A Novel Treatment for H_2S-Contaminated Landfill Gas

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Outline

- Motivation and Background
- Site Selection and partnerships
- Preliminary Results
- Scale-up
- Future work

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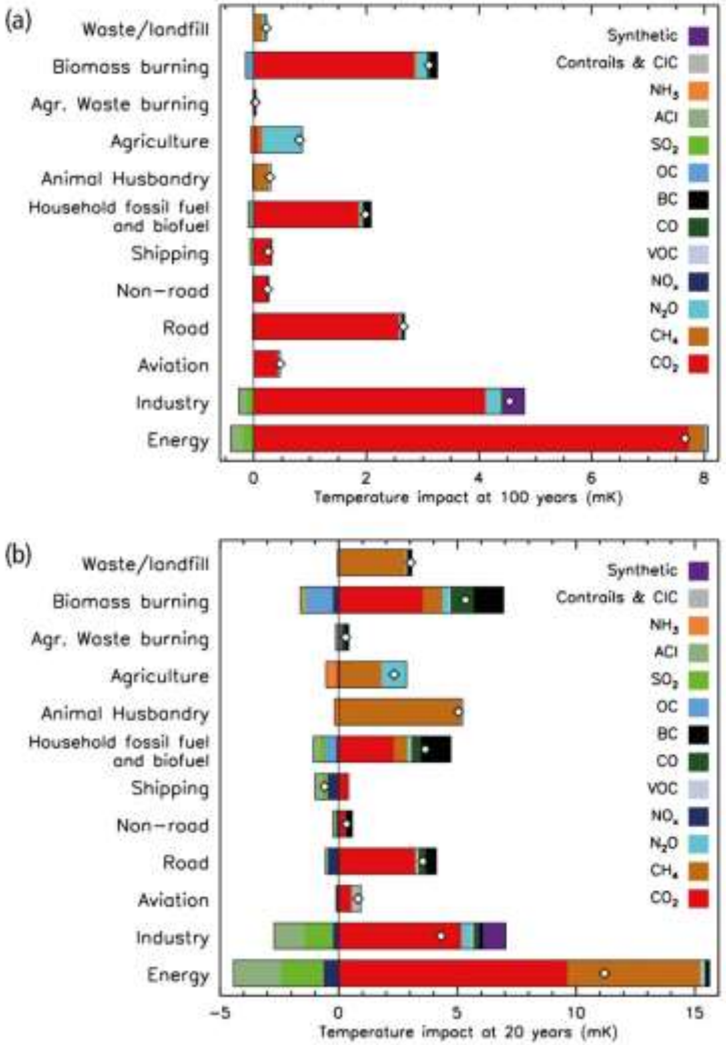
Motivation and Background

Anthropogenic emissions and global temperature impacts



Net global mean temperature change by source sector after (a) 100 and (b) 20 years (for 1-year pulse emissions). Emission data for 2008 are taken from the EDGAR database. For BC and OC anthropogenic emissions are from Shindell et al. (2012a) and biomass burning emissions are from Lamarque et al. (2010)

