Research Skills (1)

Scientific Writing

Scientific Writing: Easy when you know how, Jennifer Peat, BMJ Books 2002

Ahmad Alakraa

Outline

- Reasons to publish
- Effective scientific writing
- Components of a scientific paper

What is written without effort is in general read without pleasure.

Samuel Johnson (1709–1784)

Reasons to Publish

Scientists communicate the fruits of their labor mostly in writing, and mostly in scientific journals.

Conferences and other forms of verbal communication, including the evening news, play an important role but the written word reaches the widest audience and constitutes the archival message.

Kenneth Rothman

Reasons to Publish

- It is unethical to conduct a study and not report the findings.
- You have some results that are worth reporting.
- You want to progress scientific thought or improve something.
- You want to give credibility to your research team.
- You want your work to reach a broad audience.
- Your track record will improve.
- You will add credibility to your reputation.
- You will improve your chance of promotion.
- You are more likely to obtain research grants.

A well-written paper is one that is easy to read, tells an interesting story, has the information under the correct headings, and is visually appealing.

Generally, keep it short and to the point. It is not a novel you are writing. If you get stuck, take a break. Leave the draft by your bedside. Sometimes a phrase just comes to you, and it is a shame to lose it.

Anthony David

If you became a good writer

- Writing time is more productive and less frustrating.
- Peers will take you more seriously.
- Your research is more likely to lead to publications.
- Your grant applications are more likely to be funded.
- Your expertise will help you to become a good reviewer or editor.

Achieving creativity

You should allow yourself to get into a writing mood.

- Finish the background reading, the review of the literature, and the work to date.
- You know it inside out.
- Relax.
- Take deep breaths.
- Just let it flow.
- Wear comfortable clothes; select the place and timings.

Basic aspects to effective scientific writing

- ***Thought*** is a matter of having some worthwhile results and ideas to publish. New results that you can interpret correctly.
- ***Structure*** is simply a matter of getting the right things in the right place.
- ***Style*** is a matter of choosing the fewest and most appropriate words and using the rules of good grammar.

Components of a scientific paper

- Title
- Abstract
- Keywords
- Introduction and literature review
- Methods or Experimental
- Results and discussion (including illustrations)
- Conclusions
- Acknowledgment
- References
- Supporting info.

It is logical to begin by writing the methods and then the results sections.

The introduction and discussion can be pieced together as you progress, and finally you will need to condense it all into an abstract.

Title

First thing to be read

- Be short, accurate, attractive and unambiguous.
- Convey the main topics of the study.
- Highlight the importance of the research.
- do not contain **abbreviations**
- Give your paper a distinct personality.
- Begin with the subject of the study.
- Do not repeat words in titles.
- Pure guards, Electropool, TRIPURE WATER, Gray2Grow are all **inappropriate** titles for a manuscript dealing with water purification.

Abstract

250 words added to a public database

- Provides a condensed, potted history of your results.
- Conveys only the **most** interesting and **most** important parts of your work.

should be organized as following:

aims ⇒ basic study design and methods ⇒ main results including specific data and their statistical significance ⇒ conclusion and interpretation.

Bad Abstract

Pt-based catalysts have a long history of use in formic acid oxidation reaction (FAOR). Although the single metal Pt is active in FAOR, it is costly, scarce and rapidly deactivates. Recognizing the mechanism of FAO over Pt is essential for rational catalyst design. Because of CO poisoning of Pt active sites via the dehydration pathway, Pt nanomaterials deactivate quickly. The addition of another transition metal (Au) and/or metal oxide (FeOx) improves the performance of Pt-based catalysts through ensemble and *bi*-functional. The prepared catalysts' morphologies were examined using file emission scanning electron microscopy (FE-SEM), and their chemical compositions were determined using X-ray diffraction (XRD) and Energy-dispersive X-ray spectroscopy (EDS). The electrochemical engineering of spherical Pt nanoparticles (nano-Pt: ~ 146 nm in average diameter) was accomplished with spherical Au nanoparticles (nano-Au: ~ 182 nm) and intersected iron oxide nanowires (nano-FeOx: ~ 42 and 172 nm in average diameter and length). The FeOx/Au/Pt/GC catalyst exhibited ∞ and 0.65 in the catalytic activity and poisoning tolerance, respectively, of the formic acid oxidation reaction (FAOR). It is noticeable that the surface of the FeOx/Au/Pt/GC catalyst is no longer poisoned by CO, the surface of the FeOx/Au/Pt/GC catalyst mitigated CO poisoning completely. In addition, it enhanced the transmission of the charge and stability of the catalyst during FAOR.

