2009 DOE Hydrogen Program Review

Electron-Charged Hydrogen Storage Materials

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June 9, 2010

Project ID # ST051

Overview

Timeline

- Project start: July 1, 2005
- Project end: Sept 30, 2010
- Percent complete: 75%

Budget

- Total project funding
  - DOE share: $1,562K
  - Contractor share: $390K
- Funding received in FY09: $303,010
- Funding for FY10: $0

Barriers

- Cost: use inexpensive graphite
- Weight and volume: use high density graphite, maximizing capacity
- Efficiency: add electron charge to increase storage rate
- Durability: use electron charge to control cycles
- Refueling Time: use electron charge to increase fueling rate
- Codes and Standards
- System Life-Cycle Assessments

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Objectives

Overall	Development of a hydrogen storage material and device for hydrogen quick charge and discharge, high wt% and vol% storage capacities, good durability over many cycles, and safe handling and transport.
2008	• Combine internal electron-charge (doping) and external charge to increase hydrogen storage capacities • Investigate performance optimization and prototype container systems
2009	• Reselect the best hydrogen storage materials for charge modifications • Carbon-based materials, such as AX-21 and other high surface carbon using polymer as precursor; metal-modified carbon; and borane-ammonia

Milestone or Go/No-Go Decision

Month/Year	Milestone or Go/No-Go Decision
July 30, 2009	Task 4. Characterize the electron device and the material properties of the carbon based material with CCA/CTA (pore size, density, surface area, etc) Task 5. Prepare samples for independent evaluation. Install framework structure to improve charge distribution Task 6. Scale-up to an 11 liter tank for fueling demonstration to show 50% hydrogen storage increase.
June 30, 2010	Go/No-Go