IPCC (2013) AR5

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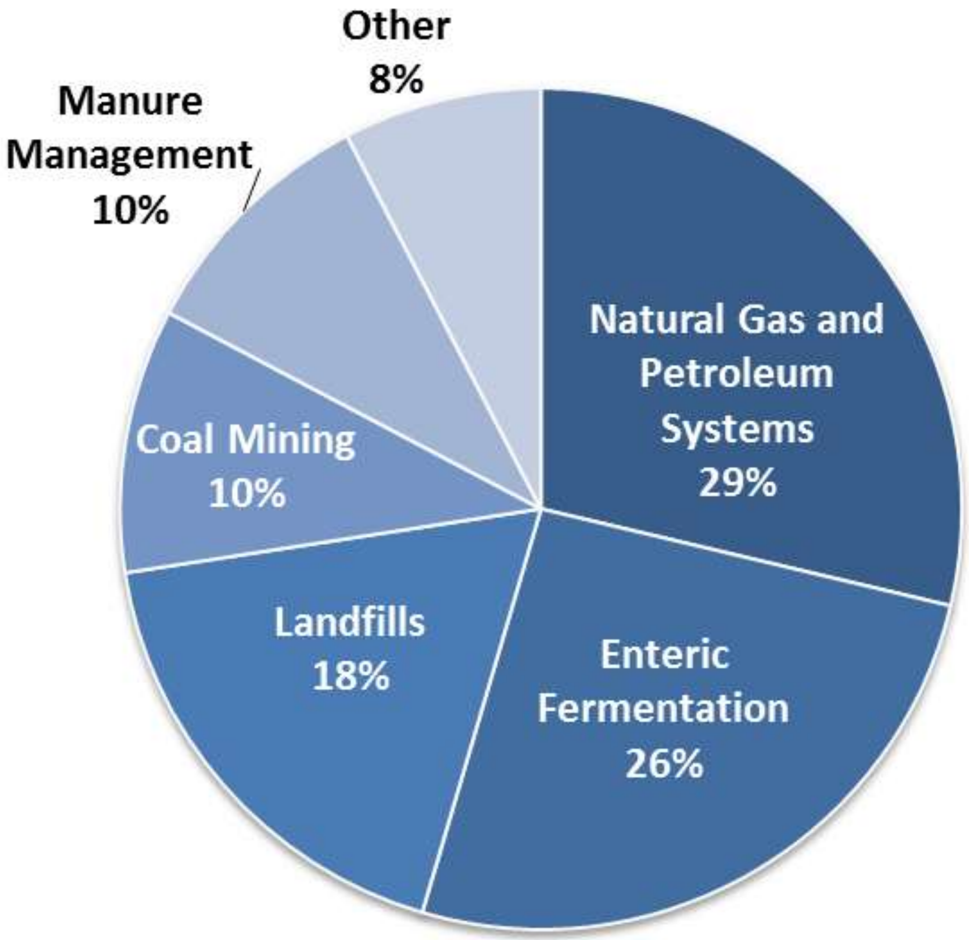
Sources of Anthropogenic Methane

- Landfills #3 U.S. Source
- 83.1 million metric tons of CO_2 equivalent ($MMTCO_2e$) was released to the atmosphere in 2012
- Methane has 25x the heat trapping potential of CO_2



EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2013 (April 2015)

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Total Potential Biogas from Sources on Long Island
(Patel et. al, 2011)

Potential source	Currently exploited	Current/potential CH_4 yield ($\times 10^6\ m^3$)	Optimal use	Technology barriers
Sludge	No	70.5	Pipeline quality gas	ADs are needed. Upgrading tech.
LGRF	Yes	46.4	Pipeline quality gas	Upgrading tech.
MSW	No	44.7	Pipeline quality gas	ADs are needed; upgrading tech.
C&D	No	43	Pipeline quality gas	Upgrading tech.
Agriculture waste	No	24.9	On-site electricity	ADs are needed.
Yard waste	No	4.8	On-site electricity	ADs are needed.

