Decomposition of Toluene and Naphthalene (model tars) via Application of Atmospheric Pressure Dielectric Barrier Discharge Plasma

Victor H. Zendejas Lopez, Viacheslav Plotnikov*, and Gerardo Diaz, PhD*

*Sustainable Plasma Gasification Lab, University of California Merced

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ASPIRES
Accelerated STEM Pathways through Internships, Research, Engagement, and Support

What is Biomass Gasification ?

- Biomass Gasification is the process of converting solid biomass fuel into a gaseous combustible gas called syngas through a sequence of thermochemical reactions
- Syngas can be used for power or refined for production of hydrogen, ammonia, and synthetic hydrocarbon fuels
- Syngas can be extracted from non recyclable carbon based materials such as tires and plastics

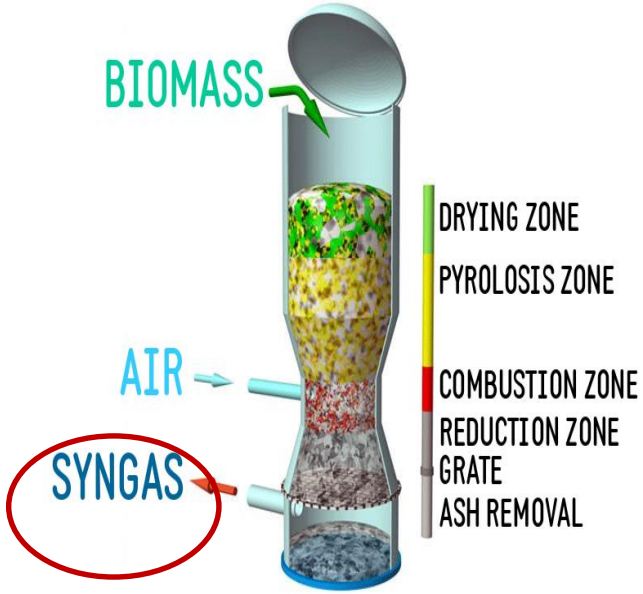


Figure 1. downdraft gasifier

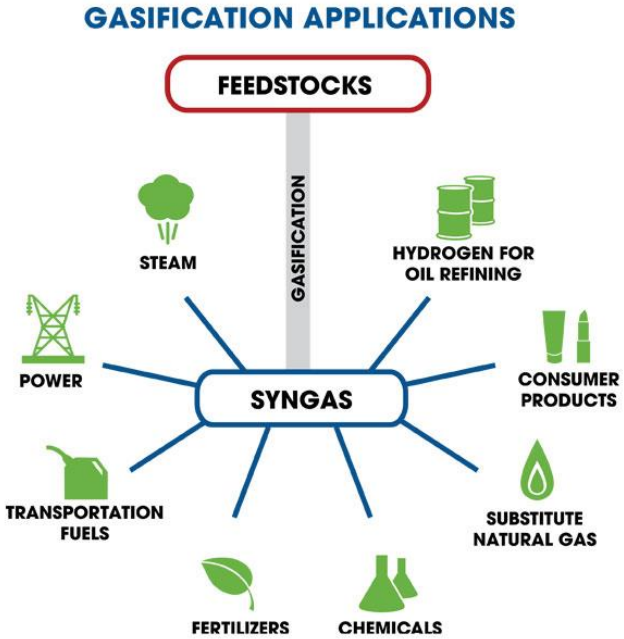


Figure 2. possible uses of syngas

Figure 3. tire field & plastic patch

What is Thermal/Nonthermal Plasma?

