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Non thermal plasma-assisted catalytic oxidation of methane: effect of catalysts.

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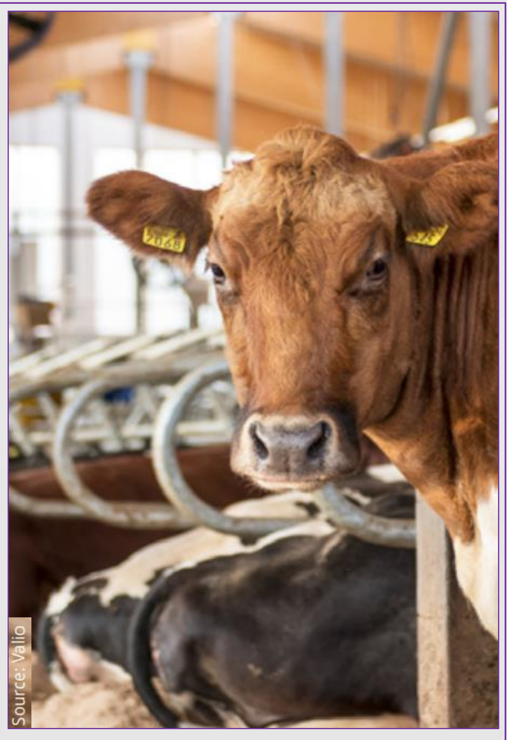
Introduction



- Agriculture accounts to 10% of total green house gases in EU [1].
- Methane contributes 54% of these emission which is produced by rumination and belching by cattle [1].
- Methane, a potent greenhouse gas, has 28 times the global warming potential of CO2 [2].
- Methane emissions in dairy barns and cattle farms are dispersed and occur in low concentration (20 – 200 ppm) [1, 2].
- Currently, no feasible technology to abate these low concentration of methane from dairy barns.
- **Goal of CANMILK project:** to capture methane emission from dairy barn and convert them into CO2 using plasma and catalysis.
- Plasma, an ionized gas, triggers chemical reactions, but gas-phase plasma reactions are not selective [3].
- The use of oxidation catalysts can improve complete oxidation of methane into CO2 [3].

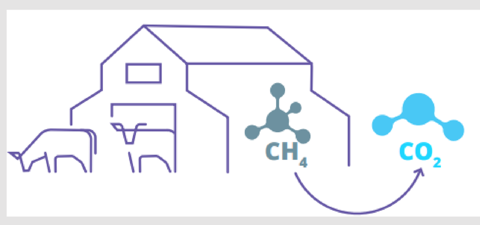


Figure 1. Goal of CANMILK project[1].

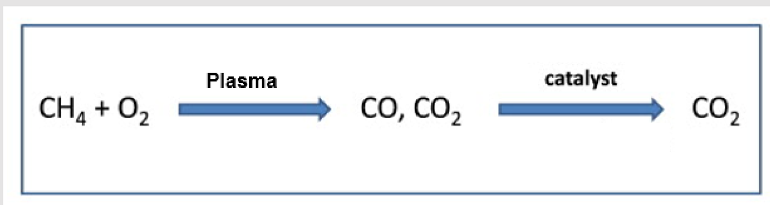


Figure 2. Plasma oxidation scheme [4].

Experimental

- 10 different catalysts composition: 1% Pd/Al_2O_3, 1% Cu/ Al_2O_3, 1% Pt/ Al_2O_3, 1% Co/ Al_2O_3*, 1%Fe/ Al_2O_3*, 3% Pd/ Al_2O_3, 1% Pd – 0.5% Cu/ Al_2O_3, 1% Pd - 0.5% Co/ Al_2O_3*, 1% Pd – 0.5% Fe/ Al_2O_3*, and 1% Pd – 0.5% Pt/ Al_2O_3*.
- Prepared by vacuum impregnation, calcined at 500 °C and 8 hour in air. Sequential impregnation for bimetallic catalyst.
- Catalysts are characterized by N2 physisorption, SEM-EDS, and XRD.

