4-1-2019

Electrocatalytic Properties of Lanthanum-based Perovskites for Water Splitting and Energy Storage Applications

Xavier R. Martinez
Pittsburg State University

Khamis Siam
Pittsburg State University

Pawan K. Kahol
Pittsburg State University

Ram K. Gupta
Pittsburg State University

Electrocatalytic Properties of Lanthanum-based Perovskites for Water Splitting and Energy Storage Applications

Xavier R. Martinez, Khamis Siam, Pawan K. Kahol, and Ram K. Gupta

Pittsburg State University, Pittsburg, Kansas

Background

- In the glaring demand for clean and renewable energy sources, cheap multifunctional materials have been silhouetted to lead the way
- Hydrogen production for use in a fuel cell has great potential to be a viable green energy alternative
- The electricity made available from fuel cells would be most effective if excess were able to be stored and distributed when and where it was needed
- Perovskite metal oxides are stable structured materials that have shown desirable properties as both an electrocatalyst and an energy storage medium

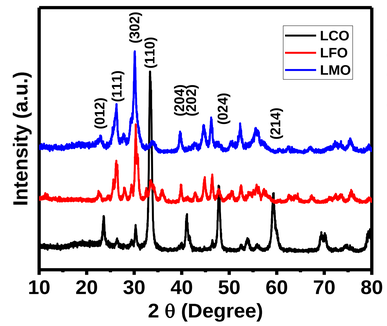
Challenges

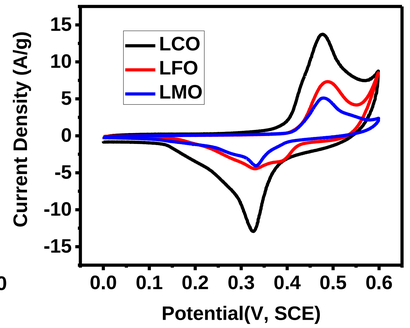
- For a material to be utilized in an energy storage device, good specific capacitance, higher energy/power densities and electrochemical stability are desired
- Current materials being used for supercapacitor applications lack in electrochemical stability in the long run
- Efficient electrocatalysts for oxygen evolution reaction (OER) and hydrogen evolution reaction (HER) should lower overpotentials and be cost effective
- Current most efficient electrocatalysts are not very cost effective and stable in performance

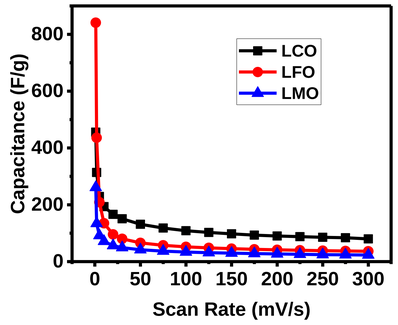
Solution Through This Research

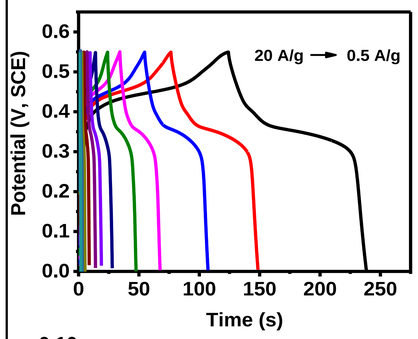
- Using readily available transition metals, three lanthanum based perovskite nanostructures were studied as a multifunctional material solution
- A consistent 650 ^{o}C calcination process was employed to produce $LaCoO_3$ (LCO), $LaFeO_3$ (LFO) and $LaMnO_3$ (LMO) metal oxides
- Each material was prepared into electrodes and examined with linear scan voltammetry (LSV), electrochemical impedance spectroscopy (EIS), and cyclic voltammetry (CV) and showed positive activity toward OER, HER and supercapacitor properties

