Ternary Platinum Catalysts with Enhanced Activity: Electrochemical and XAS Characterization

R. Atanasoski, H. Boand, M. Debe, G. Haugen, K. Lewinski, S. Maier, A. Steinbach, J. Thomas, G. Vernstrom

Fuel Cell Components Program, Corporate Enterprise Development, 3 Company, St. Paul, MN

M. Balasubramanian and J. McBreen

Brookhaven National Laboratory

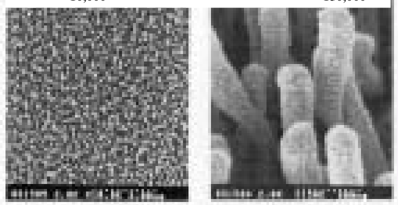
Goal: Improve the catalytic activity of Pt by adding non-noble metals.

How: Take advantage of nontraditional *ternary* catalyst combinations through 3M's *unconventional* processes and *unique* substrate.

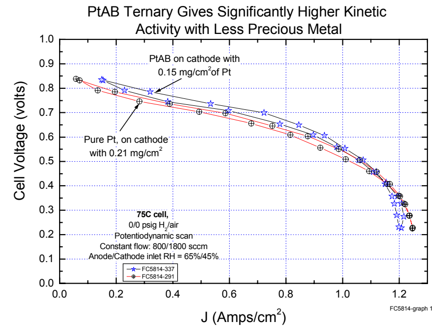
Variety of PtAB compositions are under evaluation. Results presented here are for a single specific PtAB composition and compared with PtA.

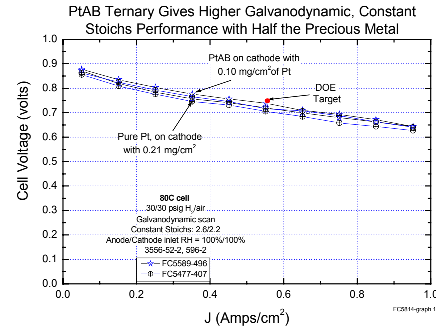
In this poster: Present improved Fuel Cell performance data and *insights into the catalyst* through Electrochemical and XAS Characterization with emphasis on the *role of the third component.*

Pt coated nanostructured thin film catalysts at different magnification

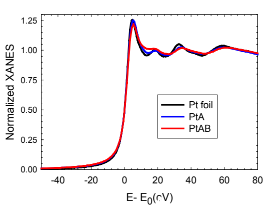


For details see: M. Debe: "Novel catalyst, catalyst support and catalyst coated membrane methods" in Vielstich, Gateiger , Lamm, eds., *Handbook of Fuel Cells*, vol. 3, 2003 Wiley&Sons





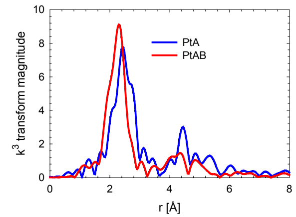
Pt L_3- XANES



Large changes are seen in PtAB, indicating a more disturbed atomic and electronic structure of an average Pt atom

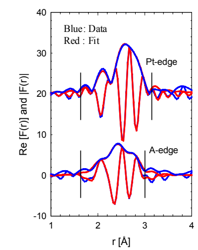
For XAS review see: J. McBreen and S. Mukerjee: " In situ X-Ray Absorption Spectroscopy of Carbon-Supported Pt and Pt Alloy Catalyst" in A. Wieckowski ed., *Interfacial Electrochemistry*, 1999 Dekker

A-edge Fourier transform



The large difference in the FT's suggest that the local environment of the average A atom is very different in the two samples.

Two shell fit to PtA at Pt and A-edges

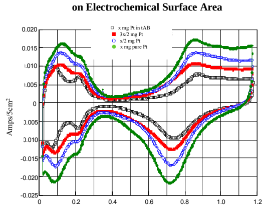


Vertical lines indicate the fit range covered

Quantitative analysis of the structure of PtA and PtAB in 1.5-3.2 Å range. Note the increase of component A in PtAB.

