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EXCELENCIA SEVERO OCHOA

POLYXOMETALATE-STABILIZED METAL NANOSTRUCTURES: POTENTIAL CANDIDATES FOR ENERGY STOAGE APPLICATIONS

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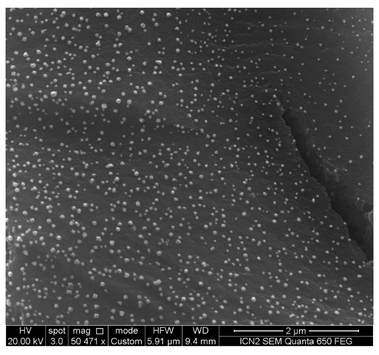
INTRODUCTION

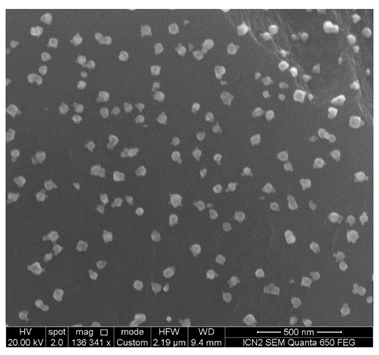
Polyoxometalates (POMs), redox active anionic metal–oxide clusters,[1] are potential candidates to achieve a high capacity for energy storage applications. POM-functionalized nanocarbon materials have been used applications in hybrid supercapacitors (SCs), as the carbon support contributes double-layer capacitive effects, while the POM provides faradaic charge storage.[2] However, POMs have poor electrical conductivity, which can have a detrimental influence on specific capacitance and cycling stability. Nobel metal (M^0) nanostructures have been widely used as conductive dopants in electrode materials for SCs.[3,4]. Here, we present a green, facile, electrochemical-reduction-assisted assembly of Ag^0 / POM / activated carbon (AC) hybrid material; using the POM ($PW_{12}O_{40}^{3-}$) as reducing and stabilizing agent for the formation of Ag^0 nanostrucutres in the AC matrix. The composite is characterized and its potential as electrode material for energy storage application is preliminary assessed.

Ag^0 NPs / POLYOXOMETALATE / ACTIVATED CARBON HYBRIDS

Step 1

$$PW_{12}O_{40}^{3-} + {}_{ox}AC \xrightarrow[\text{Ar bubbling}]{\text{Electrolysis}} PW_{12}O_{40}^{5-} + {}_{red}AC \xrightarrow[\text{in air}]{\text{Stirring}} \boxed{PW_{12}O_{40}^{3-}/{}_{red}AC}$$

