Pure culture bio-capturing dissolved CO_2 at different potentials in microbial electrosynthesis cell (MES)

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Carbon dioxide (CO_2) is well known as a greenhouse gas (GHG), but it also is a naturally available gas involved in the carbon cycle. Nowadays its anthropogenic emissions are around 35.5 Gtons/y, and they are seen as one of the main causes of climate change (Mac Dowell *et al*, 2017). In order to mitigate CO_2 emissions, the EU and UN had proposed different strategies such as the Green Deal and the Sustainable Development Goals (SDGs) (EU commission). There are different biotechnologies used to biocapture this gas for example microalgae, photoautotrophic bacteria and bioelectrochemical systems (BES) (Mohan *et al*, 2016). In this scenario, the possibility to use these new technologies to mitigate the carbon dioxide emissions and also to uptake the emitted CO_2, take great place. Particularly, BES are technologies used to treat different type of waste depending on the final product to be obtained (for example, miocrobial fuel cell MFC can produce energy from a wastewater). A typical BES to bio-capture CO_2 is the microbial electrosynthesis cells (MES) which is very commonly used both to produce biobased product and for wastewater treatment (Patil *et al*., 2015). In fact, MES are now used to fix CO_2 by means of autotrophic bacteria such as purple non sulfur bacteria (PPB) and the mostly known in literature are *Rhodobacter sphaeroides* and *Rhodopseudomonas palustris*. These bacteria are capable to switch their metabolism depending on the condition in which they are placed; nonetheless the best environment is anaerobic condition, light, and inorganic carbon as for most photo-autotrophic bacteria. As seen in the study of Li *et al* (2021), usually, PPB are used to produce autotrophically H_2 from carbon dioxide or, in other study (Ma *et al*, 2021; Pankan *et al*., 2020), this gas is used to produce biomethane using BES technologies.

In the present study, we wanted to understand which is the better potential to uptake dissolved CO_2 expressed in terms of alkalinity using a pure culture and filtered and diluted anaerobic digestate in a MES reactor (H-type configuration). The different potential tested were: -1.2V vs Ag/AgCl; -1.3V vs Ag/AgCl and -1.4V vs Ag/AgCl; also,the biofilm formation was evaluated as the applied potential could influence the growth mode of the. We also evaluate the formation of a biofilm on the cathodic electrode (working electrode, WE).

The H-cell was made of two glass bottles (each with a total volume of 1000 mL) representing the anodic and cathodic chambers that were separated by a proton exchange membrane (PEM). The working and counter electrodes were graphite rods connected to the potenziostat (Ametek, Berwyn, Pennsylvania, USA) by titanium felt while the reference was an Ag/AgCl KCl saturated electrode placed in the cathodic compartment. The experiment lasted 60 days and was divided in 3 parts corresponding to the 3 different potentials mentioned above. A sample was taken daily from both the control (open circuit, no voltage applied) and the test (applied voltages). During the experimental period, the current was monitored by means of the potentiostat. In terms of biomass, the microbial quantity added to the substrate was measured in term of optical density (OD_{600}). The filtered and diluted digestate was characterized according to the standard methods (APHA, AWWA, WEF, 2007) and is reported in Table 1.

Table 1. Characteristic of the filtered and diluted anaerobic digestate (COD= chemical oxygen demand, TS= total solid, TVS= total volatile solid, ww= wet weight)

Characteristic	Unit	Diluted & filtered anaerobic digestate
Total solids	gTS/kg(ww)	0
Volatile solids	gTVS/kg(ww)	0
Total COD	gCOD/L	0,6
Ammonia	mgN-NH_4/L	246
Alkalinity	mg$CaCO_3$/L	1350
pH	-	10

As it can be seen in Figure 1 the solids in the supernatant had variation when the potential was changed. In fact, every time there were the switch between the potentials some of the biofilm present on the surface of the electrode resuspended in the supernatant. Alkalinity on the other hand seemed to be more uptaken at -1.2V vs Ag/AgCl rather than the other potential (300mg/l consumed while in the other potential it remained stable), in fact, in Figure 2 is reported its trend. In terms of current, it seemed to be affected by the formation of the biofilm over the electrode as, after the potential

switch, the current stabilized a much lower intensity at potential -1.3V and -1.4V vs reference (respectively, -14mA and -19mA).

In conclusion the best tested applied potential for the uptake of dissolved CO_2 in terms of alkalinity was @-1,2V vs Ag/AgCl; while the formation of biofilm more significant @-1,4V vs Ag/AgCl. At this last potential was also appreciable the change in color of the supernatant which became clearer than at the beginning of the test. This effect could be associated to the electrolysis of the water that happen at -1.2V vs Ag/AgCl.

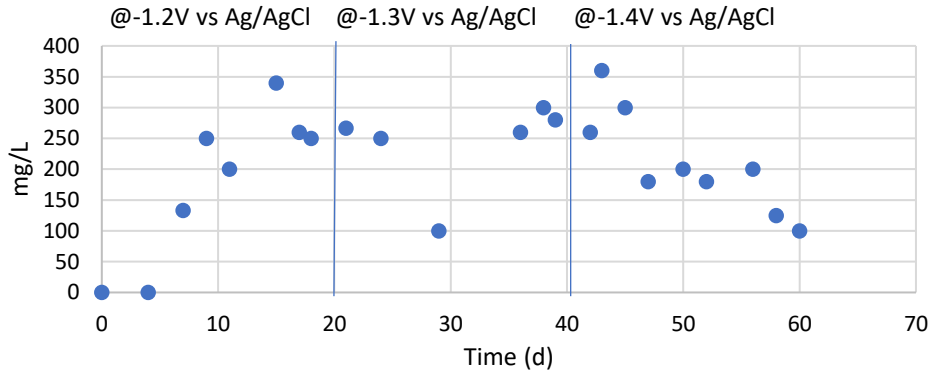

Figure 1 Solids trend in the supernatant during the experimental period

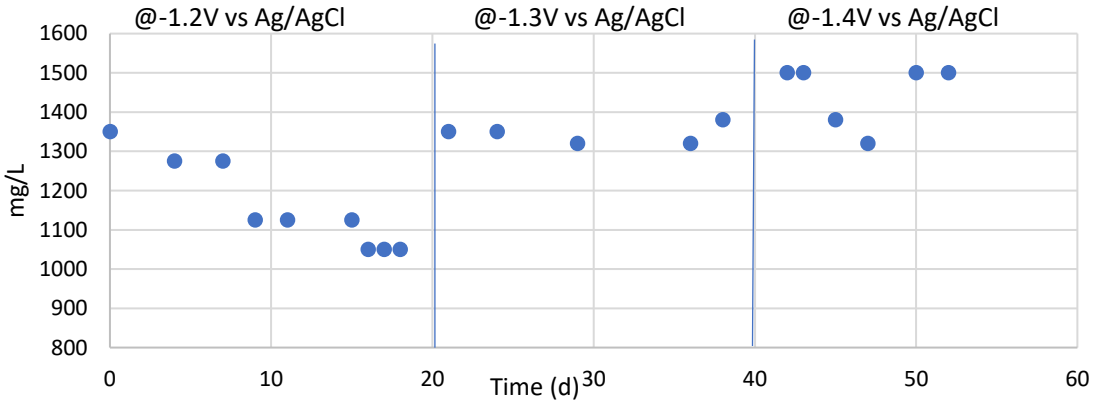

Figure 2 Alkalinity trend during the experimental period

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