# Nano-architectures of metal oxides and *Albizia Procera* leaves derived carbon for electrochemical water splitting


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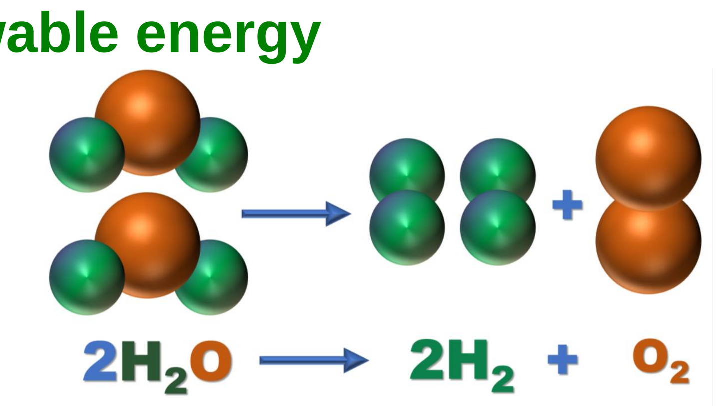
**Abstract:** Electrocatalytic splitting of water provides a potentially cost-effective, renewable, and clean path to produce hydrogen gas. In this process, the efficiency of water oxidation ($2H_2O \rightarrow 4H^+ + 4e^- + O_2$) is important. In the last few decades, the earth-abundant metal catalysts have been focused by the researchers that could substitute the benchmark catalysts for electrochemical water splitting. However, much attention has been achieved by catalysts ba sed on earth-abundant metals including cobalt and manganese. Especially, significant improvements have been done in the preparation of nanomaterials of oxides of these elements to meet the demands of electrochemical water oxidation. Here, we present a simple and straight-forward thermal decomposi tion method to prepare $Mn_3O_4$NPs and $Co_3O_4$NPs on cheap, and homemade *Albizia Procera* derived carbon for electrochemical water oxidation. Various s amples (electrocatalysts) were prepared by varying the amount of the Co or Mn precursor with the fixed amount of carbon using the same thermal deco mposition parameters. Due to straight-forward and simple preparation, low cost, efficient electrocatalytic property, and good stability, the optimum nano -$Co_3O_4$ or nano-$Mn_3O_4$-coated carbon nanocomposites could be counted as promising materials for electrochemical water splitting.


## Introduction

**Electrochemical water oxidation is a very important step to produce $H_2$ gas for renewable energy**




→ **Available non-noble based electrocatalyst for water oxidation:** Oxides nanoparticles of Fe, Ni, Co, and Mn

→ **Support** like CNT, graphene, and **biomass-derived carbon** play a significant role for increasing the electrocatalytic properties by reducing the aggregation of the nano-electrocatalyst, increasing conductivity

→ **Preparing carbon** from locally available biomass like *Albizia procera* leaves could be beneficial by pyrolysis for minimizing the cost as well localizing the technology

→ **Preparing metal oxide nanoparticles (NPs)** on support by direct thermal decomposition of respective commercially available inorganic salt in the presence of support without pre-functionalization could be straight forward and economic

→ **Loading amount of metal oxide NPs** on support could play significant role toward electrocatalytic water oxidation

