Methane Decarbonization in Hot Products of Laminar Premixed Flames

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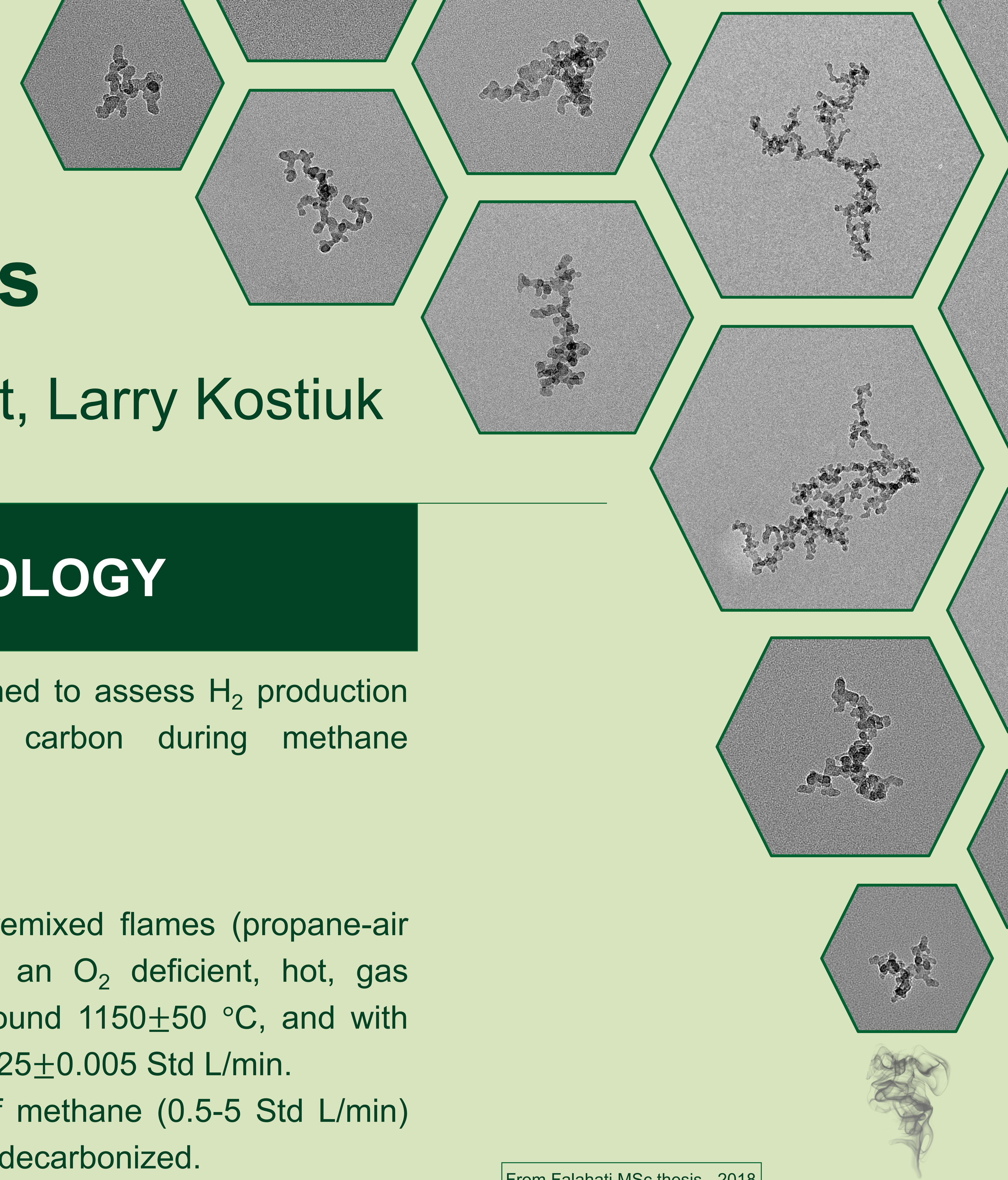


