Novel Approach to the Synthesis of Supported Gold Nanoparticles for HMF Oxidation

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Background

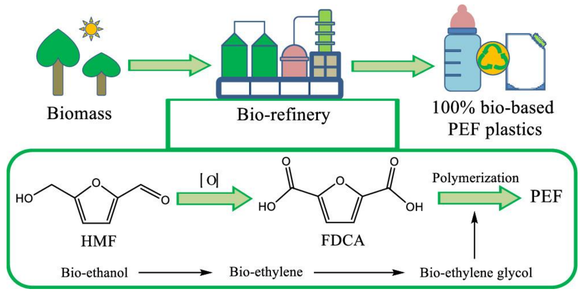


Figure 1. Schematic of the eco-friendly application of HMF in plastics industry.[1]

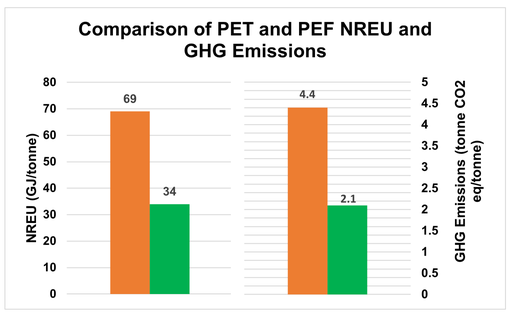
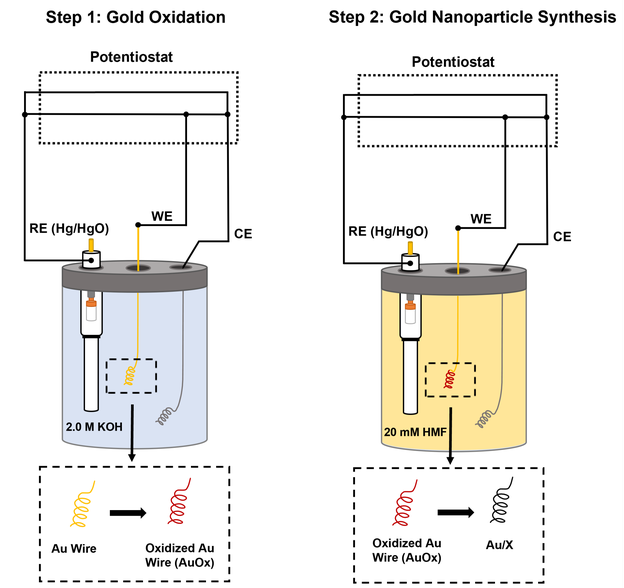


Figure 2. Non-renewable energy usage (GJ/tonne) and greenhouse gas emissions (tonne CO2 eq/tonne) for PET (orange) and PEF (green).[2]

- Biomass-derived feedstock offers a sustainable solution for biodegradable plastics production.
- 2,5-furandicarboxylic acid (FDCA) is a key component, produced via 5-hydroxymethylfurfural (HMF) oxidation.
- Gold-based electrocatalysts show promise for enhancing HMF oxidation reactions (HMFOR) due to their low onset potential and robust stability.

Synthesis Method



Morphology Techniques

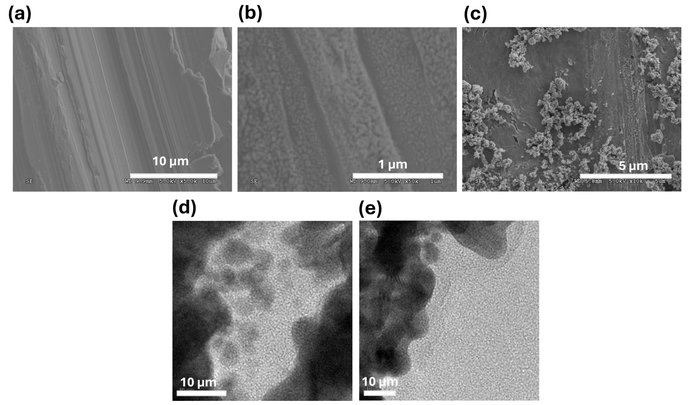


Figure 4: SEM and HR-TEM Images of Au Surfaces

- **Figure 4a-b:** SEM images showing the surfaces of the oxidized gold wire and the synthesized Au/X with CV treatment, respectively.
- **Figure 4c:** SEM image of the Au/X wire without CV, highlighting the less uniformly distributed and rough, porous structure compared to **4b** with CV.
- **Figure 4d-e:** HR-TEM images of the Au/X wire that display the formation of Au nanoparticles (Au NPs). The nature of surrounding film/layer (X) is under investigation.