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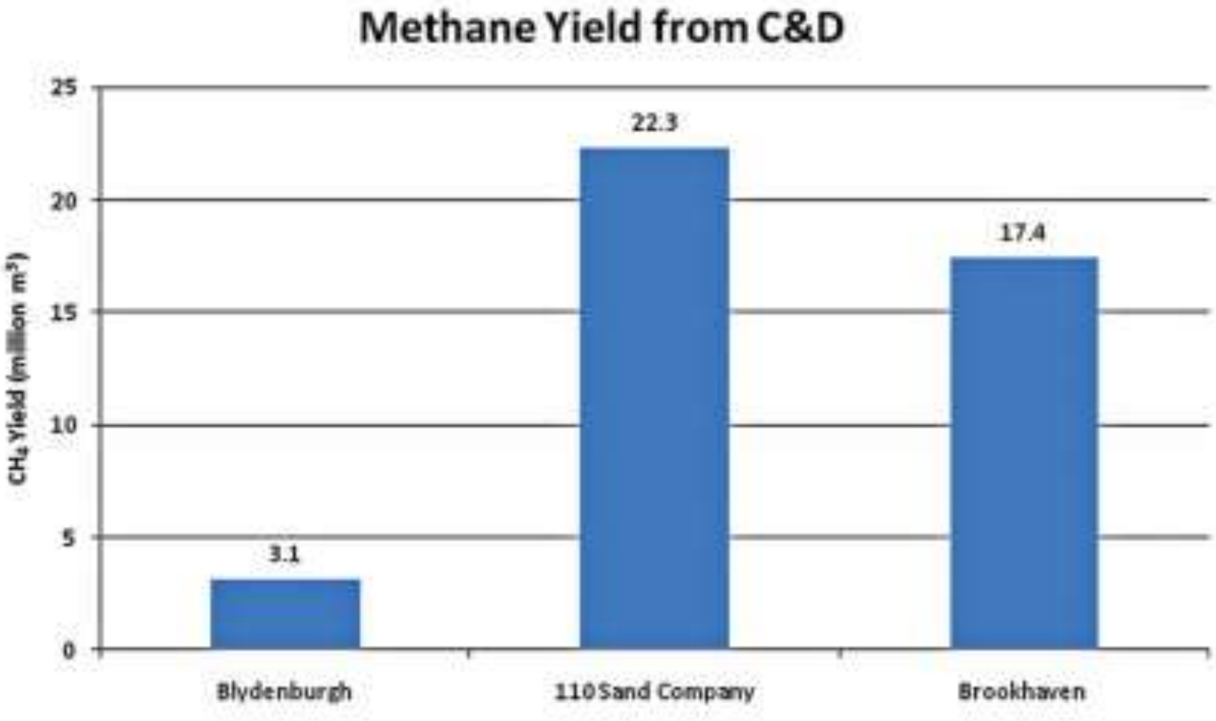
Construction and Demolition



- Three active landfills on L.I. that manage C&D from NYC
- Estimated 2008 CH_4 yield = 43.4 x 10^6 m^3 (approx. 30% of potential)
- Due to high H_2S levels (up to 8000 ppm), gas is flared

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Why does C&D produce high H_2S?

- calcium *sulfate* dihydrate, a soft mineral
- Used to make drywall chalk
- Every year, new construction releases 8 billion lbs of drywall scraps in the U.S.
- Under anaerobic conditions, bacteria will break down gypsum and release Hydrogen Sulfide
- 4 tons wallboard produces 1 ton H_2S

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Site Selection and partnerships

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Brookhaven Landfill ~ 540 acre site

- Cells 1-3 received mostly MSW (8MT) and closed in 1993
- Cell 4 received Ash, C&D, and MSW (2.5-3MT) closed in 1997
- 1-4 gas to engine produce 1MW at capacity
- Cell 5 received Ash, C&D and other materials (7MT)
- Cell 6 operating for 12 years (12MT) receiving ash, C&D, and other materials

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Advanced Energy Research and Technology Center (AERTC)

- Nanoparticle catalyst and biochar for sulfur removal of landfill gas
- Testing small scale sulfur removal system
- Landfill gas analysis using multiple gas chromatographs (GCs): CH_4, CO_2, CO, H_2S, H_2, N_2

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Stony Brook University partners with Brookhaven

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Preliminary Results

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Brookhaven Gas Collection

a) Gas pumping station
b) Active landfill site
c) Well collection system

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Present Commercial Technology for Sulfur Removal

- Higher sulfur Landfill gas from cells 5&6 is pumped through Sulfatreat media
- 8'x8'x40 containers filled (110,00 lbs)
- Post treatment, gases are flared

- SULFATREAT

$$Fe_XO_Y + H_2S \longrightarrow FeS_2 + H_2O$$

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Preliminary analysis of Brookhaven system

- 4 visits to Brookhaven for baseline gas samples
- Lab results show a 50% reduction in H_2S