Good Abstract

Under Pub.

A successful amendment of semi-spherical platinum nanoparticles (nano-Pt, ca. 146 nm in average diameter) that were assembled onto a glassy carbon (GC) rod with gold nanoparticles (nano-Au, ca. 182 nm in an average diameter together with nano-Pt) and iron oxide nanowires (nano-FeOx, ca. 43 nm in average diameter and 172 nm in average length) presented a robust catalyst for the electrochemical oxidation of formic acid (EOFA). The layers' sequencing of the catalyst was critical in optimizing the catalyst's efficiency. Surprisingly, the modification of the Pt/GC catalyst first with nano-Au and next with nano-FeOx (FeOx/Au/Pt/GC catalyst) decreased the electrochemical surface area of nano-Pt ca. 16-times, which is highly desirable. Besides, it increased tremendously the activity (two-orders of magnitude), stability (ca. 18-fold) and tolerance against CO poisoning (7-times) of the catalyst for EOFA. Moreover, it saved up to ca. –236 mV in the onset potential of the "non-poisoning" dehydrogenation pathway of EOFA. With the aid of multiple materials and electrochemical inspections, the catalyst's development was confirmed, and the role of catalytic ingredients was elucidated. Interestingly, nano-Au hindered geometrically the adsorption of poisoning CO molecules onto the Pt surface, whereas nano-FeOx improved significantly the charge transfer kinetics of EOFA.

Introduction ~ 1 page

- should be short, attractive and informative about the reason why you undertook the study.
- Its structure should funnel down from a broad perspective to a specific aim.
- The first paragraph should be a very short summary of the current knowledge of your research area.
- The second paragraph that summarizes what other people have done in this field, what limitations have been encountered with work to date, and what questions still need to be answered.
- The last paragraph should clearly state what you did and why.

Template for Introduction

Paragraph 1:

What we know

Paragraph 2:

What we don’t know

Paragraph 3:

Why we did this study

Notes about Introduction

- Be innovative in addressing & developing a problem.
- Topic sentences are a great help.
- You do not need to review all available **literature (cite)**.
- Discard scientifically weak studies.
- Avoid including a lot of material in the introduction section that would be better addressed in discussion.
- Readers will not want to be told basic information that they already know.
- Do not begin by quoting the literature.
- Last paragraph should give details of your aim or hypothesis not a quick summary of your own results.

Good Introduction

The energy and environmental crises have become global issues as a result of the overexploitation and rapid depletion of fossil fuels [1,2]. Currently, H_2 is enjoying unprecedented momentum as a lively clean fuel and energy carrier for its abundance, small size, odorless, colorless, tasteless, no carbon content, and high mass energy density (143 MJ kg^{-1}) [3]. Hydrogen fuel cells (HFCs) that resemble the galvanic reactors in converting the chemical energy into electricity utilizing the H_2 (that can be supplied directly or from proton-containing or storing materials) oxidation and O_2 reduction have found potential applications in transportation and in several portable, stationary and emergency backup power devices [4-6]. Yet, H_2 owns a low volumetric energy density (~10 kJ L^{-1} at 298 K, 1 atm), extreme flammability, very low density in the gaseous state, high cost of miniaturization for its containers, and insecure delivery that stood obstacles against a practical commercialization [3,7-9]. Suggested scenarios to overcome these challenges included the use of various solid and liquid hydrogen storage materials as metal hydrides [10], sodium borohydride [11], hydrazine hydrate [12], ammonia [13] and amine-borane complexes [14]. However, their exorbitant price and their poisonous, flammable and explosive nature have limited their implementation [7].