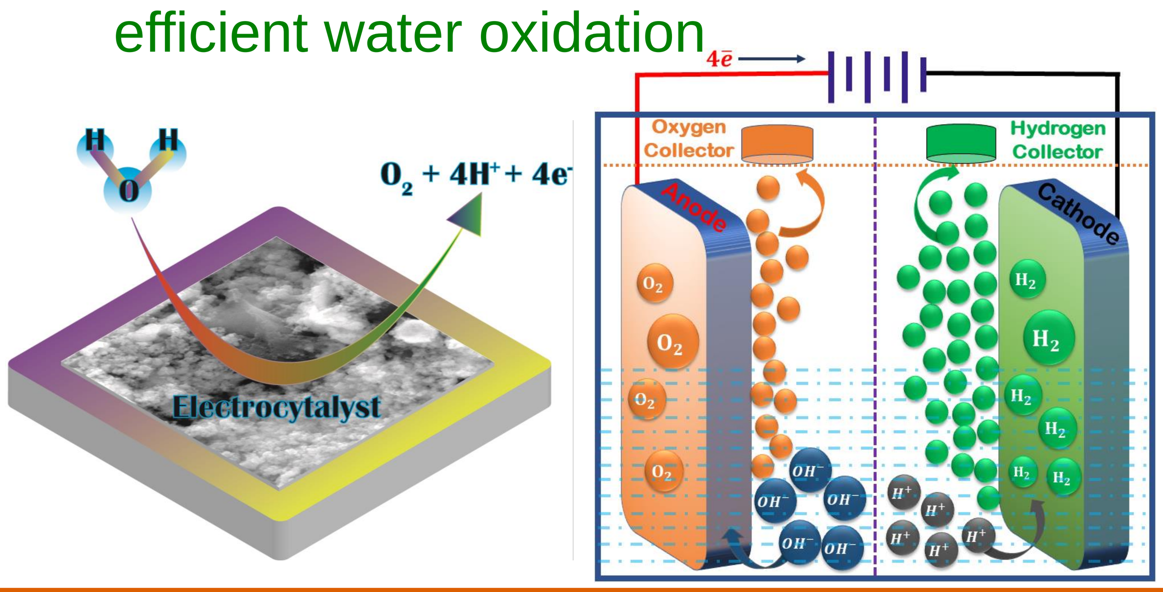
## Objectives

i. Preparation of *Albizia procera* leaves-derived carbon

ii. Preparation of $MnO_x$NPs-C and $CoO_x$NPs-C electrocatalysts, obtained by the thermal decomposition

iii. Characterization of the electrocatalysts

iv. Electro-oxidation of water using $MnO_x$NPs-C or $CoO_x$NPs-C and finding optimum loading of $MnO_x$ or $CoO_x$ for efficient water oxidation