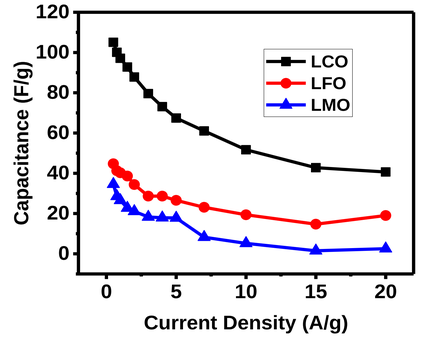
Results and Discussion

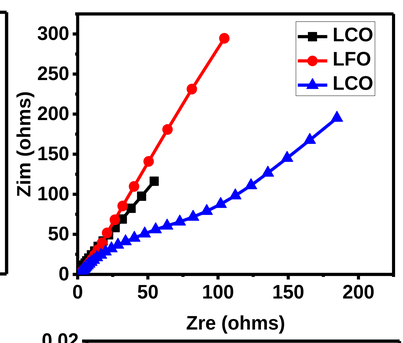


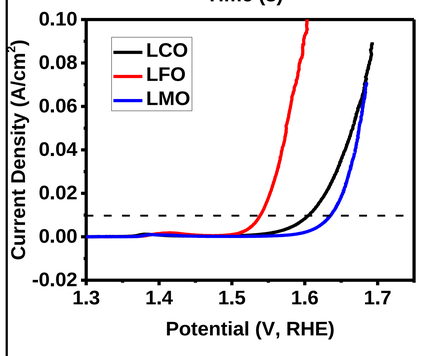


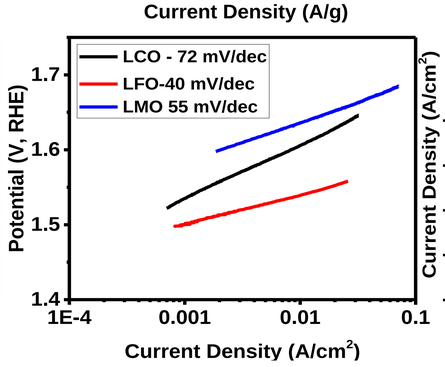


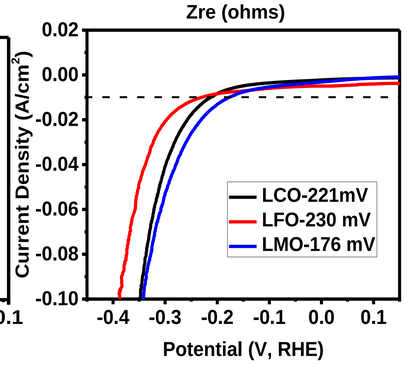












- LCO, LFO, and LMO were synthesized via uniform hydrothermal calcination process and structural verification with X-ray diffraction was examined
- Perovskite materials were dip coated on Ni foam substrate and electrochemically analyzed for activity toward OER, HER and supercapacitor capabilities
- With respect to supercapacitive properties, LCO showed overall higher capacitance of 105 Fg^{-1} compared to LFO (45 Fg^{-1}) and LMO (35 Fg^{-1})
- LFO exhibited the lowest overpotential of 316 mV at 10 mV/cm^2 toward OER while LCO and LMO displayed higher overpotentials of 376 mV and 419 mV, respectively
- Tafel slopes substantiate LFO as a more efficient electrocatalyst for the OER over LMO and LCO, the latter revealing lower overpotential than LMO, but a higher Tafel slope
- In reference to overpotential toward the HER, LMO displayed the lowest in relation to LCO and LMO

Summary

- Three lanthanum-based perovskite metal oxides were synthesized and fashioned into electrodes
- These materials showed decent electrocatalytic activities towards OER and HER applications
- These perovskites were also used for energy storage applications
- Substitution of transition metals in each material highly influenced the activity and charge storage capacity
- Our research suggests that lanthanum-based perovskite metal oxides could be used for multifunctional applications such as electrocatalysts for water splitting and supercapacitors

Acknowledgements

- Thank you to the Kansas Polymer Research Center (KPRC) for use of facilities, PSU Chemistry Dept. and fellow group members

Future Work

- We would like to fabricated supercapacitor devices for energy storage applications and electrolyzer for water splitting