**Catalysts are prepared but not tested for activity yet.*

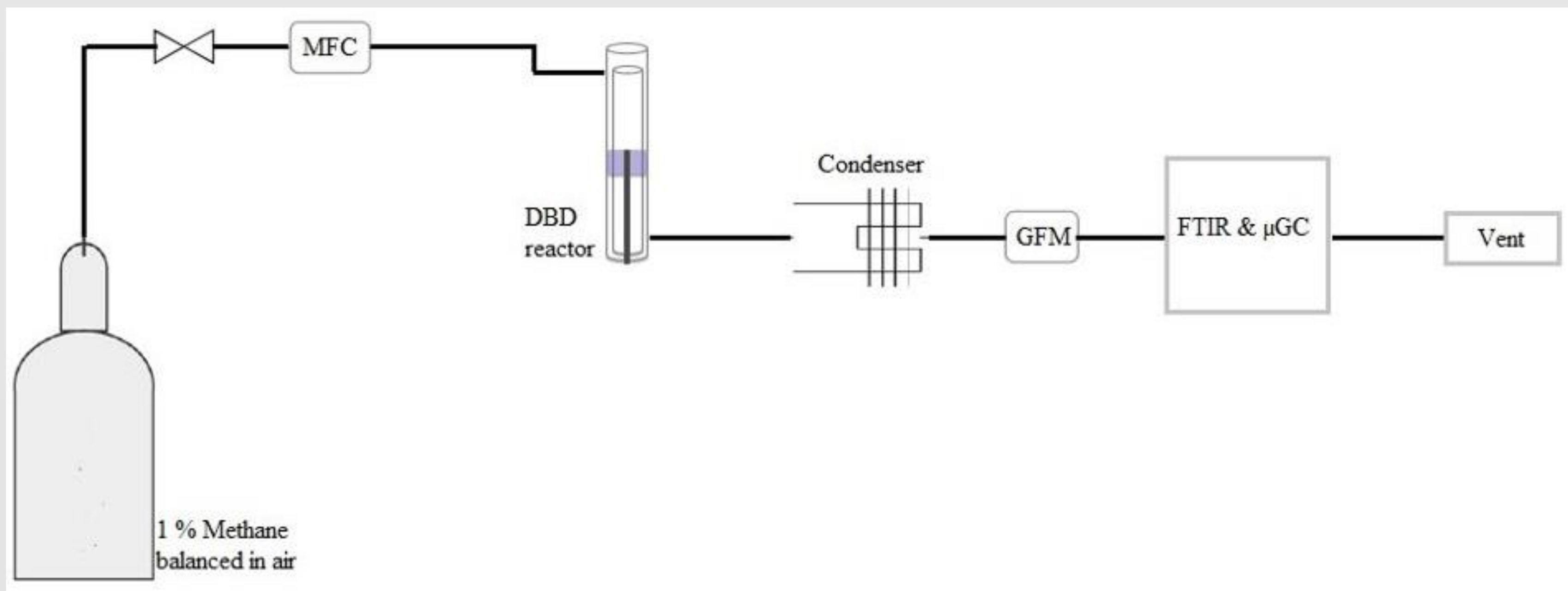


Figure 3. The experimental set up.

DBD reactor

- Co-axial Dielectric barrier discharge (DBD) reactor.
- Two concentric quartz tubes.
- Discharge length: 2 cm and discharge gap: 2 mm.
- Stainless steel electrodes: Higher voltage inner electrode and outer ground electrode.
- Catalysts were placed inside the plasma discharge zone.

