solanum lycopersicum* (cv. 'Cherry'). Fe electrodes had better performance at lower power consumption and operation costs, followed by Zn and Mg. Electrocoagulation changes biomass and supernatant nutrient composition. Electrodes precipitated Mg and Ca from the nutrient media, enriching *N. oceanica* biomass, but increased Pb 2–4 times and depleted P in supernatants. Finally, Fe and Mg electrode metals in the biomass were proven bioavailable to *S. lycopersicum* seedlings, making electrocoagulation harvested biomass a promising bioresource to agricultural applications.

1. Introduction

Microalgae harvesting is still a bottleneck to its commercial-scale application. Most harvesting technologies are based on mechanical processes, such as centrifugation or filtration (Kadir et al., 2018). While these are viable options to harvest and concentrate microalgae biomass (Roselet et al., 2019), their high maintenance and energy requirements lead to expensive operation (Najjar and Abu-Shamleh, 2020), accounting for 20–30% of the total microalgae production costs (Acién et al., 2017).

Electrocoagulation (EC) is a low-cost technology that can harvest a wide variety of microalgae species with high recovery efficiencies (Landels et al., 2019). During EC, an electrical current is applied through reactive electrodes, commonly made of aluminum (Al) or iron (Fe), that are submerged in the microalgae suspension. The electrode anode suffers electrolytic oxidation, releasing metal ions that act as coagulant agents to microalgae cells, while the generated O_2 and H_2 from water electrolysis promote the flotation of microalgae flocs (Vandamme et al., 2011). The main advantages of electrocoagulation compared to conventional chemical flocculation are: faster harvesting, less water in microalgal flocs (therefore concentrating more the biomass), no pH adjustment requirements (since it performs well at different pH ranges), and the absence of counter ions, such as chloride and sulphate normally present in chemical flocculants (Visigalli et al., 2021). Electrocoagulation has been shown to require less energy than conventional technologies, either for Al (0.06–0.40 kWh/kg) or Fe (0.18–1.79 kWh/kg), which can save energy compared to a one-step centrifugation scenario (Matos et al., 2013; Visigalli et al., 2021). However, electrode corrosion increases harvesting costs and affects biomass quality. Fe electrodes were shown to be more sacrificial than Al ones at the same operation parameters: 1.4–4.6% (w/w) in Fe and 1.0–1.8% (w/w) in Al (Baierle et al., 2015), but 0.6–1.5% of Al were also found in the biomass harvested by EC using Al electrodes (Matos et al., 2013; Vandamme et al., 2011). Nevertheless, while most studies report the concentration of the main corroded material (e.g. Fe^{2+} in biomass from Fe electrodes), the effects of electrocoagulation on biomass and supernatant mineral composition were not yet evaluated.

Not much information can be found in literature on using electrode materials other than Fe or Al to harvest microalgae. Bleeke et al. (2015) studied magnesium (Mg), copper (Cu), and zinc (Zn) electrodes, besides Fe and Al to harvest *Scenedesmus acuminatus*. The highest recovery efficiency (90%) was achieved using Mg, followed by Al, Zn, Cu, and Fe

* Corresponding author at: GreenCoLab - Green Ocean Technologies and Products Collaborative Laboratory, CCMAR, University of Algarve, Campus de Gambelas, 8005-139 Faro, Portugal.
E-mail address: luisa.gouveia@lneg.pt (L. Gouveia).

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