

Biogas Purifications for Fuel Cells

SulfaTrap™ Sorbents



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Clean-up for Fuel Cell
Applications**

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Laboratory**
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Background - SulfaTrap™ Sorbents



Bio-ethanol desulfurizer

SulfaTrap™ sorbents for stationary/mobile fuel cell applications

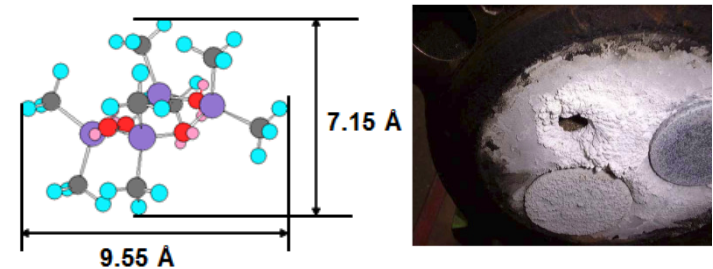
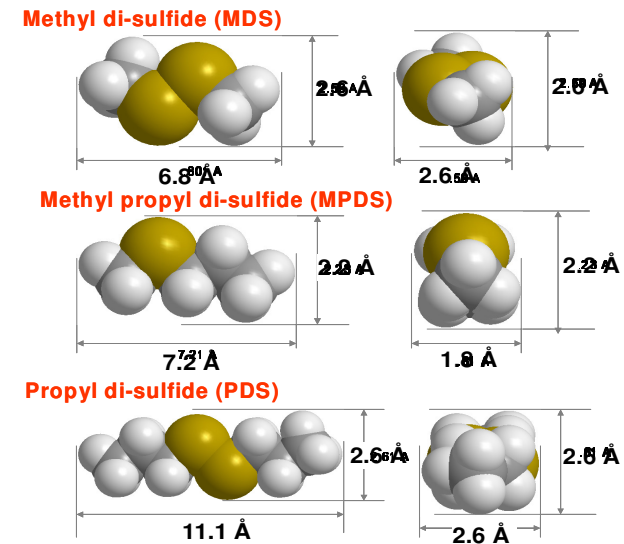
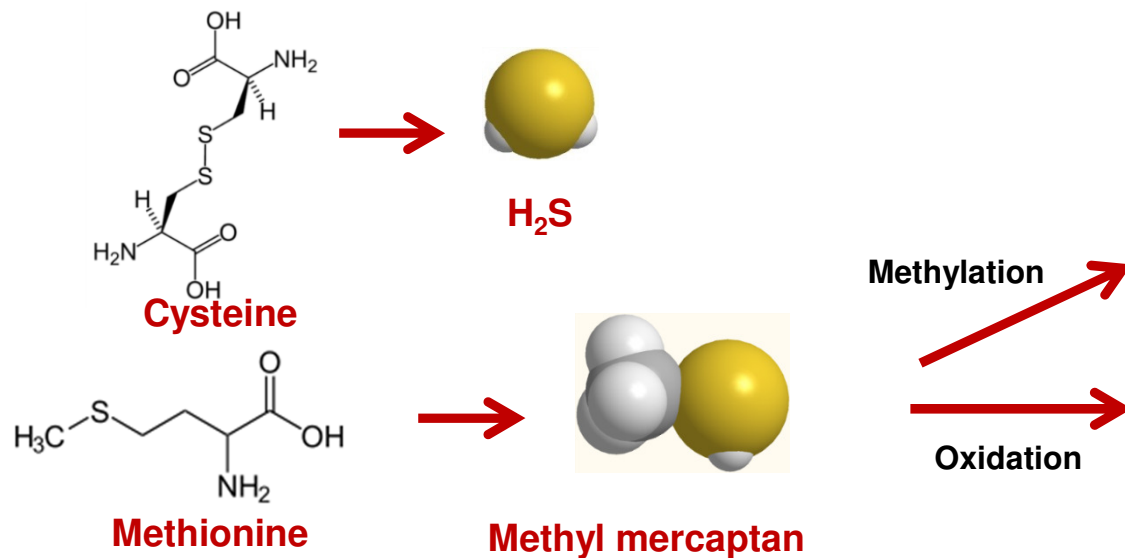
- **Fundamental work started at TDA Research in 2002**
- **SulfaTrap LLC was established as a TDA spin-off in March 2013**
- **SulfaTrap LLC supplied over 70 tons of sorbent products for distributed fuel cell systems and chemical synthesis plants**
 - **Natural gas, LPG, biogas, ethylene and reformat gas desulfurization**