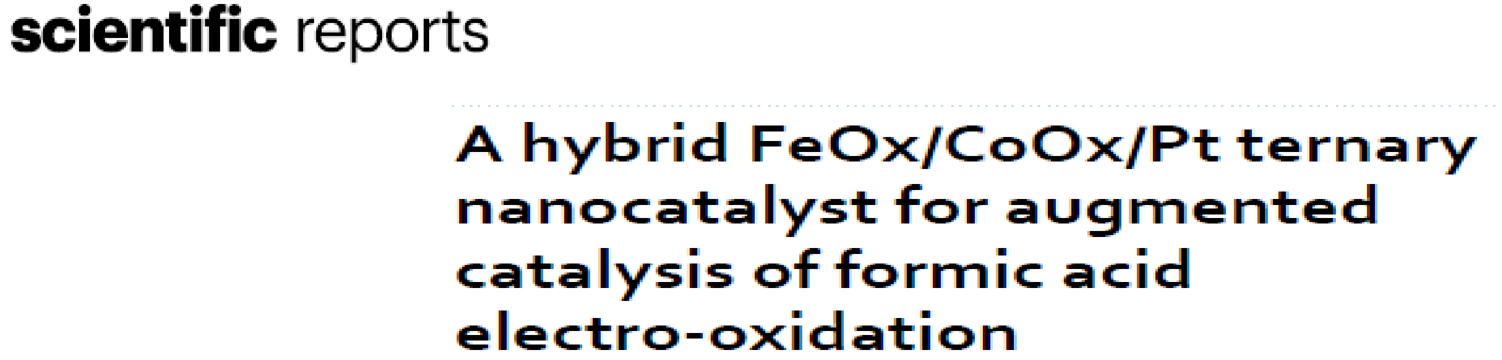
Formic acid (FA) has next appeared as a potential hydrogen carrier with a high availability, non-toxicity, non-flammability, high hydrogen capacity (~ 4.4 % by mass), high volumetric hydrogen content (53 g L^{-1} under standard temperature and pressure), high specific energy (5.3 MJ kg^{-1}) and high volumetric energy density (6.4 MJ L^{-1} at ambient conditions) [9,15-20]. It compensates its comparatively lower theoretical energy density to that (~22 MJ kg^{-1}) of methanol with its much lower crossover rate through the Nafion membrane; opening opportunity to use much higher fuel concentrations and to design portable compact power systems [21-25]. However, to efficiently comply FA for fuel cells' technology and to adopt the direct formic acid fuel cells (DFAFCs) for a convenient, economic and robust transformation of the chemical energy into electricity, durable and competent catalysts for the FA electro-oxidation (FAO) must be developed.

Platinum and Pt-based materials have long been recommended for the oxidation of small organic molecules including FA [20,26,27]. However, the high price of Pt as a precious element together with its deactivation in a long-termed operation by accumulated poisonous intermediates (e.g., CO) remained an issue to be resolved [28,29]. To design cost-effective catalysts and to improve the electrocatalysis of FAO in DFAFCs, it is critical to understand the FAO mechanism and the variables affecting the reaction kinetics [30].

Since the 70s, several mechanisms have been proposed for the FAO on Pt, which have recently been reevaluated after several spectroscopic studies and density functional theory (DFT)-based theoretical calculations [26]. Capon and Parsons [31] suggested the first possible mechanism, consisting of the direct and indirect routes. A fast reaction through a reactive intermediate, which is immediately oxidized further to CO_2, is involved in the direct route. The $^{-}COOH$ species (bonded by a carbon atom) was previously suggested as a potential candidate, but no spectroscopic evidence could be obtained in this direction that could be replicated. Formate ($HCOO^{-}$) was proposed by Osawa *et.al*. [32,33] as a reactive intermediate in the direct route in a bridge-bonded configuration, which means both oxygen atoms are bonded to two surface sites. The other indirect route involves a step in the creation of an inhibiting intermediate that impedes further FA adsorption. The adsorbed CO (CO_{ads}) was established unambiguously as the poisonous species for this indirect route [26,34]. However, the mechanism of the dual route and the role of the bridge-bonded formate as an active intermediate were discussed controversially [35]. One significant argument is that the faradaic current observed experimentally increases more rapidly than the coverage of the bridge-bonded formate in chronoamperometric measurements with different concentrations of FA.

