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Investigation of Spillover Effect to Enhance Hydrogen Storage

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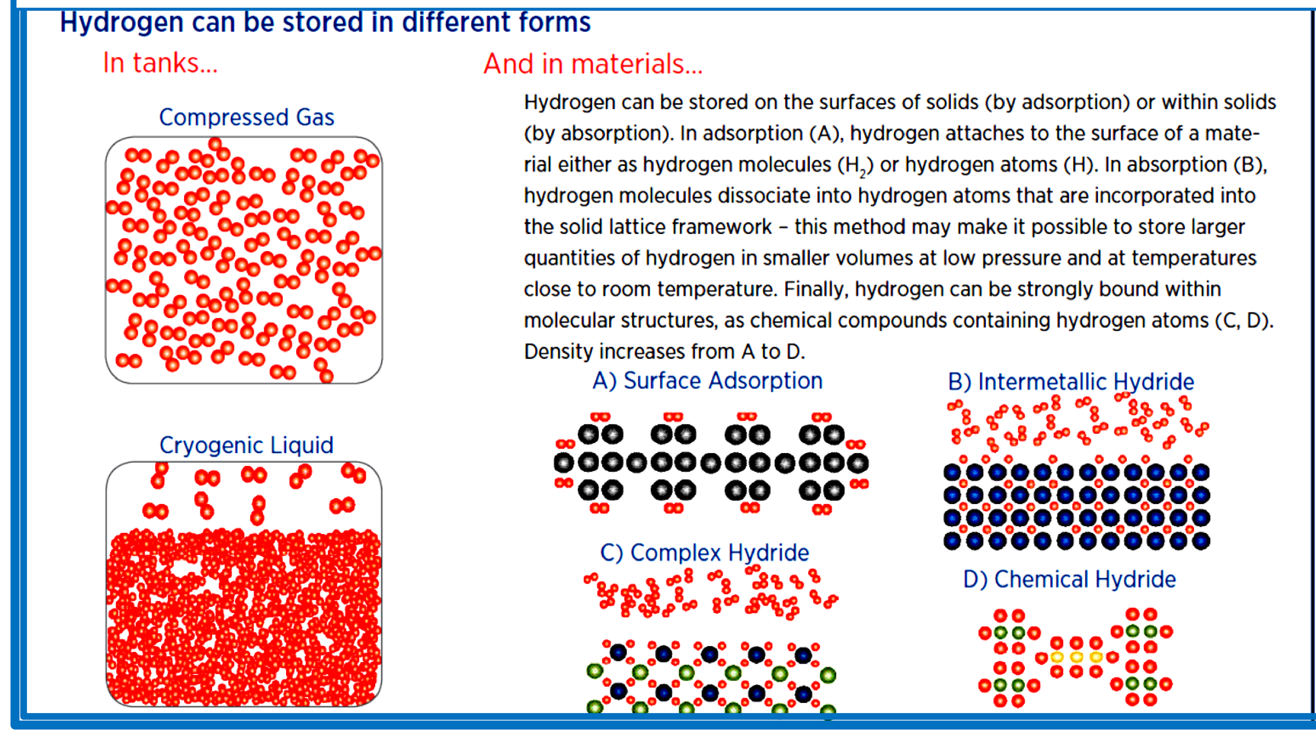
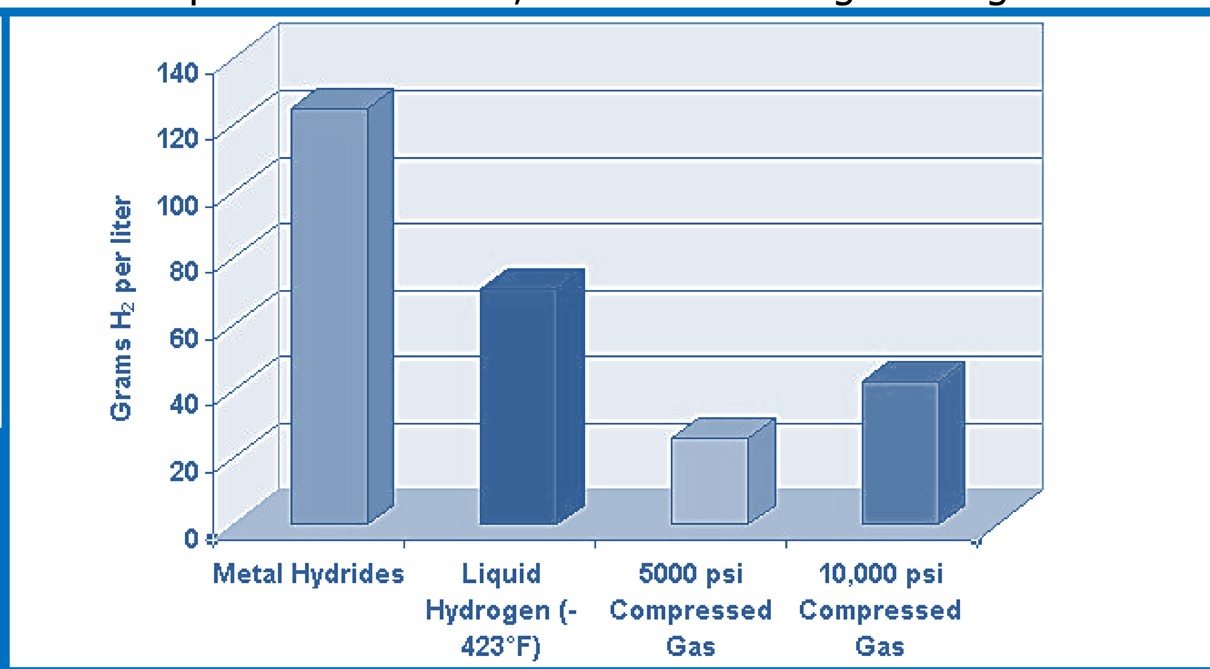
OVERVIEW

