

Synthesis and Electrochemistry of Platinum Deposited Monometallic Carbides

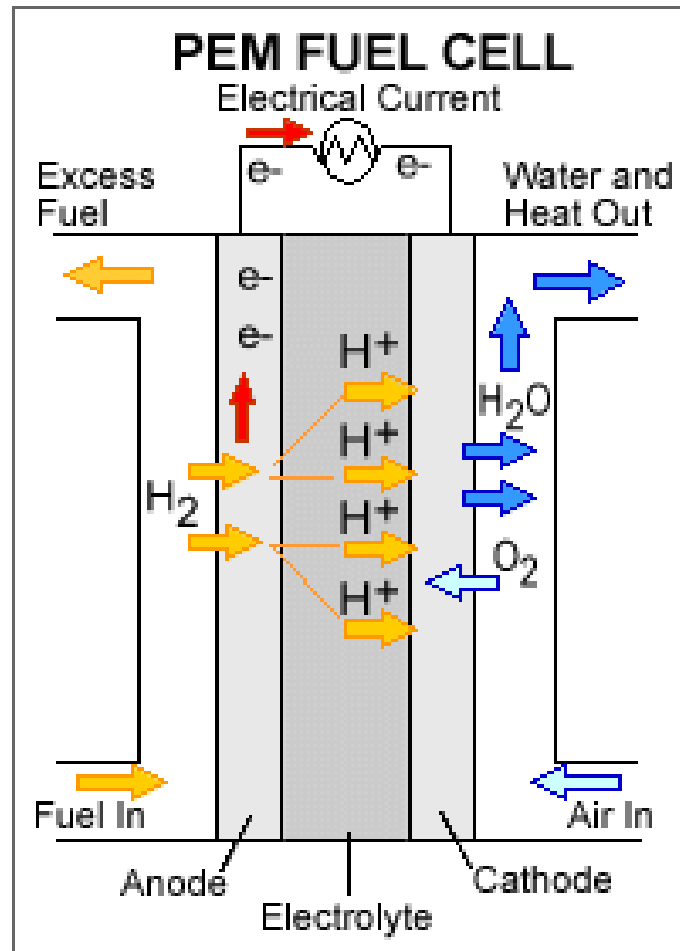
Kyle Duffee, Yagya Regmi, Dr. Brian
Leonard

Need for Renewable Fuels



Photo Credit: US National Park Service

PEMFC



Platinum



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PEMFC Cathode

- Hydrogen Evolution Reaction (HER)
 - $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$
- Oxygen Reduction Reaction (ORR)
 - $\text{O}_2 + 4\text{e}^- \rightarrow 2\text{O}^{2-}$
- Overall Balanced Cathode Reaction
 - $4\text{H}^+ + \text{O}_2 + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$

TMCs

- TMCs have been demonstrated to be catalytically active for HER and ORR.^{1,2}
- Advantage of nano-scale platinum.