Sample	Edge	Neighbor	N	r (Å)
PtA	A	A	1.9 (7)	2.66(2)
		Pt	6.3(9)	2.69(1)
	Pt	A	0.78(4)	2.69(1)
		Pt	9.3 (9)	2.75(1)
PtAB	A	A	7.0(6)	2.57(2)
		Pt	3.1(4)	2.62(1)
	Pt	A	2.3(3)	2.62(1)
		Pt	7.2(7)	2.74(1)

The Influence of Pt Loading in PtAB Catalyst on Electrochemical Surface Area

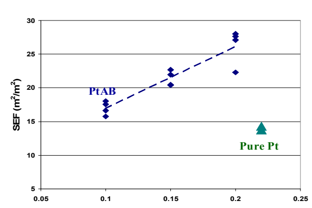


Cyclic voltammograms of Pt and PtAB in fuel cell arrangement; 100 mV/s.

In comparison to pure Pt, the amount of adsorbed H more than doubles indicating surface area increase.

Note the 30 mV shift of the 'weakly' adsorbed hydrogen indicating stronger interaction of adsorbed H with PtAB catalyst relative to Pt.

The Surface Enhancement Factor as calculated from the CVs



CONCLUSIONS

•Depending on the catalyst composition, Pt can reside either in an environment that is similar to pure Pt (binary) or an environment that resembles the solute metal (ternary)

•The XANES results indicate differences in the Pt electronic structure in the two environments

•These differences are further manifested in the electrochemical properties, through the shift in the hydrogen adsorption and the enhanced surface area

•Finally, the ternary catalysts improve the fuel cell performance and/or decrease the Pt loading

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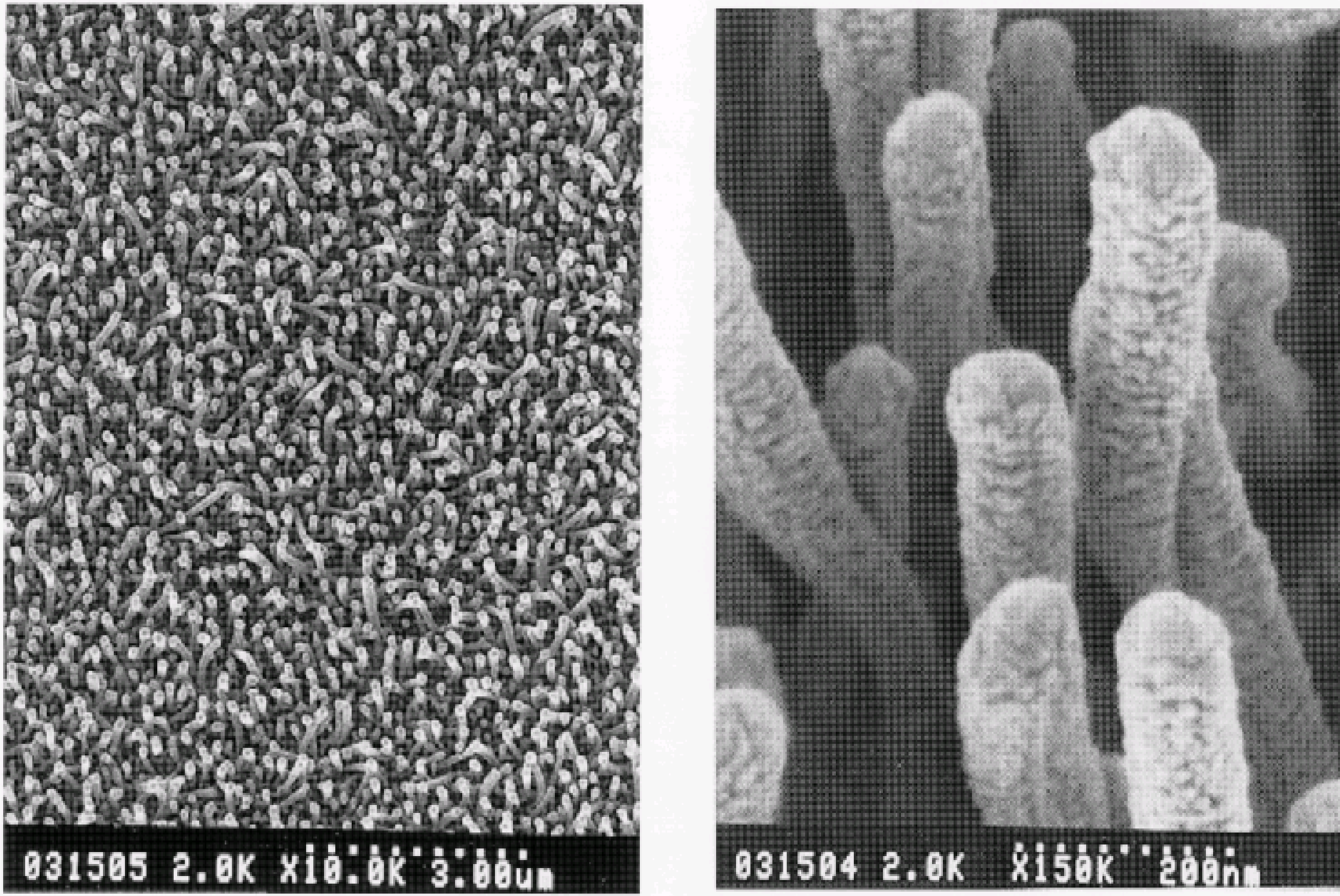

