Biogas: Efficiency through New Technologies

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UNISON SOLUTIONS

Reducing Capital and Maintenance Costs-H_2S Removal

Digester or Landfill

Hydrogen Sulfide Removal

Gas Compression/ Moisture Removal

Siloxane Removal

Micro Turbine

IC Engine-Generator

Boiler

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Why Hydrogen Sulfide Removal?

- Equipment damage from corrosion (Hydrosulfuric Acid)
- SO_x Emissions
- Health and safety issues (1,000 ppm will cause an individual to lose consciousness)
- Odor control
- Causes fouling of siloxane removal media
- Measure levels with either lab testing, Draeger tubes, or onsite meter

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Hydrogen Sulfide Removal Systems

Ferric Oxide, Fe_2O_3 coated (reaction)

- Wood based
- Clay based

Ferric hydroxide pellet (adsorption)

Wausau WWTP, WI

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Hydrogen Sulfide Removal Media

- Ferric Hydroxide, FeO(OH)
  - Used on saturated gas
  - Conditioning step – Ca to $CaCO_3$
  - Tolerant of variable or low moisture content
  - Sulfur is pulled into pores and media remains granular
- $2\ Fe(OH)_3 + 3\ H2S \rightarrow Fe_2S_3 + 6\ H2O$
- Exothermic reaction when exposed to oxygen

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Persigo WWTP, Grand Junction , CO

	Persigo WWTP Summary
Start Up Date	April 6, 2015
System Flow	100 scfm
Inlet H_2S:	3,000 ppmv
Oxygen:	0.229%
Moisture:	4-20 mg/l* (*25 mg/l = 100% saturation)
Vessels:	(2) 8' Ø x 12' ss

Media Type	Media Cost/Change out	*Estimated days before change out with saturated gas	Actual days before change out (50 ppmv)
SulfaTreat	$31,394	102	41
Iron Sponge	$17,442	90	60
UNI-H2S	$30,500	150	104

Persigo WWTP, Grand Junction, CO

Sulfatreat and iron sponge both require 100% saturated gas to operate at their optimum.

*Based on percent by weight removal capacity, assuming optimum conditions

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Hydrogen Sulfide Removal Media

Specially activated wood based media

- Remains granular
- Works on saturated gas, but can tolerate lower than 100%
- Low heat up when exposed to oxygen
- Can be used in conjunction with VOC removal media
- Chemisorb reaction takes place inside pores of media

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Hydrogen Sulfide Removal Media

St. Landry Solid Waste, LA
1 – 50 scfm & 1 – 100 scfm BioCNG system

Specially activated wood based media

- Remains granular
- Works on saturated gas
- Can be used in conjunction with VOC removal media

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Reducing Capital and Maintenance Costs

Digester or Landfill

Gas Compression/
Moisture Removal

Hydrogen Sulfide and Siloxane Removal

Micro Turbine

IC Engine-Generator

Boiler

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Hydrogen Sulfide Removal Media

- Potassium Iodide, KI impregnated
  - Coal or coconut substrate
  - Used on dry gas
  - Sulfur is pulled into pores and media remains granular
  - Cost effective on <100 ppm H_2S
  - Reduces siloxane concentration

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Danville Sanitary District, IL

- Site requirements
  - Limited space
  - Ease in media change out
- Inlet conditions
  - 55 scfm
  - 1000 ppm H_2S
    - FeCl (Ferric Chloride) used in digester
  - H_2S inlet to Unison skid – 40-100 ppm
- Siloxane Removal Vessel 1 - KI impregnated media
- Siloxane Removal Vessel 2&3 - Coal based siloxane removal media

