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Agro-food Waste as a Source for Advanced ORR Catalysts

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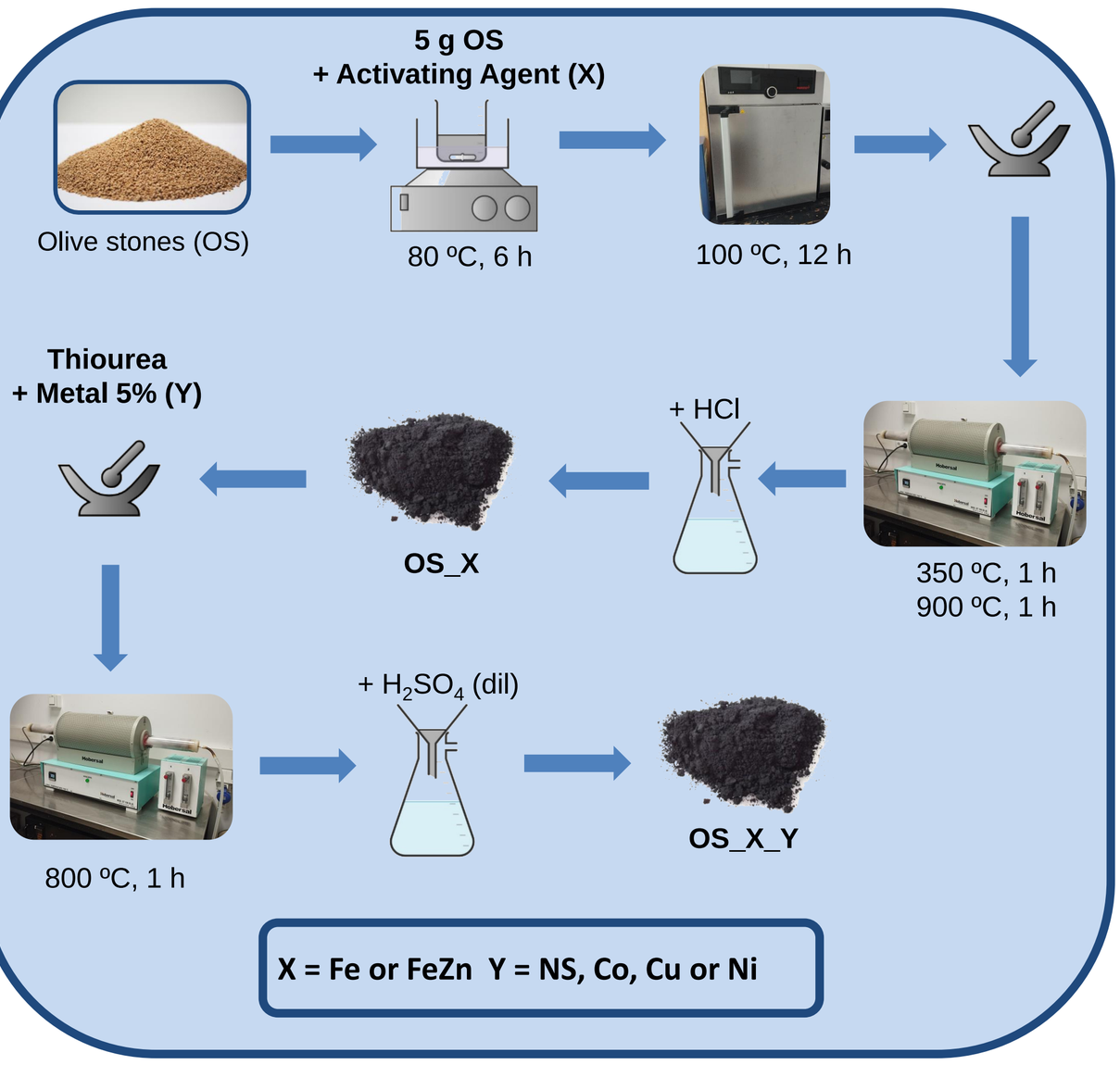
INTRODUCTION & AIM

Despite the increase of inversions in renewable energies, these can't supply the increment of energy consumption generated by the society and the industrial sector. With the aim of achieve the climate neutrality it is necessary the large-scale application of fuel cells and air/metal batteries, however, its applicability is limited by the cathodic reaction, the oxygen reduce reaction (ORR), it needs to be catalyzed. The main catalyst are based on Pt materials or transitional metals showing problems such as high-cost, scarce abundance or low durability. [1]

In this context, nanostructured carbon materials show high activity, conductivity and durability. At the same time, it is a cheap and an abundant material when it is used agro-alimentary waste as precursor. The properties of this catalyst can be enhanced by doping it with different heteroatoms and/or supporting a little amount of metals. [2,3]

METHOD



RESULTS & DISCUSSION

The results obtained by SEM, TEM (Fig 1) and XRD show that ACs by $FeCl_3$ have a development of graphenic layers in an ordered structure, while, ACs by $FeCl_3/ZnCl_2$ produce amorphous materials where the graphic layer are ordered in a turbostratic structure. Textural parameters are conditioned by the activation process, the N_2 isotherms reveal that ACs by $FeCl_3$ develop a good mesoporosity, whereas, ACs by $FeCl_3/ZnCl_2$ develop a higher microporosity and S_{BET}. ICP-OES and XPS results confirm the properly cleaning process of the metal after the activation process and the correct support of the metal phases in ACs.

