PLASMA ASSISTED REFORMING AND PLASMA ASSISTED COMBUSTION WITH USING OF PLASMA-LIQUID SYSTEMS

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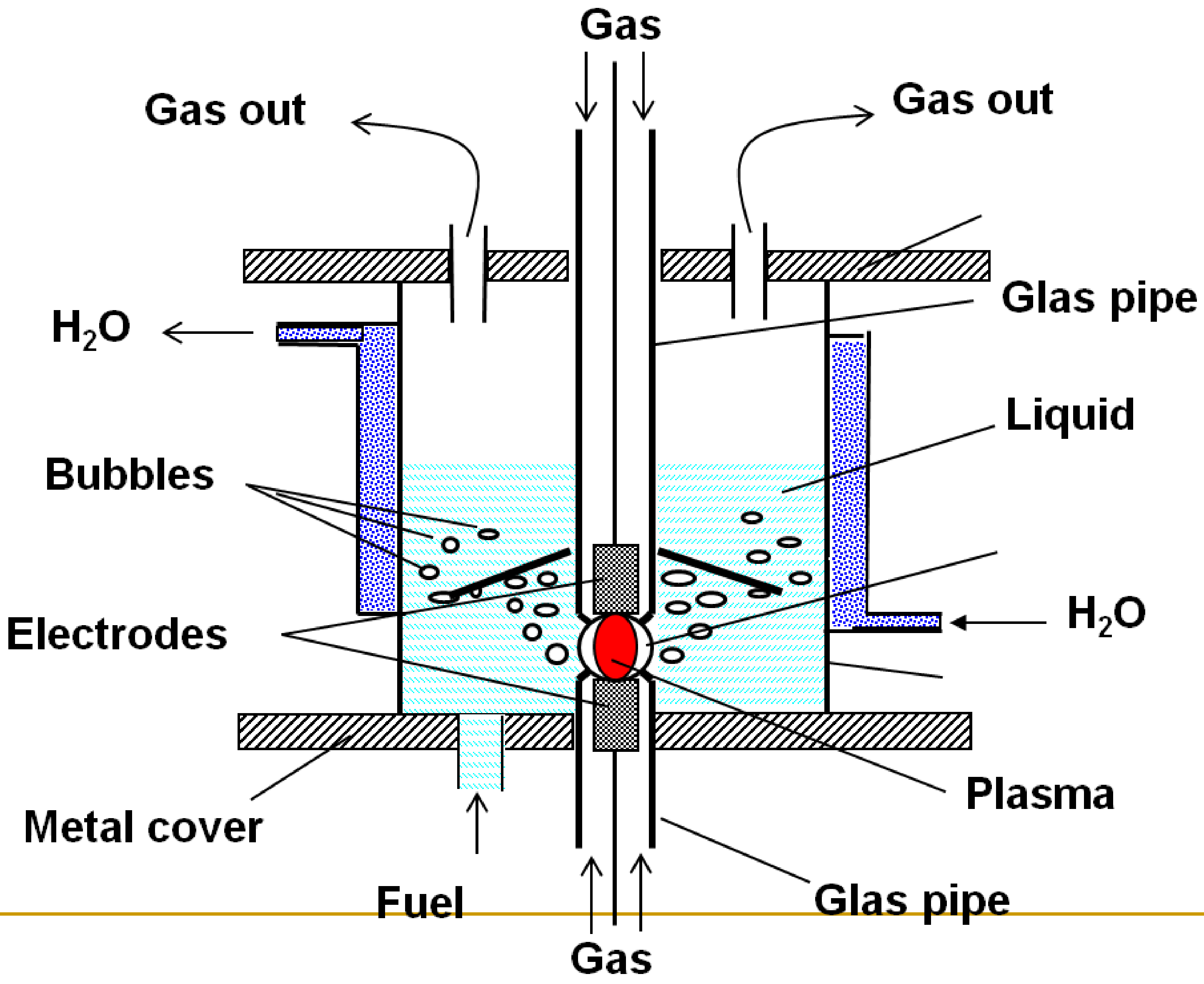
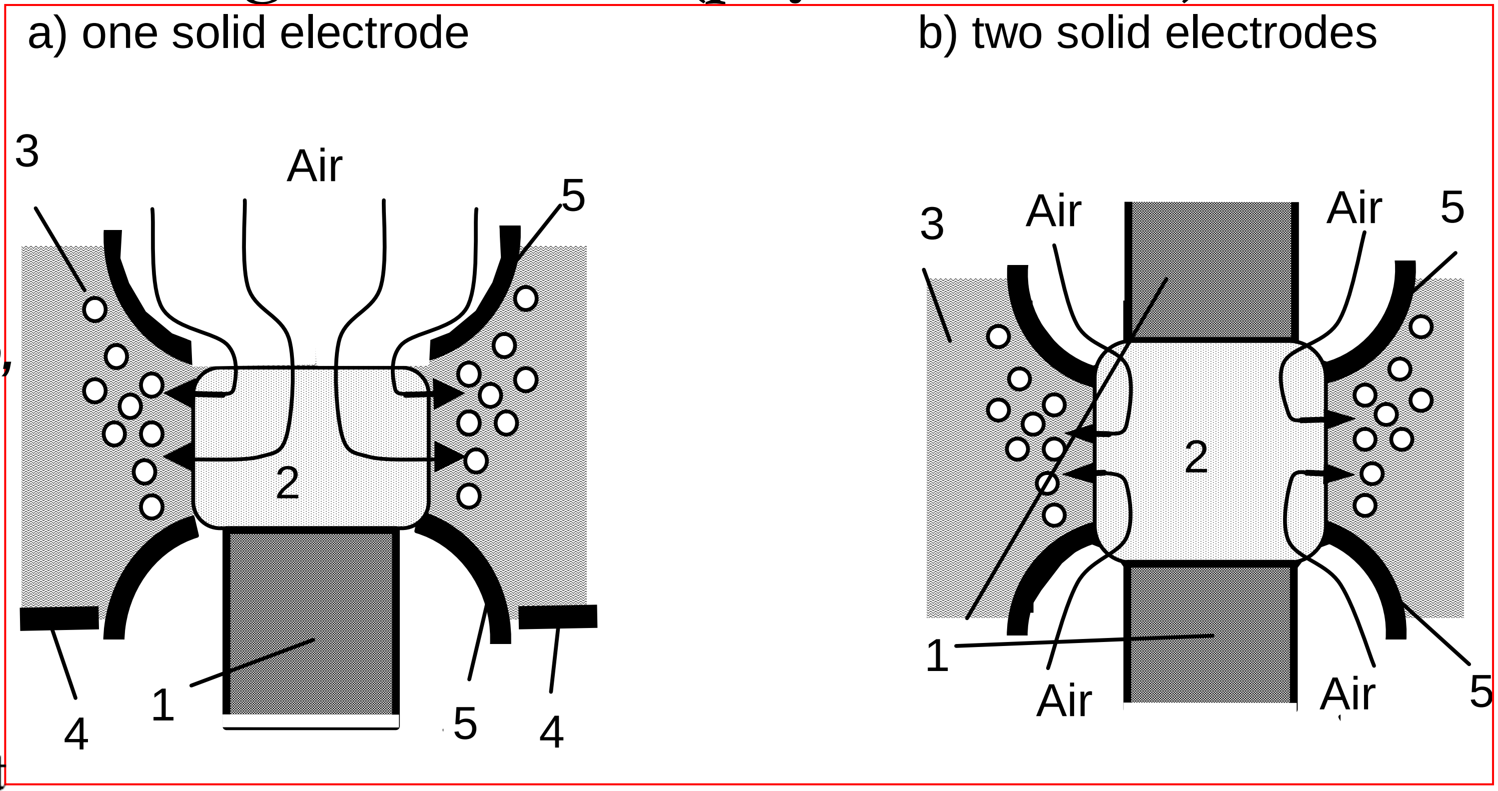
Plasma reactor with DGCLW