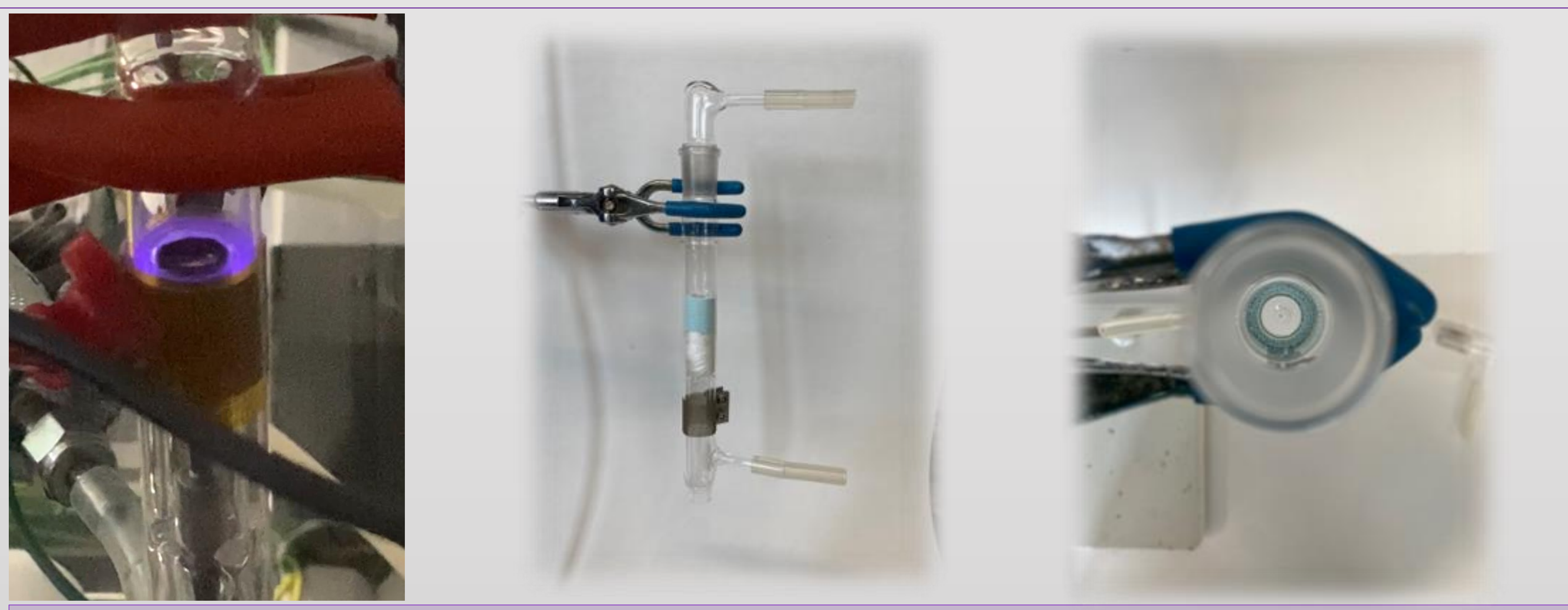


Figure 4. DBD reactor during experiment, catalyst loading inside a DBD reactor and top view of in-plasma catalyst system.

Results

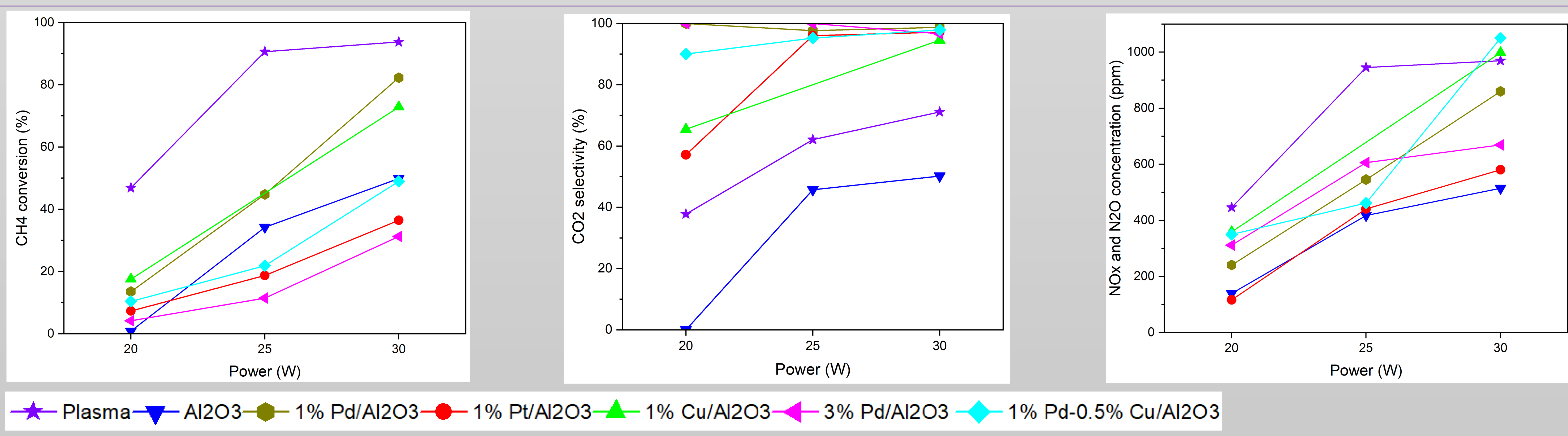


*Figure 5. Effect of plasma power and catalyst on methane conversion, CO2 selectivity and NOx and N2O formation. **Experimental conditions**: 200 mL/min (1% methane in air), atmospheric pressure and temperature*

Conclusions

- Plasma successfully activated methane, achieving a 90% conversion rate at 30 W plasma power.
- The CH_4 conversion increased with higher plasma power.
- The presence of catalyst reduced CH_4 conversion, but it resulted in complete oxidation of methane and improved CO2 selectivity.
- 1% Pd/Al_2O_3 catalyst showed 84% methane conversion and 99% CO2 selectivity, showing promising signs for application in dairy barns and meat farms.

References

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CANMILK

Please visit: ***canmilk.eu*** for more information about the CANMILK project.

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