Spillover occurs when Hydrogen Molecules near a precious metal catalyst (spillover source) dissociate into atomic hydrogen. This atomic hydrogen then migrates or 'spills' onto the carbon receptor (spillover receptor) by surface diffusion. Finally, the atomic hydrogen can then be adsorbed on the carbon receptor. This adsorption is reversible, and is thus being investigated for the on-board storage of hydrogen, with hopes of ultimately making Hydrogen Fuel Cell Vehicles more attainable.

Hydrogen is an attractive energy option because of its low environmental impact, but a critical problem is its low energy density, which makes it difficult to store. For example, the US Department of Energy (DOE) hydrogen plan for fuel cell powered vehicles requires a gravimetric density of 6.5 wt%. There are several existing hydrogen storage methods, including compressed gas, liquefaction, metal hydrides, and physisorption, (see figure below) but, at present, none of these technologies do not achieve the targets set by the DOE.

Image below: U.S. Department of Energy. *Hydrogen Storage*. Fuel Cell Technologies Program. <www.eere.energy.gov/informationcenter>





Although chemical storage methods have been claimed to be the most promising hydrogen storage technology, and activated carbons the best adsorbent, as mentioned, chemical storage methods are still far from the desired targets. The differences among chemical storage, and compressed gas or liquid forms is highlighted above. In order to try to bring these chemical storage methods closer to desired targets, research must be done to find ways to maximize chemical storage potential using different materials. Recently, there has been a resurgence of interest in the potential of carbon materials.

In order to try to move these hydrogen storage goals further toward the goals of the DOE, numerous experiments were done in altering the current materials to try to maximize the hydrogen storage potential. Experiments were done to compare the spillover effects of multiple precious metals. Also, the use of basic high surface area activated carbon (MSC-30) was compared to similar activated carbons with Boron doping with hopes of enhancing that spillover effect. Below are the elements considered to be precious metals, which act as catalysts in the spillover effect.