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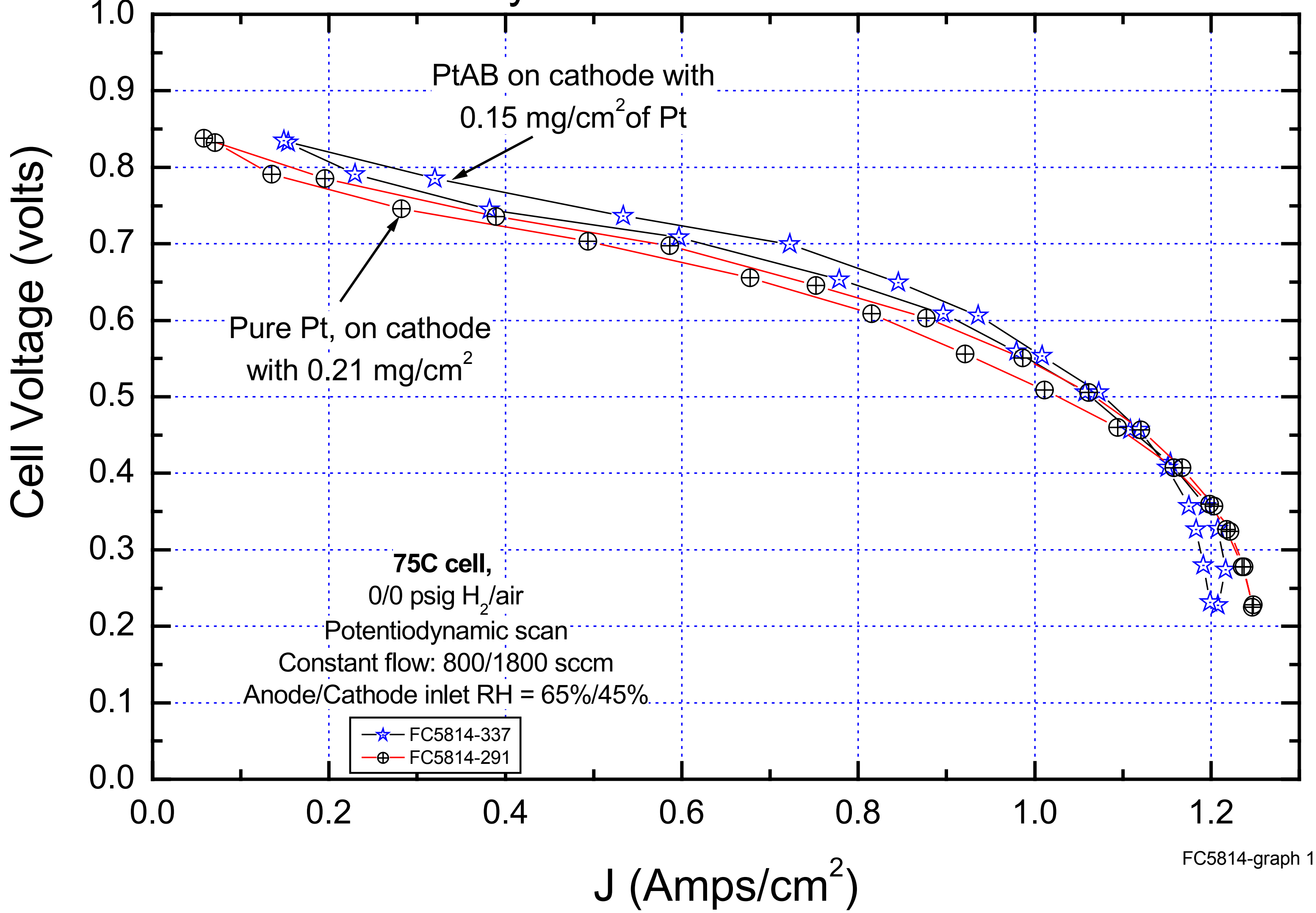
PtAB Ternary Gives Significantly Higher Kinetic Activity with Less Precious Metal