This means that in the dominant reaction route, the adsorbed bridge-bonded formate cannot be regarded as a reaction intermediate. Others proposed a third route for the FAO mechanism, based on the fact that the formate is a spectator rather than a reactive intermediate [36-38]. However, studies using improved infrared techniques which allowed monitoring the reactions dynamics together with DFT calculations showed that formate could be an active intermediate in the FAO [39,40]. While CO_{ads} initial formation rate is very slow, its accumulation on the Pt surface seriously poisons the active sites and impedes the direct route. The low reserve and high price of Pt restrict its commercial applications; thus, it is necessary to design and develop high effective Pt-based catalysts with high utilization that could reduce the use of Pt while improving the catalytic activity for FAO [41]. Modifying the Pt surface with metal (e.g., Sn [42], Bi [43], Au [44-46], Ni [47], Co [48], and Fe [49]) and/or transition metal oxides (TMOs, e.g., NiOx [50], CoOx [21,51], WO_3 [52], MnOx [53-55] and FeOx [56-59]) could effectively minimize and possibly eliminate this poisoning with a significant geometrical (third-body), *bi*-functional and/or electronic improvement of the catalytic FAO. According to the Langmuir-Hinshelwood model, poisoning CO species can be oxidatively desorbed from the Pt surface after being hydroxylated at high overpotentials in aqueous solutions [60].

This desorption was accelerated at earlier overpotentials when the Pt surface was modulated with CoOx or FeOx, that promoted the electrochemical dissociation of H_2O at the Pt surface [61,62]. The existence of TMOs (having a tendency to convert easily between low and high oxidation states, and having unfilled d-orbitals) at the Pt surface is expected, moreover, to accommodate the transferred electrons during FAO in a faster reaction mechanism, that in turns, speeds up the oxidation kinetics. Recently, Pt-based ternary catalysts have emerged as promising candidates compared to bimetallic alloys because of their ability to enhance the structural properties of Pt and thus maintaining its catalytic activity for long durations [61]. In this study, a ternary FeOx/CoOx/Pt catalyst is designed; aiming at increasing its catalytic activity and CO tolerance toward the FAO.



scientific reports

A hybrid FeOx/CoOx/Pt ternary nanocatalyst for augmented catalysis of formic acid electro-oxidation

Methods/Experimental ~2 pages

- How did you obtain your results?
- Give precise details of the study design, the methods that you used, and how you analyzed the data.
- Other researchers should be able to evaluate your work critically or repeat your study exactly the way that you did it.
- Sectioning is allowed.

Bad Experimental

2.1 Materials and methods

missing chemicals

In the electrochemical setup, the working, reference and counter electrodes were a glassy carbon (GC, $d = 3.0$ mm) encased rod, an Ag/AgCl/KCl (sat.) electrode and a Pt spiral wire, respectively. The GC electrode was conventionally cleaned before the electrochemical measurements, which were conducted at room temperature (25±1 °C) in a two-compartment, three-electrode conventional glass cell at a Bio-Logic SAS potentiostat (model SP-150) operated through EC-Lab software. The catalytic performance of the prepared electrodes toward electro-oxidation of formic acid (EOFA) was investigated in 0.3 M FA solution (pH = 3.5).

2.2 Electrochemical characterization

electrochemical characterizations?

The morphology of the catalyst and the relative compositions of the catalyst's ingredients were examined using field-emission scanning electron microscope (FE-SEM, QUANTA FEG 250) coupled with an energy dispersive X-ray spectrometer (EDS) . The diffraction patterns of the modified electrodes were obtained using an X-ray diffraction (XRD) spectroscope with grazing incidence and Cu K radiation at 45 kV and 360 mA (D8-DISCOVER, Bruker AXS.

