Electrode production from an energy crop (miscanthus) carbonization

L. Cuenca[1], J.M. Rodríguez-Rego[2], L. Mendoza-Cerezo[2], V. Montes[3], S. Román[1]*

[1]Department of Applied Physics, [2]Department of Graphic Expression and [3]Department of Organic and Inorganic Chemistry, University of Extremadura, Badajoz, Extremadura, 06006,
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Presenting author email: *sroman@unex.es

Energy transition towards a massive participation of Renewable Energies will require effective innovation steps regarding energy storage technologies and, among the various energy storage techniques, electric storage by batteries is undoubtedly the most significant one for wind or photovoltaic energy.

The commitments of the European Green Deal involve a huge number of actions to take place, to guarantee no net emissions of greenhouse gases by 2050 and the decoupling of economic growth from resource use. Within this frame, the research on metal-free inexpensive organic materials is looked with interest by scientists working on electrodes, as it is the case of biomass resources. In this field, many diverse raw materials have been proposed to produce electrode materials (Liu et al., 2017), and some controversial reports regarding the suitability of developing pores or tunning the carbon surface towards specific functionalities have been published.

Miscanthus is seen as a promising energy crop in the European area (Iqbal et al., 2014). This energy grass presents high yields of dry matter, perennial growth, efficient use of nitrogen and water, and good pest and disease resistance. Lands of this biomass have recently been introduced in Southwest Spain in poor soils, and research is being carried outregarding its potential to absorb CO_2 as well as to yield a nice raw material to produce biofuels; in this aspect, carbonization under any form (hydrothermal treatment, HTC, torrefaction or pyrolysis, PYR) could be regarded. Additional applications of the resulting carbon materials might also be investigated and in this context, the production of adsorbents, soil fertilizers or electrodes for energy storage devices might be suggested.

The aim of this work was to study the synergistic combination of HTC and PYR to produce a carbonaceous material with suitable electric performance, using Miscanthus stem as raw material. For this purpose, HTC (200 ºC, 20h, Bergof DAB-3 0.15 L autoclave), PYR (600, 800, 1200 and 1400 ºC, home made furnace) and a combination of both (to explore economic savings regarding logistics) were investigated. The carbon materials prepared were further characterized in terms of their heating value (bomb calorimeter, Parr 1351), surface chemistry (Thermo Electron Corporation IR300 spectrophotometer), surface morphology (Quanta 3D FEG equipment, FEI Company) and porosity by N_2 adsorption isotherms at 77 K (Micromeritics). Furthermore, conductimetry analyses were performed on a Swagelock-type cell.

The results obtained showed that subjecting the miscanthus to HTC is worthy because the net process yield (including further pyrolysis) improves, apart from additional advantages such as stability upon storage or energy savings associated to the former densification of the material by the hydrothermal treatment. Both processes give an overall rate of about 11.3% independently of pyrolysis temperature, and a char of a microporous structure, surface chemistry with abundant aromatic structure and microspheres that persist despite the high pyrolytic temperatures applied (Figure 1).

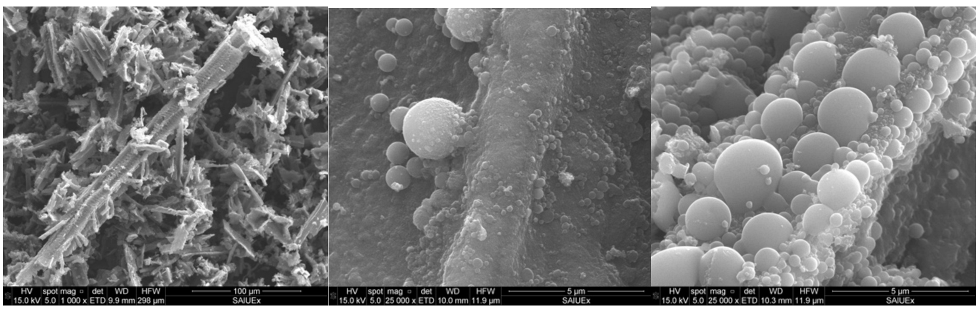

Figure 1. Surface morphology of samples MP1200 (1 and 2) and MP1400 (3), both prepared from Miscanthus, by a previous HTC, 220ºC, 20 h) and subsequent pyrolysis at 1200 and 1400 (45 min), as named.

Conductivity measurements showed that this parameter varies positively depending on the density of the sample to be analyzed (that is associated to the force applied to prepare the analysis cylinder), as found in previous findings (Sánchez-González, 2005) and in order to get independence from it, a novel 3-cylinder based method was applied. By this method, described in the patent P202130647, cylinders containing the carbon sample with different dimensions (and thus amount of material) are subjected to varying forces and the electrical conductivity is measured.

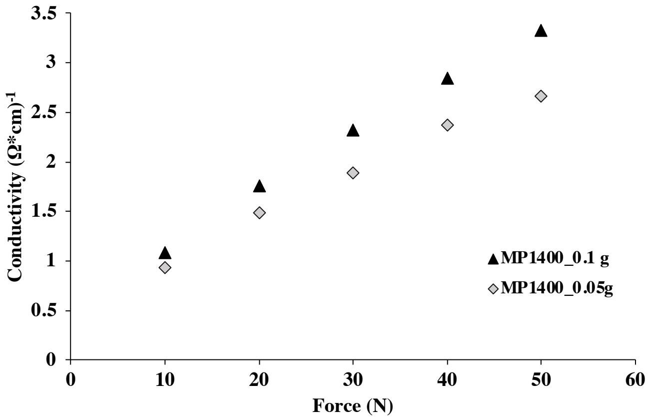

Figure 2. Conductivity of different density samples versus force applied at the cylinder

A clear increase on the conductive behaviour of the materials with the carbonization temperature was found, getting values in the range 0.2-3.2 Ωcm)$^{-1}$; surpassing 1200 ºC was necessary to provide a graphene-type behaviour.

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