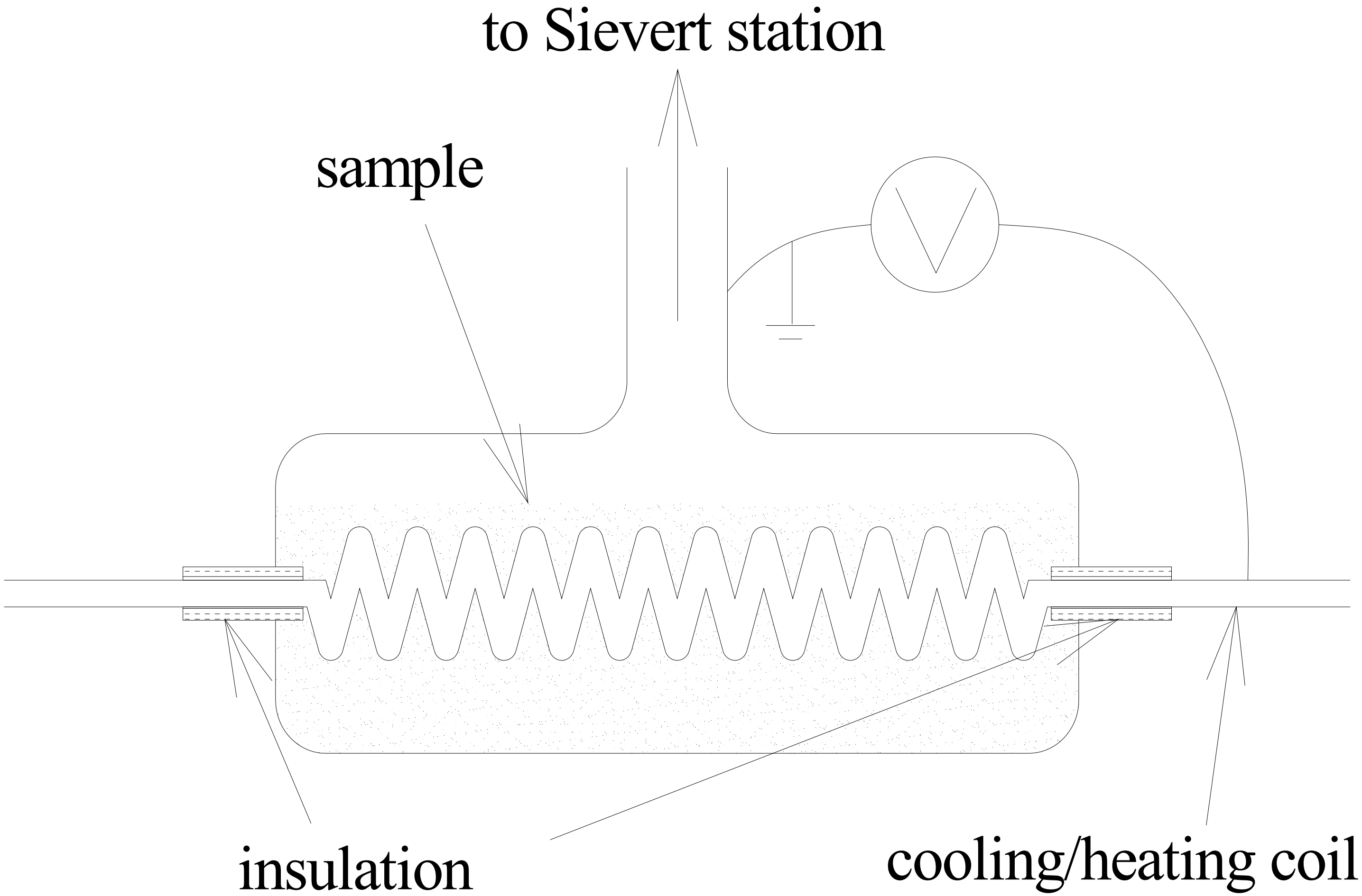
Approach

- Hydrogen storage is based on hydrogen adsorption, which is involved in electron shift (physi-sorption) and electron transfer (chemi-sorption).
- Use external electron charge to increase hydrogen adsorption and alter hydrogen desorption kinetics.
- Use internal electron-rich or -poor material to change carbon-based material surface electron density, which affects hydrogen storage.

Plan and Approach

- Select and synthesize carbon-based materials
- Test and evaluate cycles for hydrogen storage
- Test external electron charge effect on hydrogen storage
- Dynamic TGA and Sievert Tests

Approach



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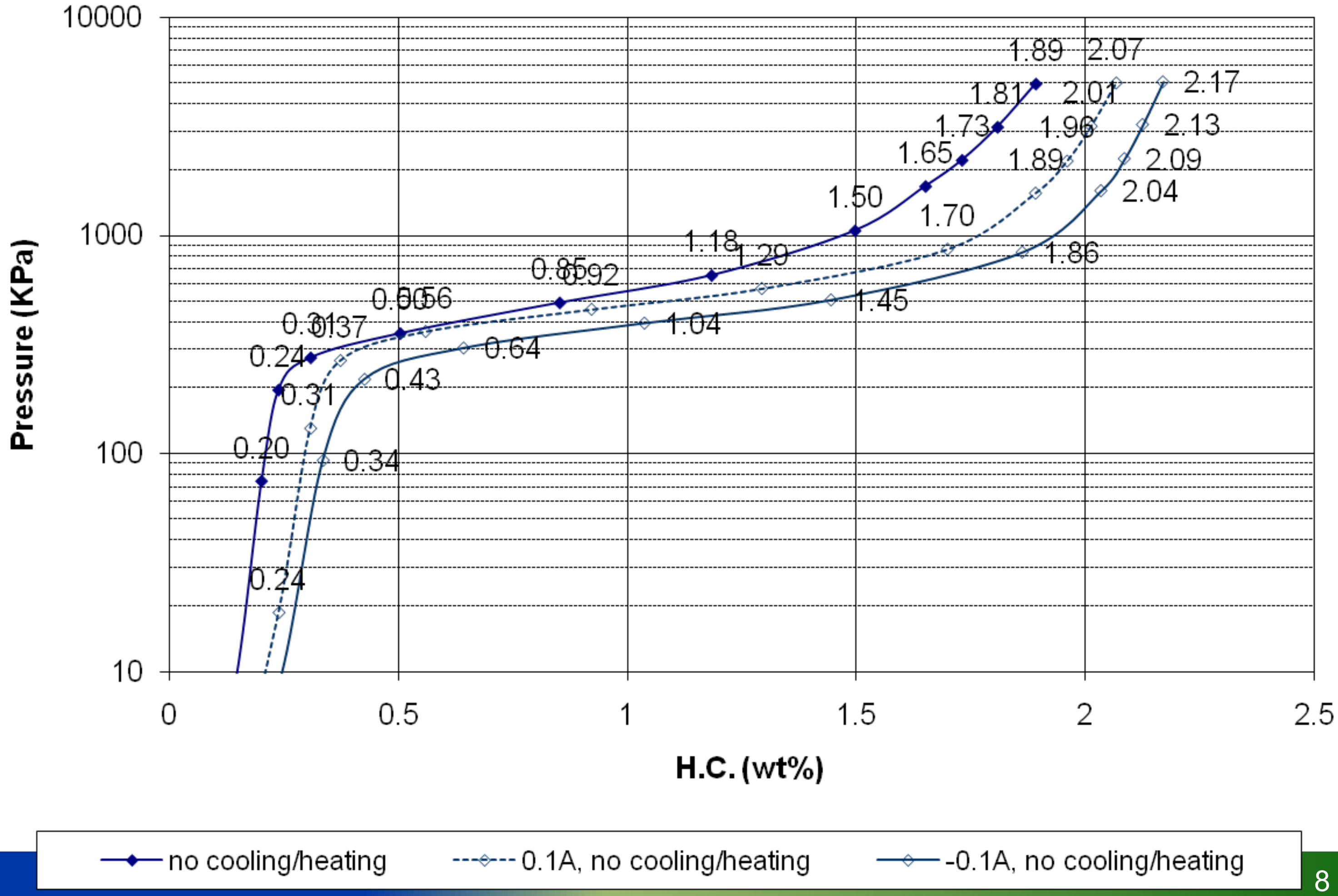
Technical Accomplishment and Progress

