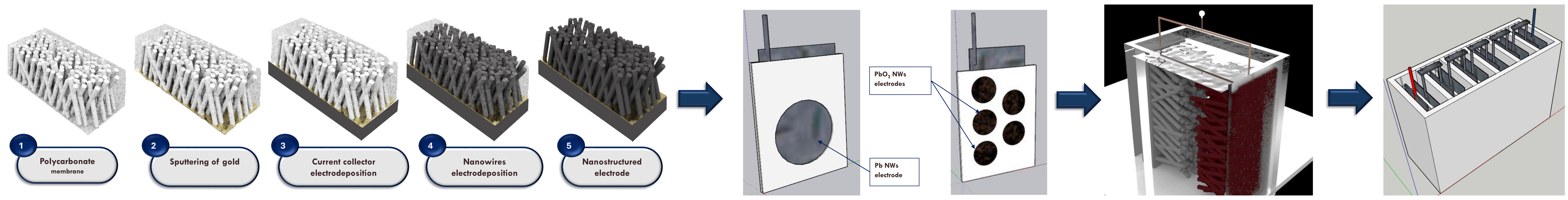
High performance of nanostructured lead-acid batteries using rGO as additive for negative electrode

Maria Grazia Insinga[1*], Roberto Luigi Oliveri[1], Nadia Moukri[1], Giuseppe Aiello[1], Bernardo Patella[1], Rosalinda Inguanta[1]

[1] *Laboratory of Applied Physical Chemistry, University of Palermo , Viale delle Scienze, Palermo, Italy*
**mariagrazia.insinga@unipa.it*

