Società Chimica Italiana
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SIOF Società Italiana di Ottica e Fotonica

GS 2025

Interdivisional Sensors Group Workshop

"Sensors and biosensors as strategic tools for health, food safety, and environmental monitoring"

15-17th December 2025

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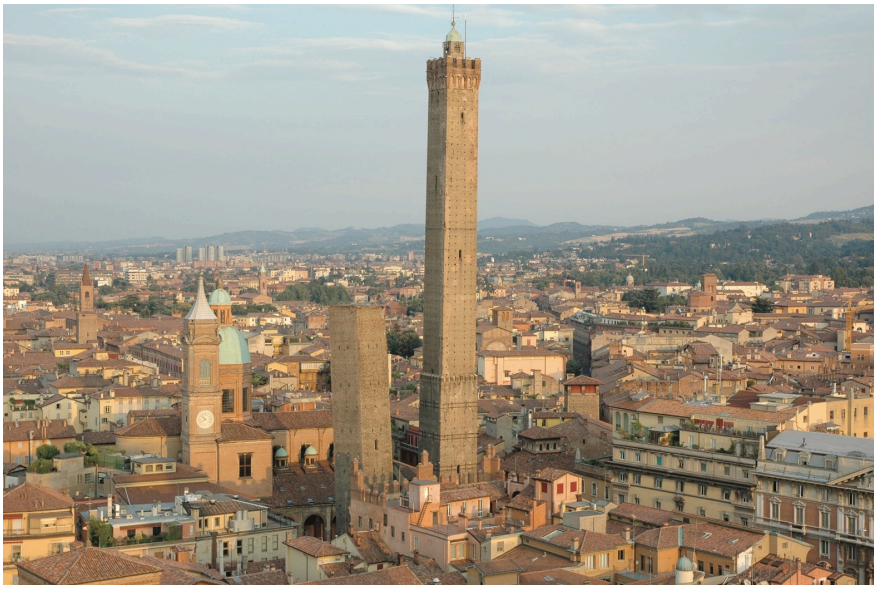

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COMMUNICATIONS

Oral communications will last 12 minutes, followed by 3 minutes of discussion.

SCIENTIFIC AWARDS

Scientific Awards will be presented during the conference:

- *"Marco Mascini" Award*
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- *SIOF Thesis and PhD Awards*

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Poster 52

NEW ELECTROCHEMICAL SENSOR DEVICE, BASED ON ARDUINO, FOR MEASUREMENTS OF RESIDUE CHARGE OF PRIMARY ALKALINE BATTERIES.

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As is well known, although so-called secondary batteries, i.e., chemical-physical devices that can be returned to a 'charged' state by appropriate charging methods, are readily available on the market; but, given their low cost, **the most widely used and widespread batteries on the market are the so-called "disposable", or non-rechargeable batteries, or alkaline batteries, or, more properly, "primary alkaline batteries"**. Of the various primary batteries that have gradually appeared on the market, alkaline Zn-Mn dioxide batteries are the most commonly used for portable equipment. These latter devices, as is well known, convert chemical energy produced by internal (irreversible) redox reactions into a flow of electrons in the external circuit. In fact, when an alkaline battery of this type discharges, the electrolytic water decomposes into H^+ and OH^- ions. The H^+ ion reacts with the contained MnO_2, forming an interstitial compound, simultaneously transferring an electron. In fact, in the reduction process: $MnO_2 + xH^+ + xe^- <=> H_xMnO_2$ (being x = 2). In this reduction process, manganese goes from an oxidation number of +4 to +2. At the same time, the hydroxyl ion OH^- oxidizes the metal zinc, which changes to zinc hydroxide, $Zn(OH)_2$, that is, the metallic zinc loses two electrons ($2\ e^-$),i.e.,: $Zn + 2OH^- <=> Zn(OH)_2 + 2e^-$ (Zn passes from Oxide Number = 0, to O.N.= +2). At the beginning of the discharge, when less than 40% has reacted ($x < 0.4$), the intermediate component H_xMnO_2 has the same structure (ramsdellite) as MnO_2. As the discharge continues, a new compound appears, MnOOH (groutite) (where the O.N. of manganese is +3). This new compound has a very different structure and cannot be transformed back into ramsdellite, even by changing the pH, i.e., by removing H^+ from the solution. This is why, during the discharge (i.e., when becomes $x < 0.5$, **the reaction is no longer reversible), i.e., the battery cannot be recharged**. For this purpose at least two main possible formats are reported in the literature). Unfortunately both of these formats, however, are rather expensive and complicated. So our research group is studying a simple and inexpensive circuit based on the Arduino UNO R3, Atmel based; **however, given the above, it is first necessary to measure the residual charge of an alkaline battery**. **This is precisely the topic of this paper**. On the other hand, accurately measuring the residual charge is a complex task. **The aim of this work is to build a simple hand-made instrument, based on Arduino [1], that estimates the state of charge of an alkaline battery**, such as AA/LR06, in three steps. The first step involves measuring the voltage with a high-impedance voltmeter (Atmel stated > 100 Mohm) with 10 steps of 1 sec, simulating no load. The second step involves a relay connecting the battery to a 100 Ohm resistive load simulate a low discharge. The third step includes a 10-second relaxation period, to allow the battery to regenerate, open a relay and the voltage is measured again with 10 steps of 1 sec with no load. So far, with our device, up to this point, we have measured the values of residual charge of 158 disposable primary batteries, obtained using the last point of the discharge each curve: from which we can conclude that 48% of the measured batteries show a residual voltage between 1.2 and 1.6 V. Once this first part of the research is complete, our study will continue by developing a inexpensive device for recharging primary batteries, again using Arduino.

References

[1] Visco, G.; Dell'Aglio, E.; Tomassetti, M.; Fontanella, L.U.; Sammartino, M.P. An Open-Source, Low-Cost Apparatus for Conductivity Measurements Based on Arduino and Coupled to a Handmade Cell. Analytica 2023, 4, 217–230.