Plasma reactor with DGCLW

Numerical modelling of DGCLW (physical model):

1 - electrode,
2 - plasma,
3 - liquid,
4 - metallic flange,
5 - glass pipe



a) one solid electrode

b) two solid electrodes

It is assumed that

- **electric power introduced into the discharge is immediately averaged in the discharge volume;**
- **internal electric field in the discharge does not vary in space and time;**
- **during the pass of air through the discharge into the reactor volume its content is totally refreshed and its flow rate in the reactor volume is the same as in the discharge gap.**

Photos of discharge in air channel with ethanol wall

Controlled parameters of ethanol reforming

α - coefficient of plasma energy transformation in syngas energy

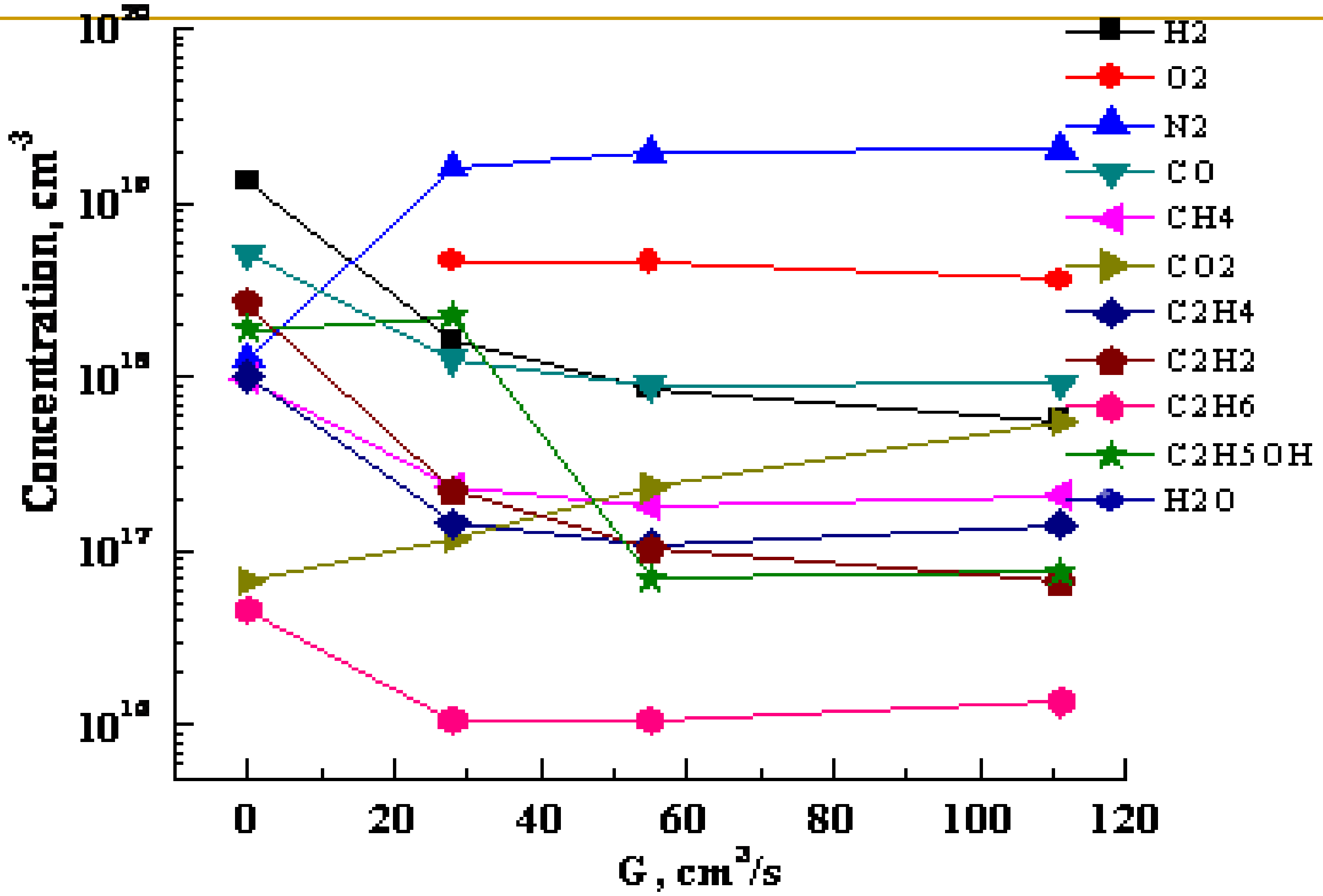
$$\alpha = \frac{\sum_i Y_i \times LHV(Y_i)}{IPE}$$