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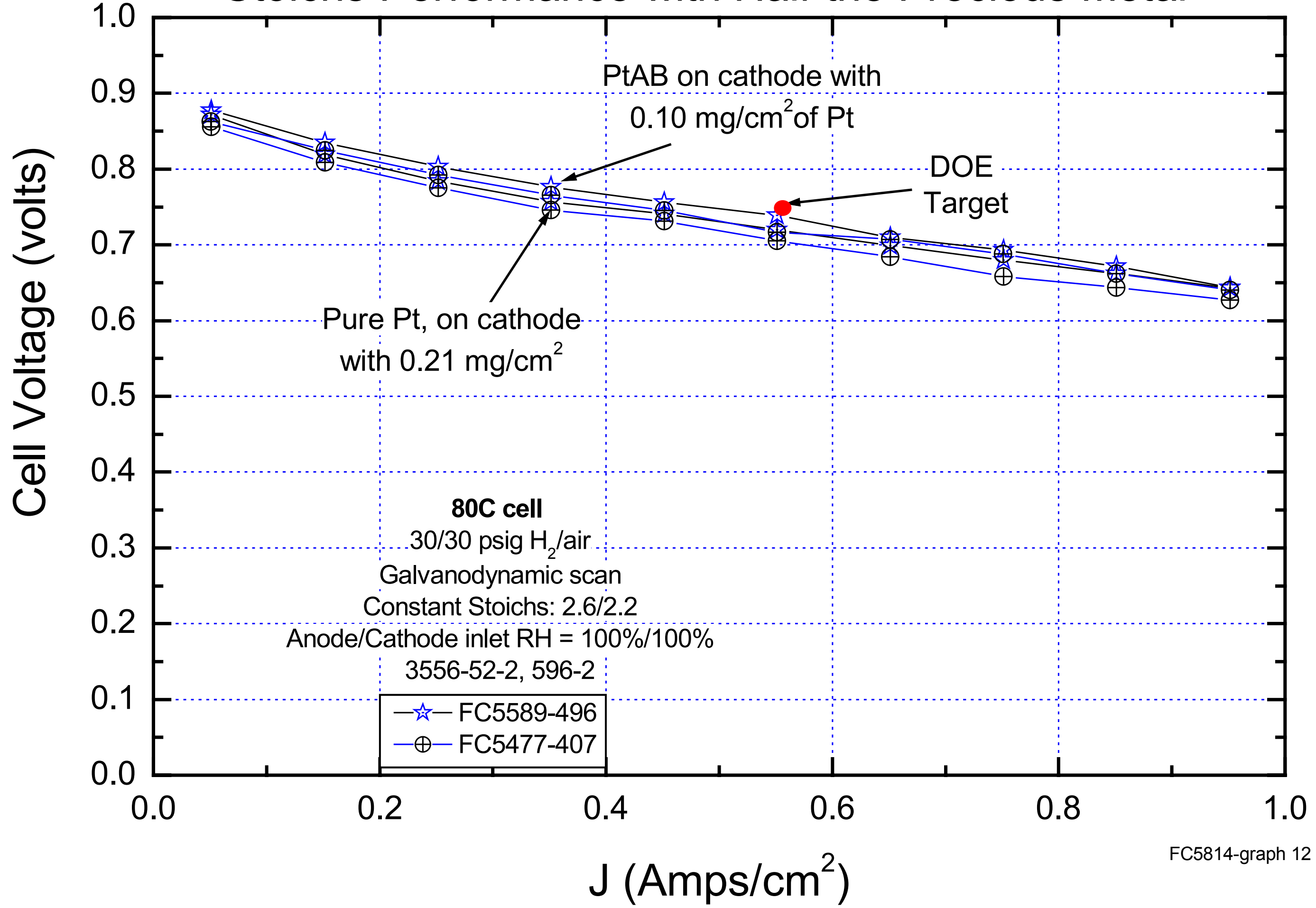
PtAB Ternary Gives Higher Galvanodynamic, Constant Stoichs Performance with Half the Precious Metal



