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BIOMEDICAL WASTE PLASMA GASIFICATION IN VARIOUS AGENTS: EXPERIMENT AND COMPUTATION

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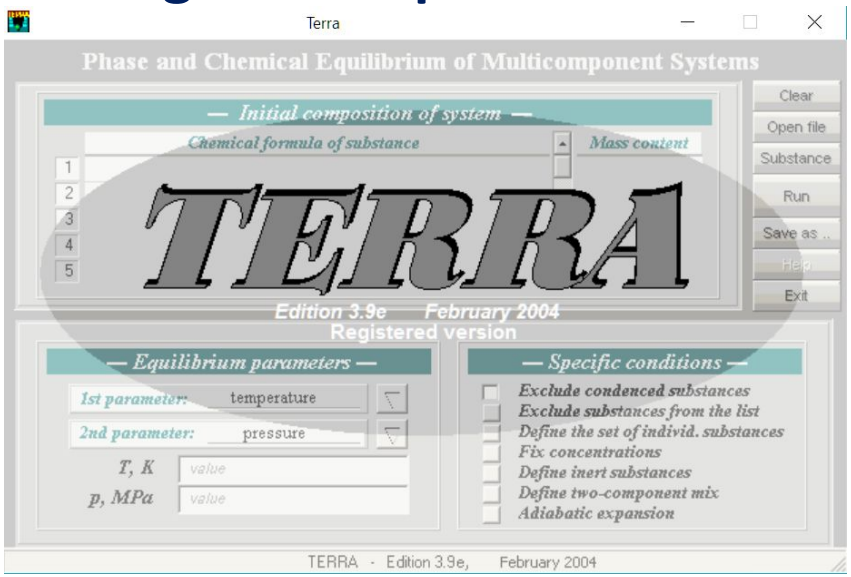
ADVANTAGES OF PLASMA METHODS FOR WASTE PROCESSING

- **Finished decomposition of waste;**
- **Co-processing of different types of waste without pre-sorting;**
- **Decrease in the volume of exhaust gas;**
- **Smaller carryover of dispersed particles;**
- **High performance with small dimensions of equipment;**
- **Creating a desired gaseous atmosphere;**
- **Operative adjustment the process by changing the flow rate of air and power of plasma torches.**

Verification of thermodynamic code TERRA

For computation of waste gasification thermodynamic code TERRA was used.

The calculations were performed over a range of temperatures from 300 to 3000 K and pressure 0.1 MPa.