Y

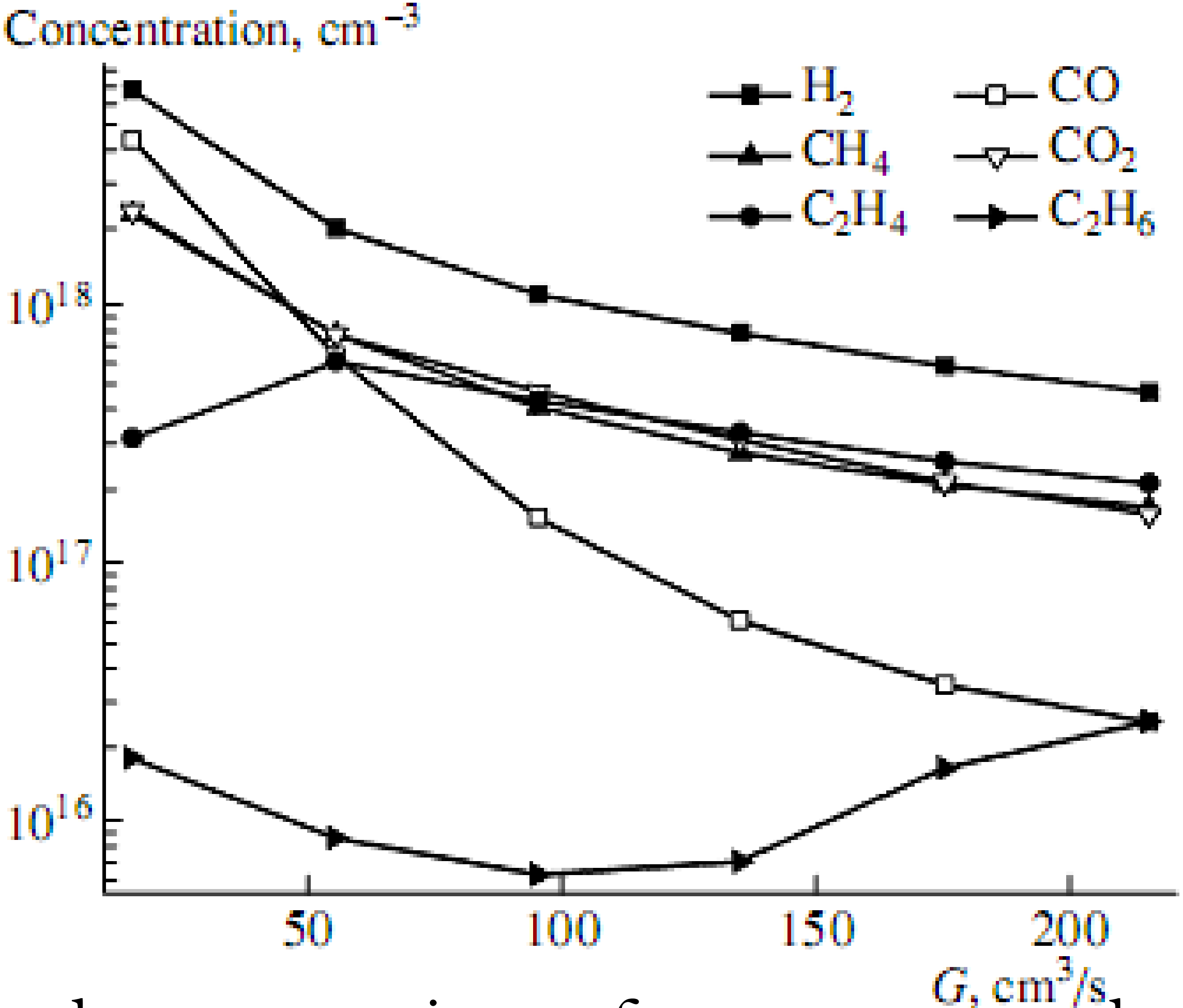
Y_i – molar fraction,
IPE **- the input plasma energy,**
LHV **- the lower heating value,**
HC – the injection hydrocarbon fuel

$$\eta = \frac{(Y_{H_2} + Y_{CO}) \times LHV(H_2)}{IPE + Y_{HC} \times LHV(HC)}$$

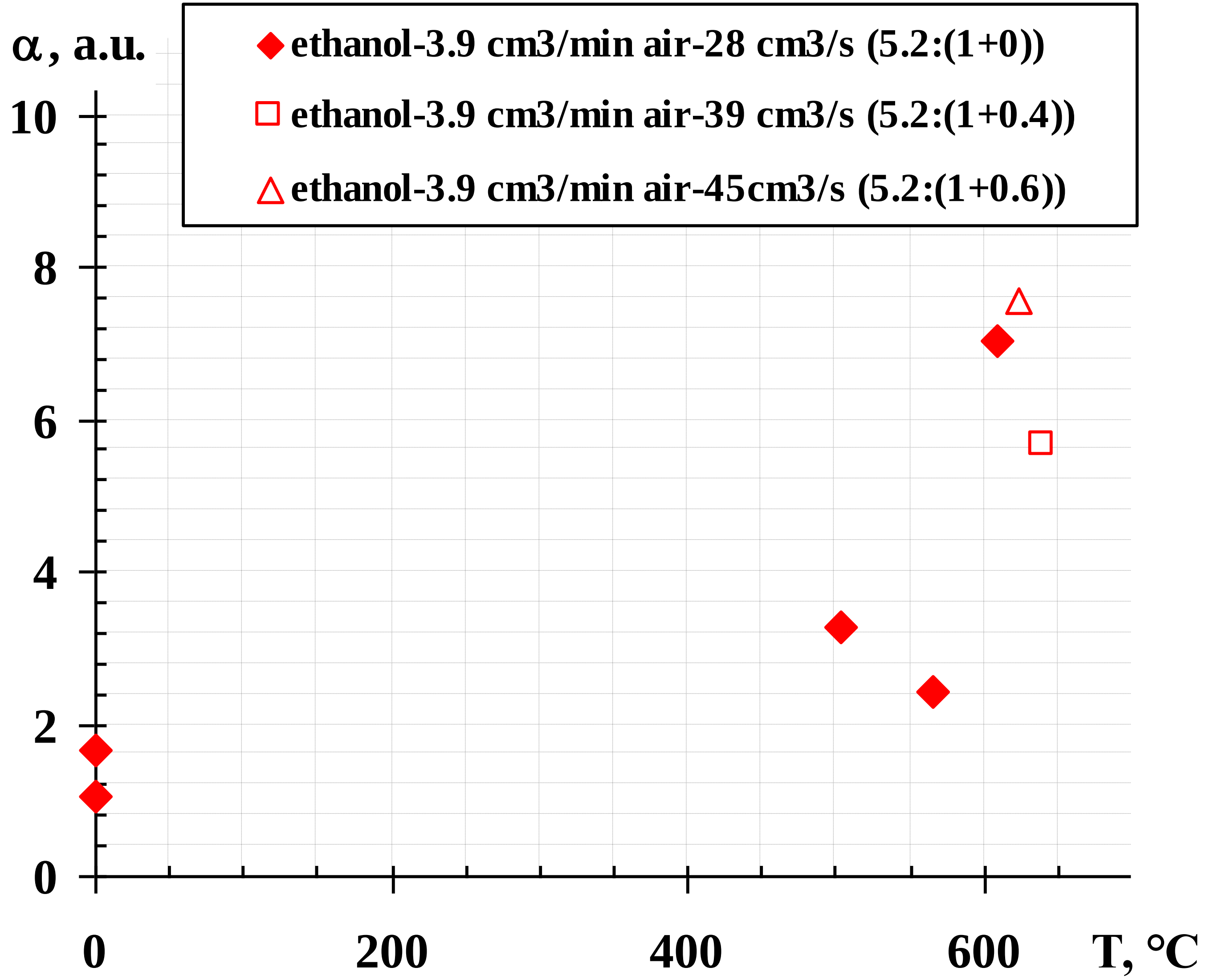
η **- efficiency** ***[G. Petitpas, J.-D. Rollier, A. Darmon, J. Gonzalez-Aguilar, R. Metkemeijer, and L. Fulcheri //Int. J. Hydrogen Energy, vol. 32, pp. 2848-2867, 2007]***



Concentrations of output gas products after the ethanol processing in the DGCLW as function of air flow rate (I_d= 100 mA).$C_2H_5OH : H_2O = 5:1$.