Good Experimental

2.1 Chemicals, setup and pretreatment

All chemicals in this investigation were purchased from trusted suppliers with analytical grades and were used without prior purification. Potassium hexachloroplatinate (IV) (K_2PtCl_6), iron (II) sulfate heptahydrate ($FeSO_4.7H_2O$), sodium hydroxide pellets (NaOH), formic acid (HCOOH), and sulfuric acid (H_2SO_4) were purchased from Sigma-Aldrich. While potassium gold (III) chloride ($KAuCl_4$) was purchased from ABCR, sodium sulfate (Na_2SO_4) was purchased from Merck. The electrochemical setup assigned a glassy carbon (GC, 3.0 mm in diameter) encased rod, an Ag/AgCl/KCl (sat.) electrode and a Pt spiral wire, as the working, reference and counter electrodes, respectively. The GC electrode was conventionally cleaned by polishing with emery paper then with aqueous slurries of finer alumina powder on a cleaning microcloth. After that, the polished GC electrode was sonicated for 10 min before washing finally with distilled water.

2.2 Catalyst's fabrication

The electrodeposition of nano-Pt onto the bare GC (assigned as Pt/GC) electrode was carried out in 0.1 mol L^{-1} H_2SO_4 electrolyte containing 1.0 mmol L^{-1} K_2PtCl_6 at a constant potential electrolysis of –0.2 V for 300 s [46]. On the other hand, nano-FeOx was deposited onto the Pt/GC (assigned as FeOx/Pt/GC) electrode using cyclic voltammetry (CV) for two cycles in the potential between –0.855 and –1.205 V at a scan rate of 100 mV s^{-1} in an aqueous solution of 0.02 mol L^{-1} $FeSO_4.7H_2O$ [10, 43, 47]. Whereas nano-Au was deposited electrochemically onto the Pt/GC (assigned as Au/Pt/GC) and on FeOx/Pt/GC (assigned as Au/FeOx/Pt/GC) electrodes from 0.1 mol L^{-1} H_2SO_4 containing 2 mmol L^{-1} $KAuCl_4$ solution at a constant potential electrolysis of –0.2 V for 300s [46].

2.3 Electrochemical measurements

All prepared catalysts were electrochemically characterized before and after modification with nano-Au and/or nano-FeOx nanoparticles by measuring their characteristic CVs in 0.5 mol L^{-1} NaOH and H_2SO_4. The corresponding real surface areas of the catalysts were estimated considering a reference value of 210 μC cm^{-2} for desorption of a monolayer of hydrogen atoms (H_{des}) from the Pt surface [43, 44]. The Pt loading in the catalysts was estimated by dissolving the Pt content from the catalyst in 13 mL 1 mol L^{-1} HNO_3 and analyzing Pt by Inductively Coupled Plasma - Optical Emission Spectrometer (ICP-OES, Agilent 5100). The electrocatalytic activity toward EOFA of the prepared catalysts was tested in 0.3 mol L^{-1} FA (pH =3.5) with the pH adjusted with sodium hydroxide. In fact, iron oxide is instable in highly acidic solutions, hence, the catalytic activity measurements were recorded in a slightly acidic medium within the iron oxide's stability domain. This pH ensures, moreover, the dissociation of a large (~ one third) quantity of FA to formate anions which improves the ionic conductivity of the electrolyte [48].

Results & discussion

~3 pages excluding Figures and Tables

- most important part that give specific answers to the aims.
- You should use an interesting sequence of text, tables, and figures to answer the study questions and to tell the story without diversions.
- Make sure the data in all representations are consistent and support each other.
- Appreciate the difference between data and analysis.
- Take it step by step and sustain harmony in your description and analysis.

- Do not depend on the blindness of readers. Do not say “ as you see” where nothing is obvious.
- Do not label something in the analysis that does not exist, as in XRD charts.
- Prepare your figures perfectly in the best way and use up to date editing programs.
- Use the same format (colors, thickness, fonts, etc.) in all figures.
- Use the same color schemes in all Figures and Tables.
- Write detailed descriptive captions.
- Figures captions are located under the figures, in contrast to Tables captions.

- You may need to repeat some measurements or add more analysis.
- Make sure to stick with SI units and common abbreviations for units: h not hour, min not minutes, s not sec or seconds, 0.5 mol/L or 0.5 mol L^{-1} not 0.5 M. kilo is represented as “small” k not “capital” K.
- Write equations with equation editor embedded in Word.
- Review numbering in text and in captions.
- Do not leave obvious variations without explanation.
- Do not start a sentence with “And”.