- Thermal Plasmas are known as “equilibrium” plasmas
- Thermodynamic equilibrium is reached when particles (atoms, molecules, and ions) and electrons reach the same energy level for the given electrical energy input
- Thermal Plasma are used in cutting, welding and used as torches. Torches can be used for gasification

- Nonthermal plasmas are characterized by high electron temperatures compared to the temperatures of heavy particles
- Ionization occurs without a drastic increase in the enthalpy of the substance
- Used for surface modification or surface activation because atoms and molecules remain relatively “cold” and does not damage surfaces

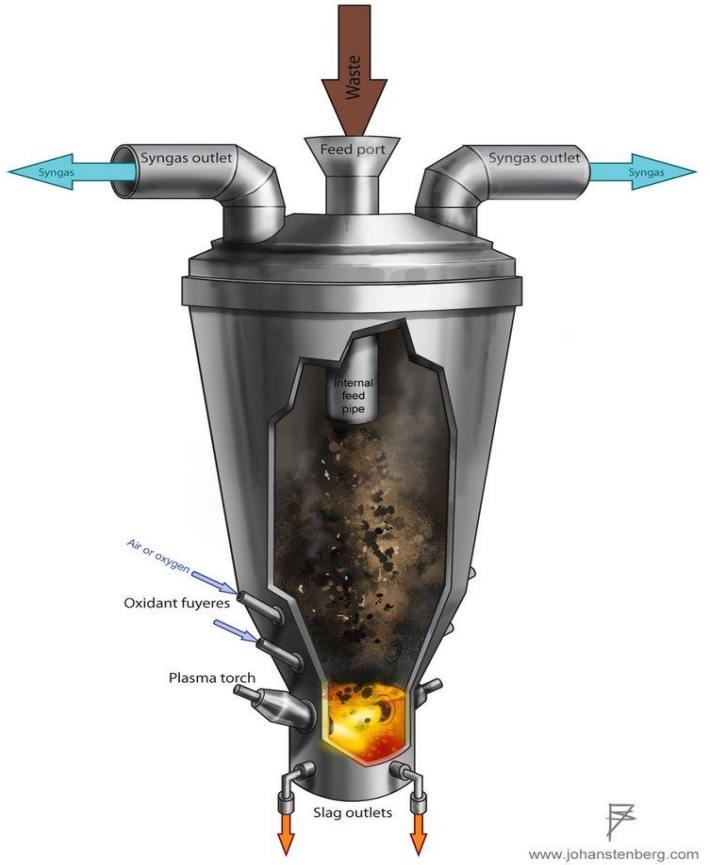
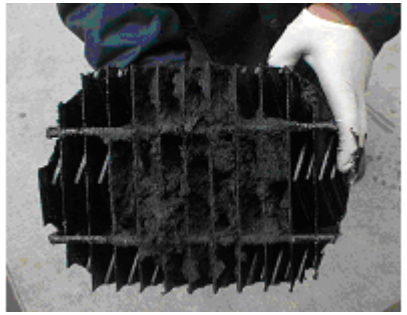


Figure 4. plasma gasification

Figure 5. nonthermal plasma treatment

Why isn’t biomass gasification more widely commercialized?

- About 5% of our energy consumption is derived from biomass gasification
- Commercialization is experiencing difficulties being competitive because of high concentrations of tars which condense and begin to deactivate catalysts and clog downstream components



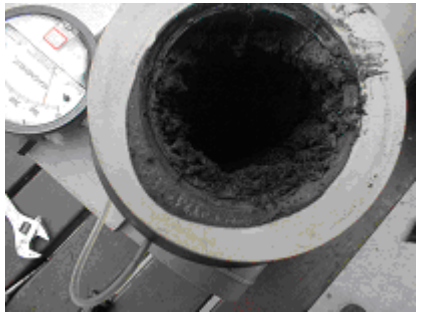


Figure 6. tars fouling and clogging of equipment

- Tars are very stable complex hydrocarbons that are hard to break down
- Excessive energy is consumed and waste is produced by current cleaning methods
- Current application of gasification plasma is thermal and requires a great deal of energy to treat material