Turn-key solutions for chemical plants

Major Contaminants in Biogas

- Sulfur and siloxanes are potent poisons for all fuel cells
- Primary source of sulfur in biomass are amino acids
 - In anaerobic digesters these degrade to form H₂S & mercaptans



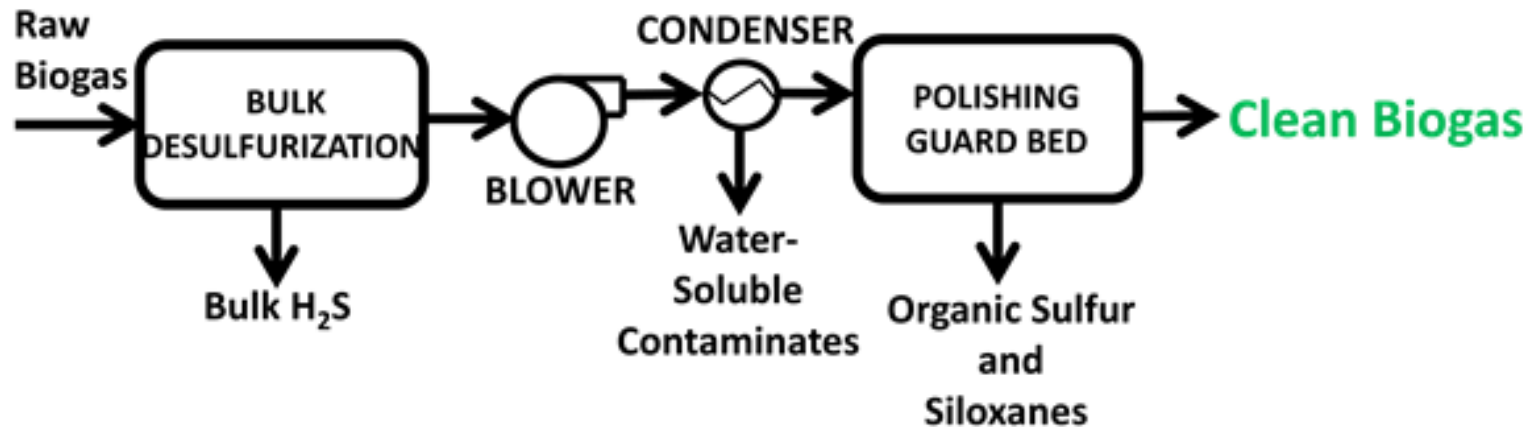
Octomethylcyclotetrasiloxane (D4)



- Siloxanes are man-made organic compounds, used in hygiene/health-care products
- When the biogas is combusted, siloxanes are converted to SiO₂ that can foul surfaces