1. S. Wirth, F. Harnisch, M. Weinmann and U. Schroder, *Appl. Catal. B*, 2012, **126**, 225.

2. G. He, Z. Yan, X. Ma, H. Meng, P. K. Shen, and C. Wang, *Nanoscale*, 2011, **3**, 3578.

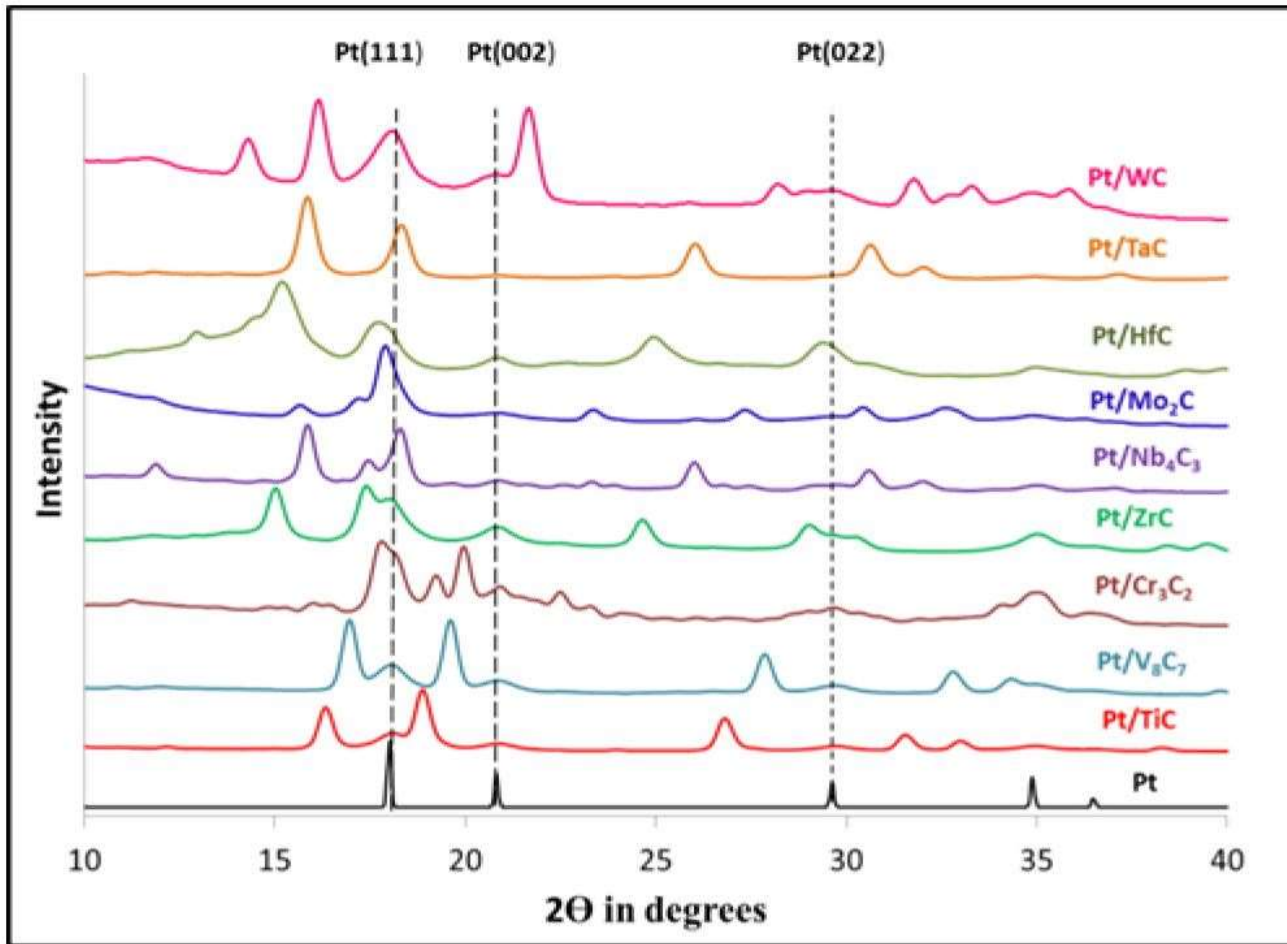
Synthesis

- Salt Flux method for TMCs
- Incipient Wetness Impregnation to deposit platinum