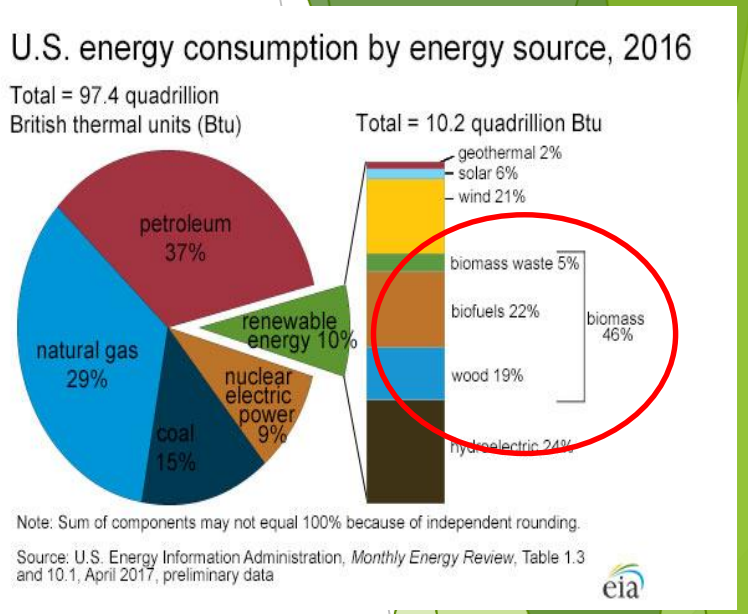


Figure 7. US energy consumption by category

Potential Solution?- Dielectric Barrier Discharge Plasma!

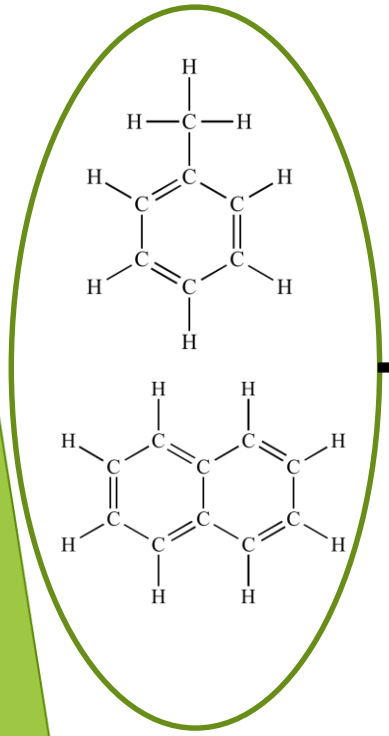


Figure 8. model tars (Toluene and Naphthalene)