PCI curve for metal hydride with different current without cooling/heating



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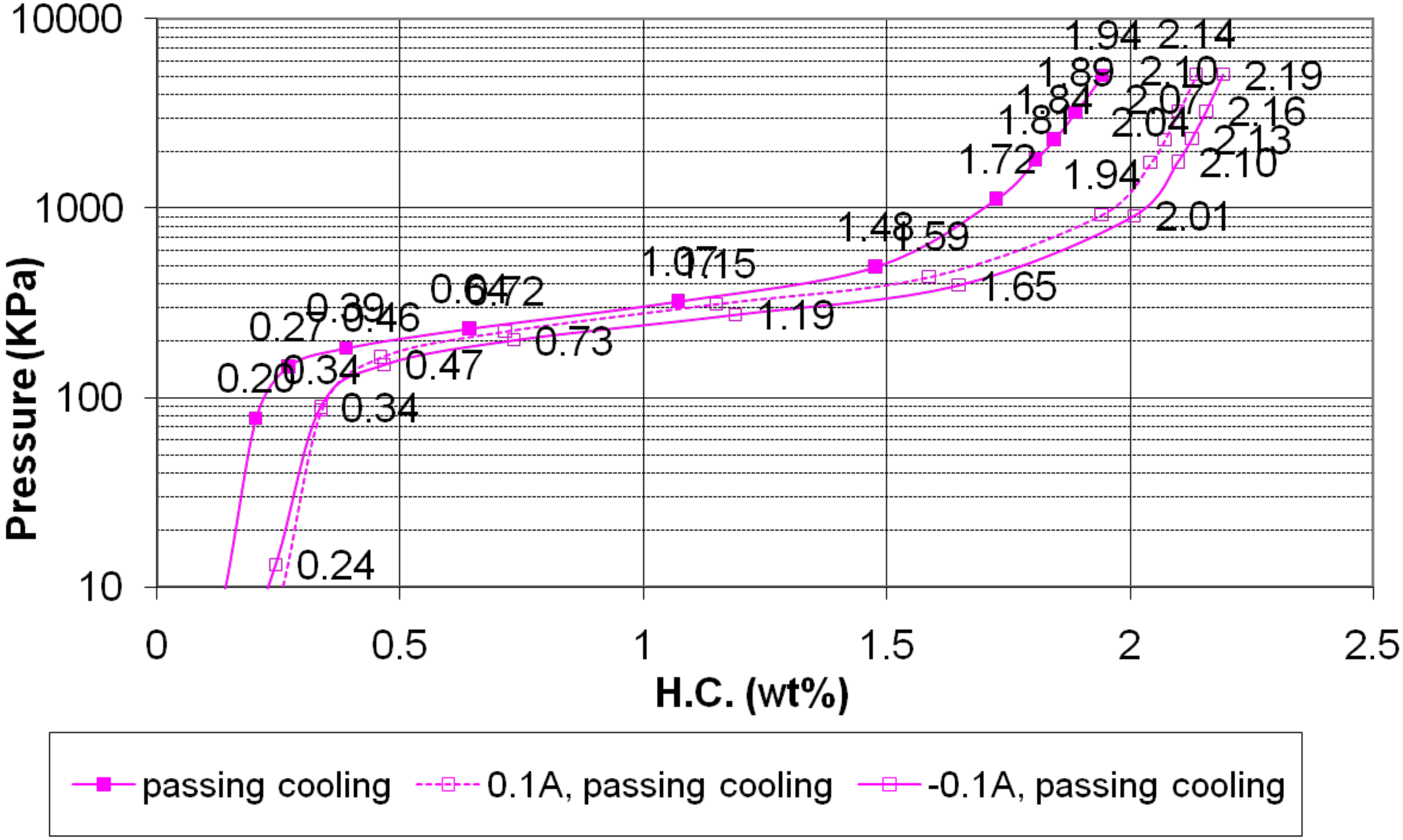
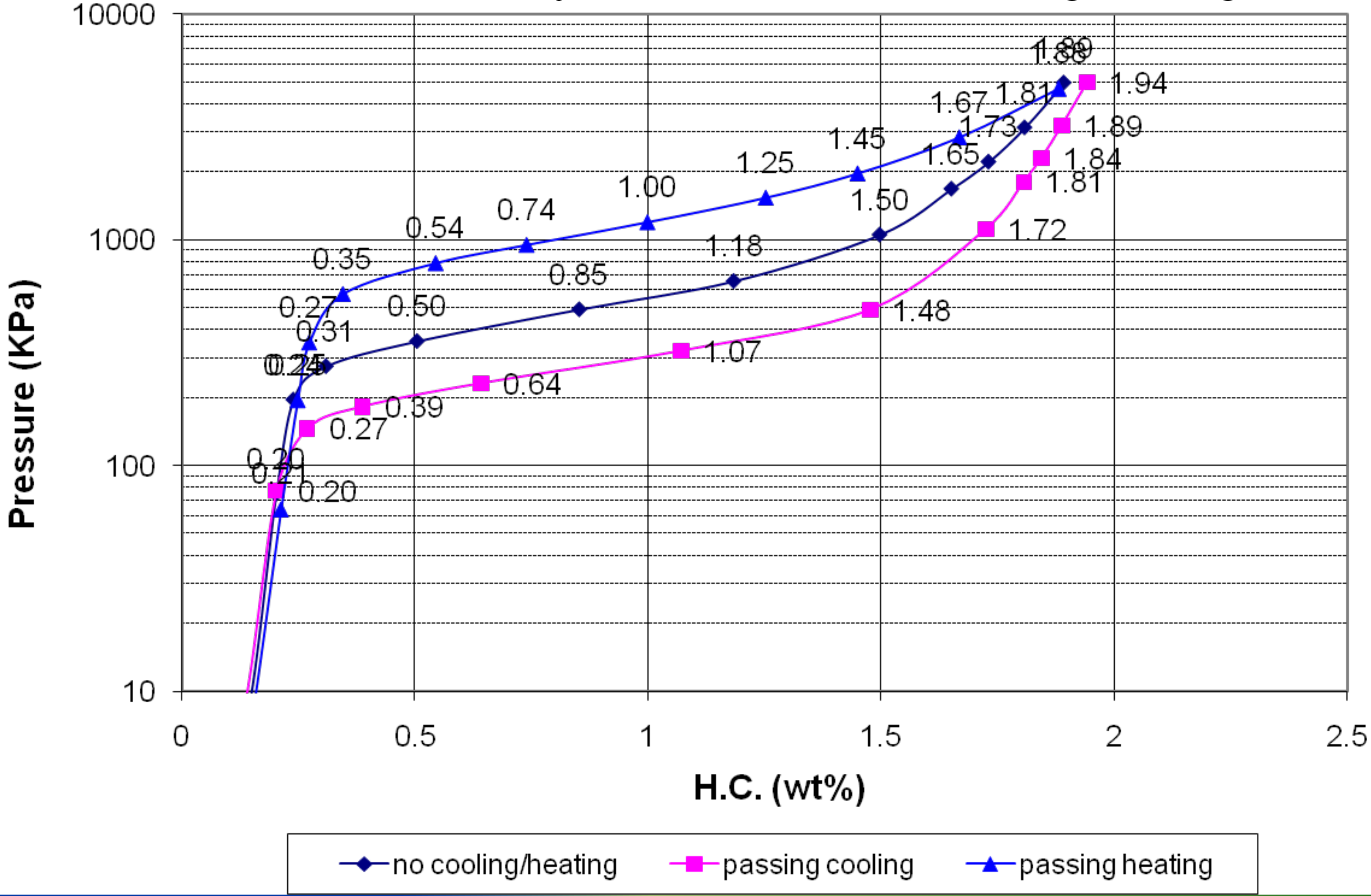
Technical Accomplishment and Progress