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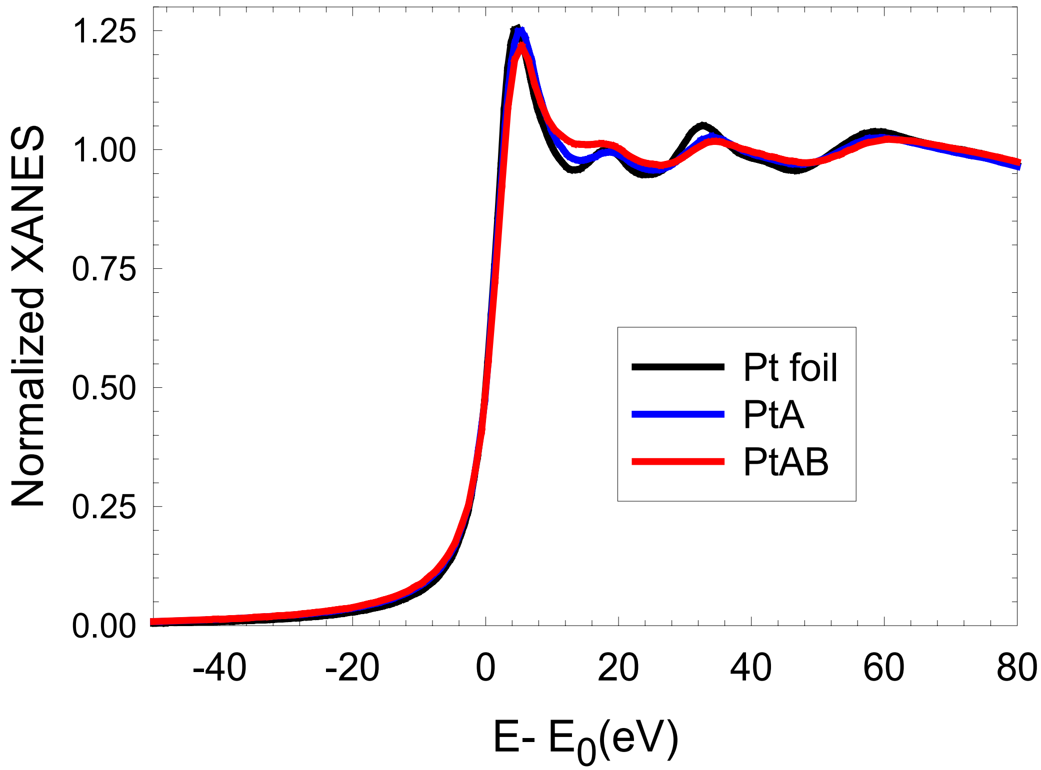