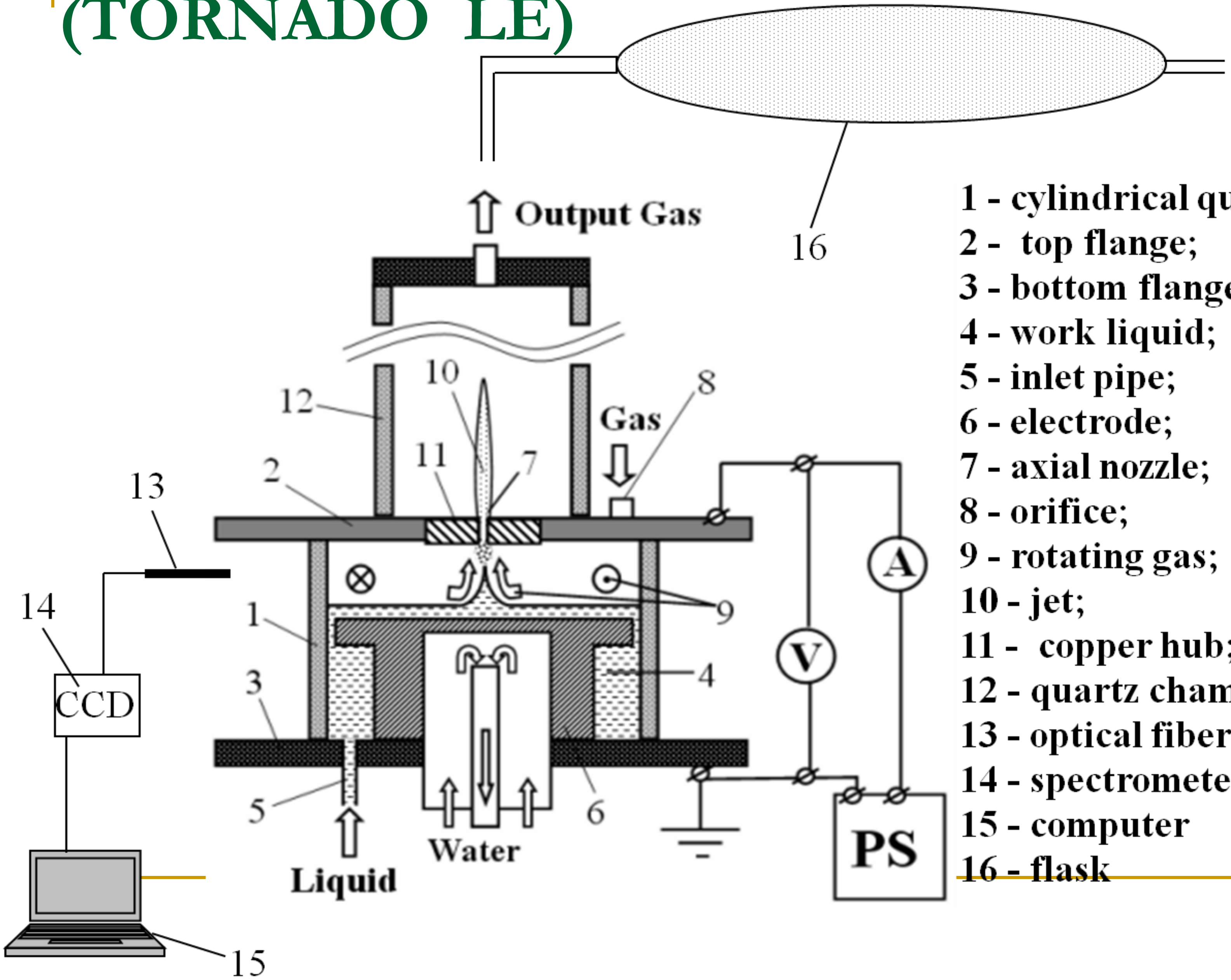


Calculated concentrations of output gas products after the ethanol processing in the DGCLW as functions of air flow rate (I_d= 100 mA).C_2H_5OH : H_2O = 5:1.



Coefficient of energy transformation α vs. temperature in the pyrolytic chamber

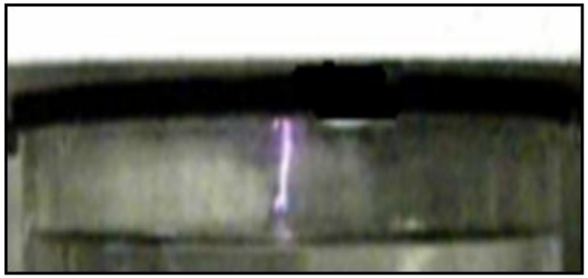
Plasma-liquid system with reverse vortex gas flow (TORNADO LE)



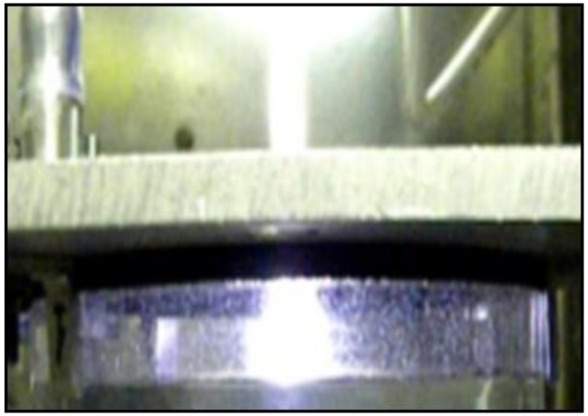
1 - cylindrical quartz vessel;
2 - top flange;
3 - bottom flange;
4 - work liquid;
5 - inlet pipe;
6 - electrode;
7 - axial nozzle;
8 - orifice;
9 - rotating gas;
10 - jet;
11 - copper hub;
12 - quartz chamber;
13 - optical fiber
14 - spectrometer
15 - computer
16 - flask

Plasma-liquid system with reverse vortex gas flow (TORNADO LE)