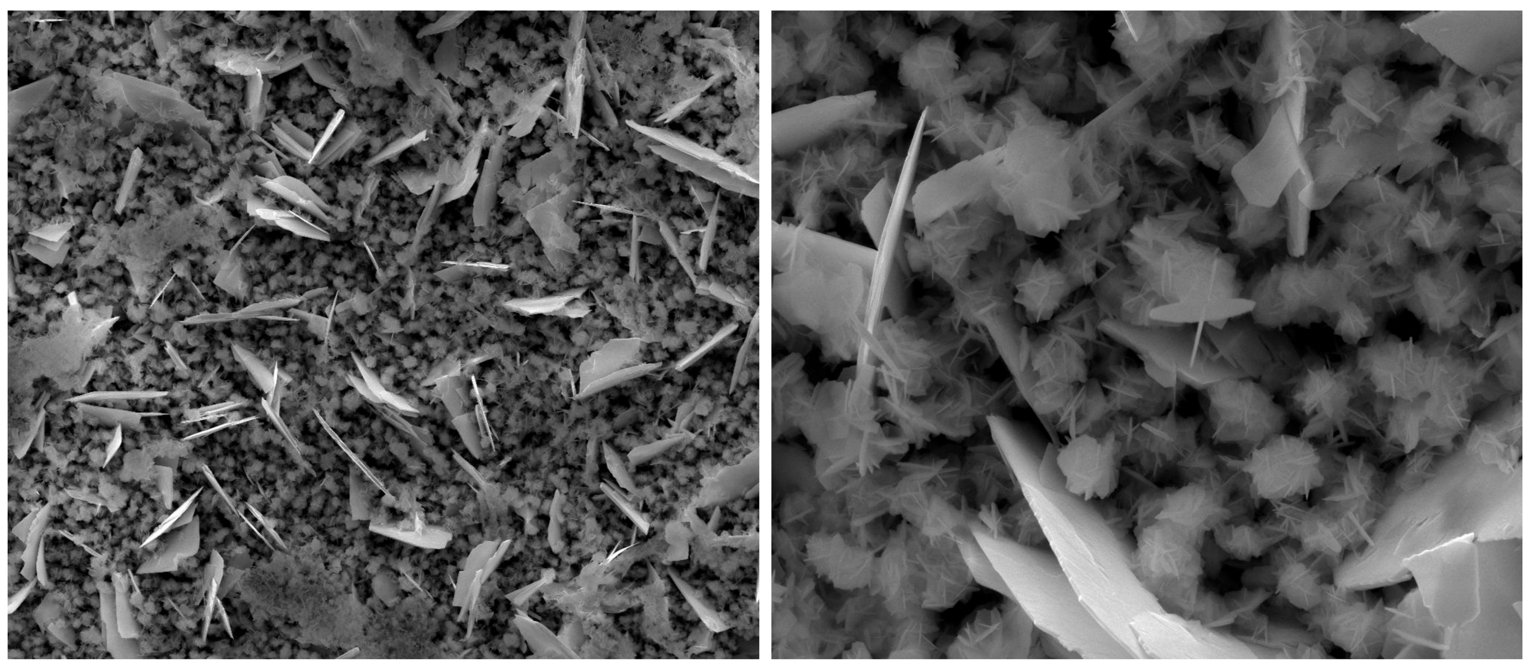
Introduction

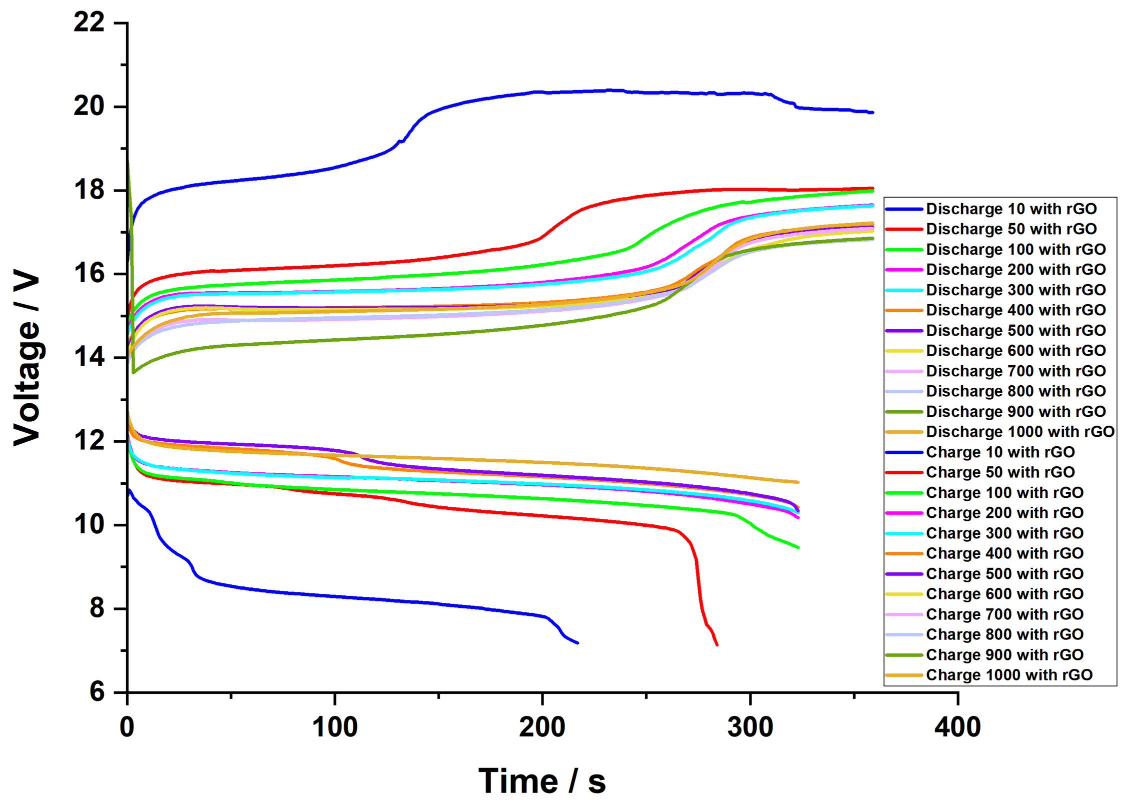
Lead-acid batteries (LABs) are among the most widely used and well-established energy storage technologies because of their dependability, affordability, simplicity of manufacture, and recyclability. Numerous studies and solutions have been put out over the years to enhance the performance of lead-acid batteries with the goal of lowering sulfurization occurrences while simultaneously extending life cycles and energy density. The use of nanostructured materials into energy storage devices stood out as a viable strategy to enhance LAB performance among all the suggested fixes. The creation of nanostructured electrodes, which have a large surface area and a high active material usage rate, is the main emphasis of this project's research activity.