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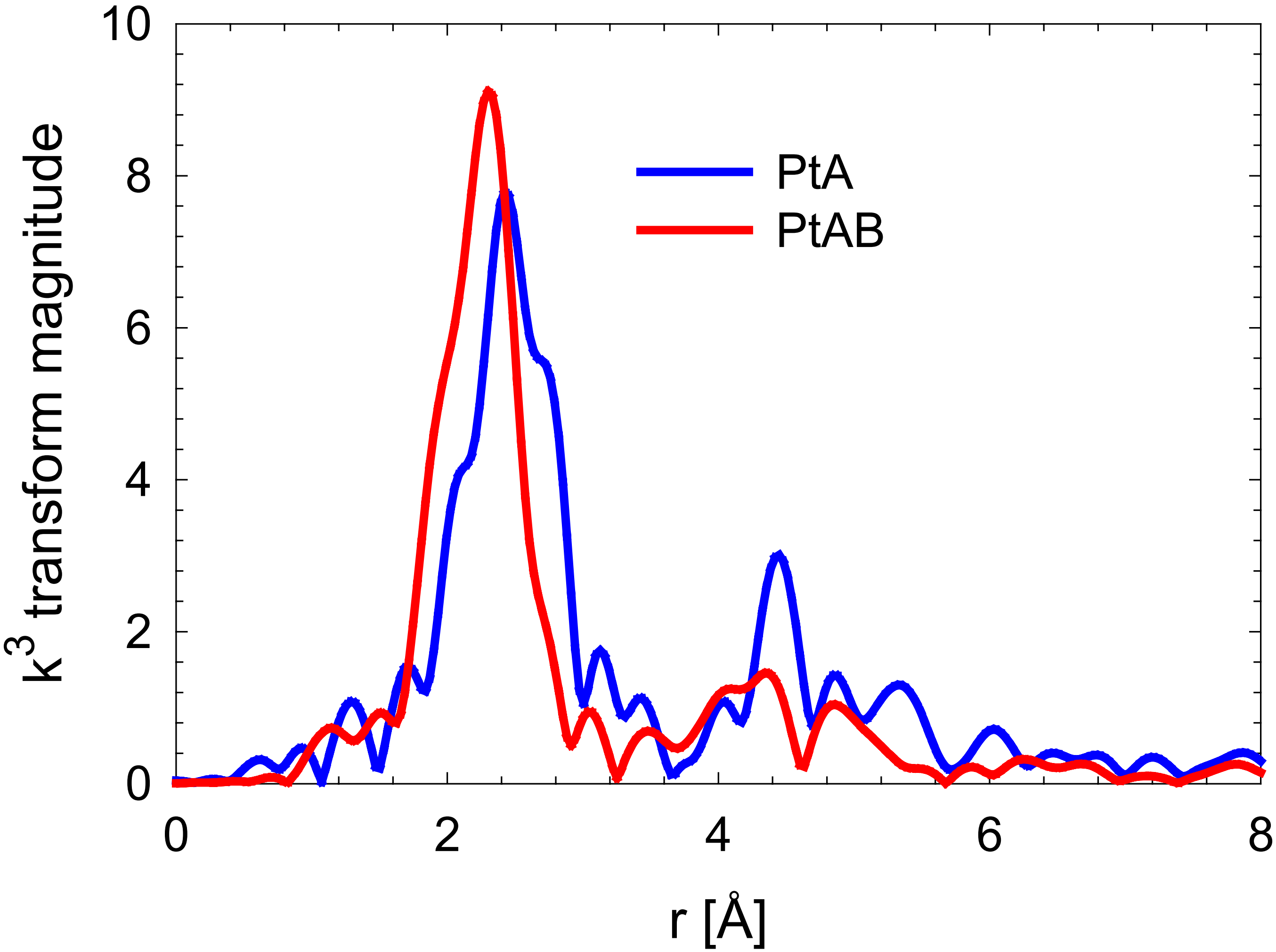