TDA's Approach

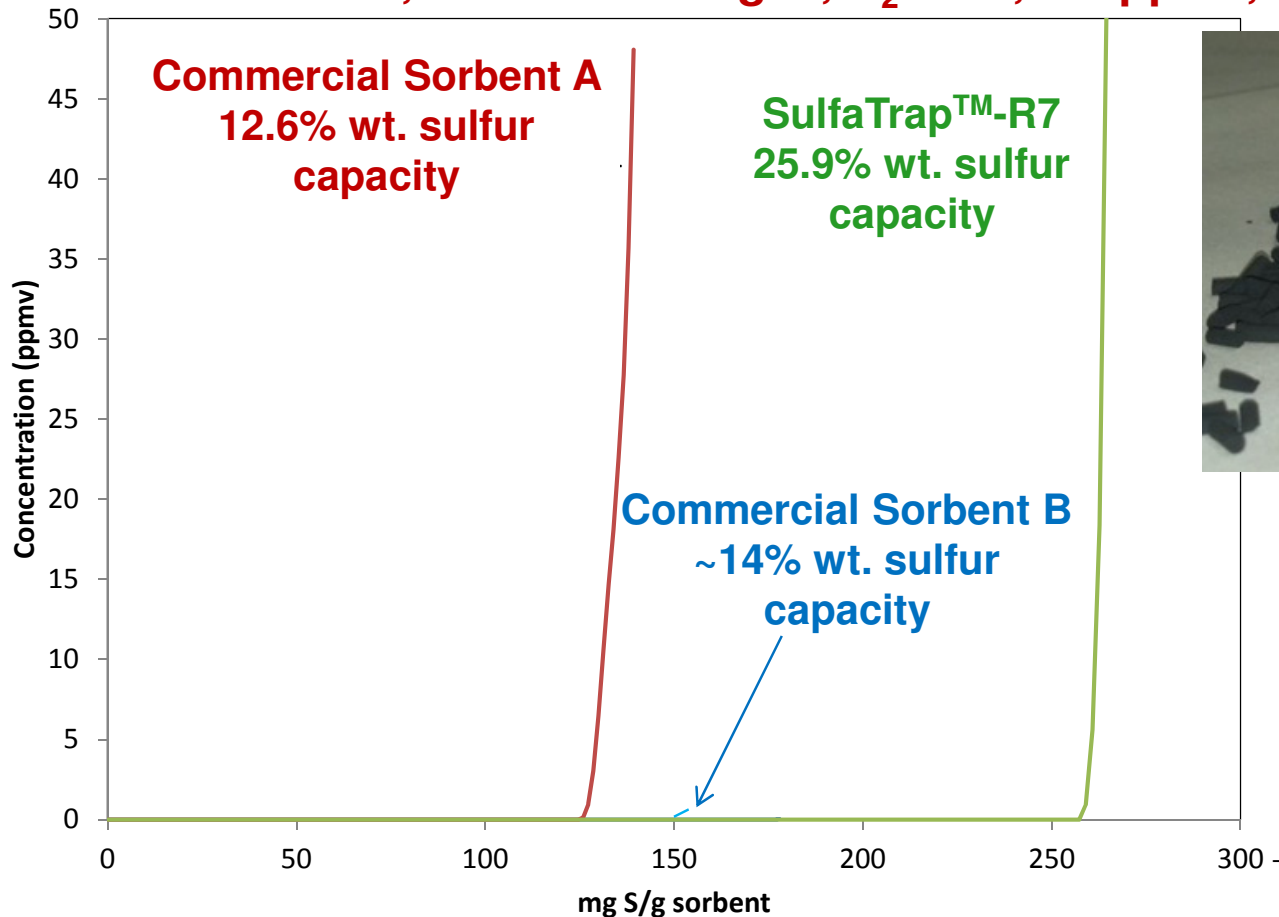
- TDA's approach is to use an ambient temperature gas clean-up system to remove all contaminants to ppbv levels
- The purification system will be downstream of a bulk desulfurization system (biological, liquid redox or solid scavengers)



- Key sorbent requirement is tolerance to high levels of moisture to eliminate the energy penalty for:
 - Biogas compression
 - Chilling
 - Biogas at 2-4 atm, 15°C could have 4,000-9,000 ppmv H₂O

Bulk H₂S Removal

T = 22°C, simulated biogas, H₂S = 4,000 ppmv, H₂O = 4,000 ppmv

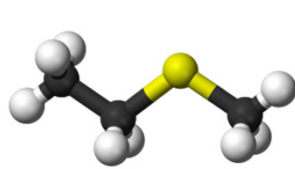


SulfaTrap™-R7 sorbent is mechanically very strong and flows well after use

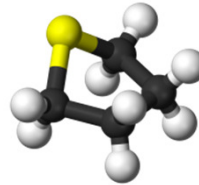
- Technologies are available to remove H₂S and light mercaptans
- Increasing mechanical integrity and reducing cost of disposal could be potential areas of improvement

SulfaTrap™ - Polishing Adsorbent

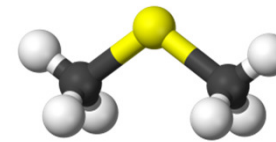
T=22°C, 50 ppmv various sulfur compounds, 4,000 ppmv H₂O, GHSV = 15,000 h⁻¹