Reducing Maintenance Costs-Siloxane removal

Digester or Landfill

Hydrogen Sulfide Removal

Gas Compression/ Moisture Removal

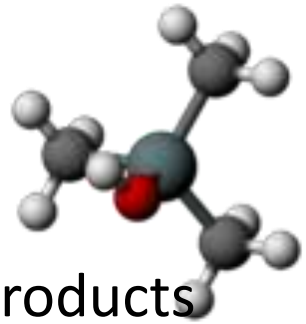
Siloxane Removal

Micro Turbine

IC Engine-Generator

Boiler

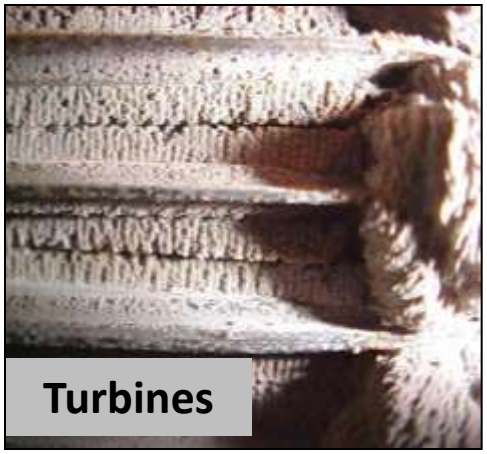
What is a Siloxane?



- Silica and organic compounds are combined (Organosilicon)
- Used in many industrial products and consumer products
  - Deicing fluid
  - Windshield Cleaning Products
  - Silicone caulks
  - Food additives
  - Commercial products for washing fruits and vegetables
  - Shampoo/conditioner
  - Laundry detergents
  - Furniture polish
- Siloxanes break down in landfills and digesters, and combine with the methane gas

https://hpd.nlm.nih.gov/cgi-bin/household/brands?tbl=chem&id=1784

Siloxane Impact on Equipment



- When methane gas is used as a fuel, the siloxanes form SiO_2 Silicon Dioxide, and precipitate to a hard deposit on surfaces

- Significant impact on electrical generation systems
  - Increased down time for maintaining equipment
  - Increased costs for components, i.e. spark plugs, valve seats
  - Engine rebuild time is more frequent