44 Ru	45 Rh	46 Pd	47 Ag
76 Os	77 Ir	78 Pt	79 Au

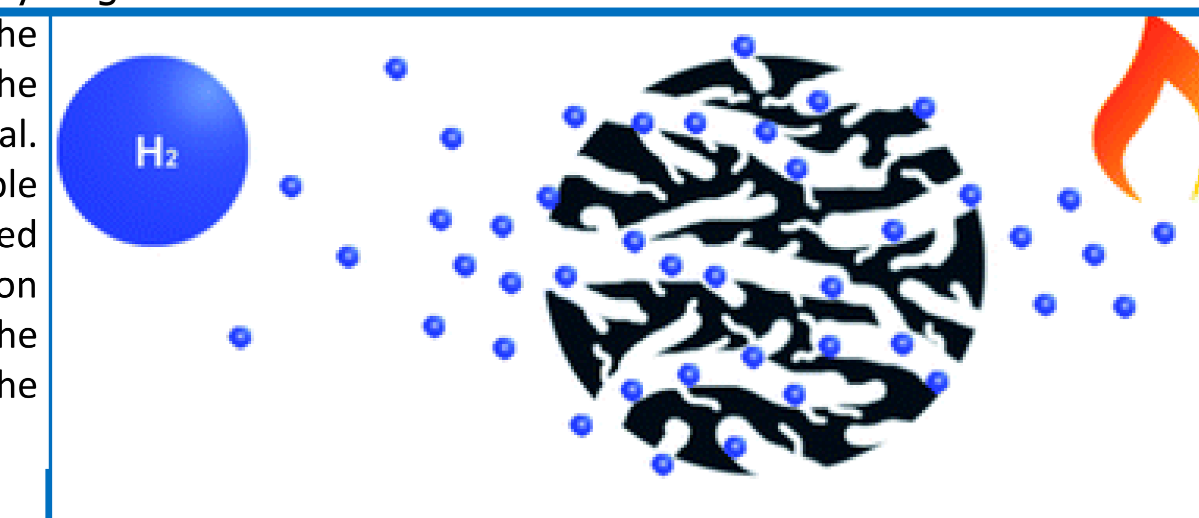
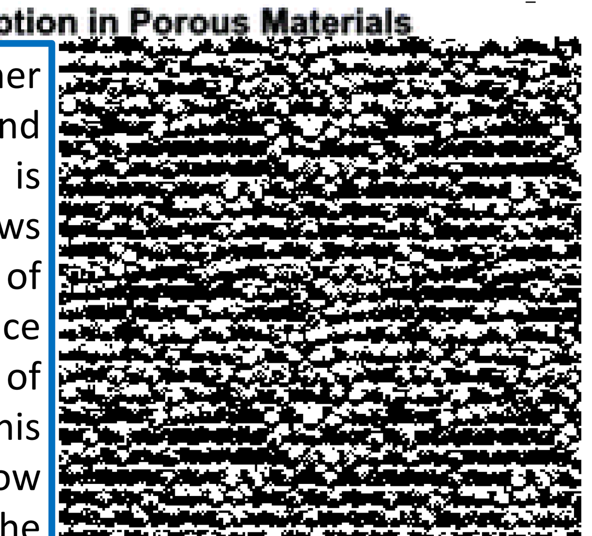


Image above: Assessment of Hydrogen Storage by Physisorption in Porous Materials. Energy and Environmental Science. < http://pubs.rsc.org/en/Content/ArticleLanding/2012/EE/C2EE22037G#>