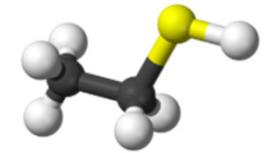
Methyl ethyl sulfide



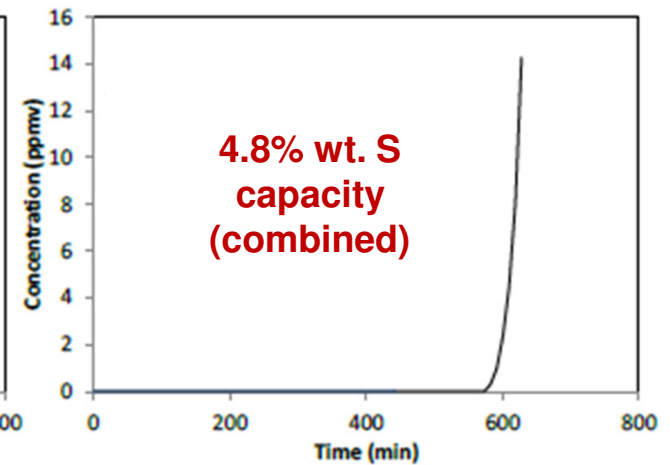
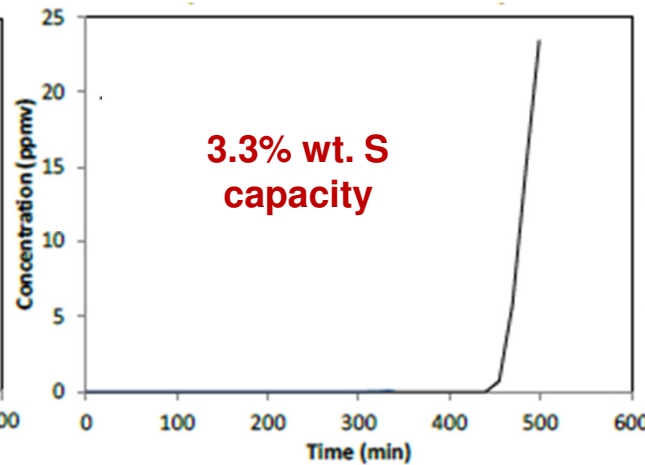
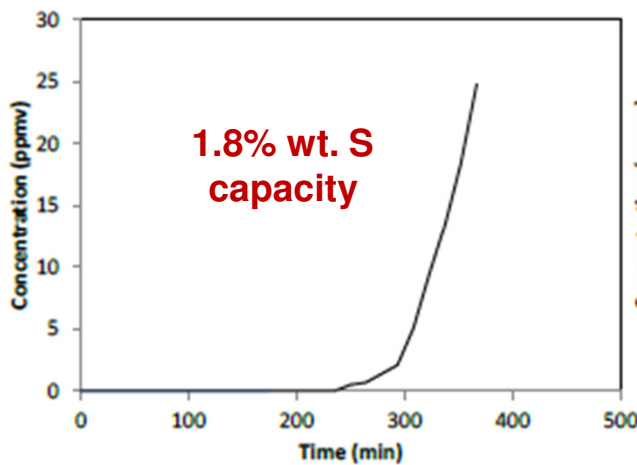
Tetra-hydro thiophene