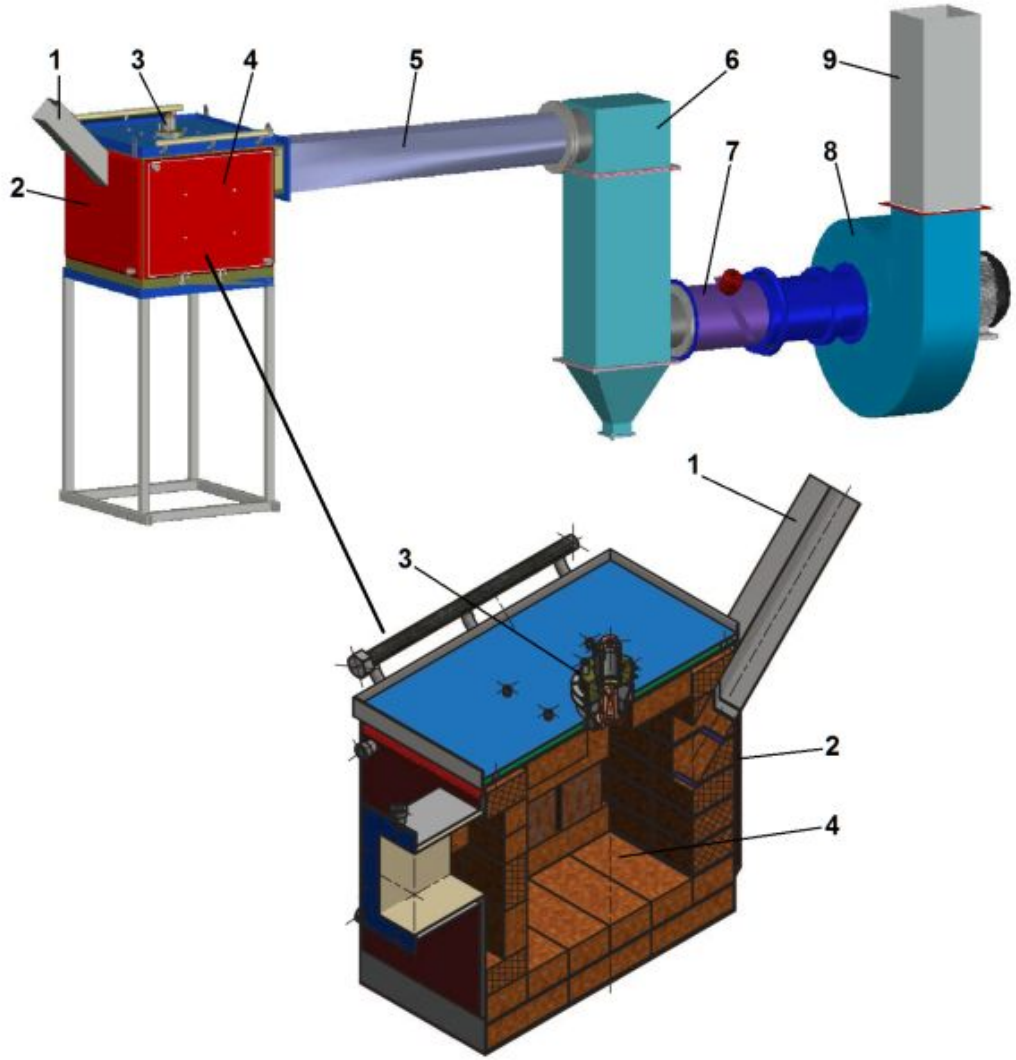
Initial Composition of the System

10 kg of waste + 4 kg of air

Chemical Composition of the Waste, Wt. %

C	H	O	N	S	Cl	H_2O	Fe_2O_3	SiO_2	$CaCO_3$
34.15	5.85	6.29	8.16	0.94	5.3	32.31	3.0	2.0	2.0

Messerle V.E., Mosse, A.L., Ustimenko, A.B. Processing of biomedical waste in plasma gasifier. Waste Management. 2018. V.79. P.791–799.