## Experimental Work

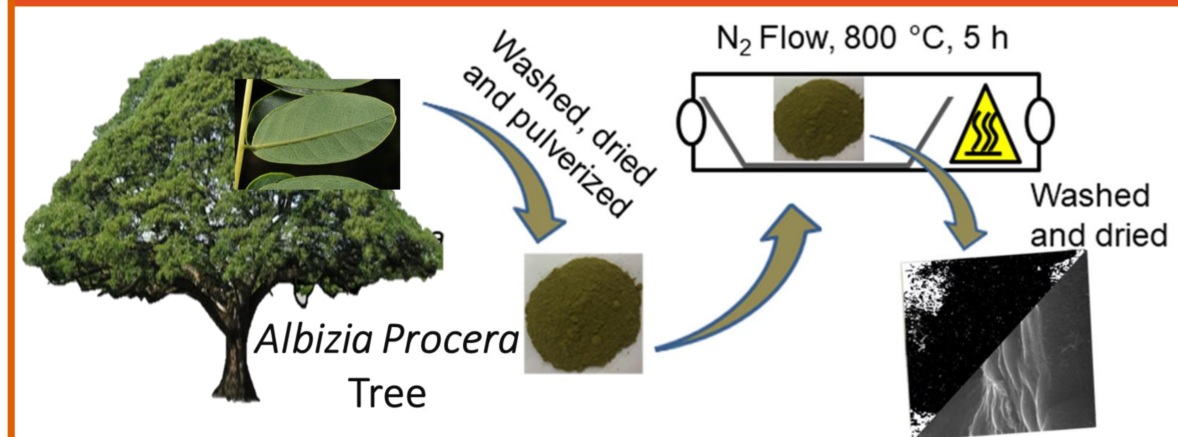



**Figure 1:** Schematic representation for the carbon preparation from *Albizia Procera* leaves.

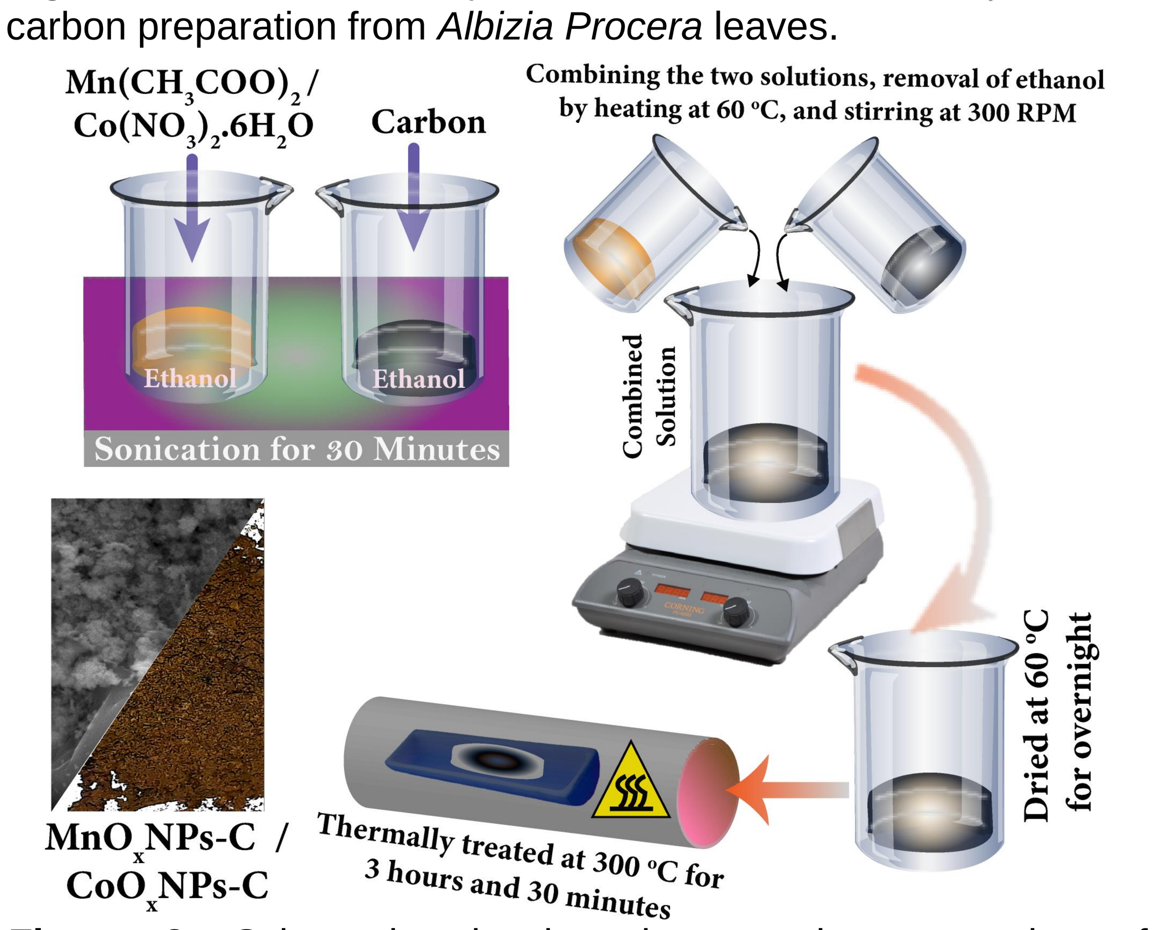



**Figure 2:** Schematic showing the sample preparation of manganese oxide / cobalt oxide and carbon nanocomposite.

## Results and Discussion

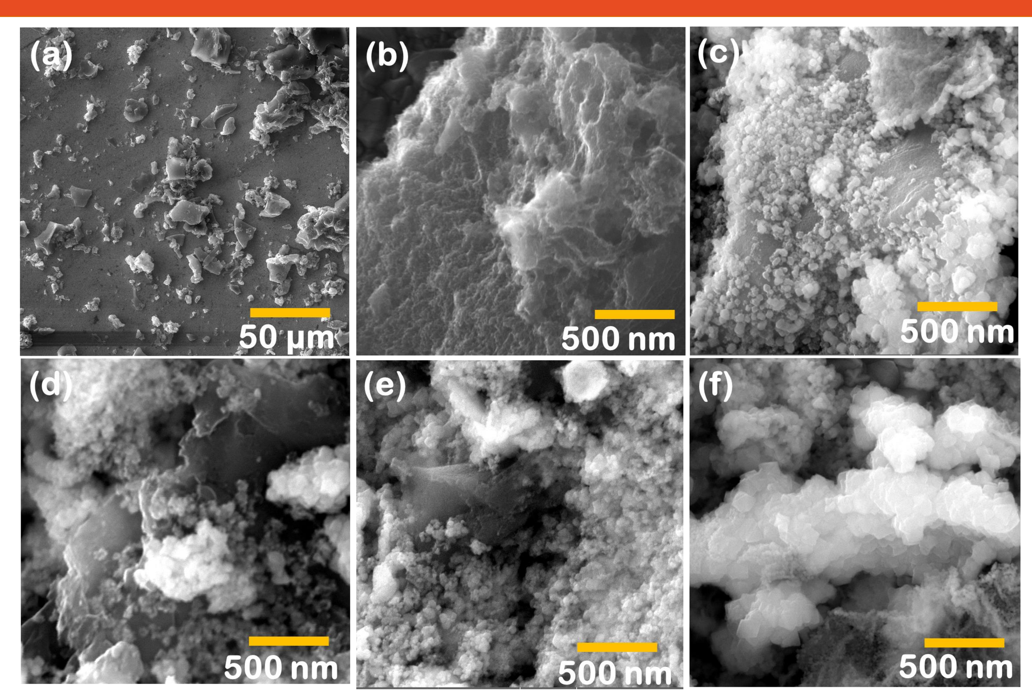