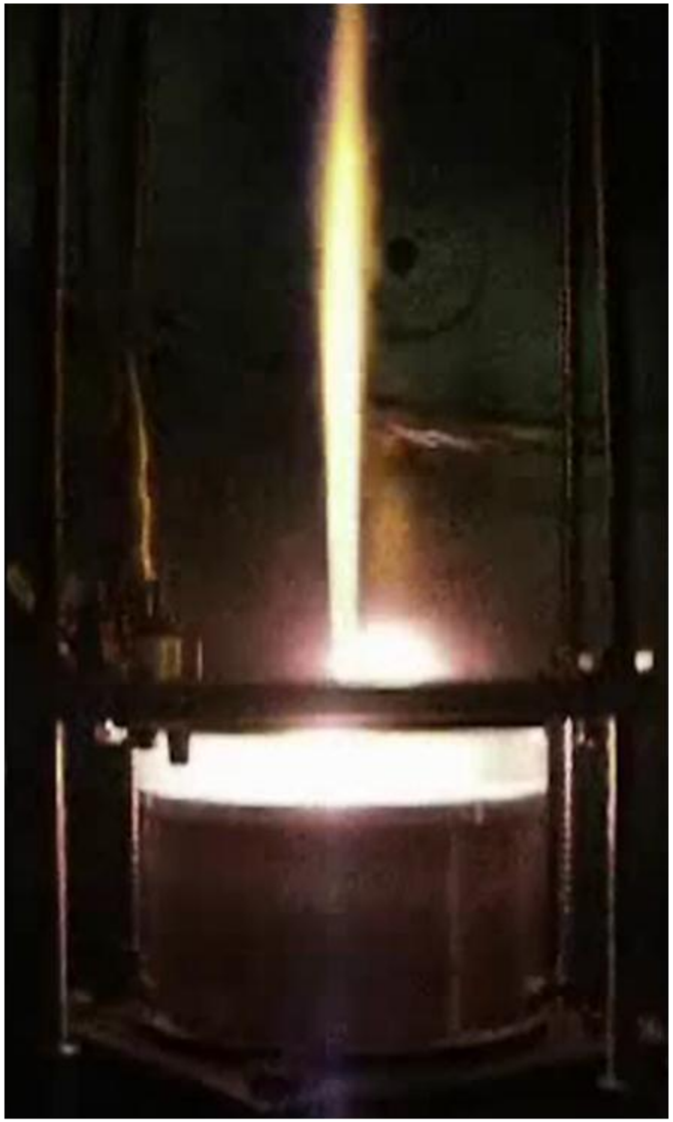
Water cone



Breakdown



Discharge burning



$C_2H_5OH : H_2O = 1 : 8$

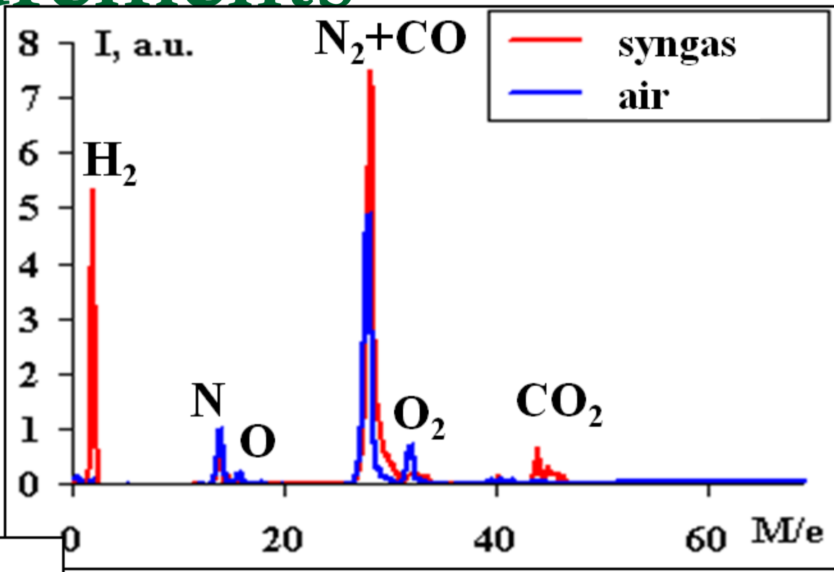
Mass-spectrometry and gas-chromatography measurements