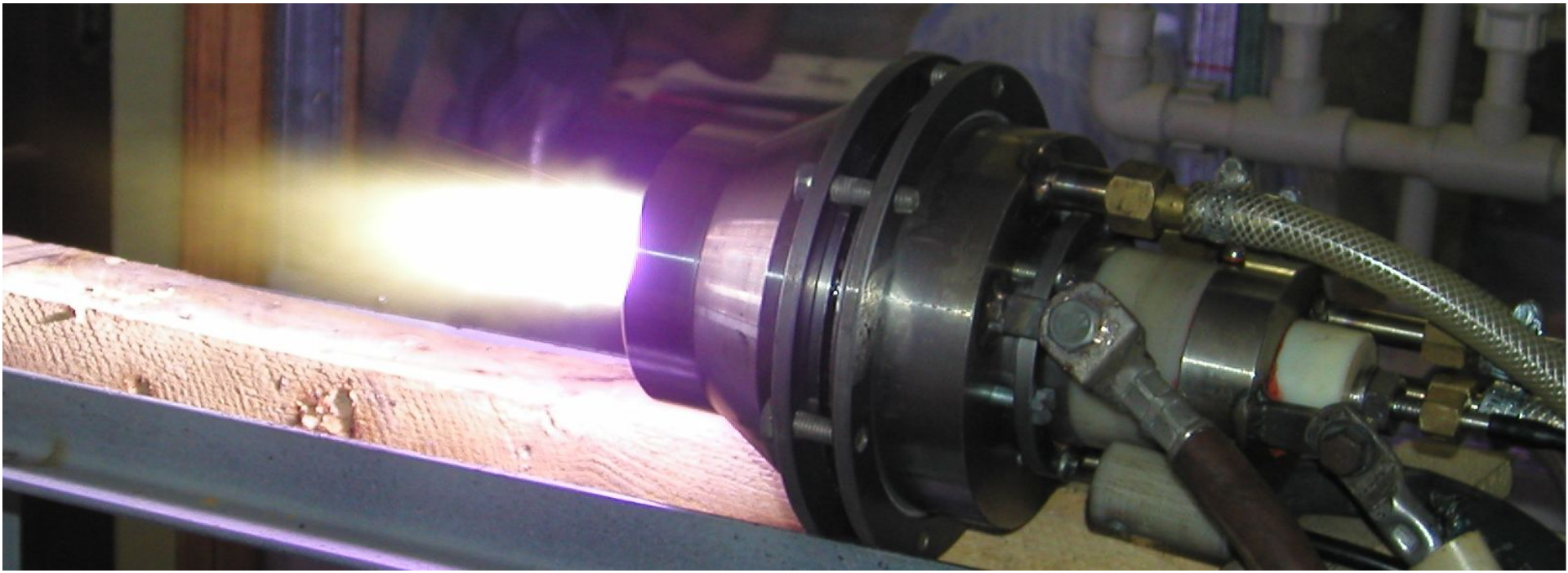


Layout of the experimental unit for solid waste plasma gasification

1 – an inlet for loading briquetted BMW into the reactor, 2 – a plasma reactor, 3 – an electric-arc direct current plasma torch, 4 – BMW gasification zone, 5 – an off-gas cooling unit, 6 – a gas-cleaning unit with a bag filter, 7 – an exhaust gas tube with a system for gas sampling and temperature measurement, 8 – an exhaust fan, 9 – an exhaust tube

- DC plasma torch output power of 35 to 70 kW.
- Plasma forming gas – air, flow 3.3 g/s (12 kg/h).
- Dimensions of the reactor: height – 0.45 m, side – 0.45 m, lining – 65 mm.
- Amount of processed BMW is 30.0 kg/h

Plasma torch is the main element of the installation



**Long-service-life plasma torch of 70 kW in operation:
temperature of the plasma flame is 5000 K**

Plasma Gasifier of BMW

10 kg of BMW + 4 kg of air

Photo of the combustible gas control flame from the pipe for supplying of briquetted waste

CO – 26.5%

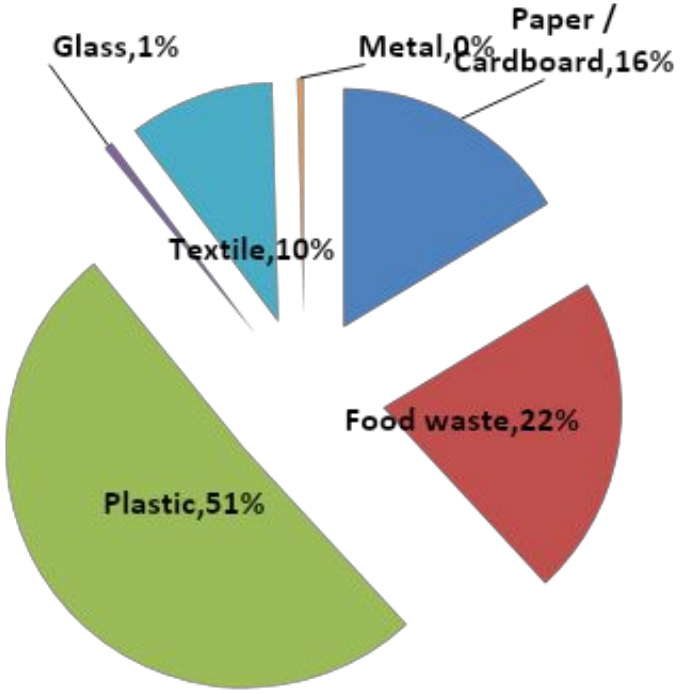
H_2 – 44.6%

N_2 – 28.9%

COMPOSITION OF THE PRODUCTS AFTER PLASMA GASIFICATION OF BMW

Products components	Percentage	
	Experiment	Computation
Carbon monoxide (CO), Vol. %	26.5	31.7
Hydrogen (H_2), Vol. %	44.6	50.7
Nitrogen (N_2), Vol. %	28.9	15.0
Total, Vol. %:	100	97.4
Carbon (C), Wt. %	2.8	0
X_C, %	91.8	100
Specific power consumption Q_{sp}, kW h/kg	2.25	1.92

TYPICAL COMPOSITION OF BIOMEDICAL WASTE



Chemical Composition of Biomedical Waste, Wt. %

C	H	O	N	S	Cl	Fe_2O_3	SiO_2	Ca	Al+Mg+Mn+Na+K+Cr+Ni+P
46.35	7.74	35.04	0.17	0.01	9.54	0.29	0.41	0.16	0.29

The calculations were carried out in the temperature range of 300 – 3,000 K at a pressure of 0.1 MPa. To calculate the gasification of BMW, the following technological mixtures were used, the composition of which provided 100% gasification of the waste:

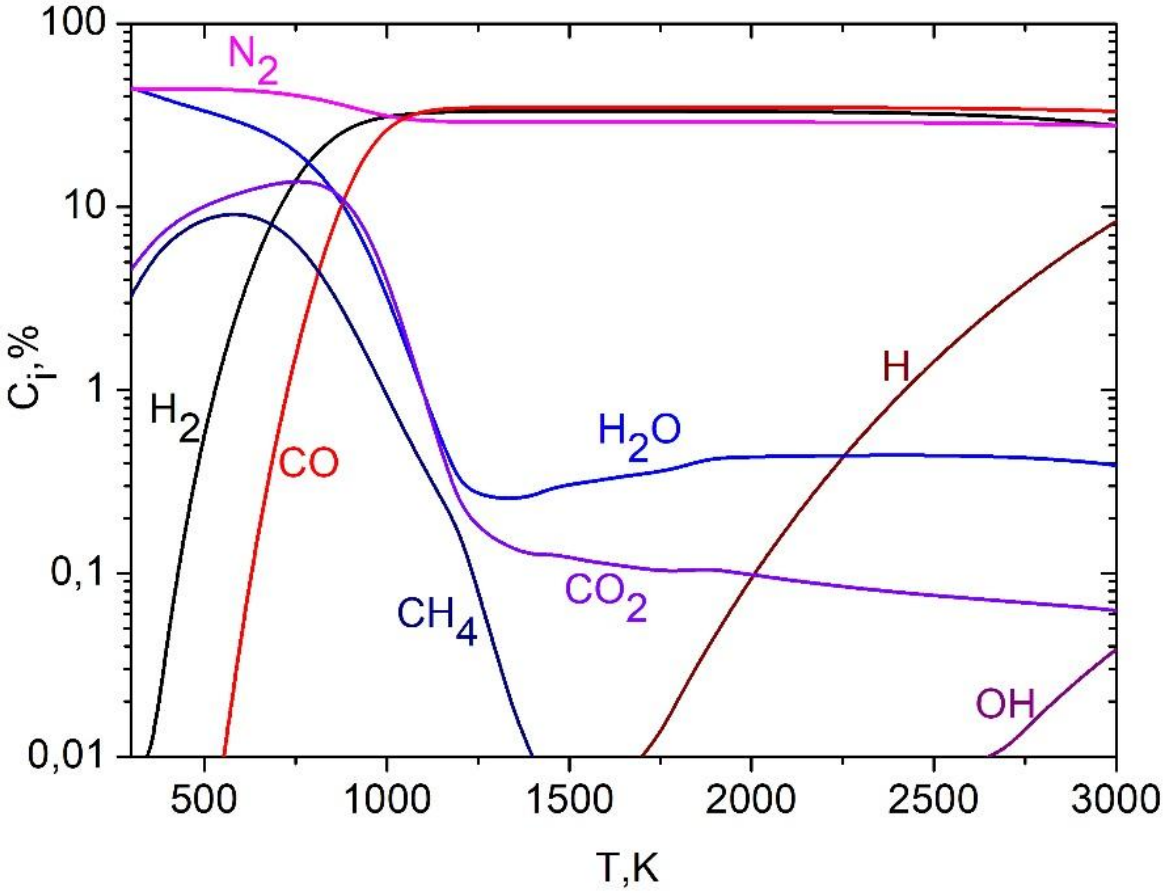
100 kg BMW + 117 kg air

100 kg BMW + 31 kg water vapor

100 kg BMW + 80 kg carbon dioxide

100 kg BMW + 28 kg oxygen

THERMODYNAMIC COMPUTATION