Siloxane/VOC Removal

Coal

Coconut shell

Wood

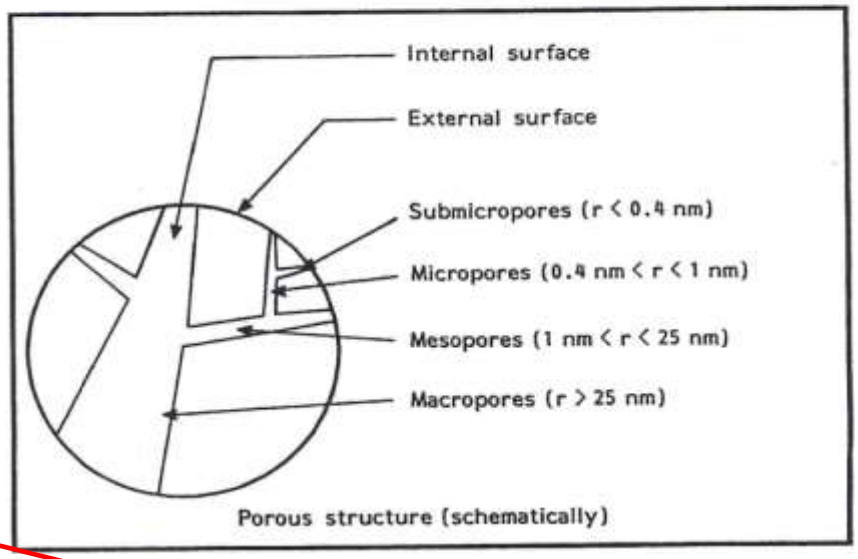
Extruded pellets

4 x 8 mesh chips

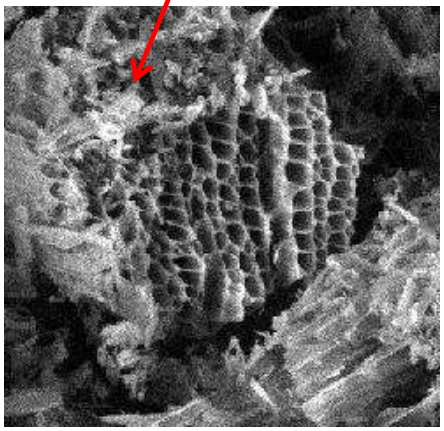
Silica gel - spheres

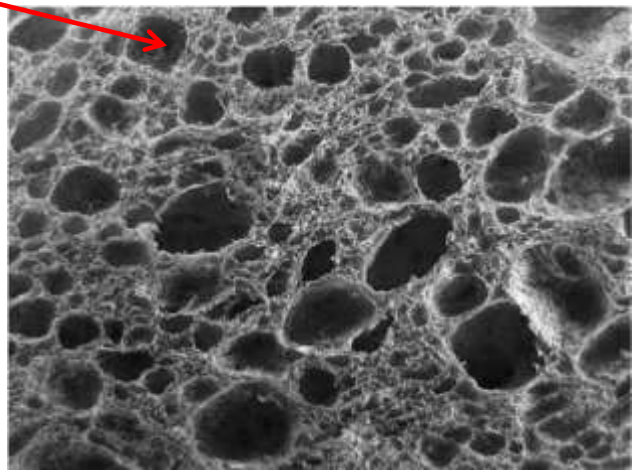
Silica gel – irregular shaped

Media After Activation



Porous structure (schematically)





Suitability Factors for Media Systems: Inlet Biogas Quality – Siloxanes, Hydrocarbons and VOC's

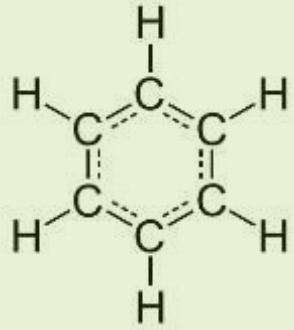
Siloxanes **Organic Compounds with Silica**
Tetramethyl silane
Trimethyl silanol
Hexamethyldisiloxane (L2)
Hexamethylcyclotrisiloxane (D3)
Octamethyltrisiloxane (L3)
Octamethylcyclotetrasiloxane (D4)
Decamethyltetrasiloxane (L4)
Decamethylcyclopentasiloxane (D5)
Dodecamethylpentasiloxane (L5)
Dodecamethylcyclohexasiloxane (D6)

VOC **Volatile Organic Compounds (Commonly Found)**
Acetone
Benzene
Chlorobenzene
Decane
Ethylbenzene
Heptane
Hexane
Isopropyl Alchohol
Octane
Xylene
Toluene
22-35 compounds typically reported

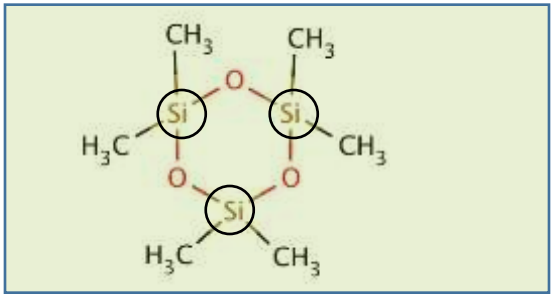
Suitability Factors for Media Systems: **Siloxanes, Hydrocarbons and VOC's**