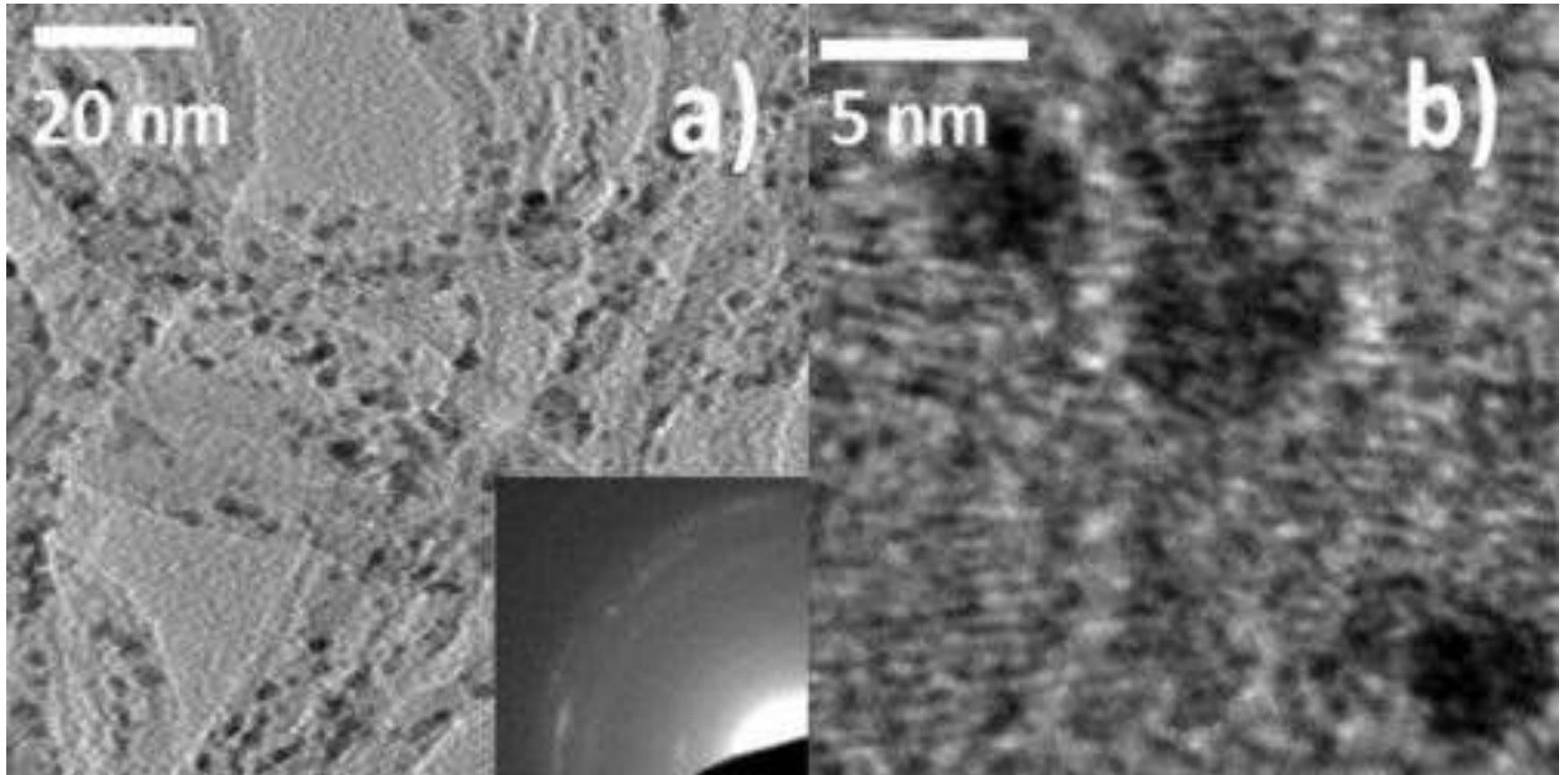
Characterization

- X-Ray Diffraction (XRD)
 - to confirm composition
- Transmission Electron Microscopy (TEM)
 - to confirm morphology
- Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)
 - to confirm platinum concentrations
- Linear Sweep Voltammetry (LSV)
 - Current density is related to catalytic activity