PCI curve for metal hydride with different current with cooling



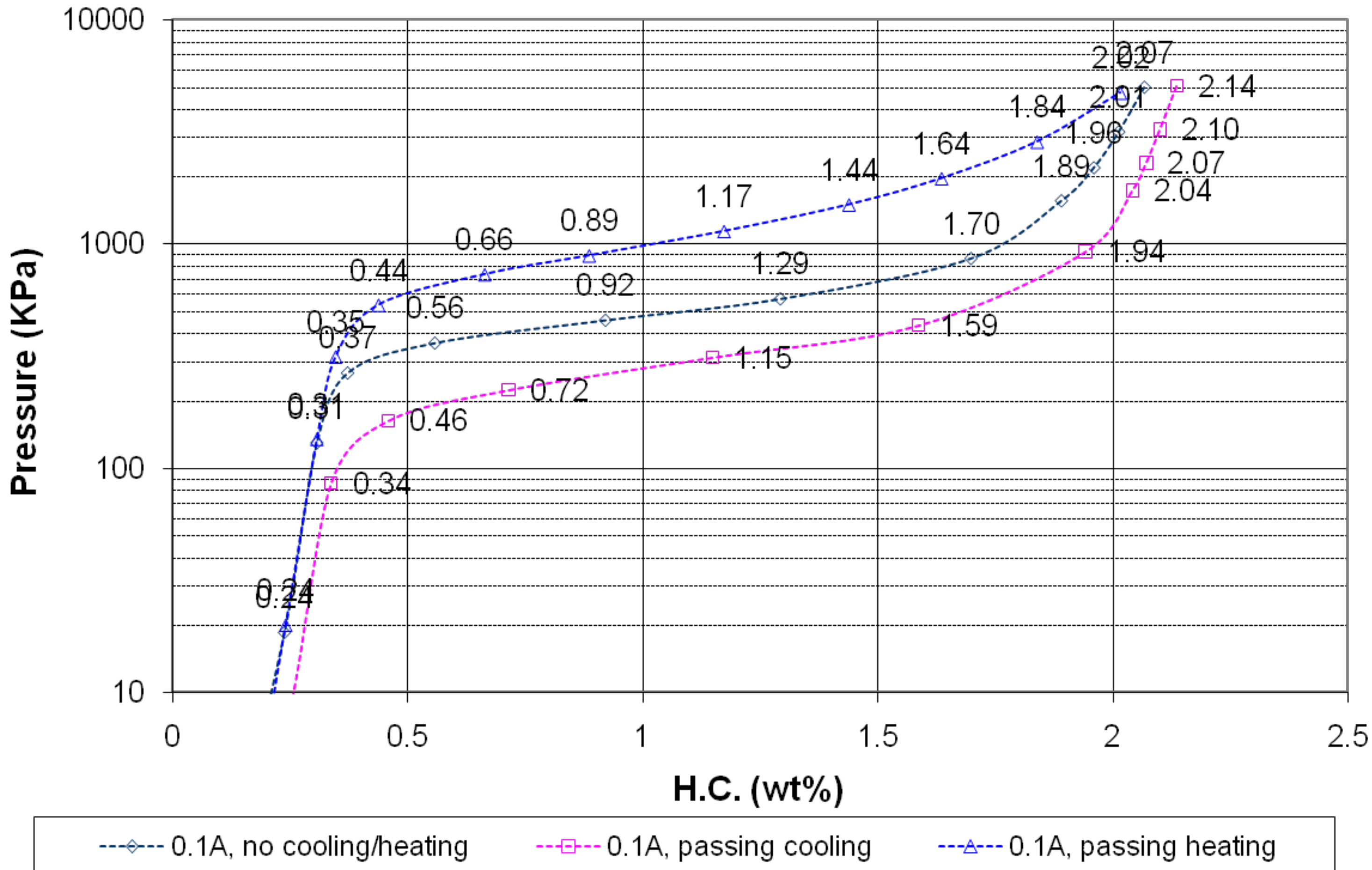
Technical Accomplishment and Progress

PCI curve for metal hydride with/without heating/cooling without current



Technical Accomplishment and Progress

PCI curve for metal hydride with/without heating/cooling with 0.1A current



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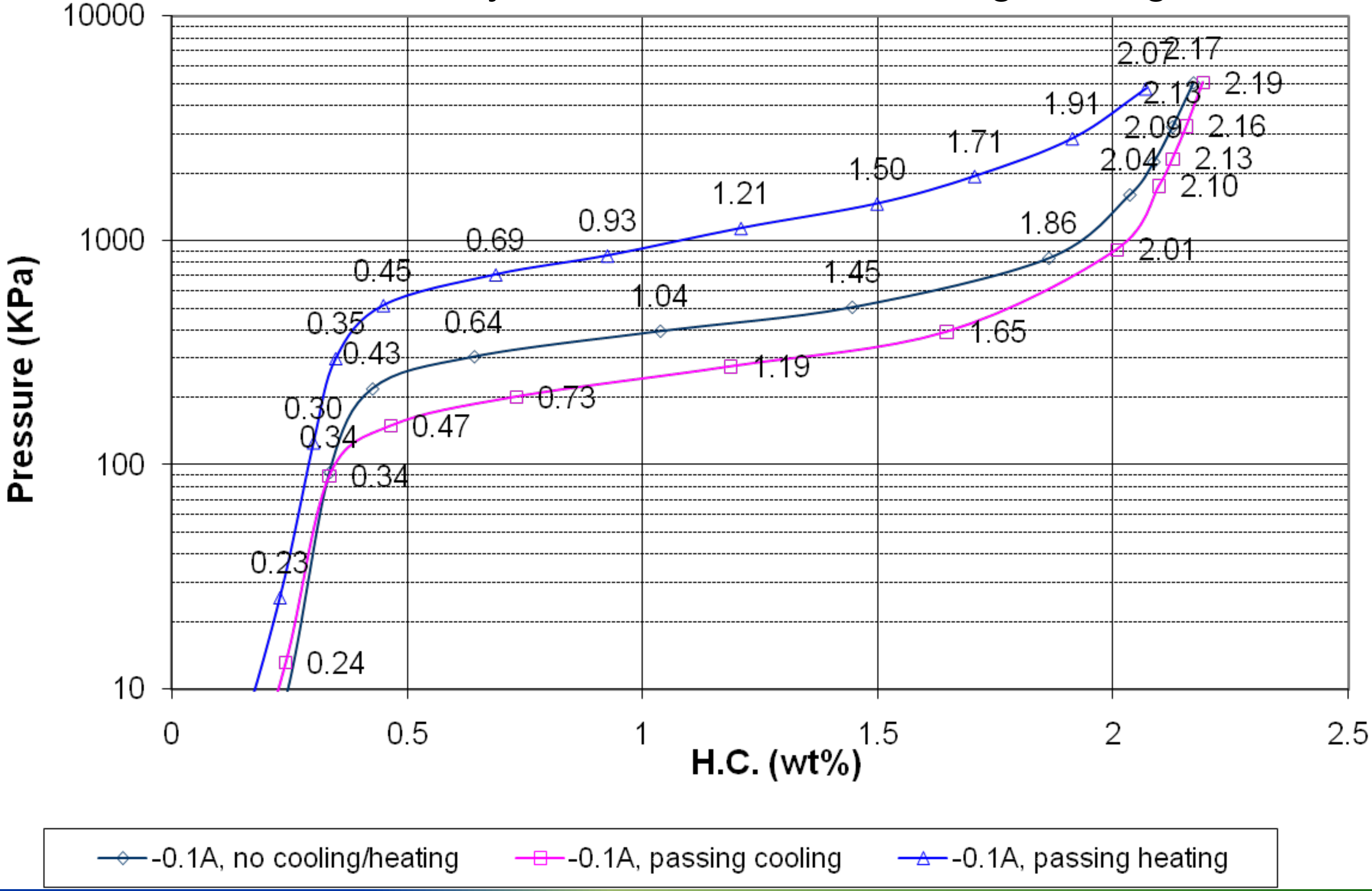
Technical Accomplishment and Progress