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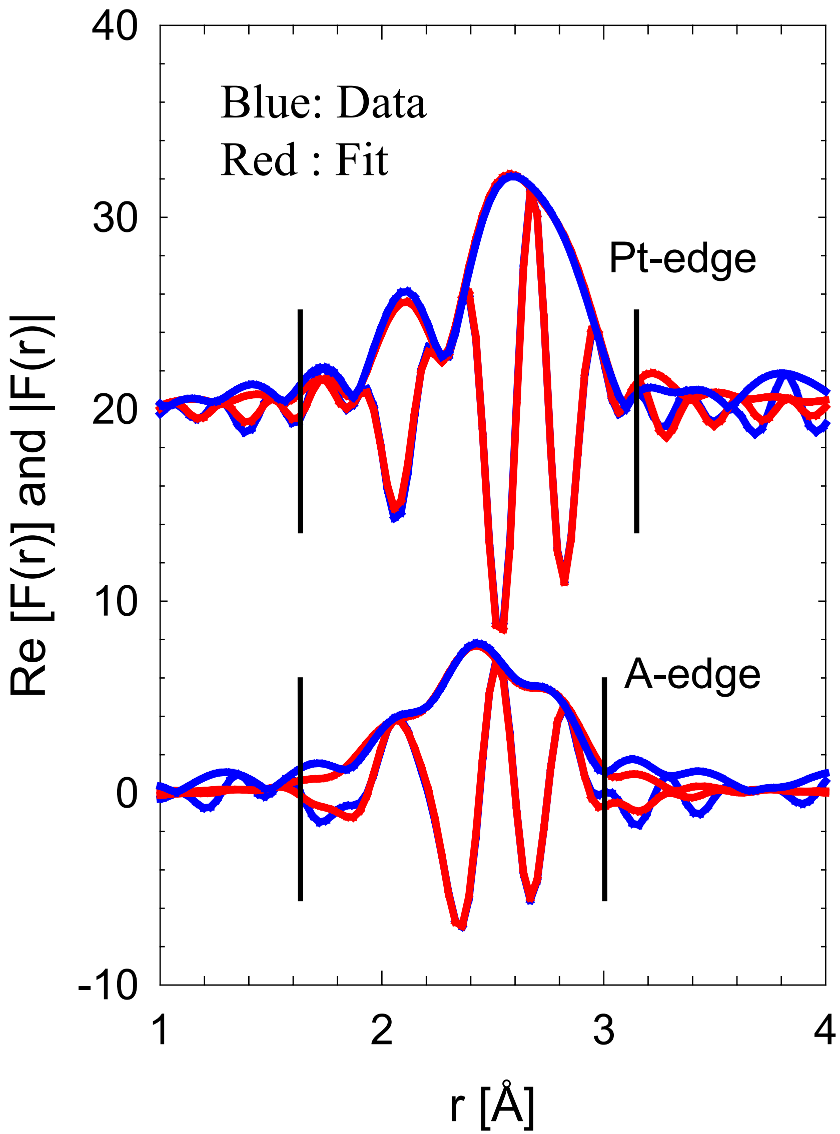

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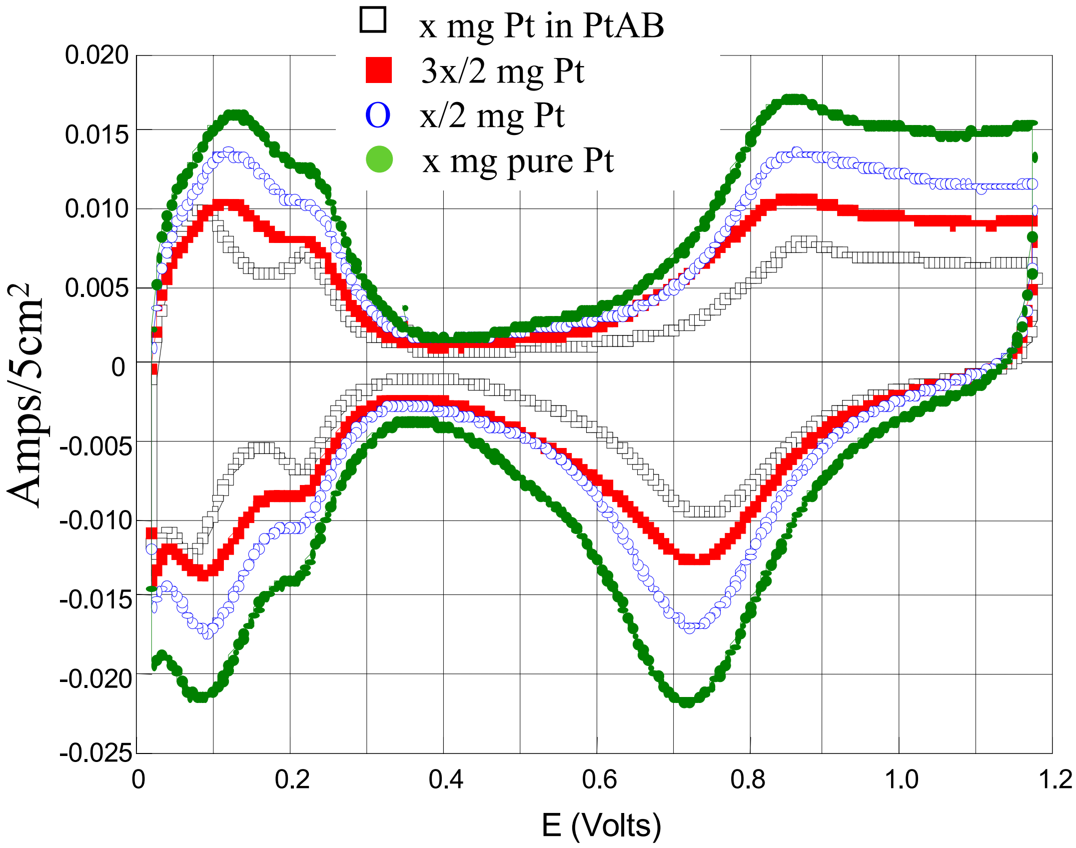