$C_2H_5OH : H_2O = 1 : 8$

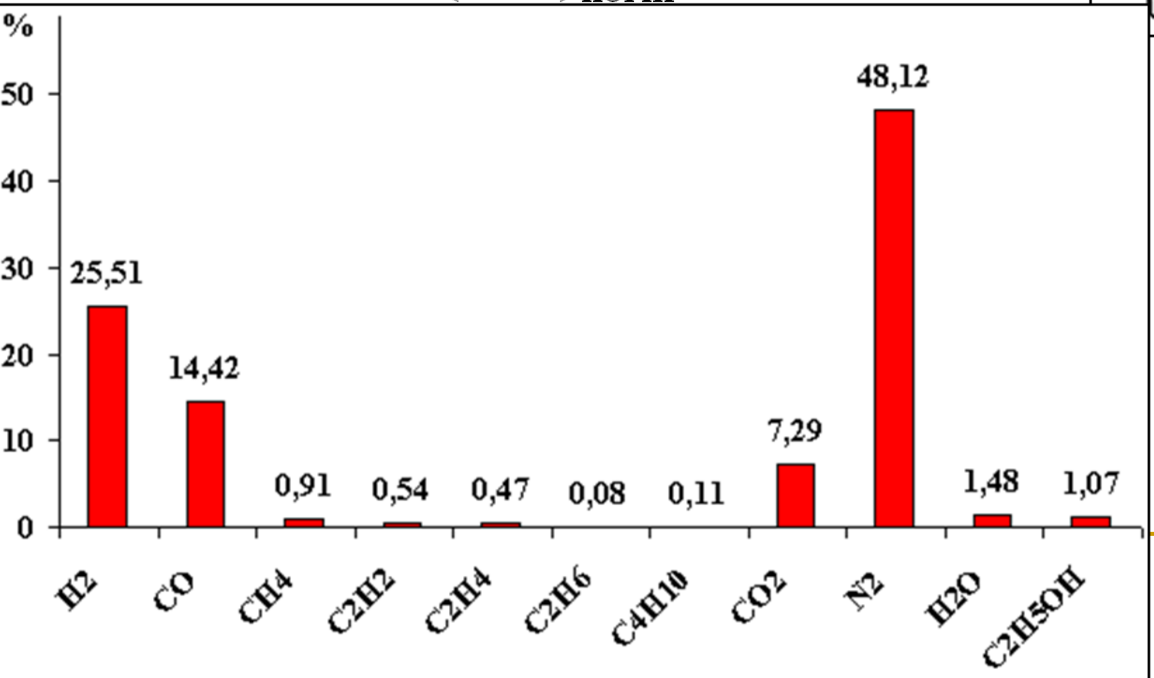
I=300 mA, G= 55 cm³/s

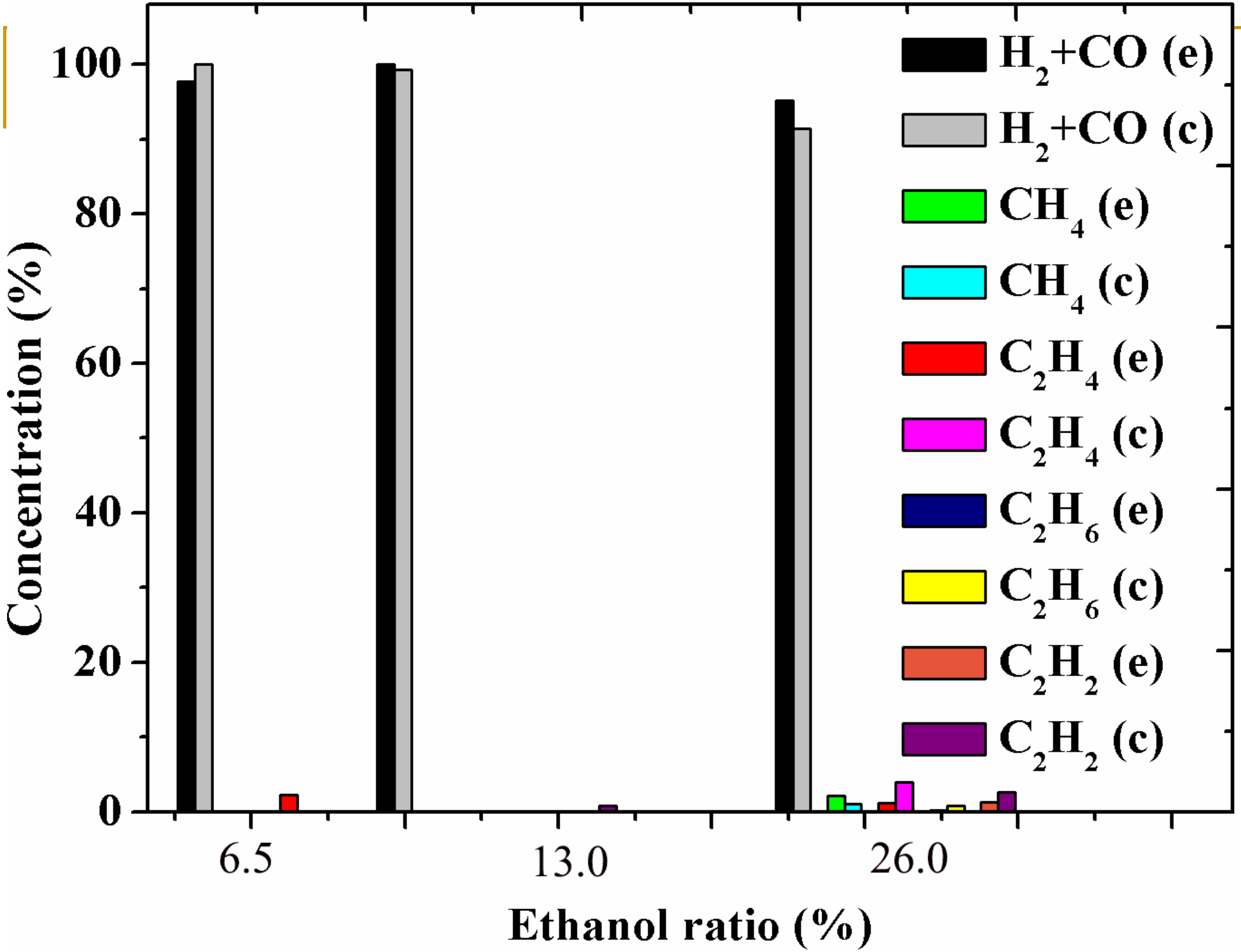
Mass-spectrometry

$(M/e)_{norm} = 14$



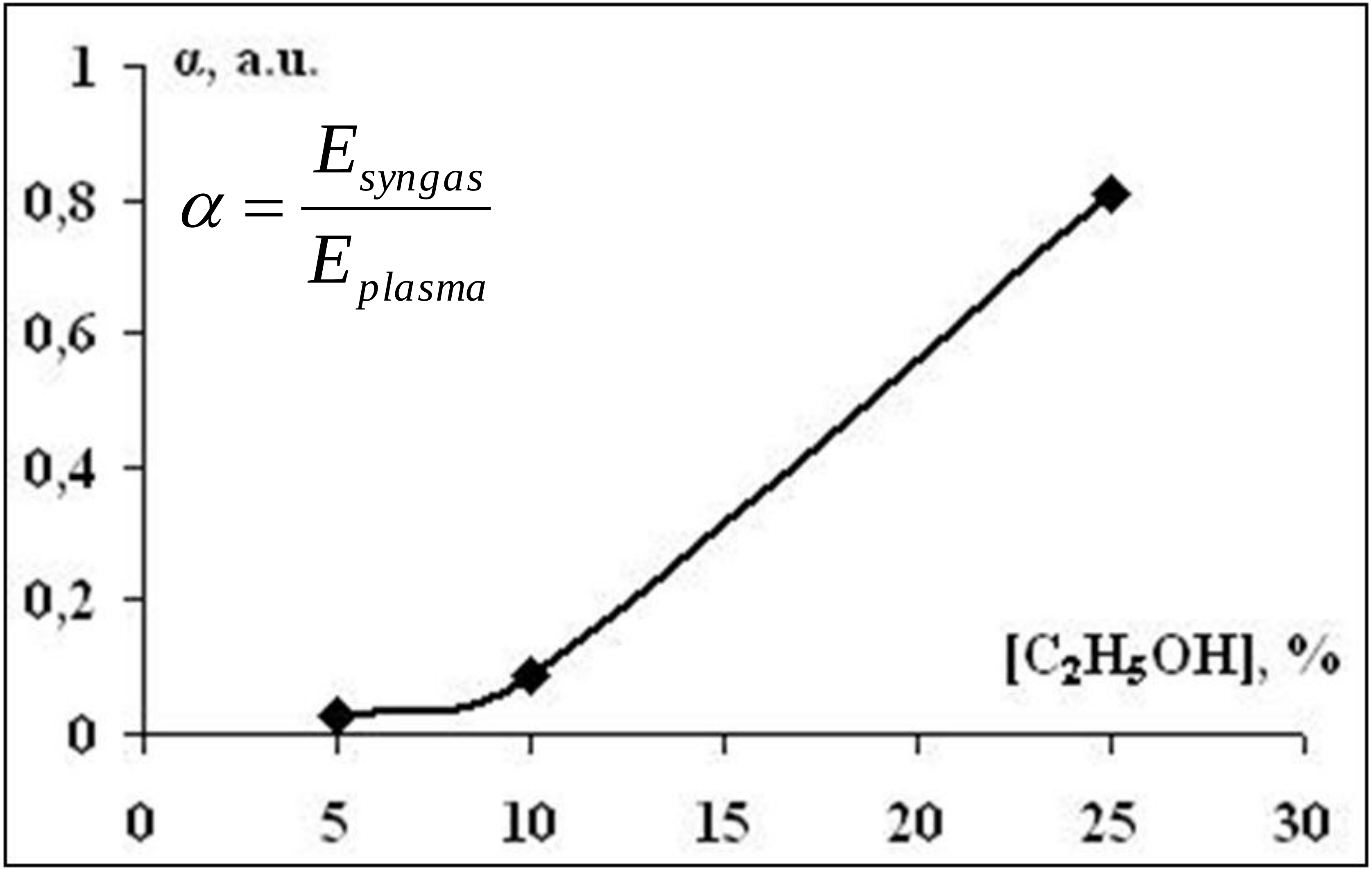
Gas-chromatography





Comparison between calculated (c) and experimentally (e) obtained concentrations of main components.