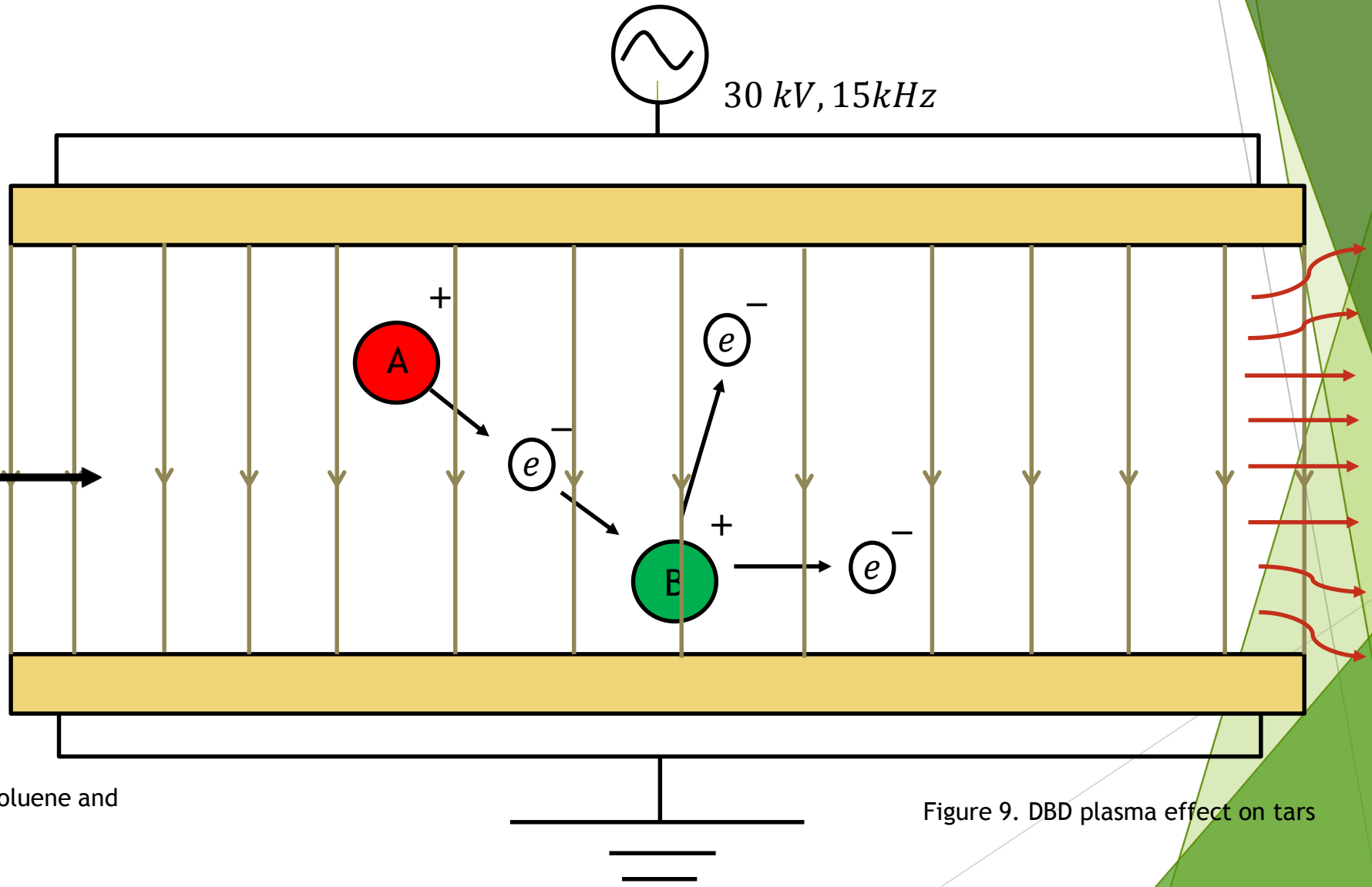


Figure 9. DBD plasma effect on tars

Design

$N_2(g)$
$\sim 15℃$
$\sim 1.0\ SCFH$

$Toluene(l)$