BACKGROUND

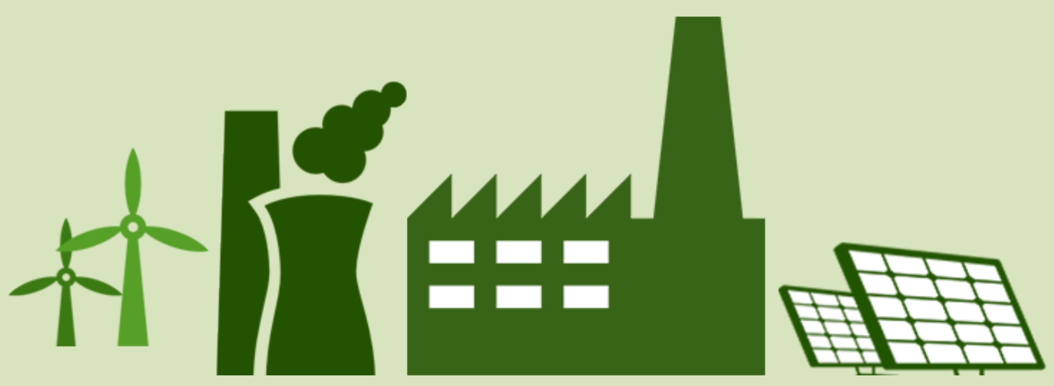
Methane decarbonization (pyrolysis) is viewed as a potential method to produce hydrogen (or heat or electricity if the hydrogen is used as a fuel) without CO_2 emissions.

At a sufficiently high temperature and in the absence of oxygen (O_2),

$$CH_4 \rightarrow C_{(s)} + H_2$$

where

- hydrogen (H_2) can be used as a carbon-free fuel,
- the solid carbon ($C_{(s)}$) can be sold for use in industrial products.



METHODOLOGY

An experimental set-up is designed to assess H_2 production and properties of generated carbon during methane decarbonization.

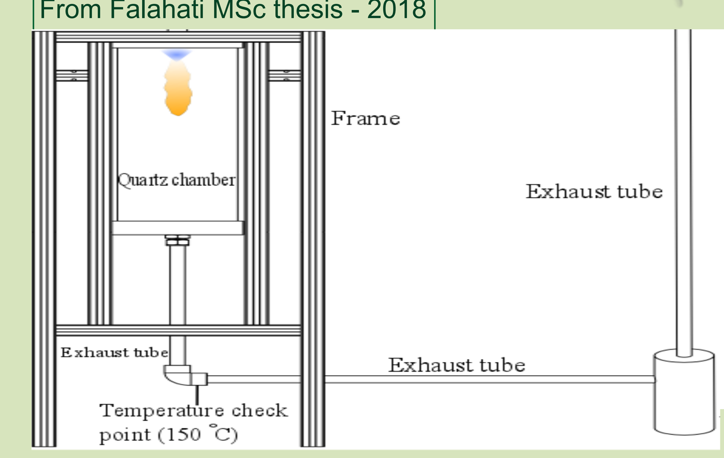
Condition of Experiment/Method:

- Using two different laminar premixed flames (propane-air and methane-air) to produce an O_2 deficient, hot, gas stream with a temperature around 1150±50 °C, and with the same total flow rate at 36.425±0.005 Std L/min.
- Injecting different flow rates of methane (0.5-5 Std L/min) into the hot gas products to be decarbonized.