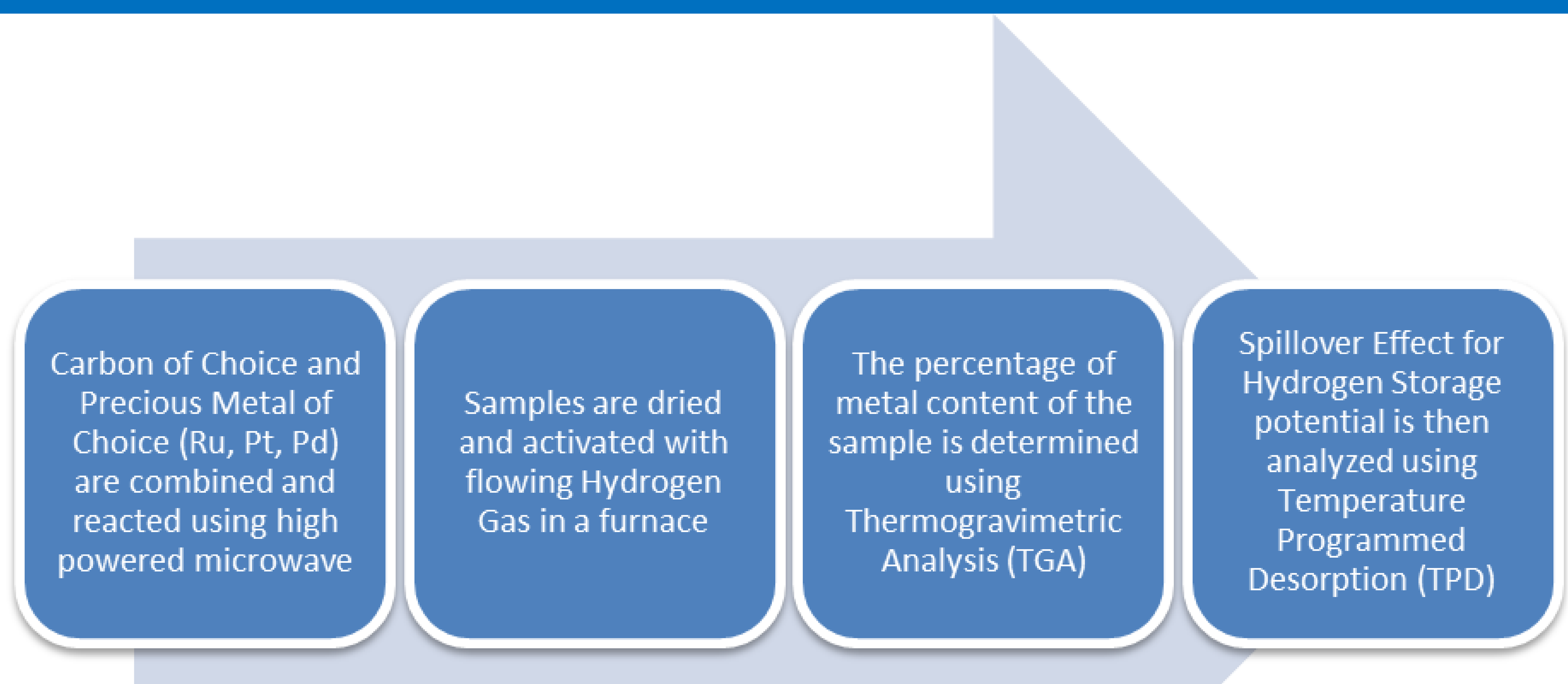
Hydrogen Storage by Physisorption in Porous Materials

Palladium is unique from the other precious metals of interest here, Ru and Pt, in that it has a structure that is porous to Hydrogen, and allows Hydrogen to seep through. Because of this there can be both surface adsorption and the formation of Intermetallic Hydrides. It is also this porous structure that is thought to allow for a greater spillover effect, as the Hydrogen can reach more catalyst sites.