Reporting Numbers

- Numbers less than 10 are words. In the study group, eight participants underwent the intervention.
- Numbers 10 or more are numbers. There were 120 participants in the study.
- Words not numbers (nor abbreviations) begin a sentence. Twenty per cent of participants …….
- Be consistent in lists of numbers. In the sample, 15 boys and 4 girls had diabetes.
- Numbers less than 1 begin with a zero. The P value was 0.013.
- Do not use a space between a number and its per cent sign. In total, 35% of participants had diabetes.

- Use one space between a number and its unit The mean height of the group was 170 cm.
- Report percentages to only one decimal place if the sample size is larger than 100. In our sample of 212 children, 10.4% had diabetes.
- Do not use decimal places if the sample size is less than 100. In our sample of 44 children, 10% had diabetes.
- Do not use percentages if the sample size is less than 20. In our sample of 18 children, two had diabetes.
- Do not imply greater precision than your measurement instrument. Only use one decimal place more than the basic unit of measurement.

- For ranges use “to” or a comma but not “–” to avoid confusion with a minus sign and use the same number of decimal places as the summary statistic. The mean height was 162 cm (95% CI 156 to 168). Or (95% CI 156, 168).

Tables

- Tables are invaluable for presenting numerical results but should not be too large.
- keep tables as simple and organized as possible.
- Row and column headings should be brief but sufficiently explanatory.
- Standard abbreviations of units of measurements should be added in parentheses.
- Impressive borders, shading, and multiple grids are both distracting and unnecessary.
- Follow instructions to authors in designing Tables.
- It is better not to present the same data in both a figure and a table, and never to repeat data from figures or tables in the text.

Figures

- A cryptic approach is to show your most important findings as a figure, but only as long as the figure does not take up much more space than reporting the data would.
- A good figure tells the story in a single grab and stays in a reader's mind.
- Should neither be too simple nor too complicated.
- The symbols, abbreviations, highlighting, line types, and bars must all be very clear.
- Figure's legend should be comprehensive.
- Tables & figures should be printed on separate pages and included at the end of the manuscript.

Points to be in Discussion

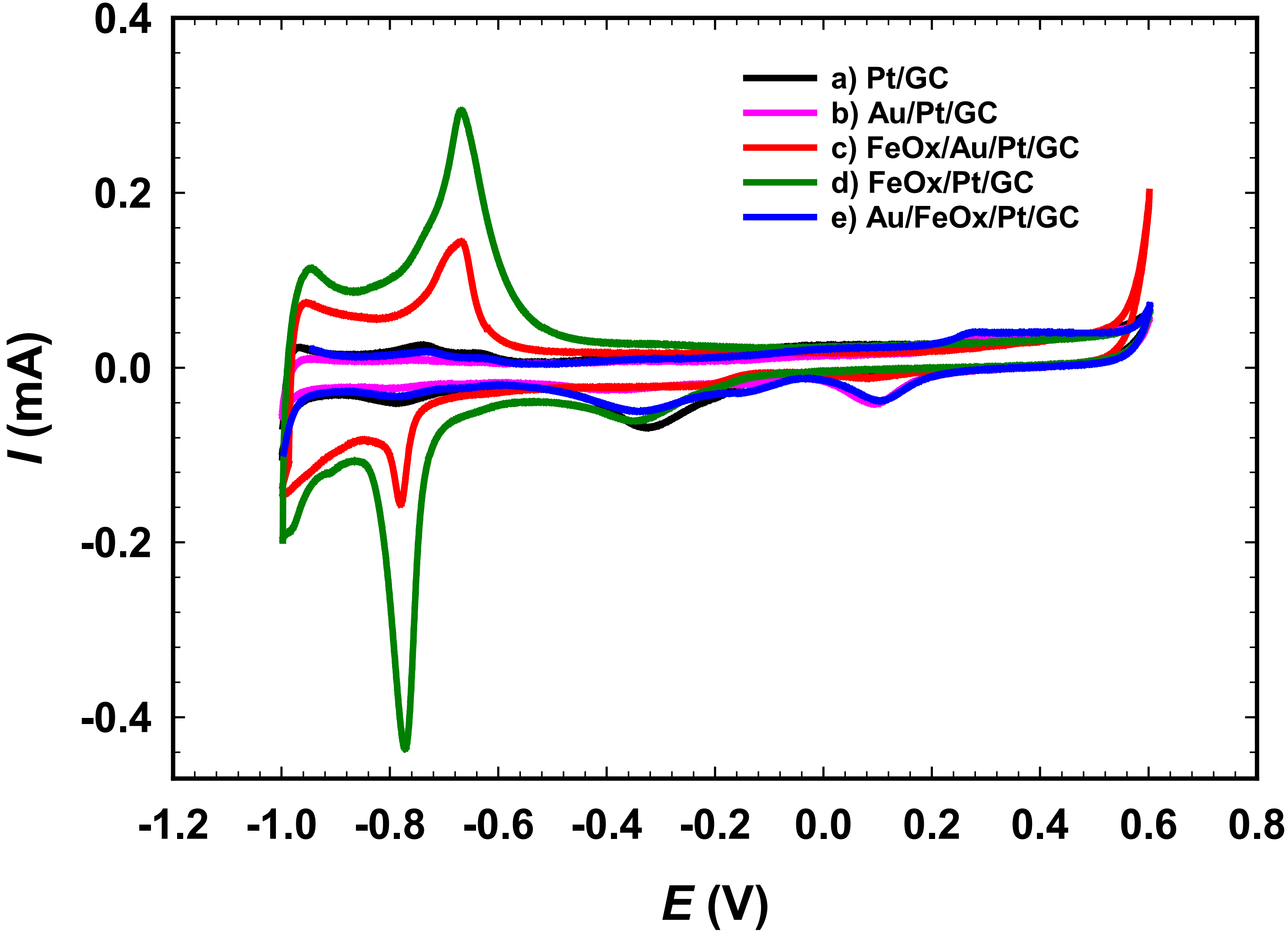
Paragraph 1: What did this study show? Address the aims stated in the Introduction