**Figure 3:** FESEM images of (a) C-200, (b) $MnO_x$-C-1500, and (c) $MnO_x$-1500 and the corresponding EDS spectra of (d) C-200, (e) $MnO_x$-C-1500, and (f) $MnO_x$-1500 prepared by thermal decomposition at 300 °C.

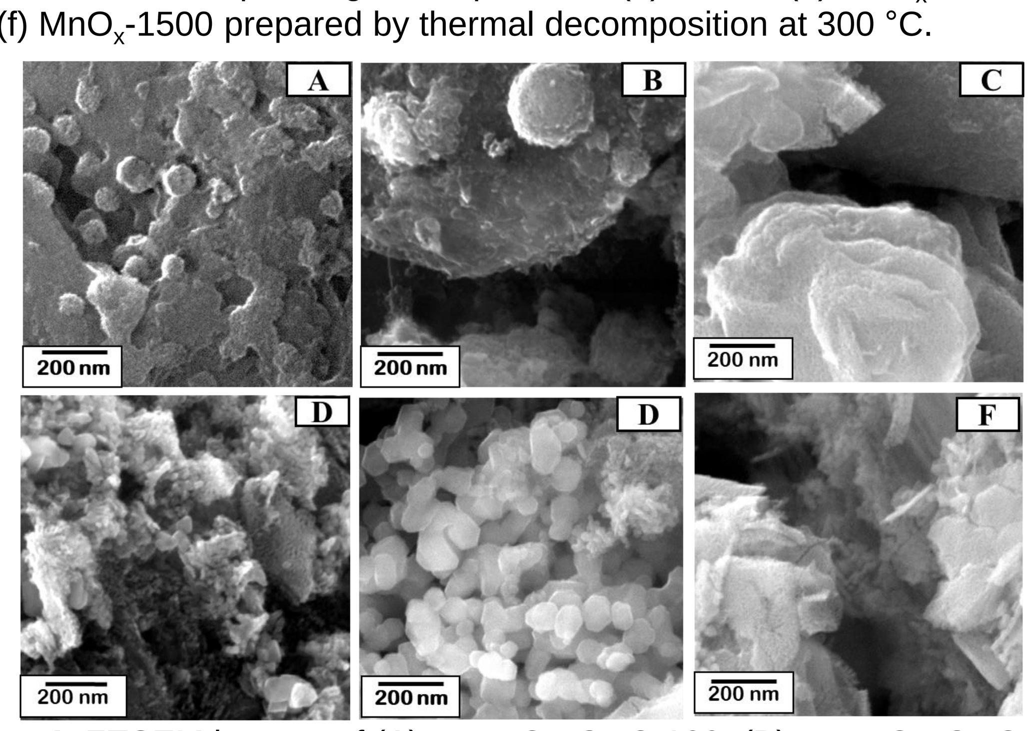



**Figure 4:** FESEM images of (A) nano-$Co_3O_4$-C-100, (B) nano-$Co_3O_4$-C-200, (C) nano-$Co_3O_4$-C-400, (D) nano-$Co_3O_4$-C-600, (E) nano-$Co_3O_4$-C-800, and (F) nano-$Co_3O_4$-C-1000.