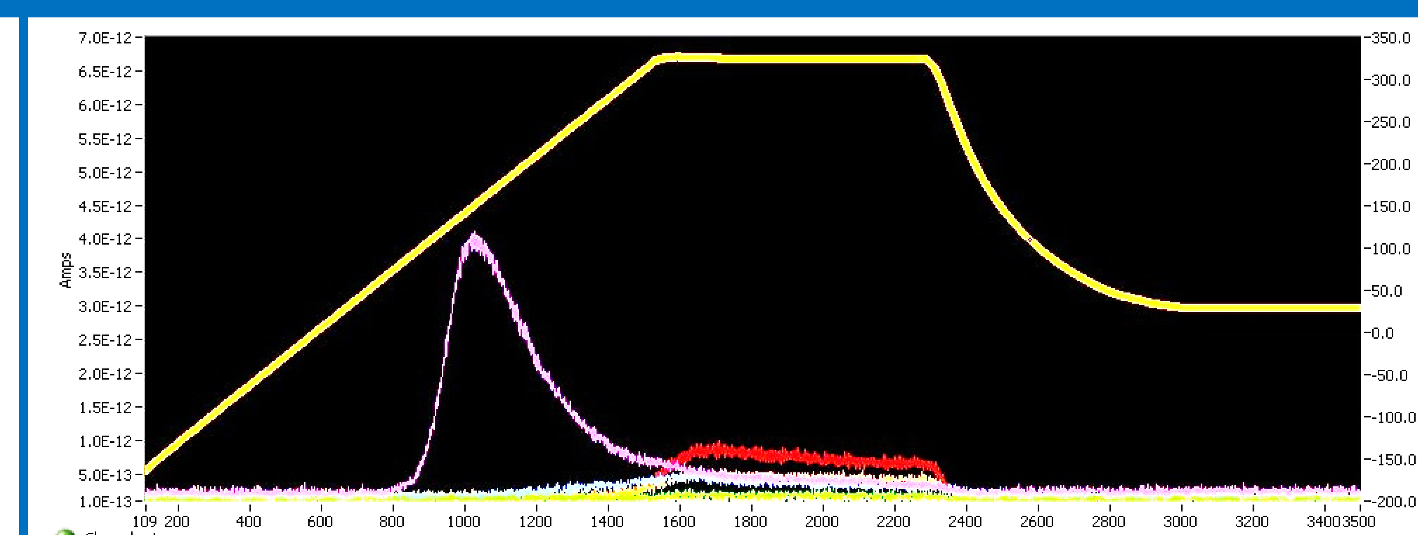


Above Image: Ralph Wolf. Soaking up Hydrogen. Design of New Materials: The Amazing Metal Sponge. < http://www.psc.edu/science/Wolf/Wolf.html>