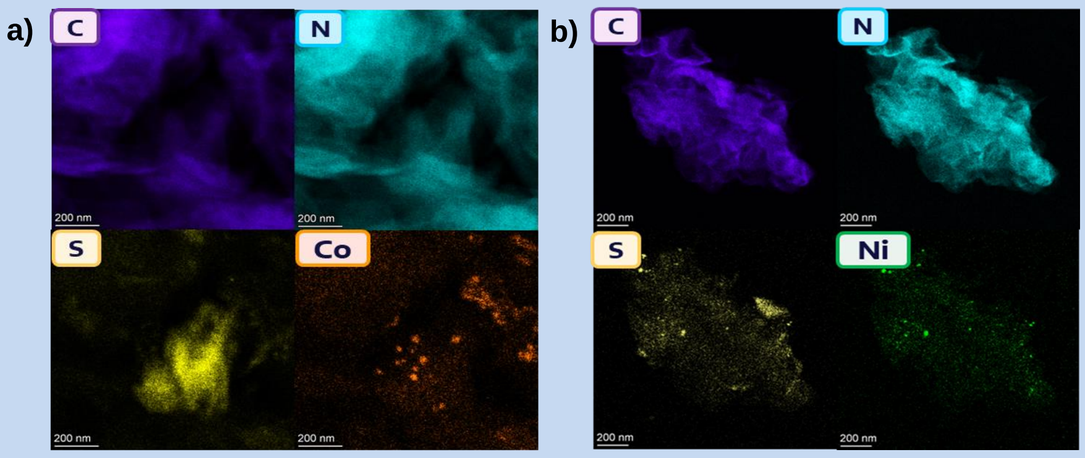


Figure 1: elemental mapping images of (a) OS_Fe_Co and (b) OS_Fe_Ni, obtained by HAADF-STEM.

The ORR evaluation shows that AC doped with heteroatoms and supporting metal phases present enhance electrochemical properties and selectivity towards the 4 electrons mechanism (Fig 2). The ECSA results indicate a relation between the microporosity and the number of active sites. Independently of the activation process the Tafel slopes results shows that the limiting step in the reaction is the same. EIS results reveal that all the ACs presents similar conductivity, however, the ACs by $FeCl_3/ZnCl_2$ allow a better mass transport. Durability tests were successfully completed for 19 hours of continues work.

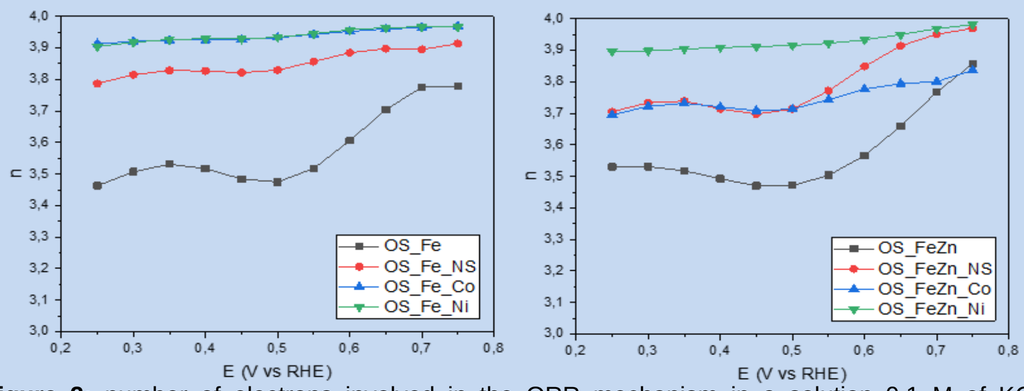


Figure 2: number of electrons involved in the ORR mechanism in a solution 0.1 M of KOH saturated of O_2 at 1600 rpm.

CONCLUSION

In this work has been synthetized different series of catalyst form a cheap and abundant resource as can be the olive stone. After a simple doping with heteroatoms and support of metal the catalyst increase their electrochemical properties and selectivity towards the 4 electrons mechanism, obtaining results comparable with the commercials Pt/C catalyst. The catalysts activated by $FeCl_3/ZnCl_2$ are the more promising, highlighting the catalyst OS_FeZn_Ni, the one who shows the better group of electrochemical properties and selectivity over all the potential range.

REFERENCES

[1] Institute, E., Statistical Review of World Energy. Energy Institute, 2024. 73rd edition.

[2] Pérez-Mayoral, E., et al., Eco-sustainable Synthesis of N-containing Heterocyclic Systems Using Porous Carbon Catalysts. 2023. 15(23): p. e202300961.

[3] Ma, J., et al., A facile preparation of nitrogen-doped porous carbons from renewable as efficient catalysts for oxygen reduction reaction. Journal of Solid State Chemistry, 2020. 291: p. 121609.

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