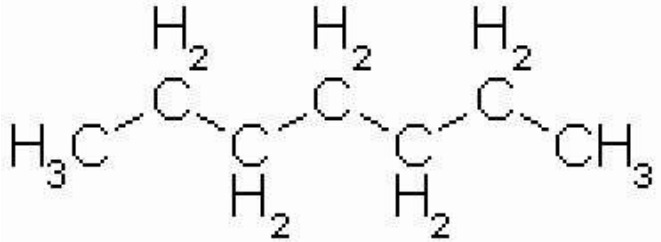
Benzene

C_6H_6



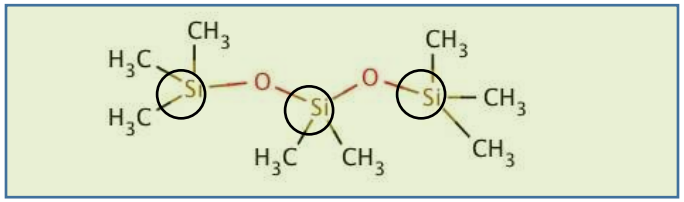
D3, Hexamethylcyclotrisiloxane





Heptane

C_7H_{16}



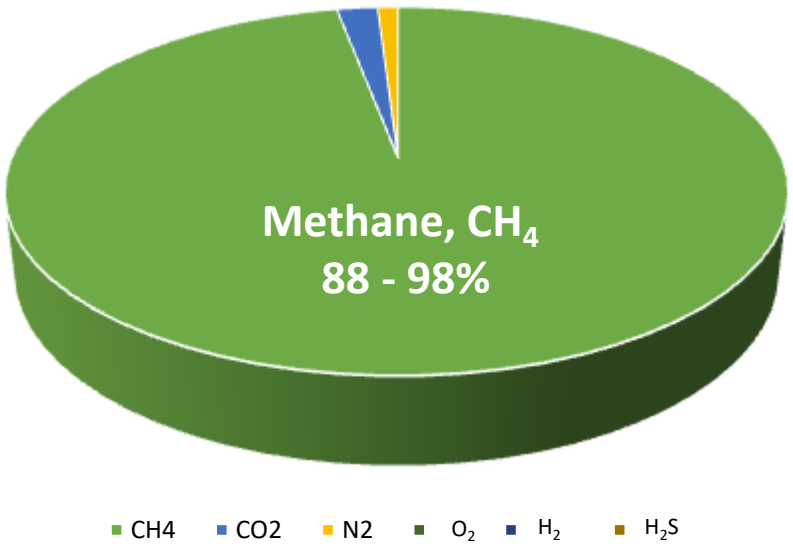
L3, Octamethyltrisiloxane

Biogas to Vehicle Fuel

bi·o·gas, ˈbīōˌgas/, *noun,* gaseous fuel, especially methane, produced by the fermentation of organic matter.

- Methane, CH_4
- Carbon Dioxide, CO_2
- Nitrogen, N_2
- Oxygen, O_2

- Hydrogen Sulfide, H_2S
- Moisture
- Particulates
- Siloxanes
- Volatile Organic Compounds



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Methods to Deliver RNG

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Digester or Landfill → Biogas Upgrading System → CNG for Vehicles

- Fast Fill Stations
- Time Fill Stations
- Dedicated Pipeline
- Virtual Pipeline
- Natural Gas Pipeline

Persigo WWTP Grand Junction, CO

- Startup: April 2015

Gas Conditioning Equipment

- Hydrogen sulfide removal
- Gas compression/ Moisture removal
- Siloxane removal
- Carbon dioxide removal

BioCNG™

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Randolph Farms Landfill, IN

- Startup: Spring 2018
- 200 scfm
- Fast Fill - vehicle fueling

SYSTEM COMPONENTS

- Hydrogen sulfide removal
- Gas compression/ Moisture removal
- Siloxane & VOC removal
- Carbon dioxide removal

BioCNG™

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Blue Line Transfer – Time Fill

- South San Francisco, CA
- 8 Dry Anaerobic Digesters
  - 11,200 tons of food and green waste diverted per year
- Gas Flow: 100 scfm
- Time Fill – CNG fueled waste haulers
- Fast Fill – small amount of high pressure storage on site for emergency fill