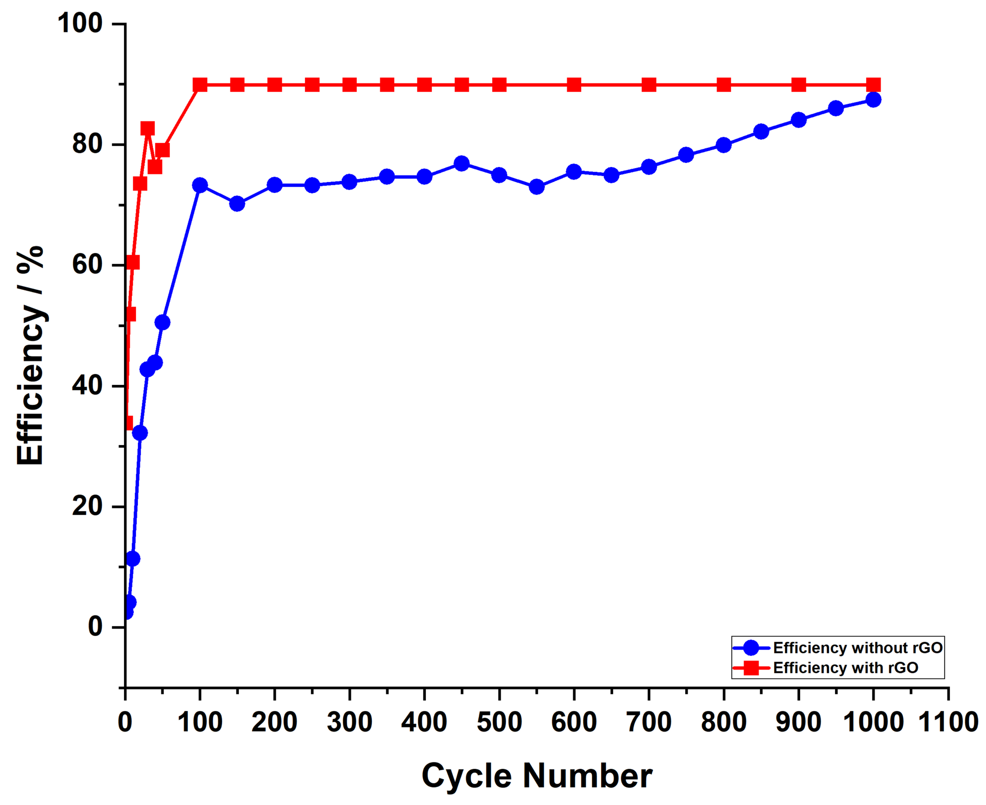


Experimental

In this work we present a 12V lead-acid batteries with nanostructured electrodes and using a Pb nanowires added with reduced graphene oxide (rGO) to improve their performance. This battery was cycled at high C-rate up to 10C (6 min to complete charge) and imposing a very deep discharge. These cycling conditions are much more stressful in terms of cut-off and charge/discharge rate in comparison to the usually functionating conditions of commercial batteries. The rGO contributes to better electrical conduction and decreases internal resistance, for higher efficiency during charging and discharging and a decrease in sulfation phenomena. Modified batteries exhibit higher specific capacity, longer cycle life, and better reaction to high currents than classic LABs.