PCI curve for metal hydride with/without heating/cooling with -0.1A current



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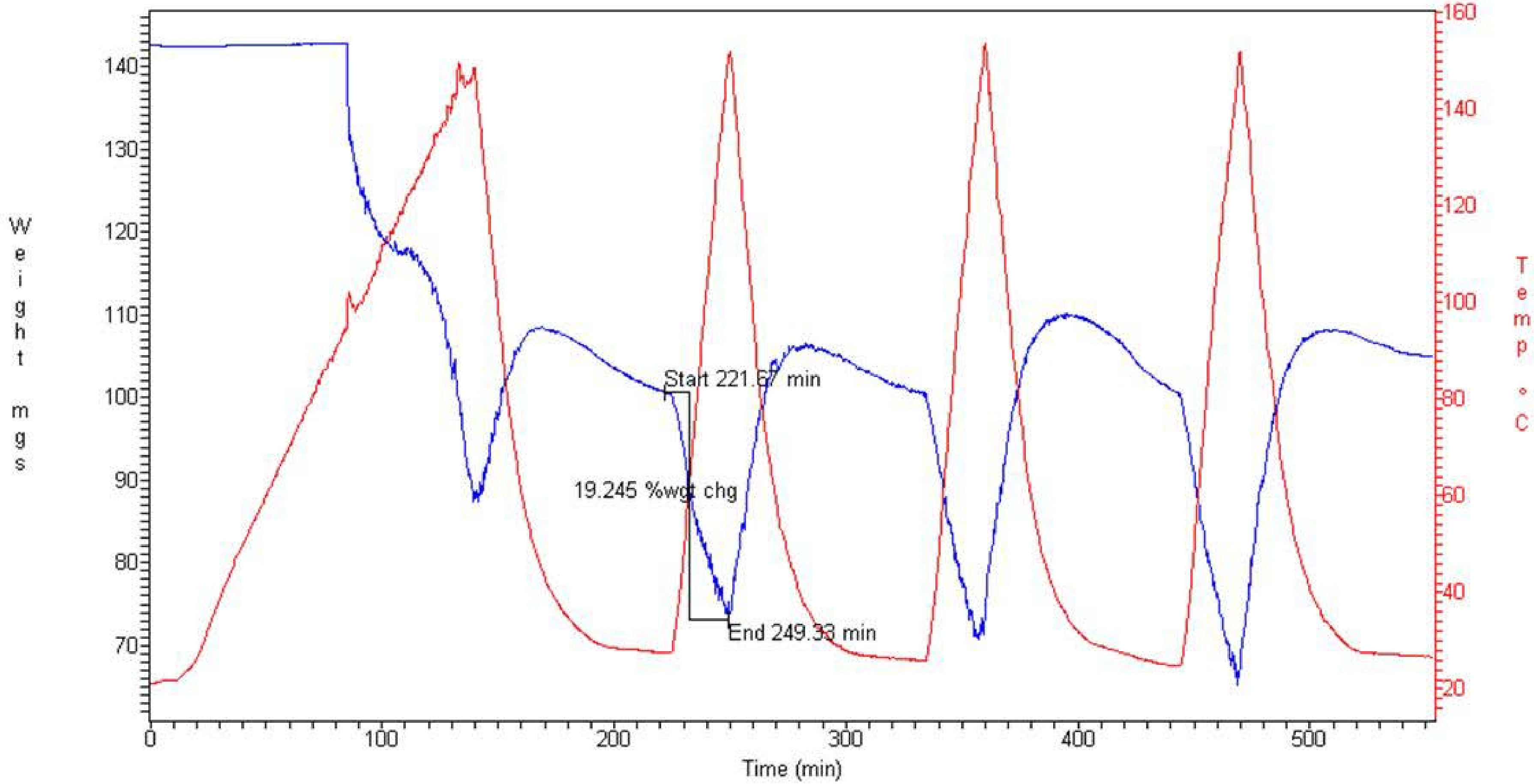
Technical Accomplishment and Progress