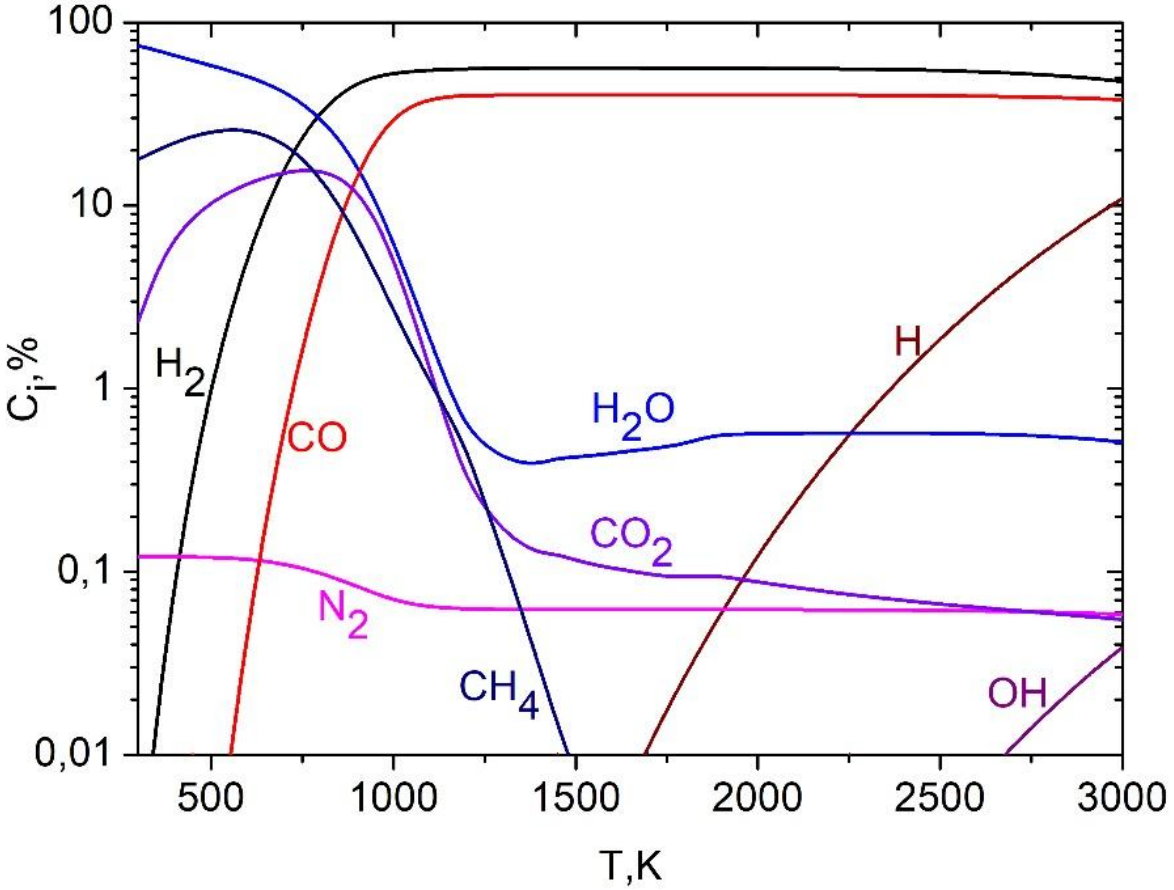
T = 1600 K:

CO – 34.8%

H_2 – 33.3%

N_2 – 29.0%

Concentration of the gas components dependence on temperature of BMW plasma air gasification