Results and Discussion

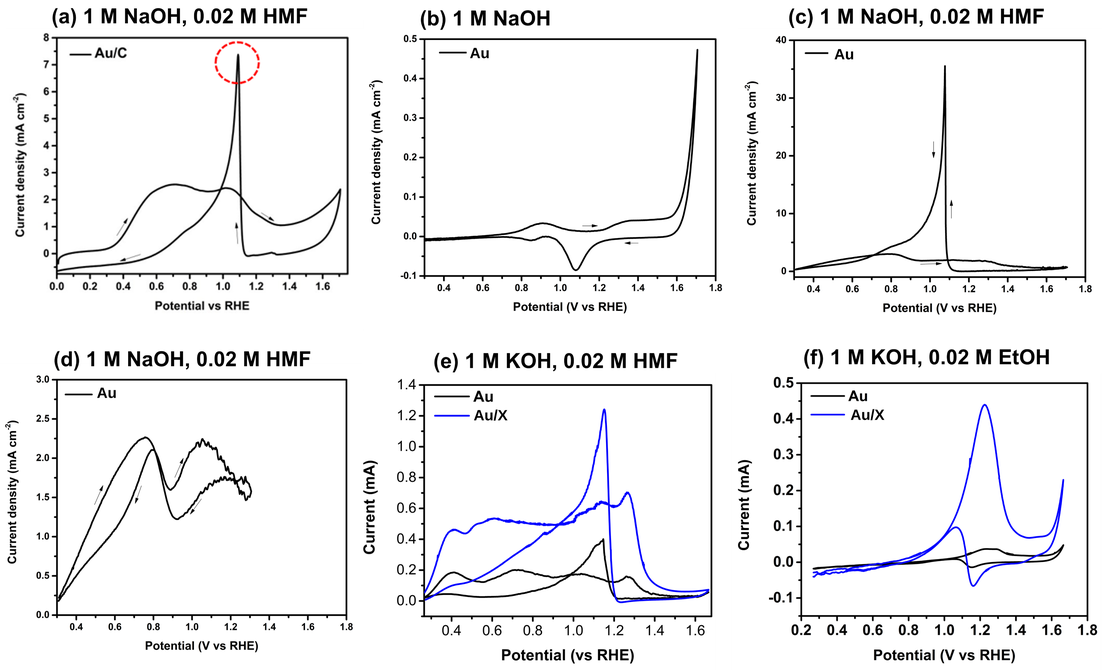


Figure 5: Cyclic Voltammetry (CV) Scans of Au/C, Au, and Au/X vs. RHE

- **Figure 5a:** CV scan of Au/C (Au NPs on carbon) on fluoride tin-oxide (FTO) glass, revealing first observation of unique peak during the reverse sweep.
- **Figure 5b and 5c:** CV scans of the Au wire in alkaline media without HMF **(5b)**, and with HMF **(5c)**. A peak is also observed only in the reverse scan around 1.1V vs RHE, where oxidized gold is reduced.
- **Figure 5d:** CV scan of the Au wire with HMF conducted below the potential range for gold oxide formation, with no reverse peak observed.
- **Figure 5e-f:** Enhanced catalytic activity observed for Au/X in HMF oxidation **(5e)** and ethanol oxidation **(5f)**.

Conclusion and Future Work

- Au/X layer significantly enhances oxidation processes in HMF and other reactants like EtOH, demonstrating the efficacy of gold as an electrocatalyst.
- A simple and reproducible method was established for synthesizing Au nanoparticles.
- Future work will focus on detailed characterization of the catalyst layer and its underlying mechanism by advanced spectroscopy and electrochemical analysis.

Acknowledgements

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2. Clare Boothe Luce Research Scholars Program

References

1. Chen, S., Li, H., Liu, Q., Wang, H., Ren, B., & Huang, H. (2021). Reaction mechanism and kinetics of the liquid-phase oxidation of 5-hydroxymethylfurfural to 2,5-furandicarboxylic acid. Industrial & Engineering Chemistry Research, 60(47), 16887–16898. https://doi.org/10.1021/acs.iecr.1c02730
2. Eerhart, A. J. J. E., Faaij, A. P. C., & Patel, M. K. (2012). Replacing fossil-based PET with biobased PEF; process analysis, energy and GHG balance. Energy & Environmental Science. Royal Society of Chemistry. https://doi.org/10.1039/C2EE02480B

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