Quantification Technique:
Emission measurement of

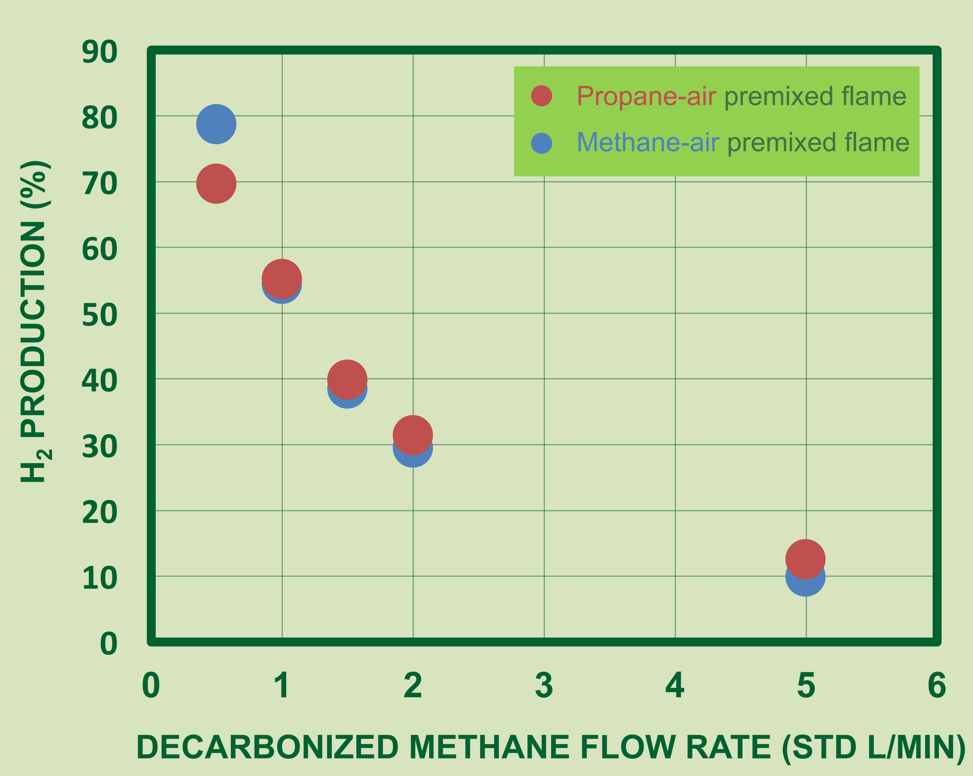
- gaseous products using a gas chromatographer,
- carbon particulates using a scanning mobility particle sizer.

From Falahati MSc thesis - 2018



RESULTS

Hydrogen production efficiency with different flow rates of decarbonized methane

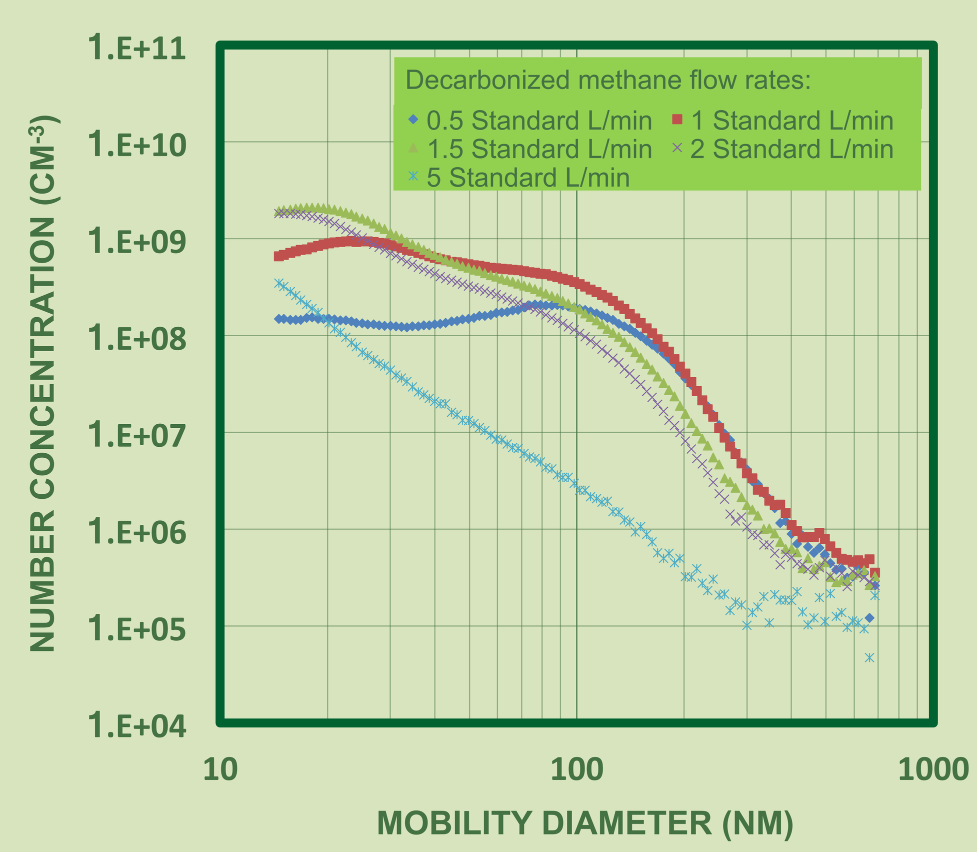


Variability of H_2 production with decarbonized methane flow rate is the same for both premixed flames.