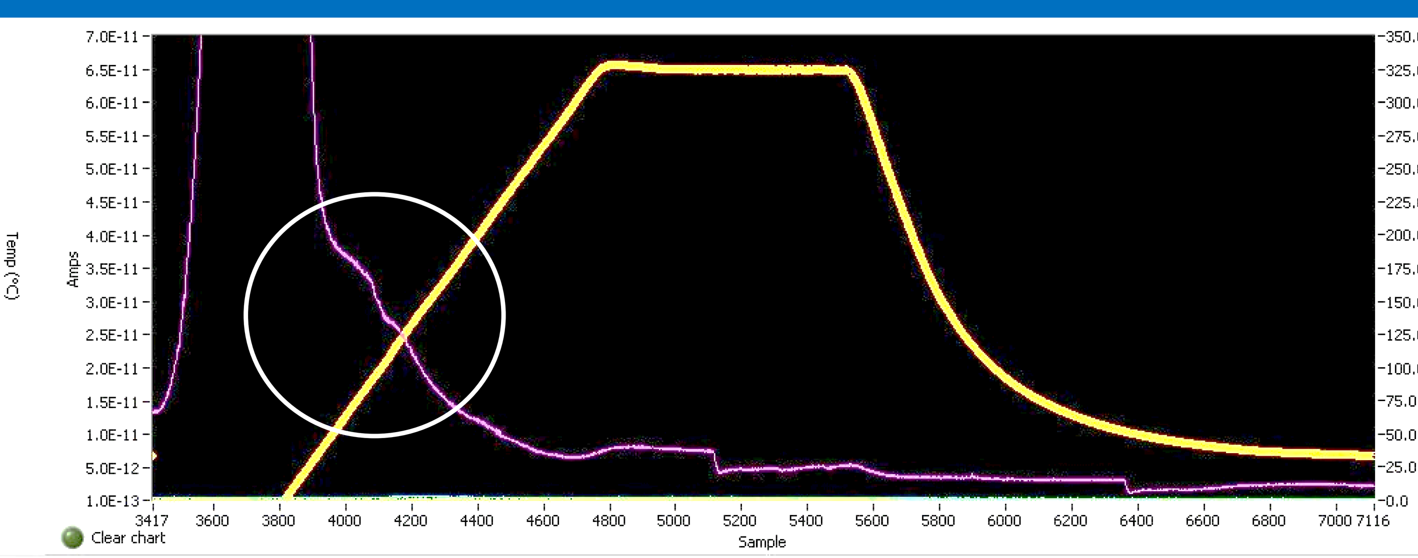
EXPERIMENTAL



RESULTS

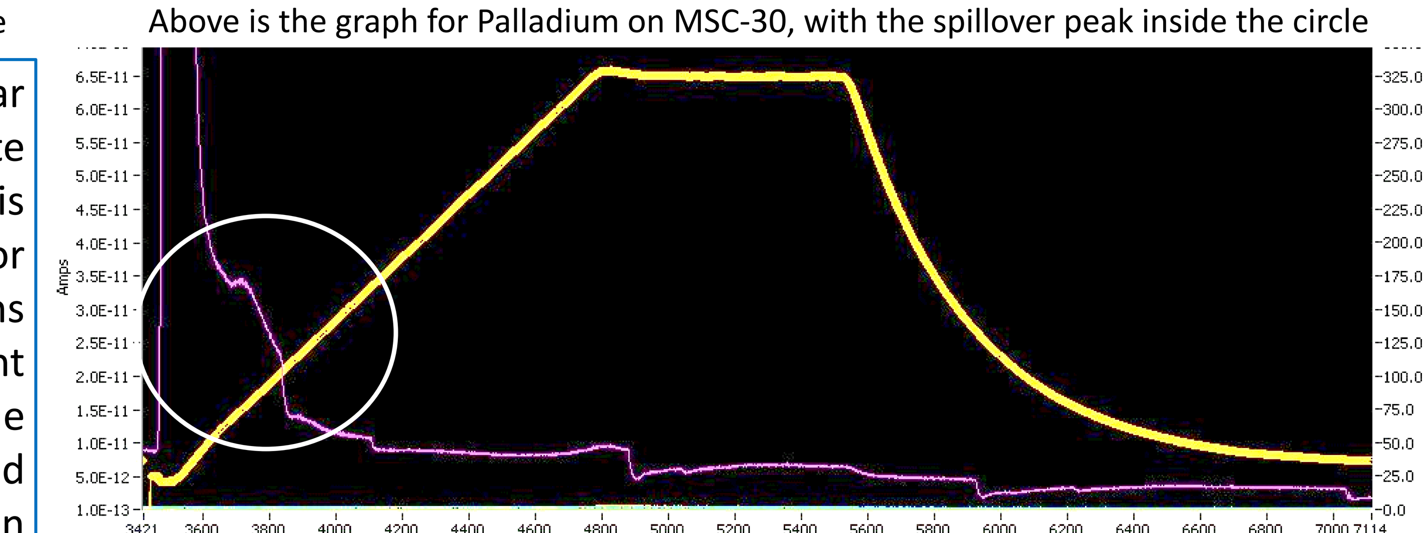


Above is the graph for Platinum on MSC-30, no spillover peak is highlighted, as there was none



Above is the graph for Palladium on MSC-30, with the spillover peak inside the circle

As can be seen when compared to the two Palladium graphs (right), it is clear that Platinum (above) shows no evidence of the spillover effect. Also, note the difference in hydrogen peak sizes between platinum and palladium is more than two orders of magnitude, emphasizing palladium's potential for hydrogen storage as compared to platinum. It can be seen via the two graphs to the right that boron doping of the Carbon substrate had no significant effect on the spillover effect. Spillover occurred at approximately the same temperature, and the peak sizes are comparable. Results were not obtained for prepared Ru samples, though they would be analyzed in a similar fashion in the future for comparison.



Above is the graph for Palladium on Boron Doped Carbon

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