Paragraph 2: Strengths and weaknesses of methods

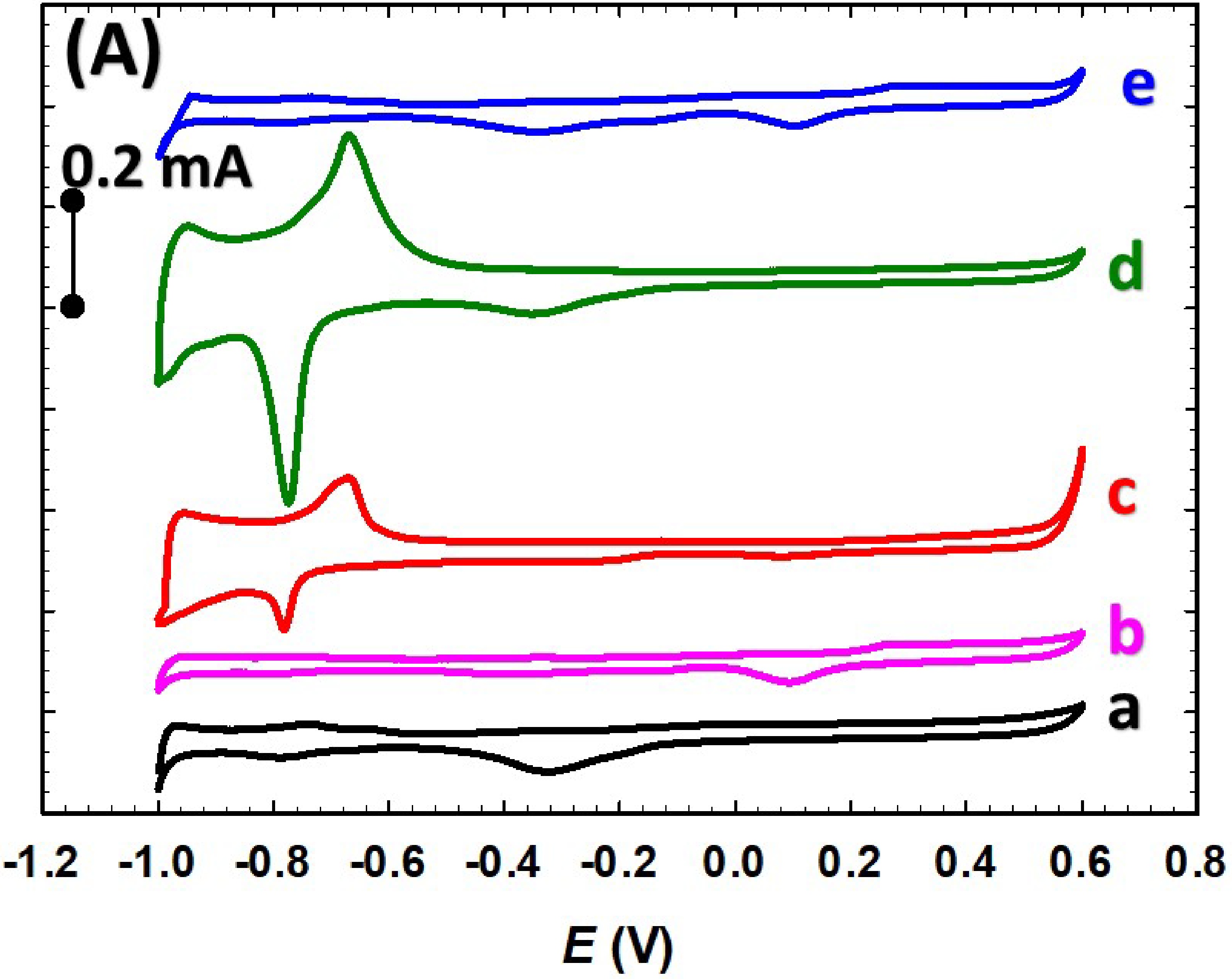
Paragraph 3: Discuss how the results support the current literature or refute current knowledge