Coefficient of energy transformation



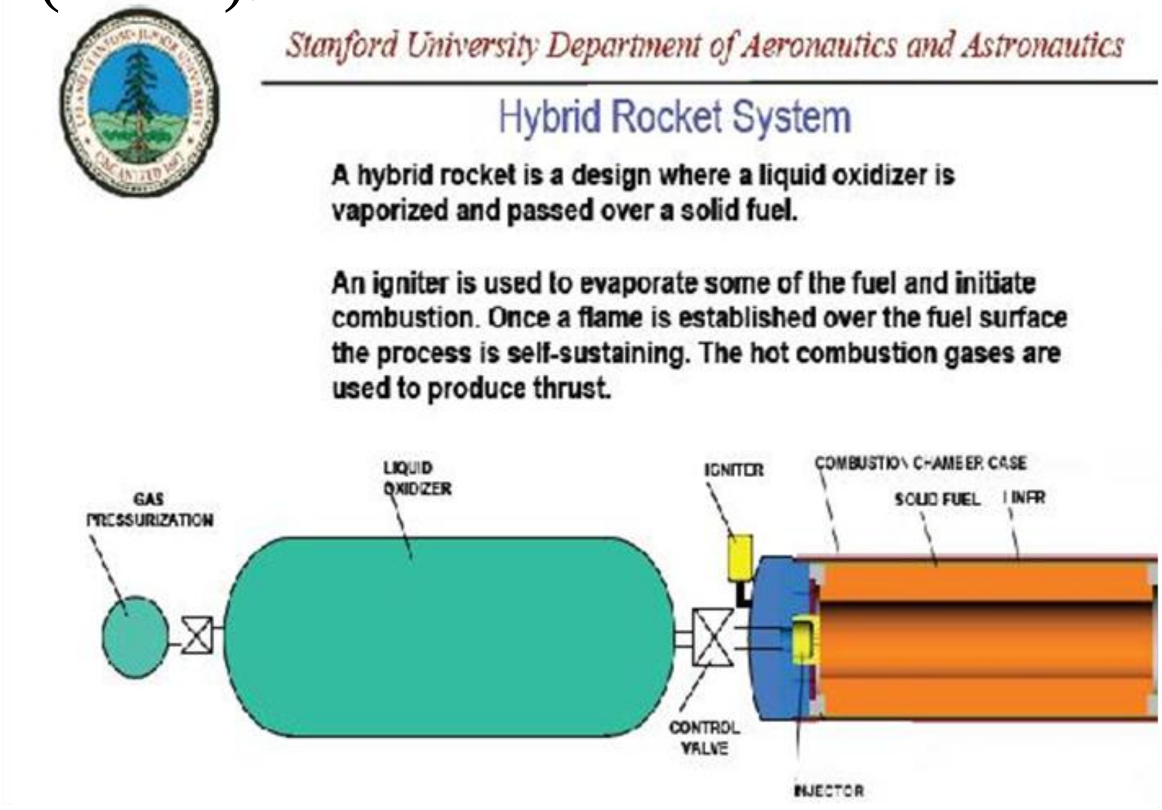
$$\alpha = \frac{E_{syngas}}{E_{plasma}}$$

Syngas speed generation – 0,2 m^3/h

Hybrid Rocket Engine

[*Stanford University Department of Aeronautics and Astronautics]*

The hybrid design concept has been known for more than 50 years. Small Hybrid rocket motors built to military specifications were used in target drone programs between 1968 and 1983 (Sandpiper, Hast, Firebolt). The fuel used was Hydroxyl-Terminated- Polybutadiene (HTPB).



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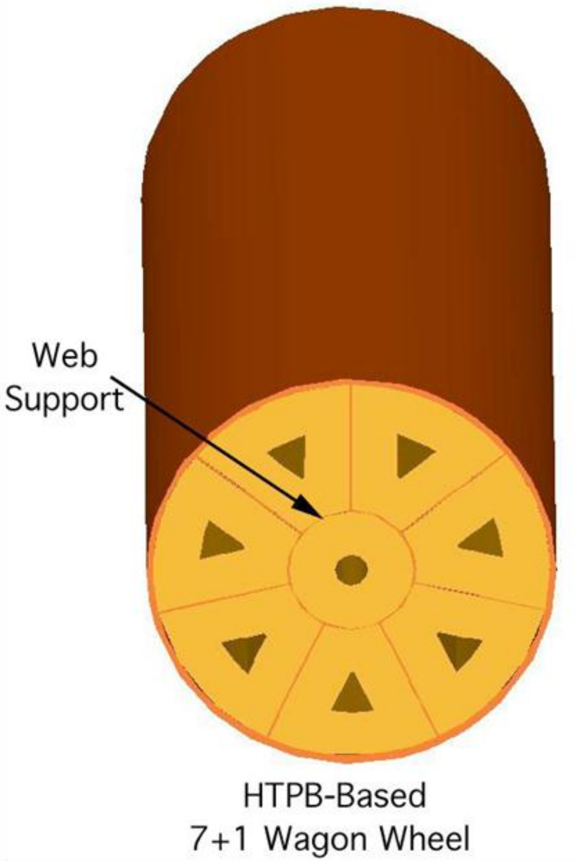
Hybrid Rocket System

A hybrid rocket is a design where a liquid oxidizer is vaporized and passed over a solid fuel.

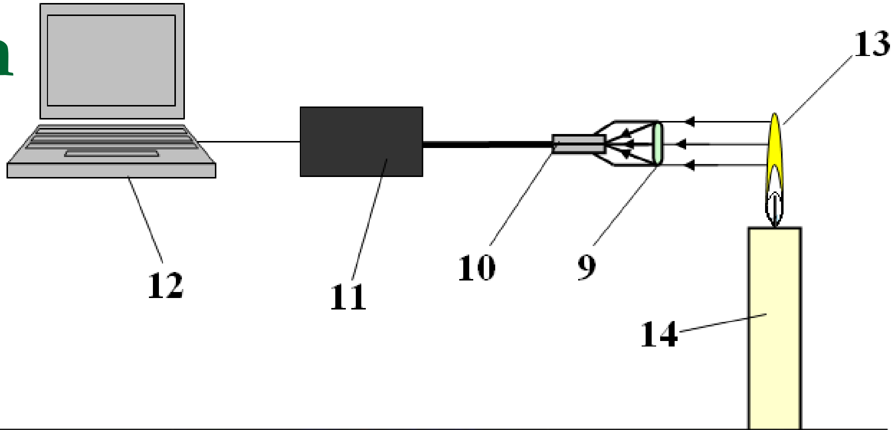
An igniter is used to evaporate some of the fuel and initiate combustion. Once a flame is established over the fuel surface the process is self-sustaining. The hot combustion gases are used to produce thrust.

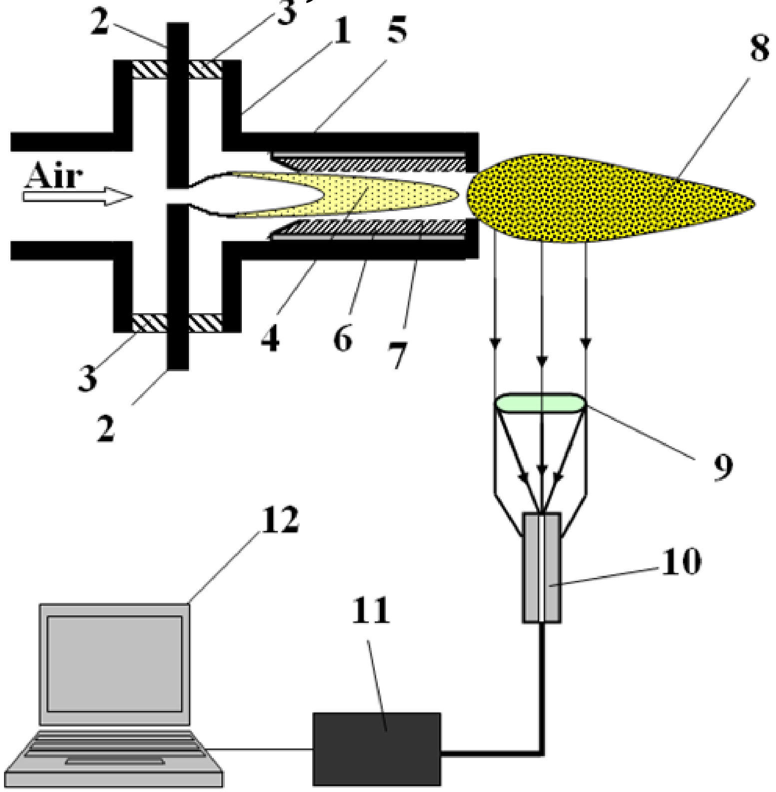


HTPB-Based
7+1 Wagon Wheel

Plasma assisted combustion of paraffin

1 – steel chamber; 2 – copper electrodes;
3 – dielectric tube plug; 4 – plasma torch;
5– stainless steel cylinder; 6 – paraffin cylinder; 7 – cylinder net; 8 –torch;
9 – optical head; 10 - optical fiber;
11 – Spectrometer Solar-TII; 12 – computer
13 – candle flame; 14 – candle.