$+ Naphthelene(s)\ (liquid)$
$\sim 25℃$
$\sim 1mL/hr$

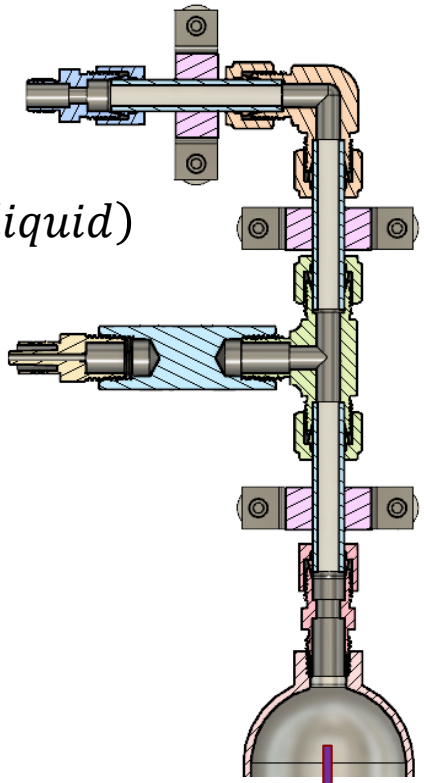
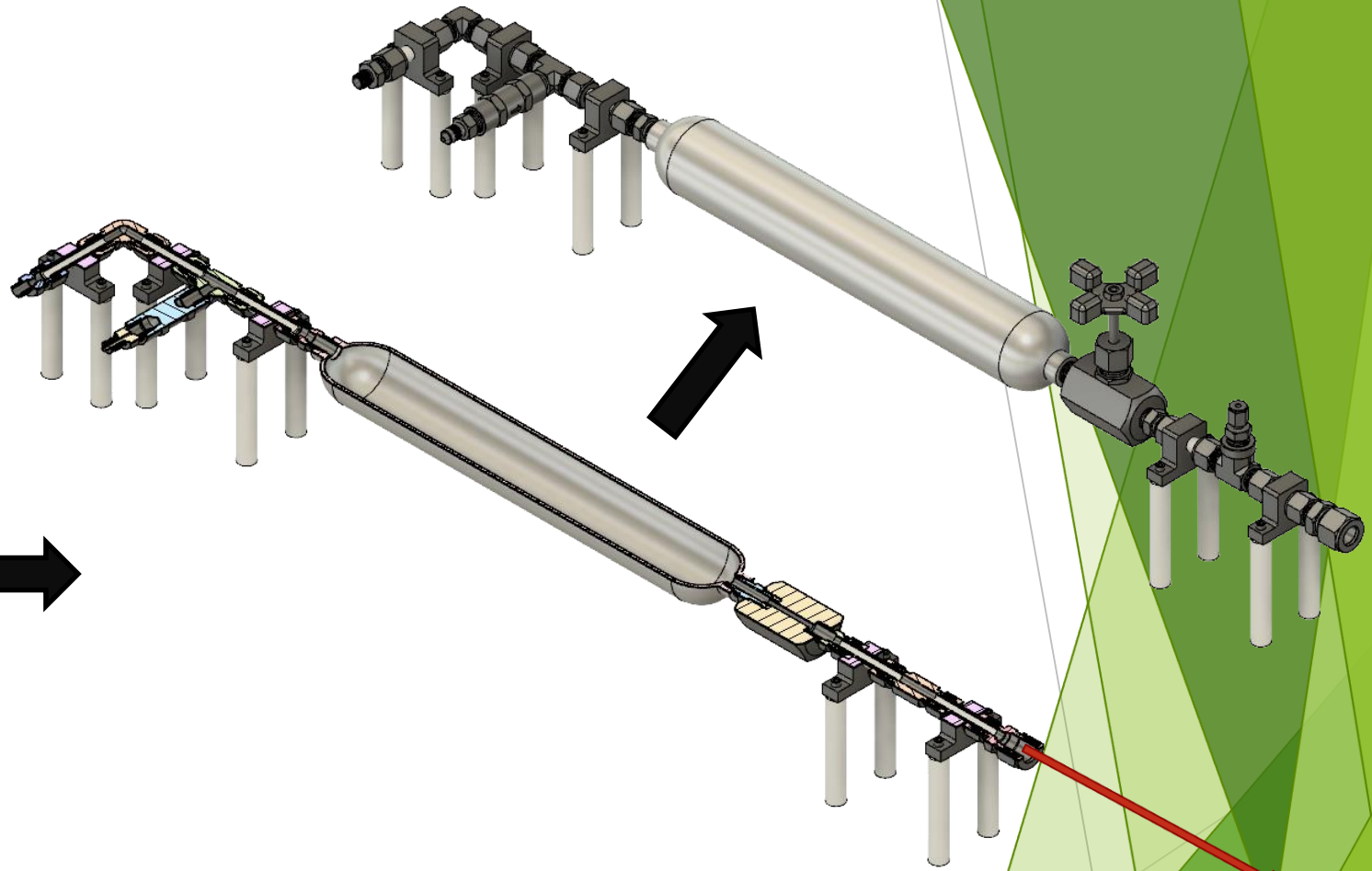