Last Paragraph: Future directions “So what?” and “where next?” Impact on current thinking or practice

Electrochemical characterization



CVs in 0.5 mol L^{-1} NaOH at 50 mV/s.



CVs in 0.5 mol L^{-1} (A) NaOH (B) H_2SO_4 for (a) Pt/GC, (b) Au/Pt/GC, (c) FeOx/Au/Pt/GC, (d) FeOx/Pt/GC and (e) Au/FeOx/Pt/GC catalysts at a scan rate of 50 mV s^{-1}.

Conclusions: One paragraph

- Remind the reader why the article was written
- Repeat the argument that has been made.
- State the most important findings and outcomes in numbers.
- Interpret your findings at a higher level of abstraction.
- Show whether, or to what extent, you have succeeded in addressing the need stated in the introduction.
- So what?
- Mention limitations of your study.
- Offer suggestion on how your research can be expanded or improved.

Good Conclusions

A propitious electrocatalyst based on the amendment of a bare-Pt electrode with Ru nanowires (nano-Ru) and iron oxyhydroxide (nano-FeOx) was recommended for the formic acid oxidation reaction (FAOR). The deposition of the different layers of the catalyst employed the layer-by-layer protocol, and the deposition order influenced greatly the catalytic activity. The best efficiency of FAOR was achieved at the FeOx/Ru/Pt catalyst for which nano-Ru and nano-FeOx enhanced perfectly the electronic and geometrical properties of Pt at the catalyst's surface. The I_p^d/I_p^{ind} ratio (= 14.44) of FAOR at this catalyst was the highest in this investigation and was much higher than many of previously reported values. It also achieved ca. 24 mV in E_{onset} which envisioned the practical and commercial application of this catalyst in DFAFCs. This modification nano-Ru and nano-FeOx enriched the Pt surface with oxygenated species (e.g., O–H groups) that boosted the indirect route of FAOR at lower overpotentials. The EIS measurements assigned the charge transfer as the rate determining step for the FAOR at these catalysts, but the kinetics of this step were improved significantly with the binary modification of the bare-Pt surface with nano-Ru and nano-FeOx.

References

- All citations must be accurate
- Include only the most important, and most recent literature.
- Quote only published journal articles or books.
- Never quote “second hand”.
- Cite only 20–35 references.

Acknowledgement

- A crucial role that express gratitude and provide a sense of credibility to your work.
- Show that your work is a collective effort.

Supporting info.

- All the experimental work you have done can be added.
- Serves as evidences.

Thank You