XRD



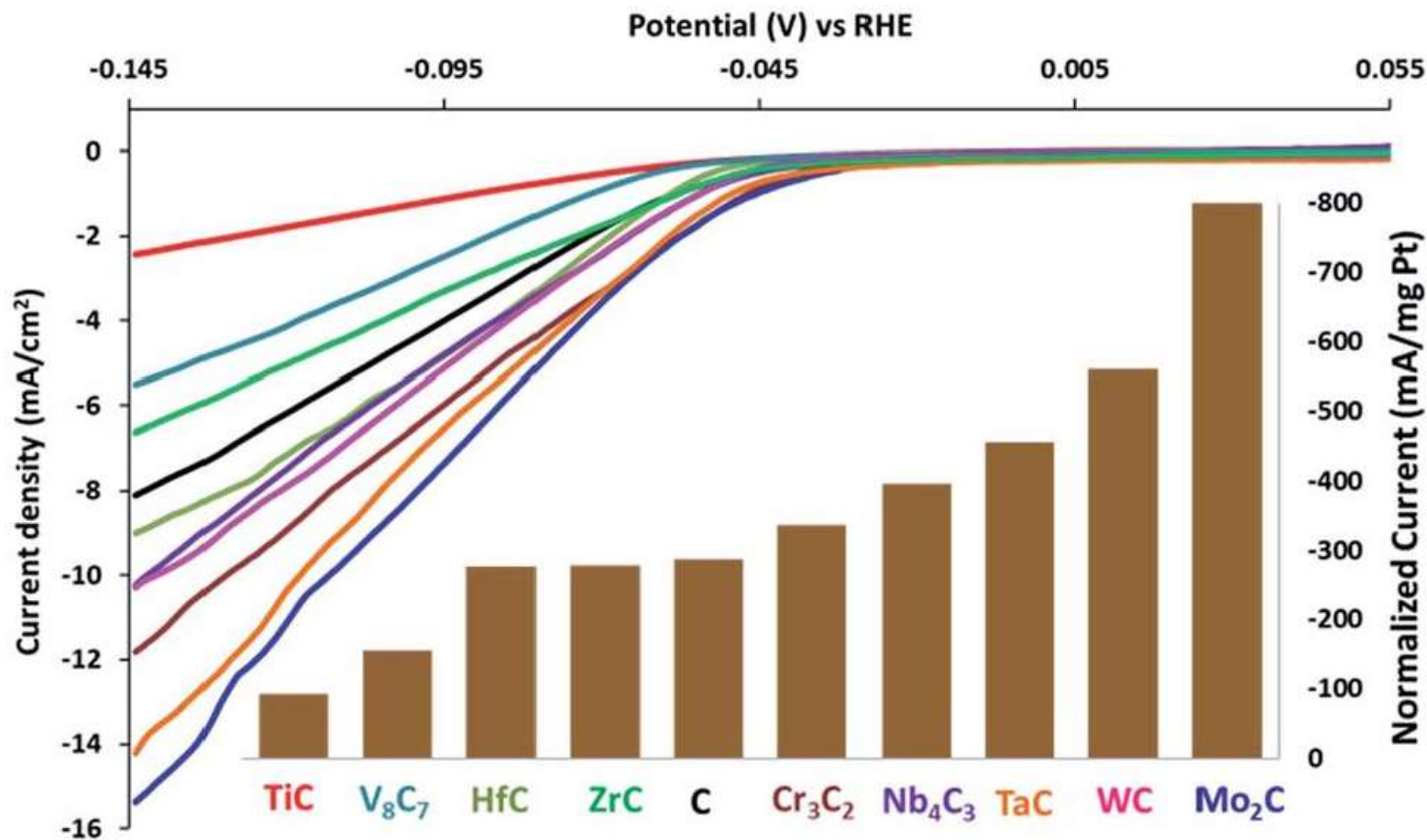
TEM



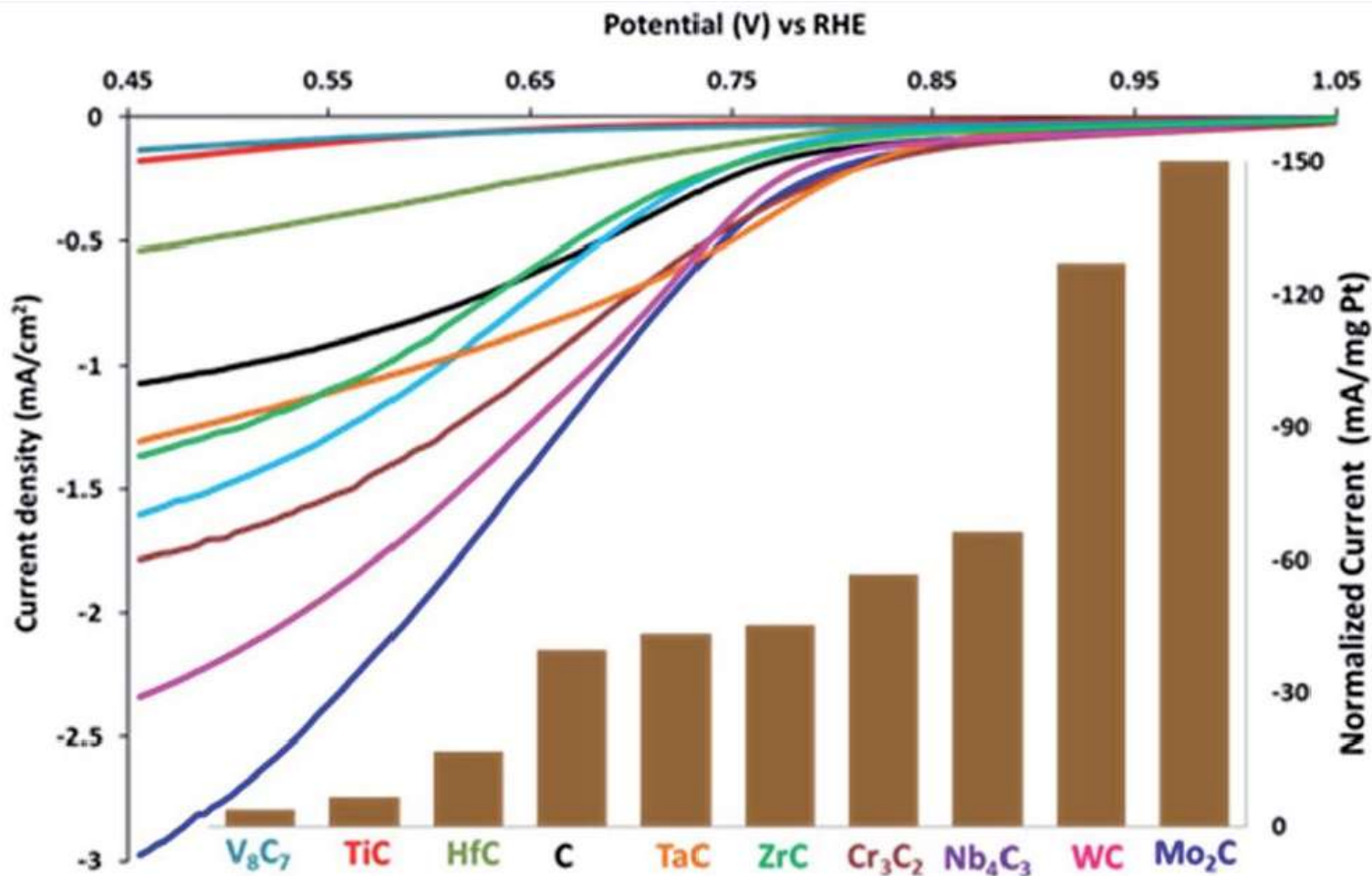
ICP-OES

M_xC_y	PPM Pt	% Pt loading
TiC	8.001	9.690
V_8C_7	10.371	12.560
Cr_3C_2	10.163	12.307
ZrC	7.015	8.495
Nb_4C_3	7.751	9.387
Mo_2C	5.956	7.212
HfC	9.601	11.627
TaC	9.119	11.044
WC	5.333	6.458

LSV-HER, Normalized Current Density at -0.144 V



LSV-ORR, Normalized Current Density at 0.456 V



Conclusion

- Pt deposited TMCs for groups 4-6 can be cleanly synthesized
- Pt/WC and Pt/Mo₂C showed highest current density for both HER and ORR
- Several other Pt/TMCs show increased catalytic activity over Pt/C control.

Acknowledgements

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