	Before Treatment			After Treatment		
Component	**6/14**	**9/14**	**1/15**	**6/14**	**9/14**	**1/15**
H_2S	.4%	.2%	.4%	.2%	.1%	.2%
CO_2	36.1%	20.4%	17.2%	30.6%	25.4%	16.9%
CH_4	33.6%	18.9%	21.3%	28.5%	23.5%	14.9%
N_2	41.6%	30.0%	41.7%	41.8%	39.2%	51.0%
H_2	-	1.0%	-	-	1.6%	-
CO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Others (O_2.......)	-	17%	-	-	7.8%	-

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Nanoparticles

- Sonication to produce nano sized particles of catalyst
- At the nano size, and at specific temperatures, the material has unique magnetic properties and a very high surface area to volume ratio

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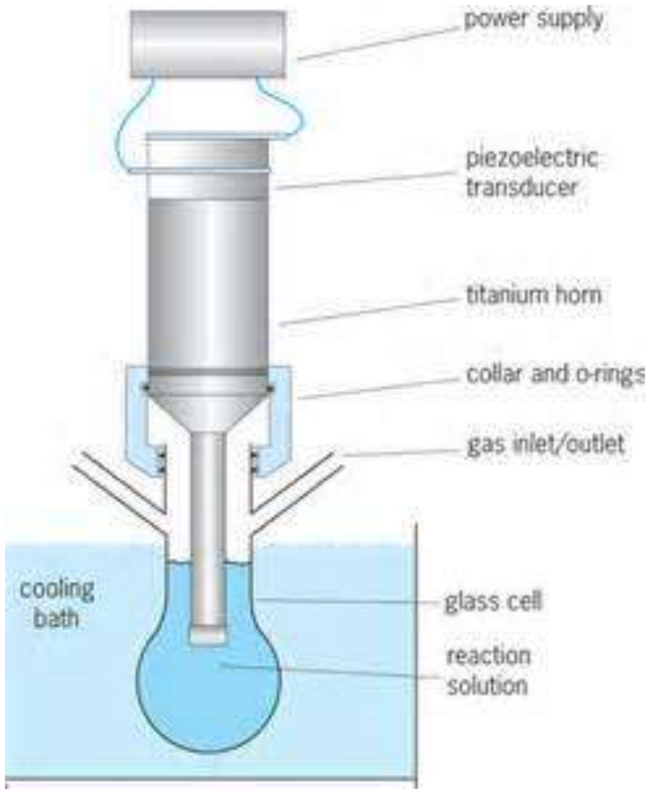
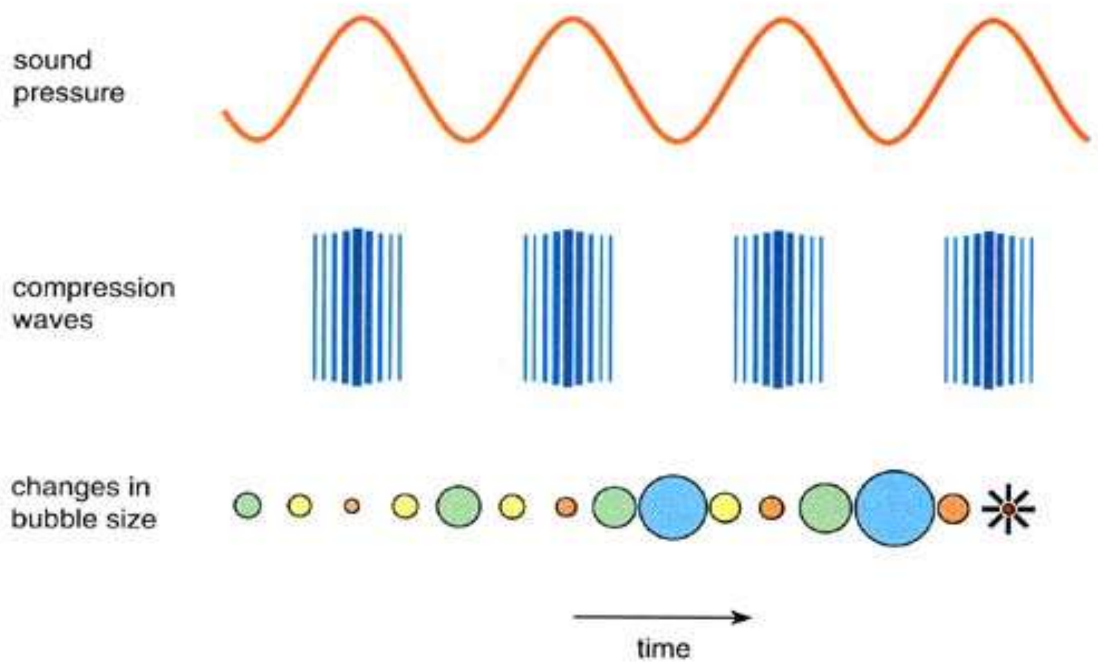
Catalyst – Sonochemistry