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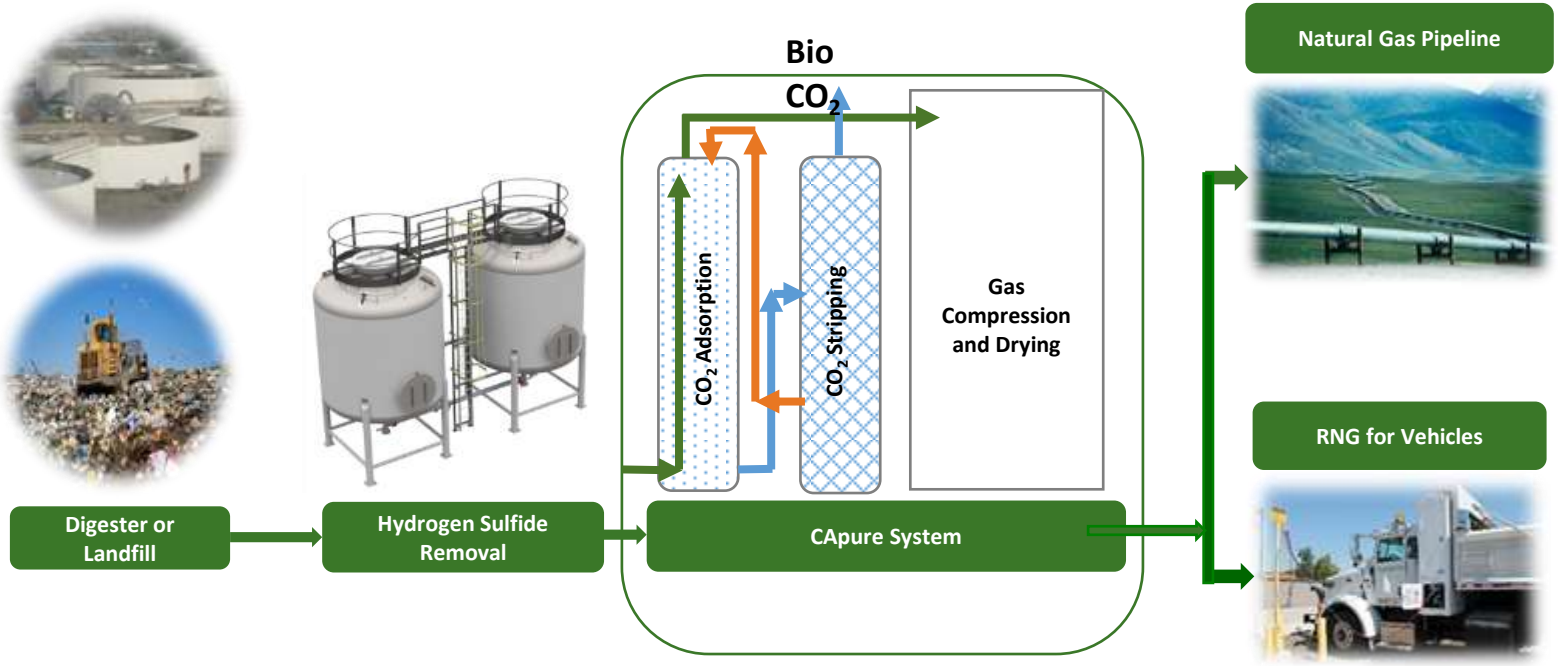
CApure Process



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CAPURE TECHNOLOGY

99.9% Methane Efficiency

- Less than 0.1% methane slip
  – Protecting our environment
- No hidden additional cost or energy requirement associated with treating the tail gas
- 99.9% of the methane in the biogas can be sold
  – Always the highest revenue

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Riverside Biogas - Scotland

- 1,060 scfm biogas from spent malt
- 99.9% methane efficiency
- Heat supplied from CHP
- Back up biogas boiler
- Injects 690 scfm biomethane direct to the gas grid
- Propane enrichment and gas network entry facility

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Thank you!

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