XXV SIMPÓSIO BRASILEIRO DE ELETROQUÍMICA E ELETROANALÍTICA
20 a 23 de outubro de 2025
Majestic Hotel - Águas de Lindóia - SP - Brasil

Teaching chemistry with Arduino: Expanding the knowledge on the biamperometric titration curve

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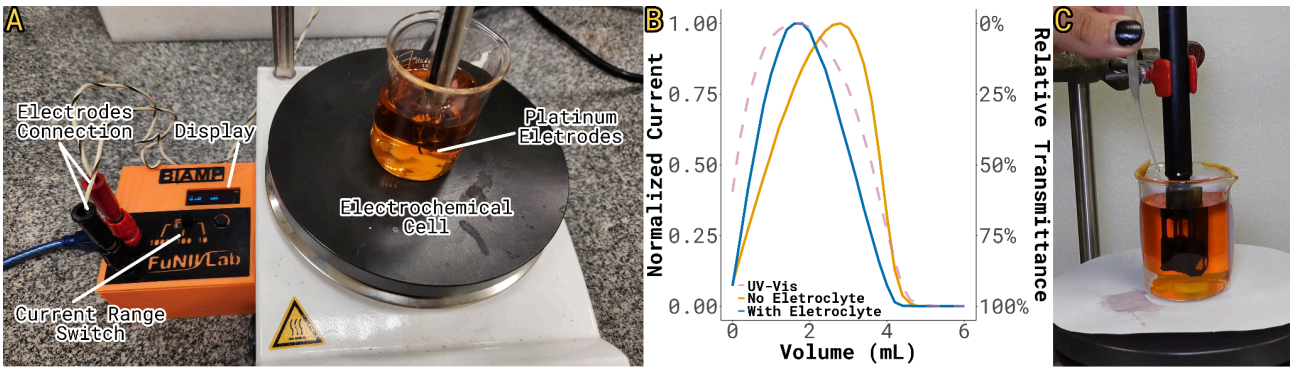
Biamperometry is an electrochemical technique commonly employed to identify the end point of titrations involving a reversible redox species, like in the titration of water by iodine in a Karl-Fisher equipment. It uses two identical electrodes biased against each other at a low overpotential to drive opposite, and self-limiting, redox reactions, perceived by the flux of current between them when a redox couple is in solution[1]. After the titration equivalence point only one of the species of the couple is in solution and there is no current flow ("dead-stop")[2]. Despite its use for teaching fundamental concepts like overpotential and reversibility [1], the current profile remains underexplored, with focus only to the identification of the "dead-stop" endpoint. We developed an affordable, Arduino-based biamperometry device, capable of measuring and recording currents (Fig A), and show that the current profile (Fig B) actually carries a wealth of information on the titration system, from solution conductivity to reaction stoichiometry. Using our equipment for the titration of I_2 with $S_2O_3^{2-}$, a usual teaching practice, we show that the current maximum is not at the stoichiometric ratio of I_2 and I^-, as taught, but rather between I_2 and I_3^- with I_3^- being both reduced and oxidized at the electrodes. We corroborate this finding by following the I_3^- concentration in solution using our lab-made, Arduino-based, optrode (Fig C). Our affordable setup demonstrates how using custom built instrumentation, allows for in depth investigation of chemical systems, helping in experimental practices and chemical teaching in general.



(A) Biamperometry experiment setup (B) I_2 dead-stop titration tracked by transmittance and biamperometry in different conditions (C) Arduino-based optrode measuring I_3^- transmittance

Acknowledgments:
FAPESP processes: 2024/18651-2 and 2021/00800-3

References: [1]Paul Delahay, Analytica Chimica Acta, 1950, 4, 635-540.[2] C. W. FoulkA, T. Bawden J. Am. Chem. Soc. 1926, 48, 8, 2045–2051