Figure 10.
preheater module
cutout



$N_2(g), Toluene(g) + Naphthelene(g)$
$\sim 250℃$

Figure 11. preheater module
cutout & without cutout

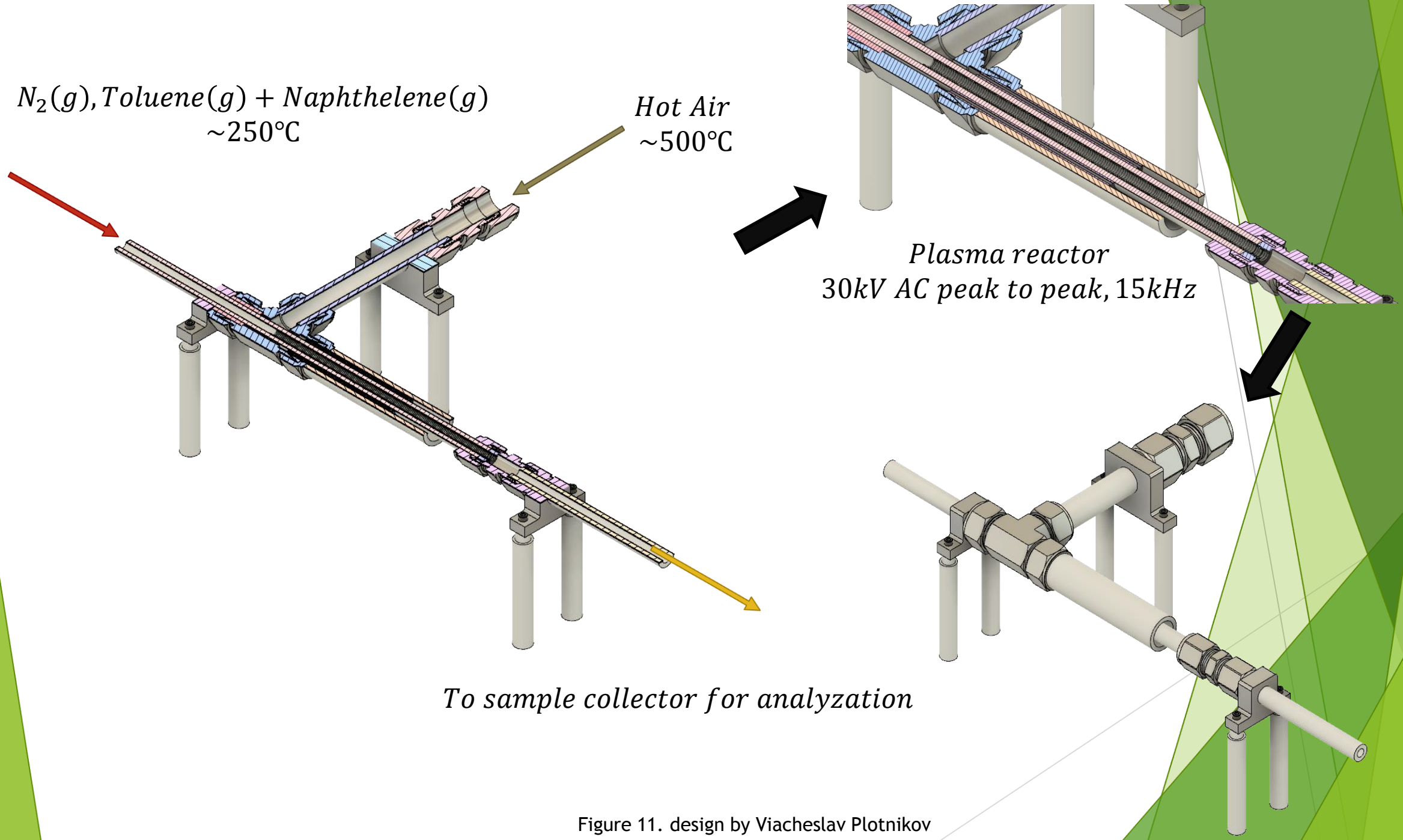
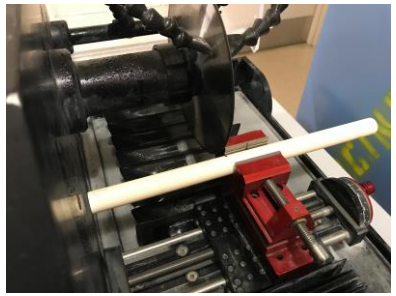
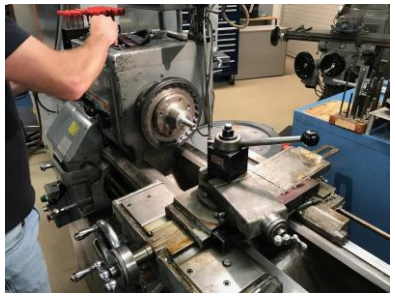


Figure 11. design by Viacheslav Plotnikov

Figure 12. combined CAD model, sampling unit designed by Juan Mariscal

Time to get our hands dirty!