- 5200K
- 1800 -2000 atm

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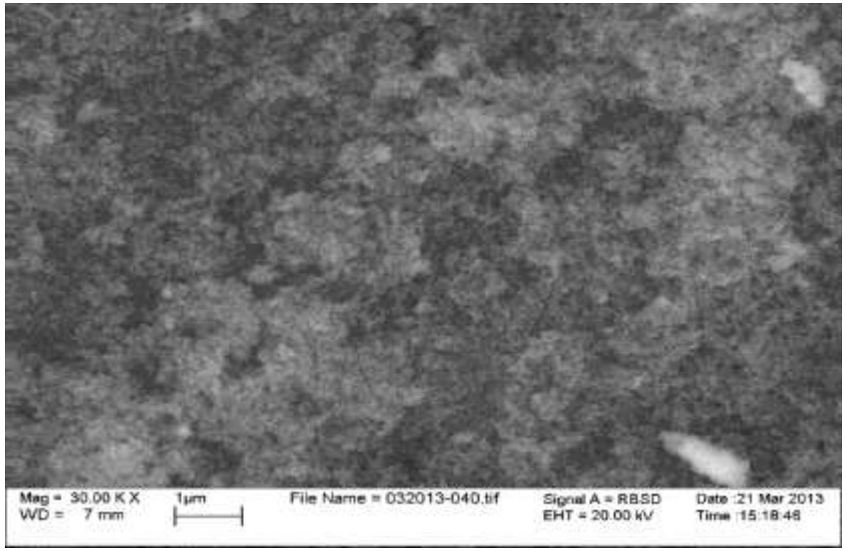
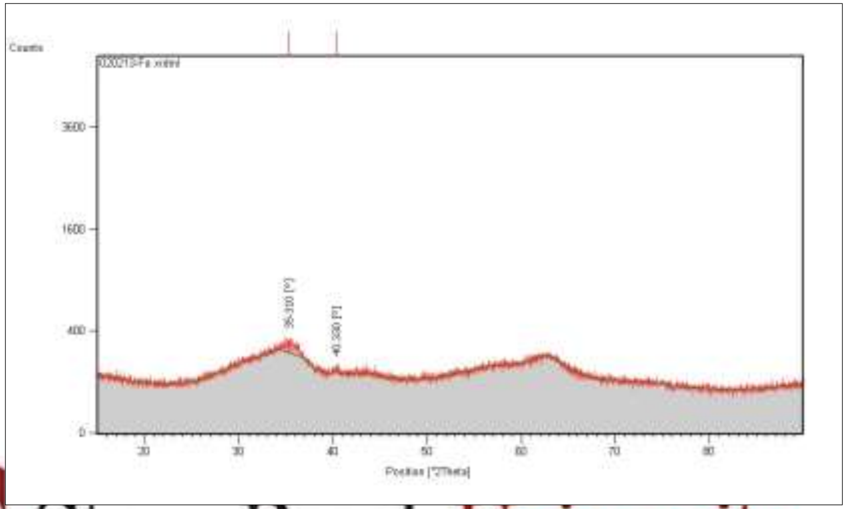
Catalyst – Particle Size and Surface Characterization