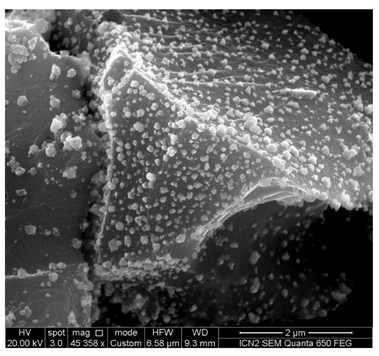


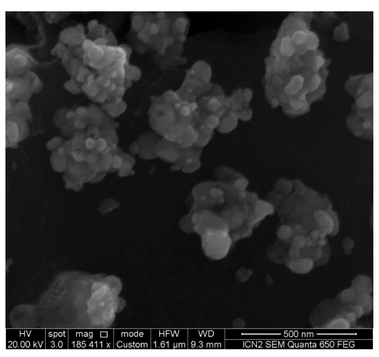


50 nm PW_{12} crystallites homogeneously distributed on the AC matrix

Step 2

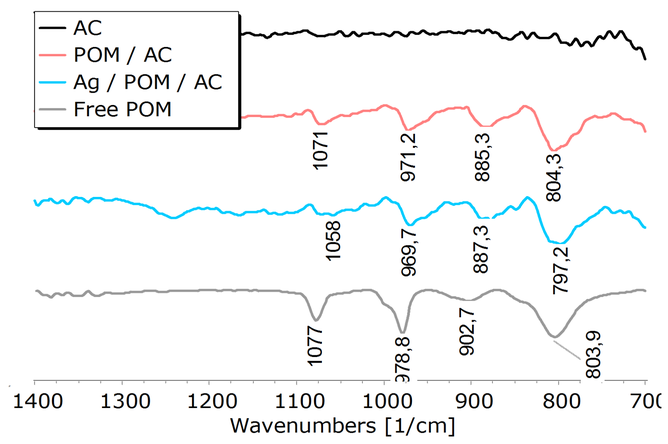
$$\boxed{PW_{12}O_{40}^{3-}/{}_{red}AC} \xrightarrow{\text{Electrolysis}} PW_{12}O_{40}^{5-}/{}_{red}AC \xrightarrow[\text{Stirring}]{AgNO_3} \boxed{\begin{matrix}Ag^0/PW_{12}O_{40}^{3-}/{}_{red}AC\\ \text{Hybrid Material}\end{matrix}}$$





Ag^0 nanostructures stabilized by POMs
W / Ag ratio = 3.02 based on weight % (EDX analysis)

CHARACTERIZATION

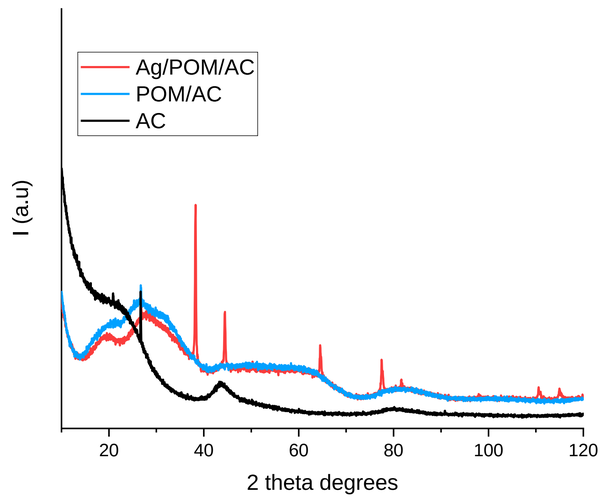


INFRARED SPECTROSCOPY

- Presence of POM in hybrid materials.
- W–O stretching bands red shifted indicating POM interactions with AC.

POWDER XRD:

- Change in local order of AC due to incorporation of PW_{12}.
- Absence of POM crystalline peals → Homogeneous distribution of POMs on the AC matrix.



HYBRID ELECTRODE PREPARATION

80% Hybrid material
12% Polyvinylidene fluoride
8% Carbon Super P

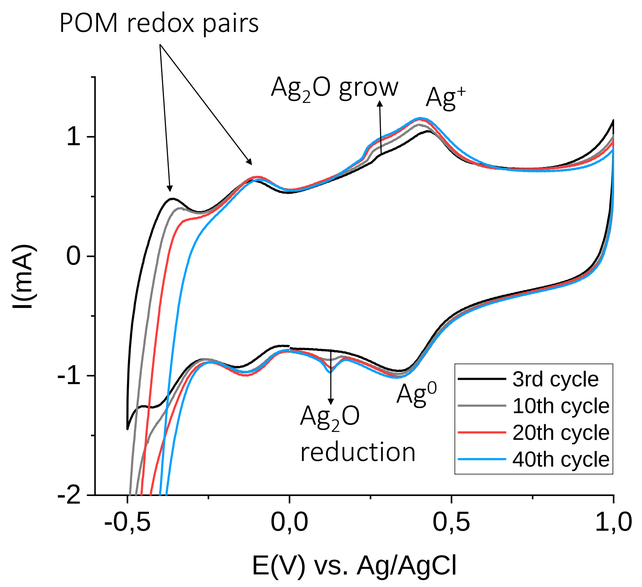
68.75 mg/mL in N-methyl-2-pyrrolidone

Film on stainless steel.
Dried at 80°C.

ELECTROCHEMICAL ACTIVITY

CYCLIC VOLTAMMETRY OF Ag / POM / AC ELECTRODES

- POM and Silver characteristic redox peaks.
- Lack of cycling stability due to material detachment from electrode.



Electrochemical cell using hybrid electrode as working electrode.

CONCLUSIONS AND FUTURE WORK

We have successfully prepared and characterized a novel ternary Ag^0/POM/AC hybrid material. The electrochemical properties of the hybrid electrode have been studied. However, an improvement on the electrode stability is under study to address its properties as hybrid SC

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