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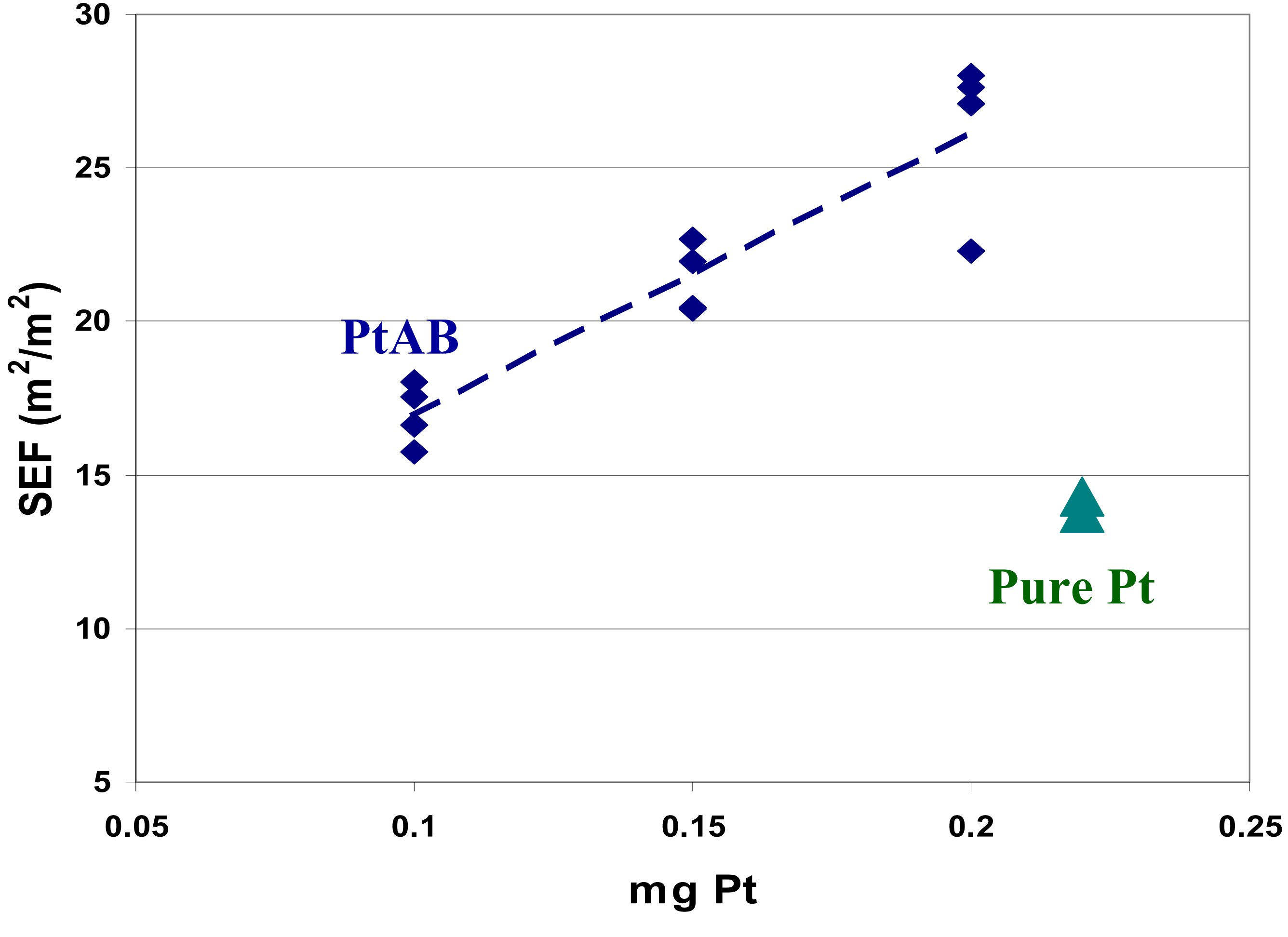

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