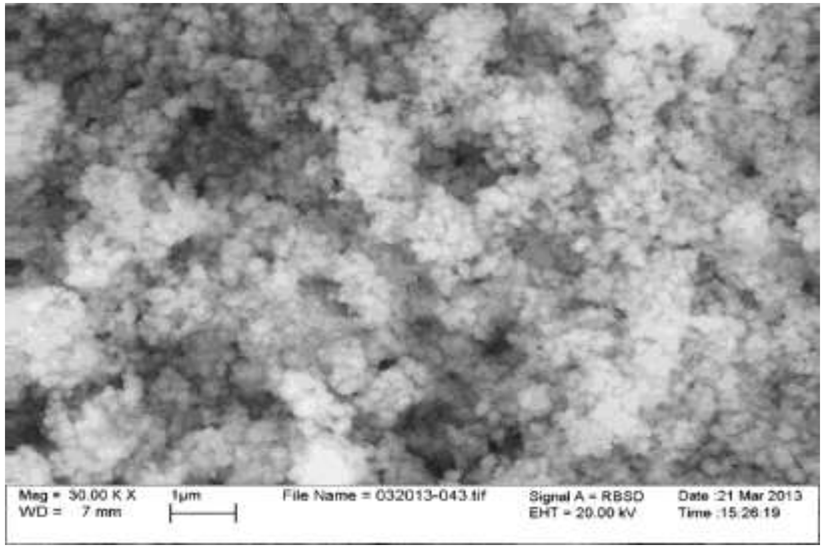


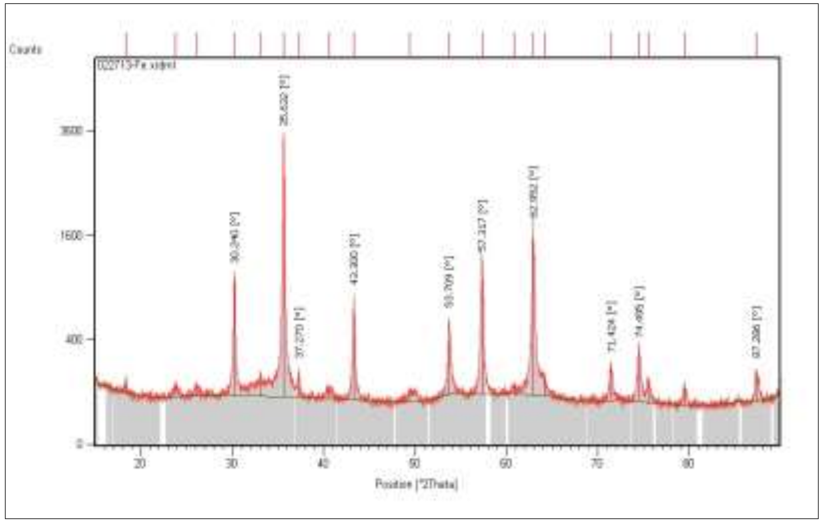


XRD, SEM and TEM

Particle size < 10 nm

Amorphous





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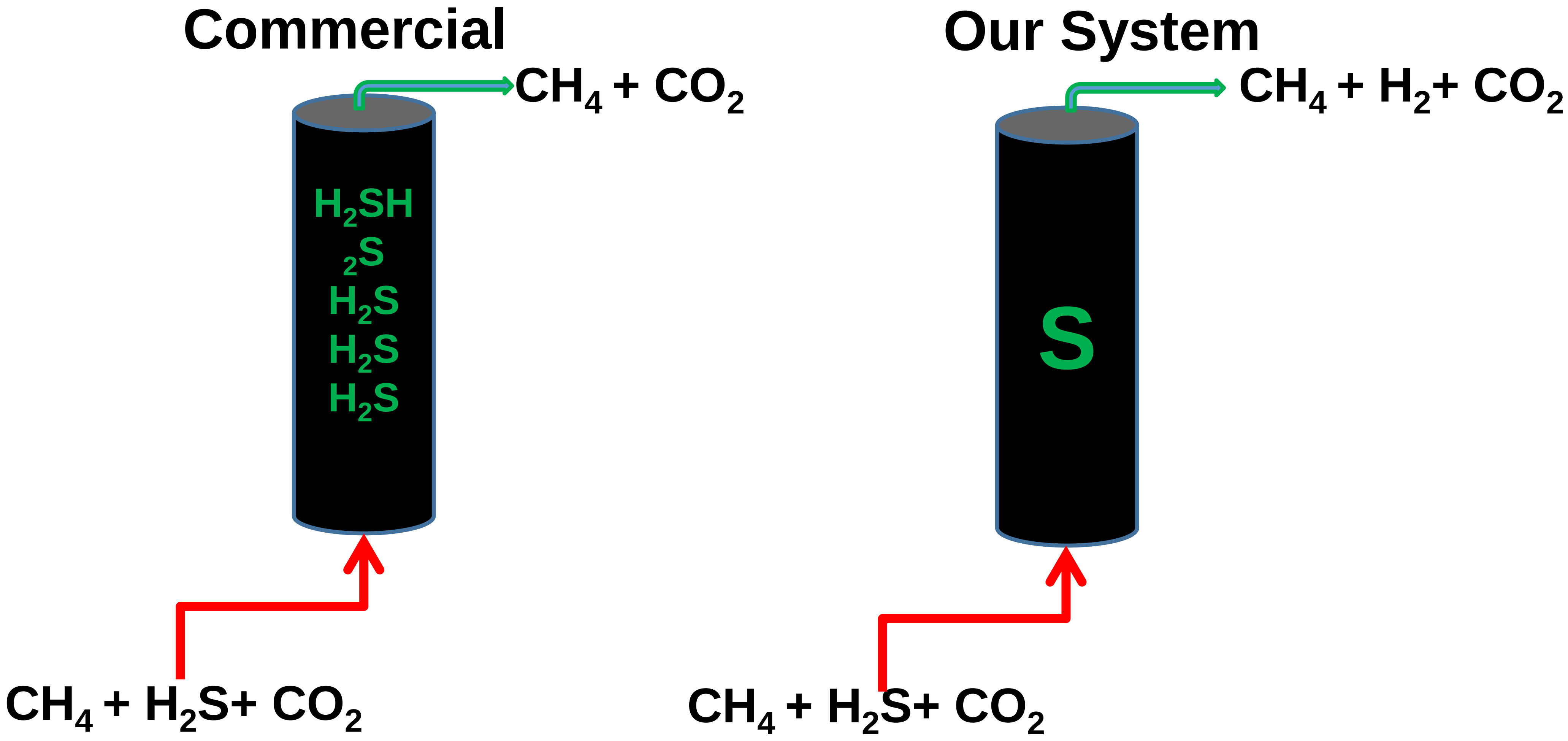
Mechanism for H_2S Removal



*Mahajan and Patel, 2013. Hydrogen Sulfide Removal

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Gas Analysis

- Gas Chromotography at AERTC
- Baseline gas analysis
- Experimental nano partical gas treatment and analysis

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Preliminary S-Removal testing in AERTC

- Yellow on glass is sulfur captured after reacting with catalyst
- Preparatory lab tests are experimenting with ratios of nano-metal catalyst and biochar

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Scale-up

A system is being developed for testing at the Brookhaven site.

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Conclusions

- Better economics of sulfur removal may allow for increased use of landfill gas recovery for energy

- Incorporation of biomass waste products into media provide a renewable resource for gas cleaning

- Preliminary lab studies show that our methods can improve capacity of H_2S treatment by several times over commercial technology.

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Thank you

Lori Clark Ph.D. candidate in Technology, Policy, and Innovation

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