## Acknowledgments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## Results and Discussion

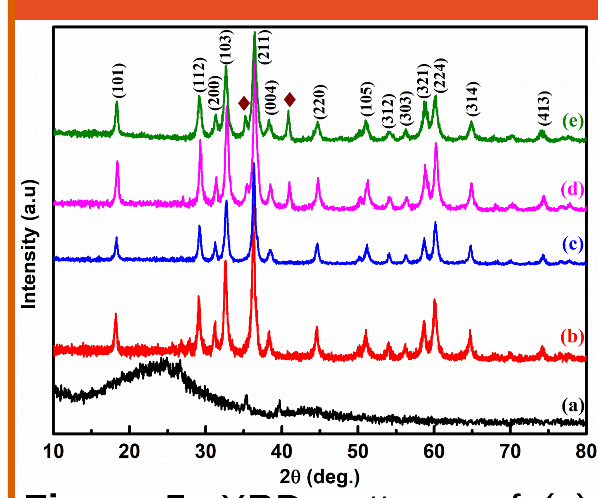


**Figure 5:** XRD patterns of (a) pure C-200, (b) $MnO_x$-C-500, (c) $MnO_x$-C-1000, (d) $MnO_x$-C-1500, and (e) $MnO_x$-1500 prepared at 300 °C. XRD peaks marked with diamond symbols correspond to MnO phase.

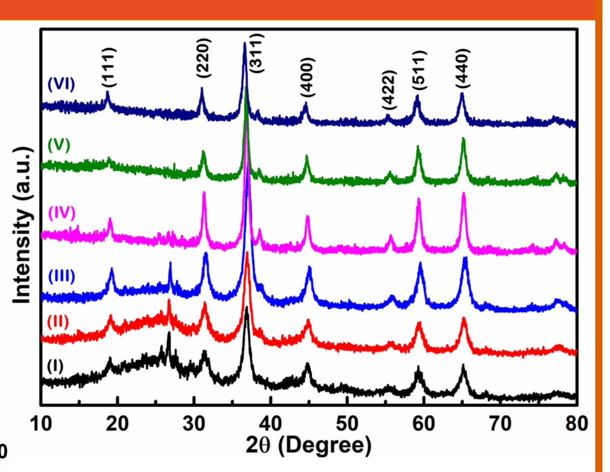


**Figure 6:** XRD patterns of (I) nano-$Co_3O_4$-C-100, (II) nano-$Co_3O_4$-C-200, (III) nano-$Co_3O_4$-C-400, (IV) nano-$Co_3O_4$-C-600, (V) nano-$Co_3O_4$-C-800, and (VI) nano-$Co_3O_4$-C-1000.