borane-ammonia based samples for hydrogen storage in both TGA

Sample content	Weight loss after 150° C (%)
BH_3NH_3:Ni (1:1)	13.828
BH_3NH_3:SAPO (1:1)	15.292
BH_3NH_3:BiPbSnCd (1:1)	10.26
BH_3NH_3:BZSM5 (1:1)	10.663
BH_3NH_3:BZSM5 with Rh (1:1)	9.742
BH_3NH_3:KA (1:1)	13.555
BH_3NH_3:BiSn (1:1)	9.008
BH_3NH_3:$LaNi_5$ (1:1)	8.583
BH_3NH_3:$FeTiO_3$:SAPO (2:1:1)	10.92
BH_3NH_3:Fe_xN:SAPO (2:1:1) x=2~4	12.362
BH_3NH_3:SiC:Rh (15:11:4)	8.662
BH_3NH_3:hydroquinone:Rh (15:10:5)	7.773
BH_3NH_3:Polyaniline emeraldine (1:1)	10.556
BH_3NH_3:BZSM5:Ag/C (15:10:5)	11.273
BH_3NH_3:TiC:BZSM5 (2:1:1)	8.826
BH_3NH_3:Pyrene:$PdCl(PPh_3)_2$ (15:15:2)	8.266
BH_3NH_3:CoPYY/C:$RhCl(PPh_3)_3$ (15:15:2)	12.546
BH_3NH_3:CoPYY/C:V:$RhCl(PPh_3)_3$ (15:8:7:2)	12.059