H_2 production drops with the increase in decarbonized methane flow rate, due to dependency on

- residence time,
- temperature.

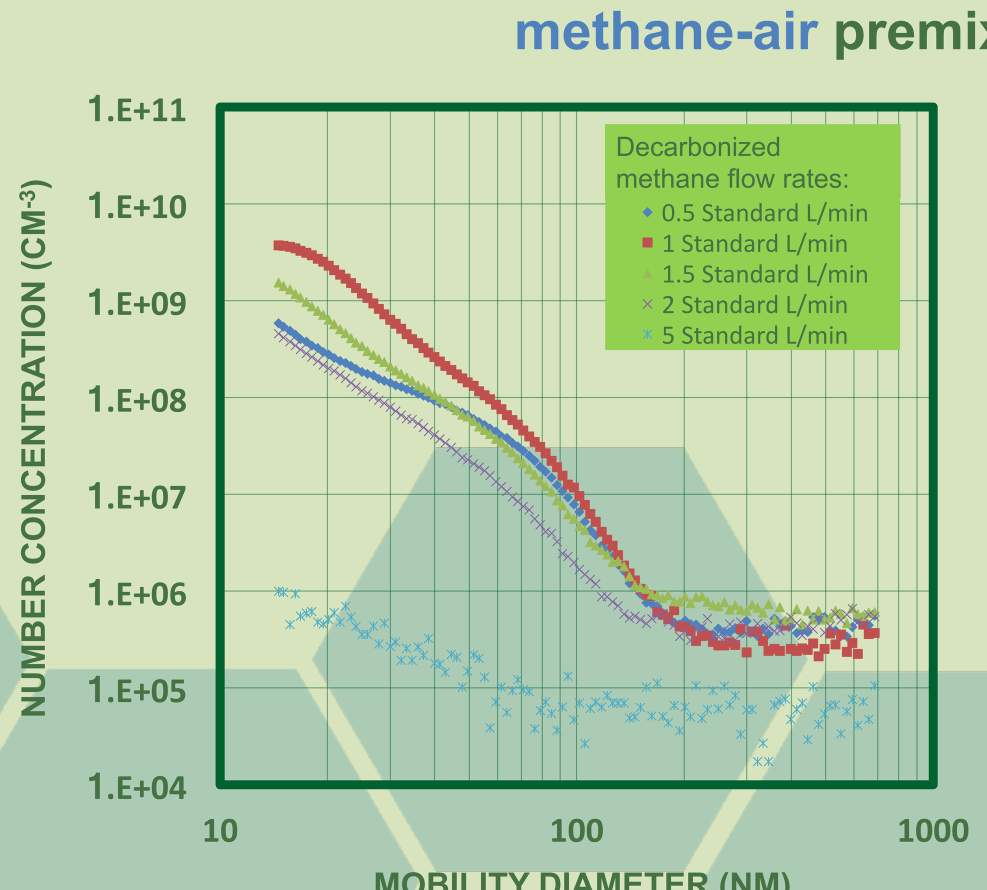
Number-size distribution of generated carbon particulates with propane-air premixed flame



Particle size distributions fall into the same trend using propane-air premixed flame, except for high flow rates of decarbonized methane (5 Std L/min).

Particle number concentrations show a peak around 100 nm, using propane-air premixed flame.

Number-size distribution of generated carbon particulates with methane-air premixed flame



Particle size distributions show similar variability using methane-air premixed flame, except for high flow rates of decarbonized methane (5 Std L/min).

Most of the generated particles with methane-air premixed flame are found to be smaller than 30 nm.

CONCLUSION

In this study, methane decarbonization in hot products of propane-air and methane-air premixed flames is investigated as a new way of H_2 production with reduced CO_2 emissions.

Results show that residence time (inversely proportional to decarbonized methane flow rate) has larger effects on H_2 production and carbon particulate properties, while type of the premixed flame (propane-air or methane-air) only affects size distribution of particles.

It is found that H_2 production decreases dramatically for small residence times (high flow rates of decarbonized methane, e.g. 5 Std L/min).

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