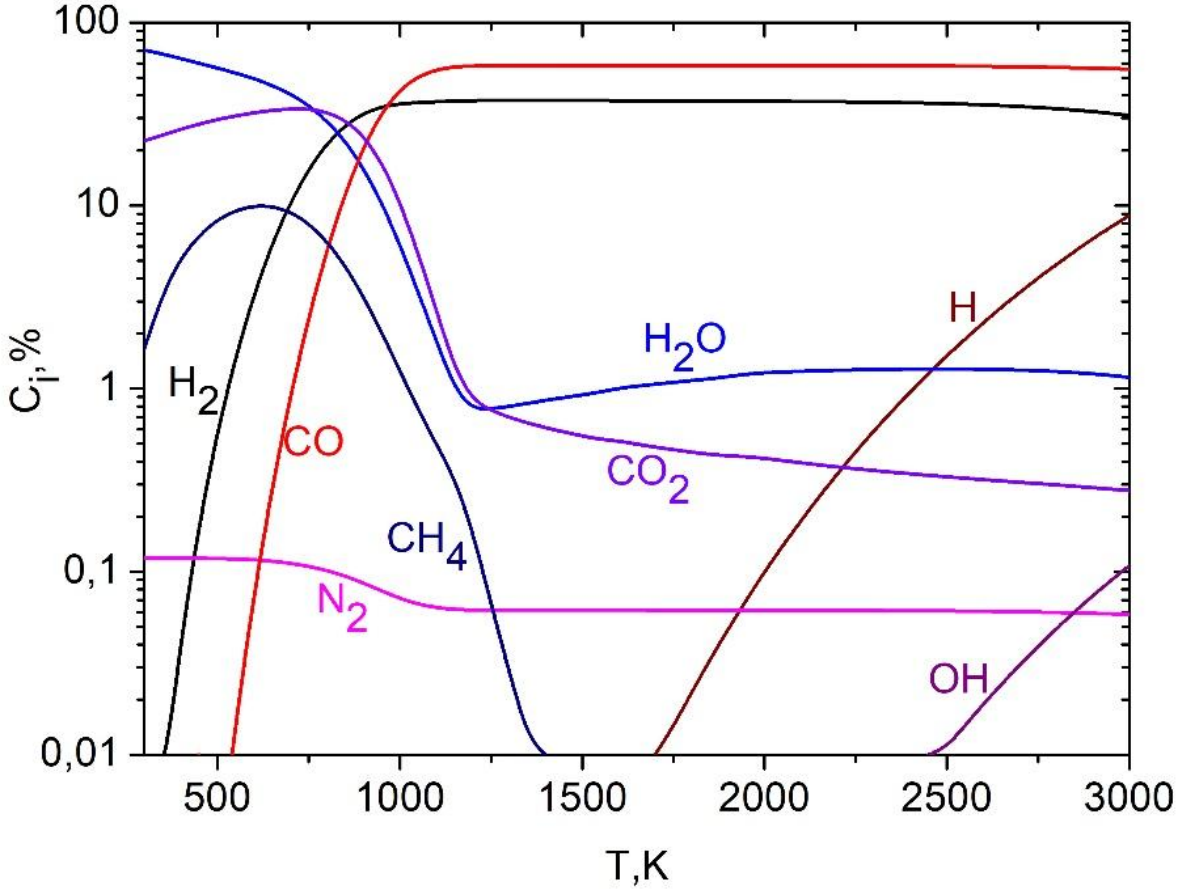


T = 1600 K:

CO – 40.2%

H_2 – 56.4%

Concentration of the gas components dependence on temperature of BMW plasma steam gasification