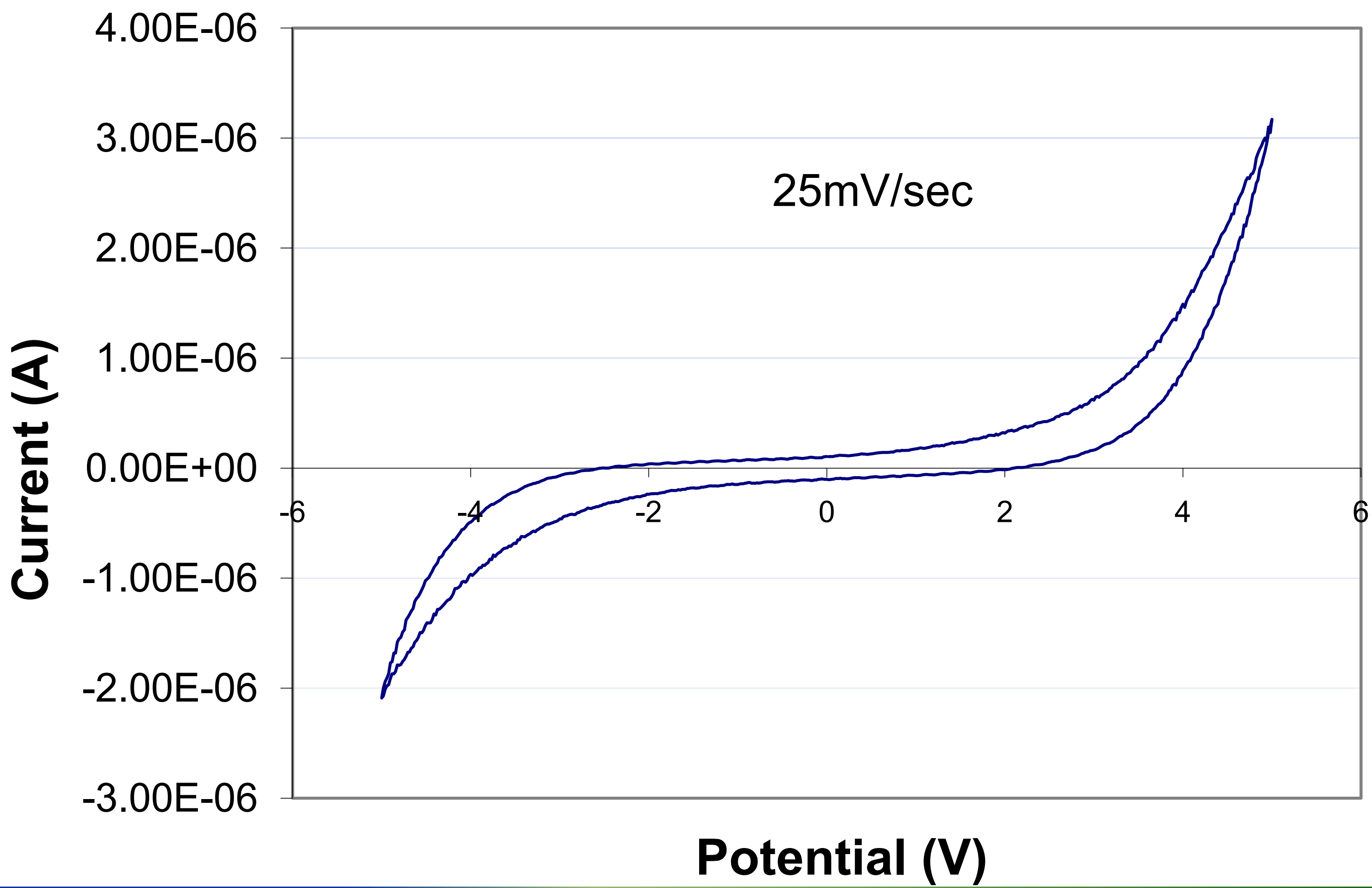
Technical Accomplishment and Progress

One H_2 storage sample subject to heat cycle, results needs to be reproduced

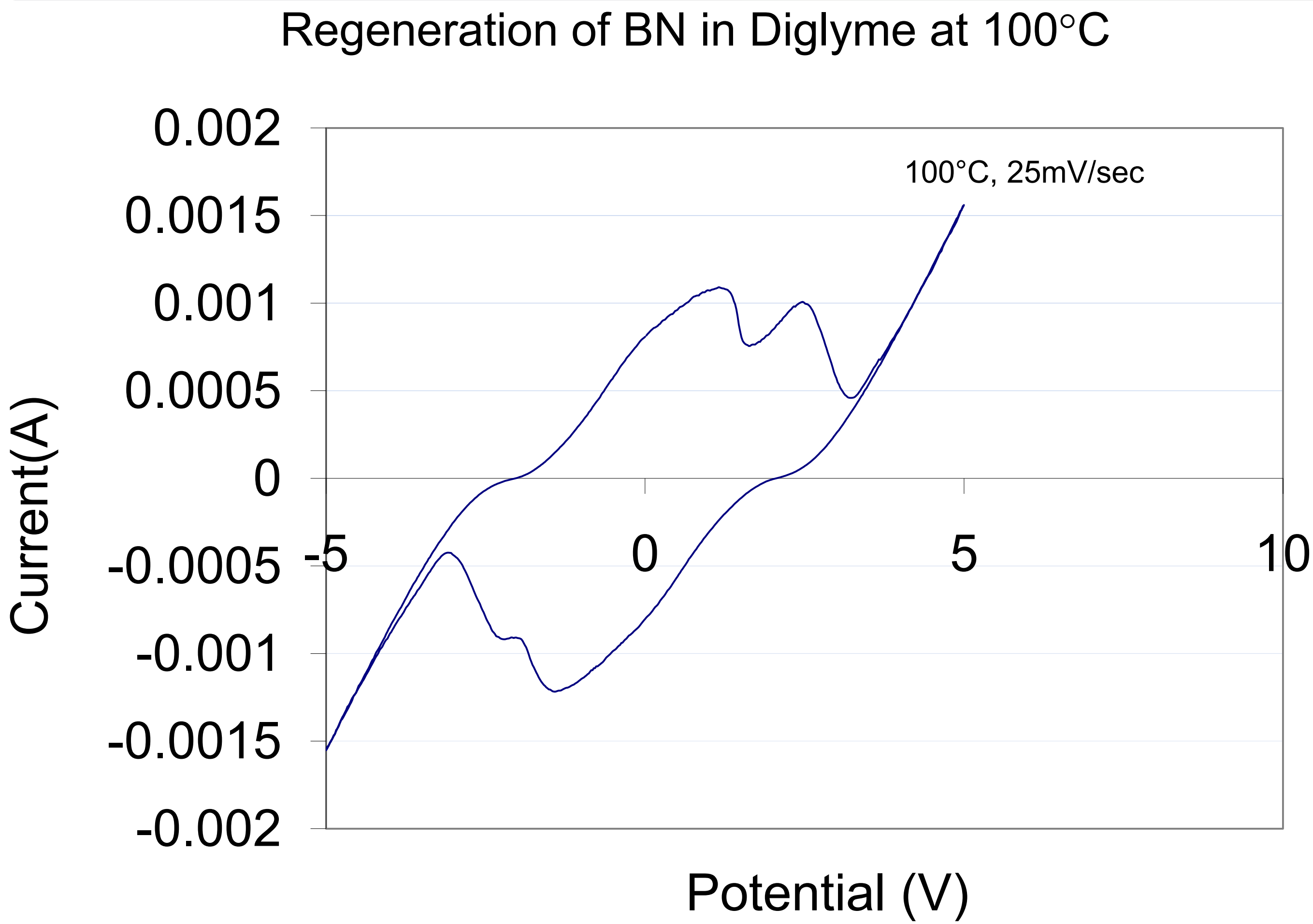


Technical Accomplishment and Progress

Regeneration of BN in diglyme at room temperature



Technical Accomplishment and Progress



Technical Accomplishment and Progress

Hydrogen Storage Material Screening without Electrical Charge

Summary of SUNY samples at 6300kPa

Sample name	0°C (wt%)	77k (wt%)
APKI-S6	0.58	6.38
APK25-N2	0.463	5.94
Ma015580-2	0	3.45
PZTAPK	0.39	5.47

Proposed Future Work

- Continue boron nitride (hydrogen storage more than 6 wt%) research and external charge bias to increase the hydrogen storage rate. Characterize the external charge effect on material physical and chemical properties (pore size, density, surface area, etc).
- Scale-up to an 11 liter tank for fueling demonstration to show 50% hydrogen storage increase.

Conclusions

- External electron charge does affect the hydrogen storage, however different substrates shows different effects
- Negative charge helps boron nitride dehydrogenation kinetics (4 times faster at 900psi) and increases the reversible hydrogenation
- External charge effect on pure carbon material is limited.

Cooperation

- State University of New York at Syracuse: Prof. Cabasso group
- Japanese CCA Manufacturer
- ATMI
- University of Houston

Acknowledgements

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- Japanese CCA Manufacturer
- ATMI