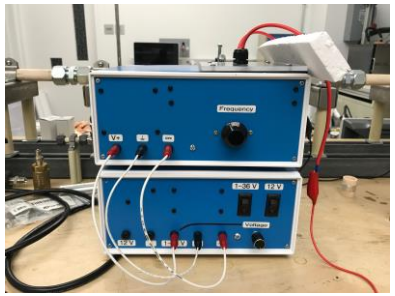
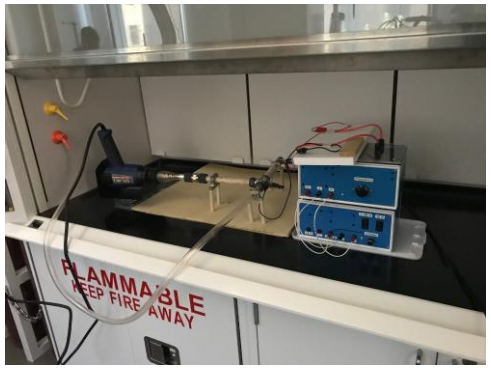





Figure 13. assembly and plasma demonstration



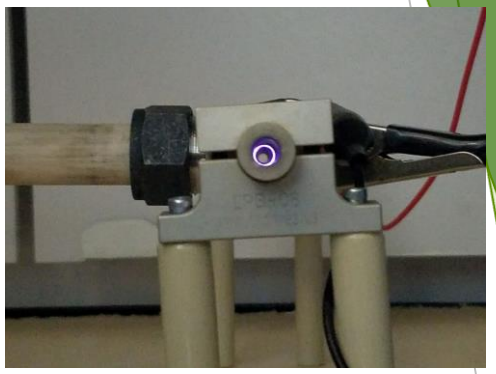


Figure. 14. plasma discharge and reactor set up

$Power\ (W)$	$Heat\ (°C)$	$Frequency\ (kHz)$	$Glowing$
75	260	15	Yes
51	260	15	No
94	260	5	Yes

Figure 15. plasma reactor power consumption

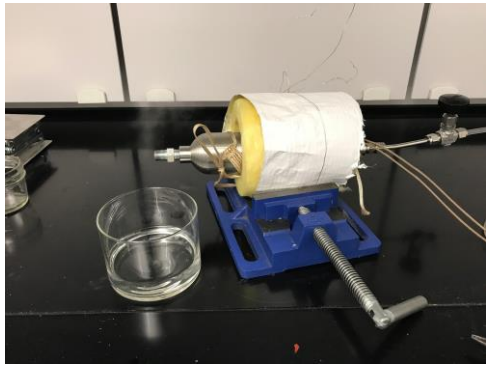
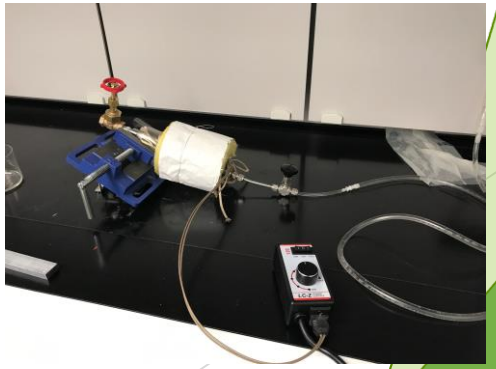



Figure 16. Heat cable testing with water (It Works!)

Conclusion/Future Work

Steam

Biomass

Gasification Furnace

Fine tune plasma generator/electrode combination

More Syngas
Less Tars ☺

Figure 17. Next Project

Acknowledgments & References

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