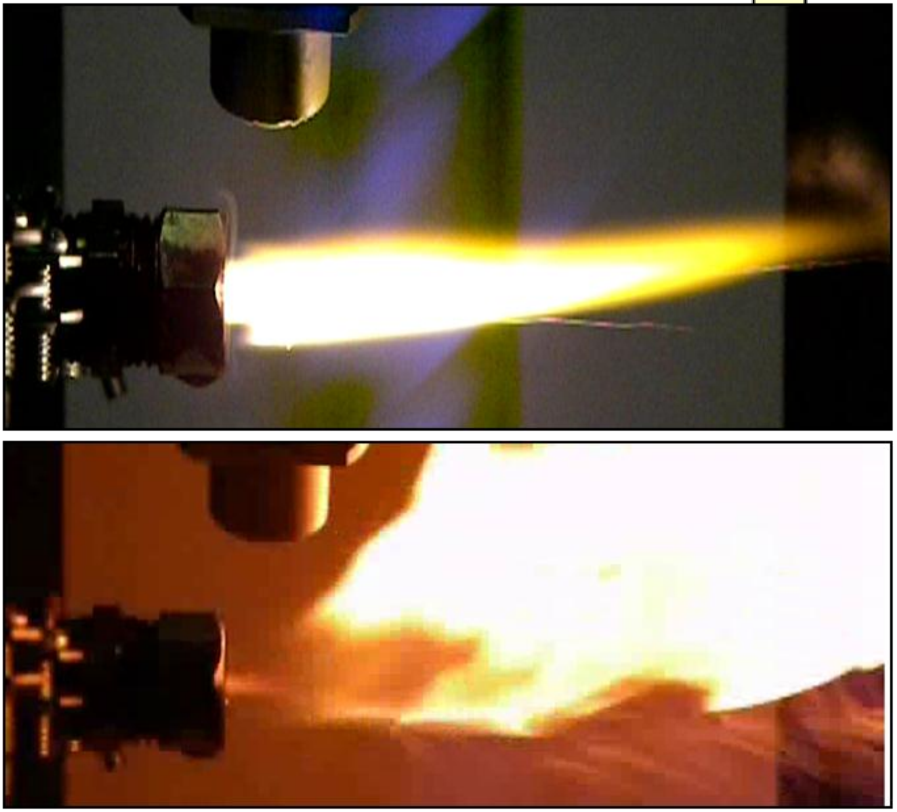
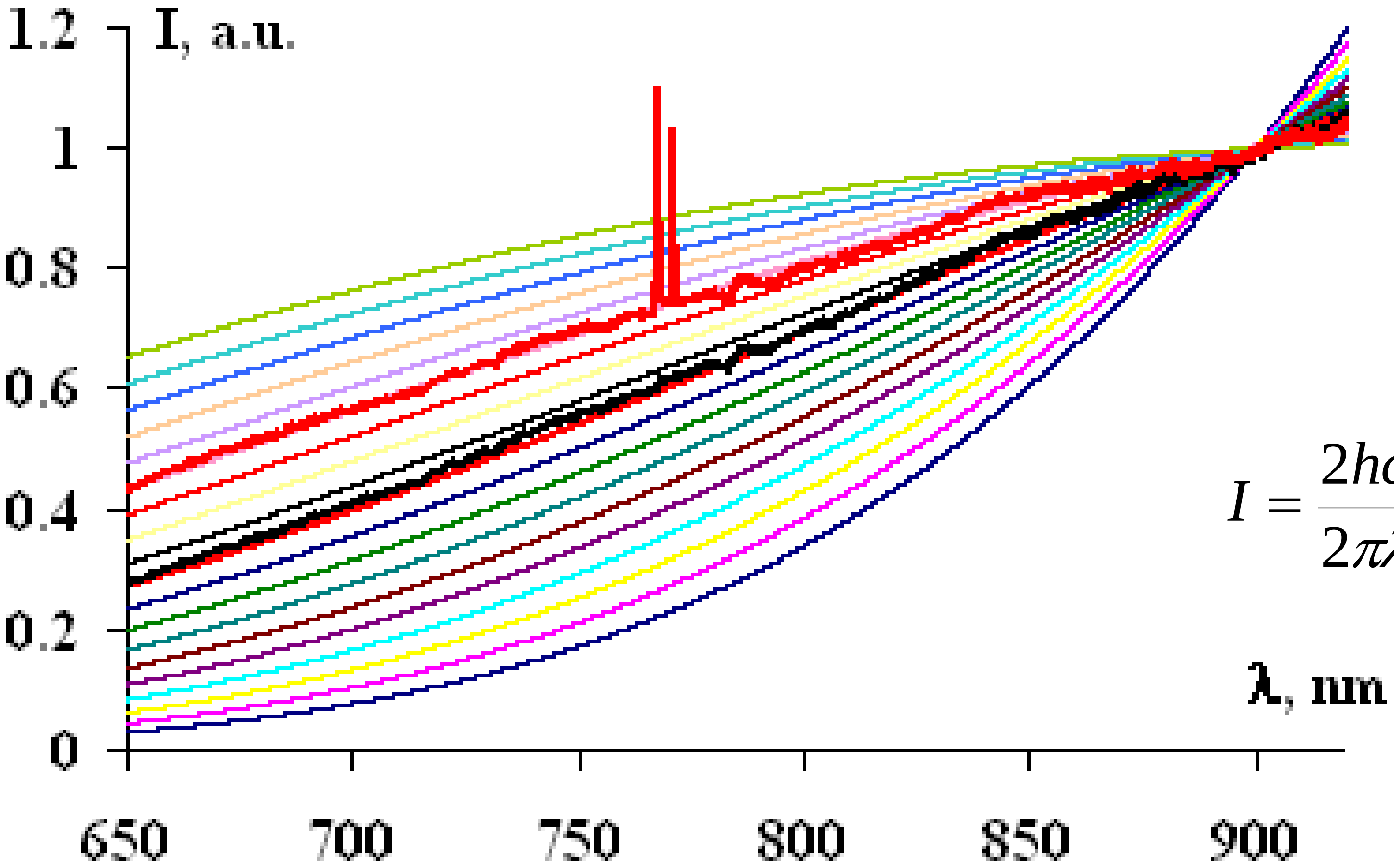


Photo of plasma assisted combustion of paraffin at different air flows: G=55 cm^3/s^{-1} (top) and G=150 cm^3/s^{-1} (bottom)

Temperature comparison:

T_{candle}=2100±100 K, T_{PASC}=2500±100 K



$$I = \frac{2hc^2}{2\pi\lambda^5}\exp(\frac{hc}{kT\lambda}-1)$$

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Thank you for attention!