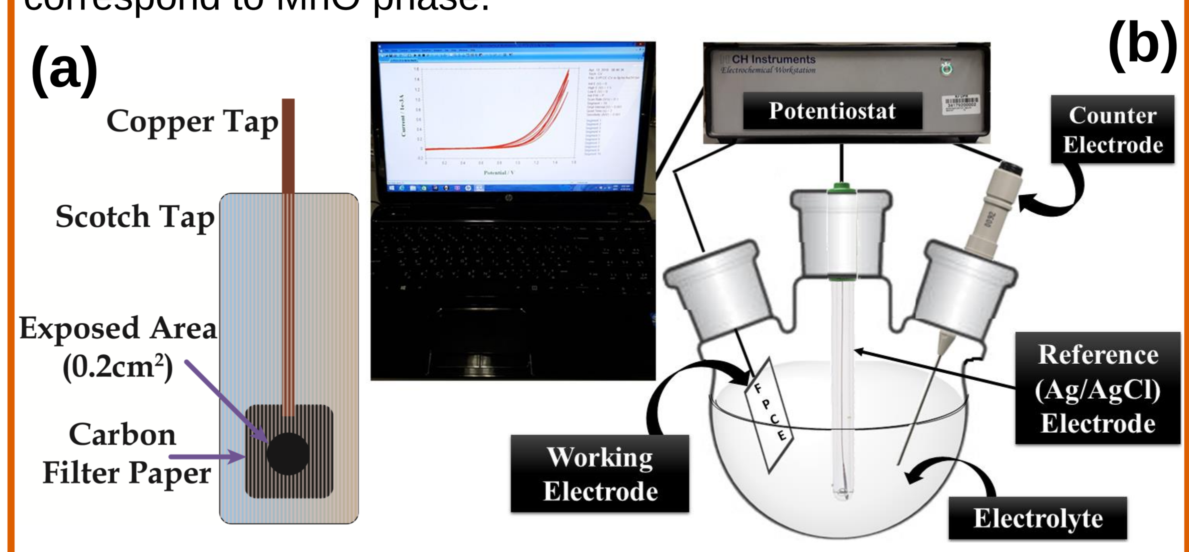


**Figure 6:** (a) Filter paper derived carbon electrode (FPCE) and (b) setup for electrochemical measurements.

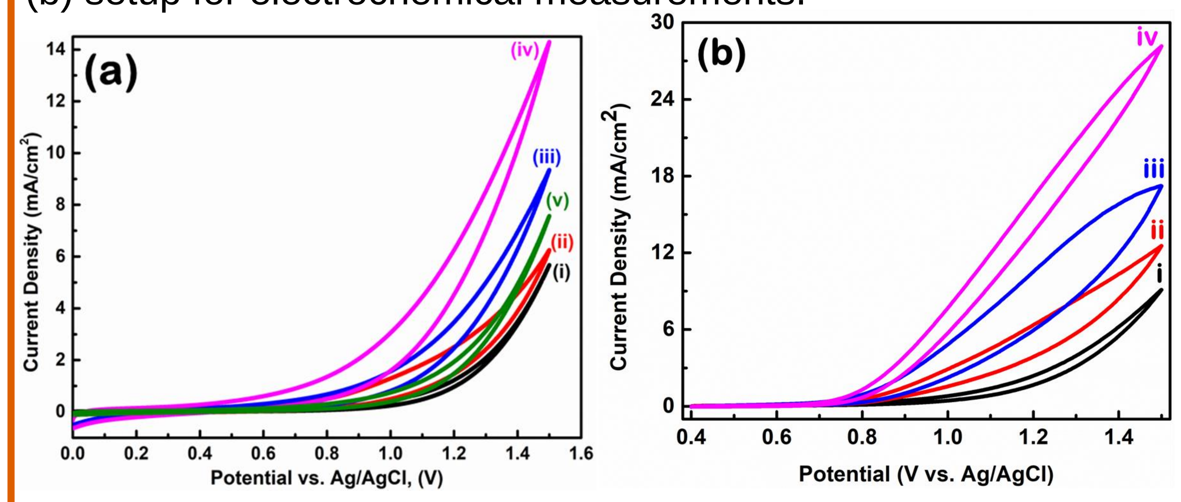


**Figure 7:** (a) CVs of (i) FPCE, (ii) $MnO_x$-C-500/FPCE, (iii) $MnO_x$-C-1000/FPCE, (iv) $MnO_x$-C-1500/FPCE, and (v) $MnO_x$-1500/FPCE & (b) CVs of (i) C/FPCE, (ii) nano-$Co_3O_4$-C-100/FPCE, (iii) nano-$Co_3O_4$-C-200/FPCE, (iv) nano-$Co_3O_4$-C-400/FPCE in 0.1M NaOH.

## Conclusions

❖ Carbon was prepared from the leaves of *Albizia Procera* by pyrolysis at 800 ºC

❖ Different samples of $MnO_x$NPs-C and $CoO_x$NPs-C were prepared with various concentrations of carbon and metal precursors by thermal decomposition at 300 °C

❖ The prepared catalysts work as electrode materials for water oxidation

❖ Carbon play a vital role as catalyst support for electrochemical water oxidation

❖ The $MnO_x$-C-1500/FPCS and nano-$Co_3O_4$-C-400/FPCE showed best electrocatalytic properties among the prepared electrocatalysts towards electrochemical water oxidation in NaOH

❖ The stability profile of the sample showed good stability of the catalysts for electrochemical water oxidation


Syed Shaheen Shah, et al., "Preparation and characterization of manganese oxide nanoparticles-coated *Albizia Procera* derived carbon for electrochemical water oxidation." *Journal of Materials Science: Materials in Electronics* 30 (17) (2019): 16087-16098.

Ismail A. Buliyaminu, et al., "Preparation of nano-$Co_3O_4$-coated Albizia Procera-derived carbon by direct thermal decomposition method for electrochemical water oxidation." Arabian Journal of Chemistry 13(3) (2020) 4785-4796.