Results and discussion

The positive impact of rGO on nanostructured Pb electrodes was highlighted in this work. High-performance nanostructured Pb electrodes added with rGO were produced. Initially, Pb NW electrodes were electrodeposited subsequently rGO on their surfaces were deposited. Both the discharge potential and the charged-discharge rate of the electrodes were selected to simulate extremely stressful conditions. A C-rate equal to 10C and a depth of discharge equal to 90% were imposed. Excellent accomplishments were achieved in spite of these circumstances. The electrodes can actually operate at an efficiency of 90% for the duration of the test, which is quite close to the theoretical utilization of active mass. Additionally, when a constant current is provided, the electrode discharges at a voltage that is nearly constant. These improved results are ascribed to the increase on conductivity of the active material due to the presence ofrGO, which inhibits the activity loss brought on by $PbSO_4$ crystal formation.

Acknowledgment

This work was partially financed by the project “SiciliAn MicronanOTecH Research And Innovation CEnter “SAMOTHRACE” (MUR, PNRR-M4C2, ECS_00000022), Spoke 3, WP2 - Università degli Studi di Palermo “S2-COMMs - Micro and Nanotechnologies for Smart & Sustainable Communities”.

References

[1] R. Inguanta, G. Ferrara, S. Piazza and C. Sunseri, «Nanostructures fabrication by template deposition into anodic alumina membranes,» Chemical Engineering Transactions, vol. 17, pp. 1-6, 2009.
[2] R. Inguanta, G. Ferrara, S. Piazza and C. Sunseri, « A new route to grow oxide nanostructures based on metal displacement deposition: lanthanides oxy/hydroxides growth,» Electrochimica Acta, vol. 76, pp. 77-87, 2012.
[3] M. G. Insinga, A. Moncada, R. L. Oliveri, F. Ganci, S. Piazza, C. Sunseri and R. Inguanta, «Nanostructured Pb electrode for innovative lead-acid battery,» Chemical Engineering Transactions, vol. 60, pp. 49-54, 2017.
[4] R. Inguanta, F. Vergottini, G. Ferrara, S. Piazza and C. Sunseri, «Effect of temperature on the growth of α-PbO2 nanostructures,» Electrochimica Acta, vol. 55, n. 28, pp. 8556-8562, 2010.
[5] M. G. Insinga, R. L. Oliveri, C. Sunseri and R. Inguanta, «Template electrodeposition and characterization of nanostructured Pb as a negative electrode for lead-acid battery,» Journal of Power Sources, vol. 413, pp. 107-116, 2019.
[6] R. L. Oliveri, M. G. Insinga, D. Tamburrino, F. Ganci, B. Patella, G. Aiello, P. Livreri and R. Inguanta, «High-rate cycling performance of lead-acid batteries with nanostructured electrodes,» in AEIT International Conference on Electrical and Electronic Technologies for Automotive (AEIT AUTOMOTIVE), Turin, 2021.
[7] R. L. Oliveri, M. G. Insinga, S. Pisana, B. Patella, G. Aiello and R. Inguanta, «High-Performance Lead-Acid Batteries Enabled by Pb and PbO2 Nanostructured Electrodes: Effect of Operating Temperature,» applied sciences, vol. 11, p. 6357, 2021.
[8] M. G. Insinga, S. Pisana, R. L. Oliveri, C. Sunseri and R. Inguanta, «Performance of Lead-Acid Batteries with Nanostructured Electrodes at Different Temperature,» in IEEE 4th International Forum on Research and Technology for Society and Industry (RTSI), Palermo, 2018.
[9] M. G. Insinga, A. Derelitto, S. Pisana, R. L. Oliveri, C. Sunseri and R. Inguanta, «Gelled Electrolyte for Nanostructured Lead-acid Battery,» Chemical Engineering Transactions, vol. 73, pp. 25-30, 2019.
[10] M. Caruso, V. Castiglia, R. Miceli, C. Nevoloso, P. Romano, G. Schettino, F. Viola, M. G. Insinga, A. Moncada, R. L. Oliveri, F. Ganci, C. Sunseri, S. Piazza and R. Inguanta, «Nanostructured Lead Acid Battery for Electric Vehicles Applications,» in International Conference of Electrical and Electronic Technologies for Automotive, Turin, 2017.

APPLIED PHYSICAL CHEMISTRY LAB

BATTERY 2030+
6 – 7 May 2025, Münster, Germany

samothrace
Sicilian Micro and Nano Techonology Research and Innovation Center