Dimethyl sulfide



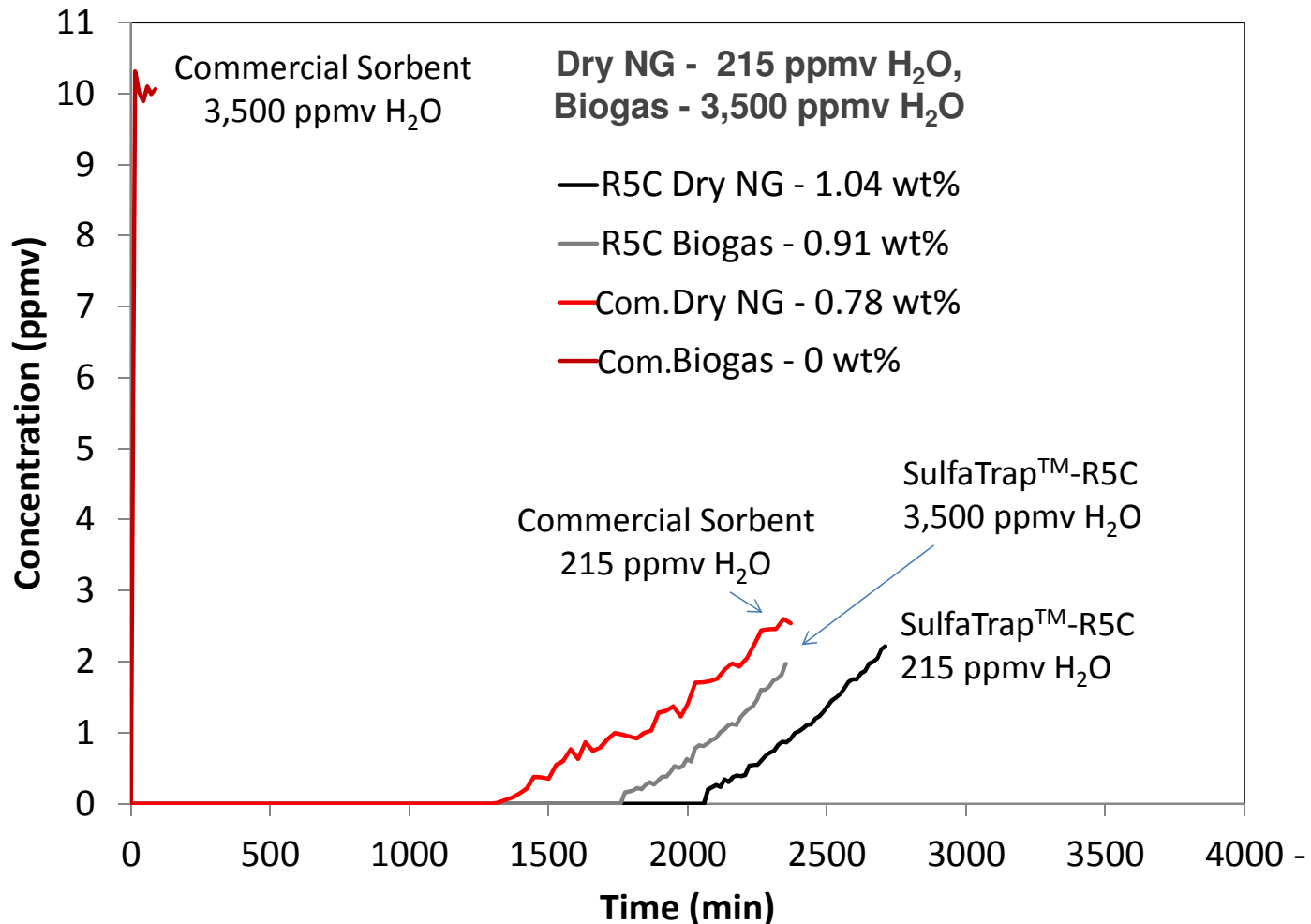
Ethyl Mercaptan



- SulfaTrap™-R2F and R8 sorbents are highly effective in removing all organic sulfur compounds from wet biogas
- High performance up to 9,000 ppmv

SulfaTrap™-R5C - Impact of Moisture

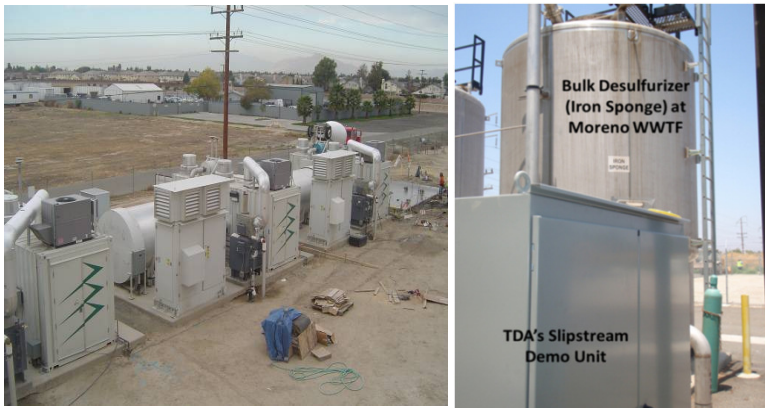
10ppmv COS, Natural Gas mixture or CH₄/CO₂ = 60/40, 3,500 ppmv H₂O, 15000 h⁻¹ GHSV



