

# Recent Developments in Single-Entity Electrochemistry

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Cite This: <https://doi.org/10.1021/acs.analchem.4c01406>

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## INTRODUCTION

At some levels, single-entity electrochemistry (SEE) is enigmatic. First defined at a Royal Society of Chemistry Faraday Discussion in 2016,<sup>1–3</sup> SEE encompasses a broad range of studies that are linked by underlying concepts, principles, and experimental/theoretical challenges that can include low current, high speed, and statistical treatments of electrochemical signals that originate from a single “thing”, that “thing” being a single nanoparticle, protein, or cell, etc. Since the inception of the general concept, the field has expanded and grown to studies beyond the original descriptions, often as technology and methods applicable to SEE have grown.<sup>4–10</sup> SEE has proven to be especially timely, as methods are often well-matched to advances in data-driven approaches like machine learning (ML) and artificial intelligence.

In this Review, we highlight selected examples from the SEE community with an emphasis on results in the last two years. Examples are classified based on technique or approach and include purely electrochemical examples, as well as opto-electrochemical examples. Additional considerations related to sample preparation, which proves to be critical for SEE, are also highlighted. Future prospects are considered as well, in context of where the field resides today.

## NANOELECTRODES FOR SINGLE-ENTITY ELECTROCHEMISTRY

The most straightforward SEE measurement consists of a single electrode employed to measure a single entity.

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