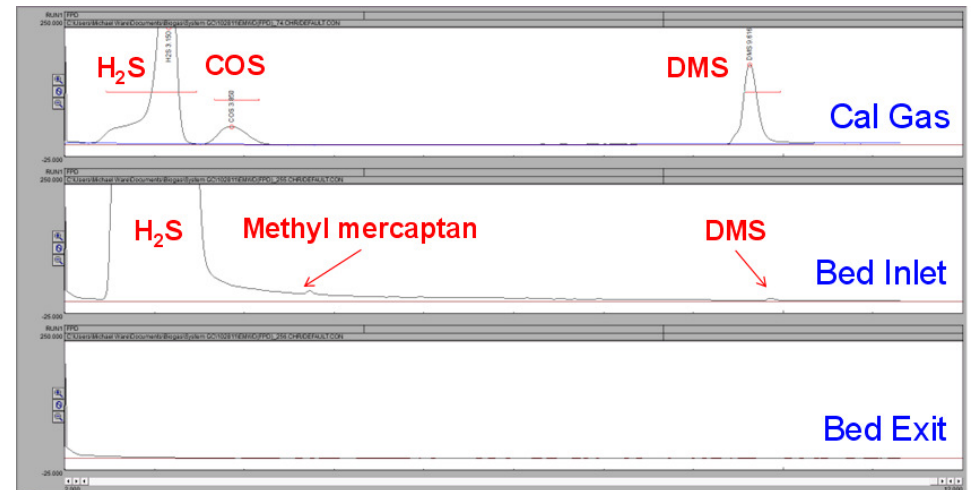
- SulfaTrap™-R5C maintains its capacity in biogas (high moisture and CO₂)

Field Demonstrations

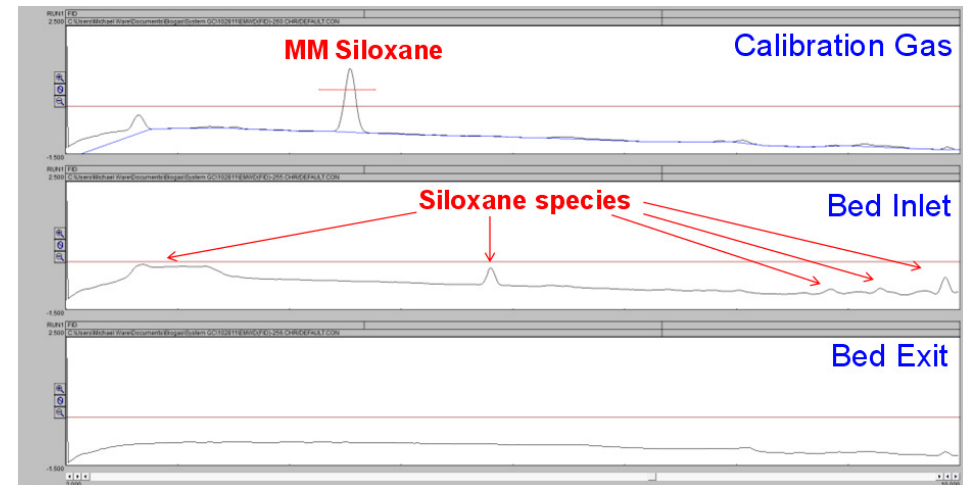
- Slipstream tests, in collaboration with FCE, at the EMWMD and City of Tulare were successful



Sulfur Removal



Siloxane Removal



Summary

- **Conventional gas clean-up systems do not meet the gas purity requirements of the bio-fueled fuel cells**
- **Presence of high concentrations of moisture reduces the sulfur capacity of conventional adsorbents**
 - Contaminants such as dimethyl sulfide and carbonyl sulfide are particularly difficult to remove from high moisture gas
- **TDA Research/SulfaTrap LLC is developing high capacity sorbents that can reduce the sulfur concentration to less than ppbv levels**
- **With government funding, the technology is progressing to full-scale demonstration**



**Lead-lag configuration with 6' x 6'
skid for a 300 kW_e system
~300L sorbent – 4 month operation**