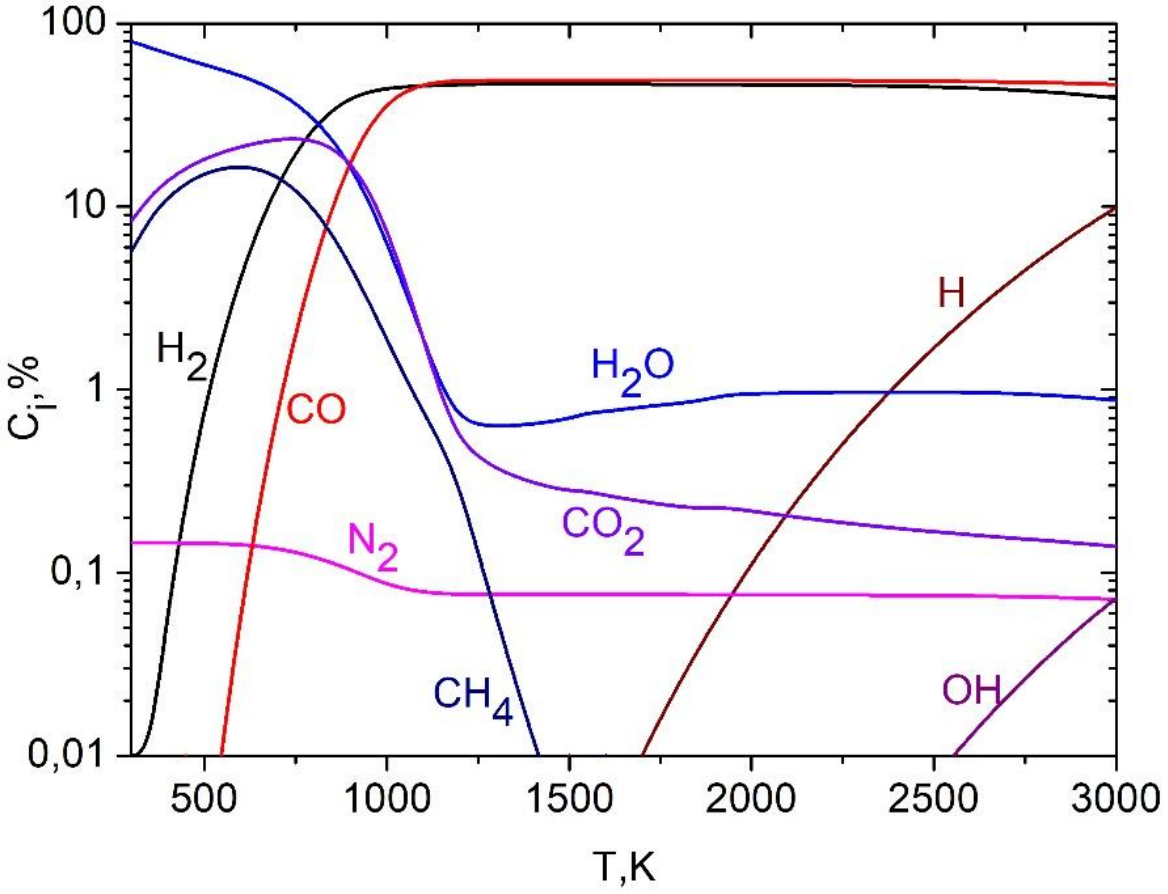


T = 1600 K:

CO – 58.2%

H_2 – 37.4%

Concentration of the gas components dependence on temperature of BMW plasma carbon dioxide gasification

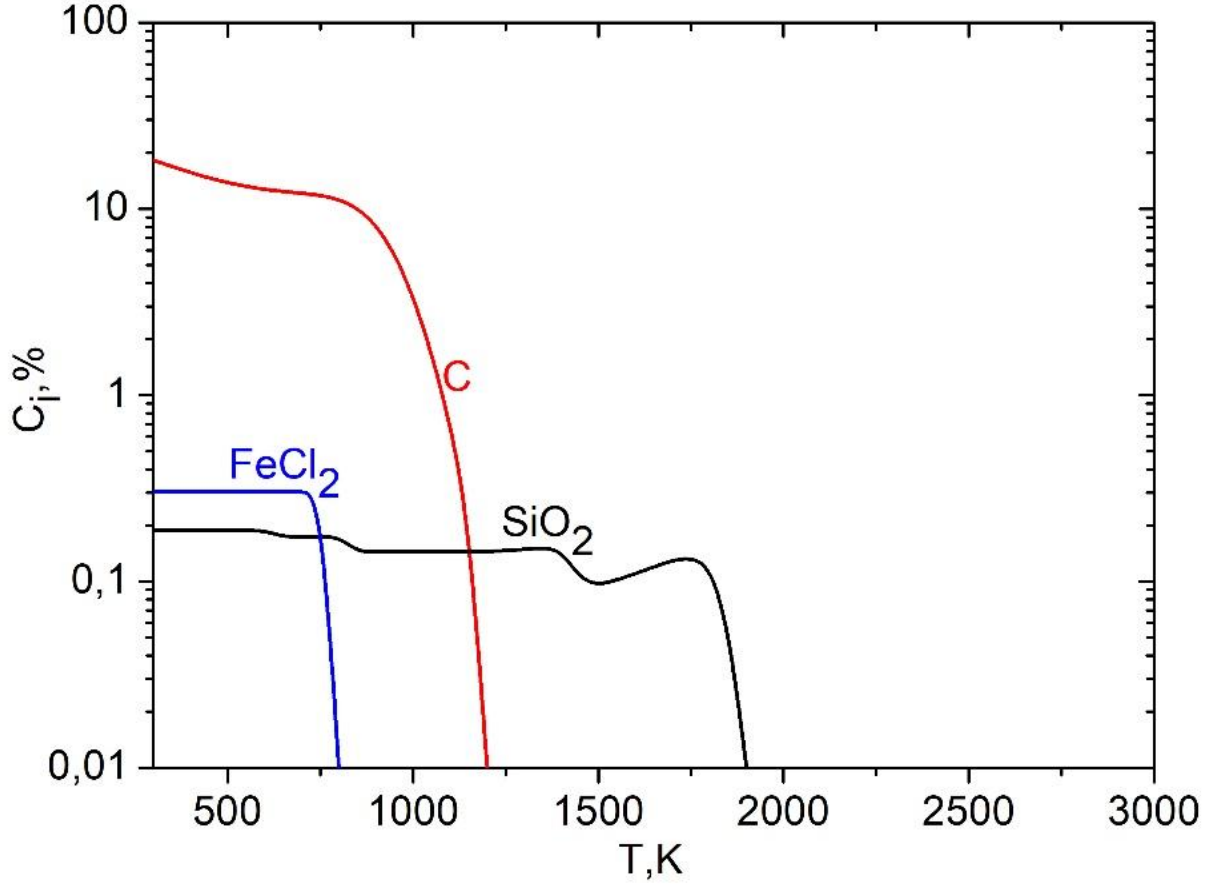


T = 1600 K:

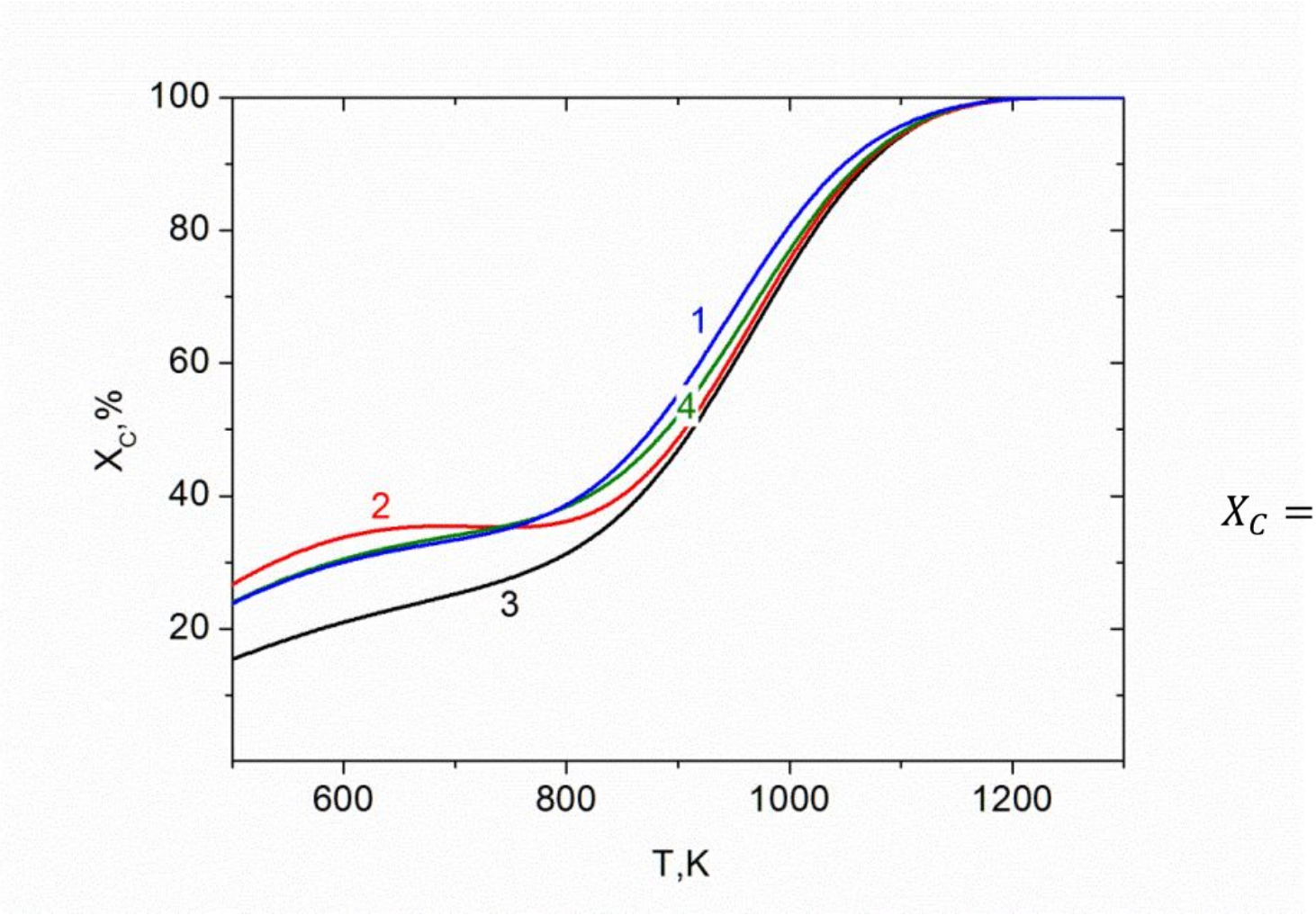
CO – 48.9%

H_2 – 46.6%

Concentration of the gas components dependence on temperature of BMW plasma oxygen gasification

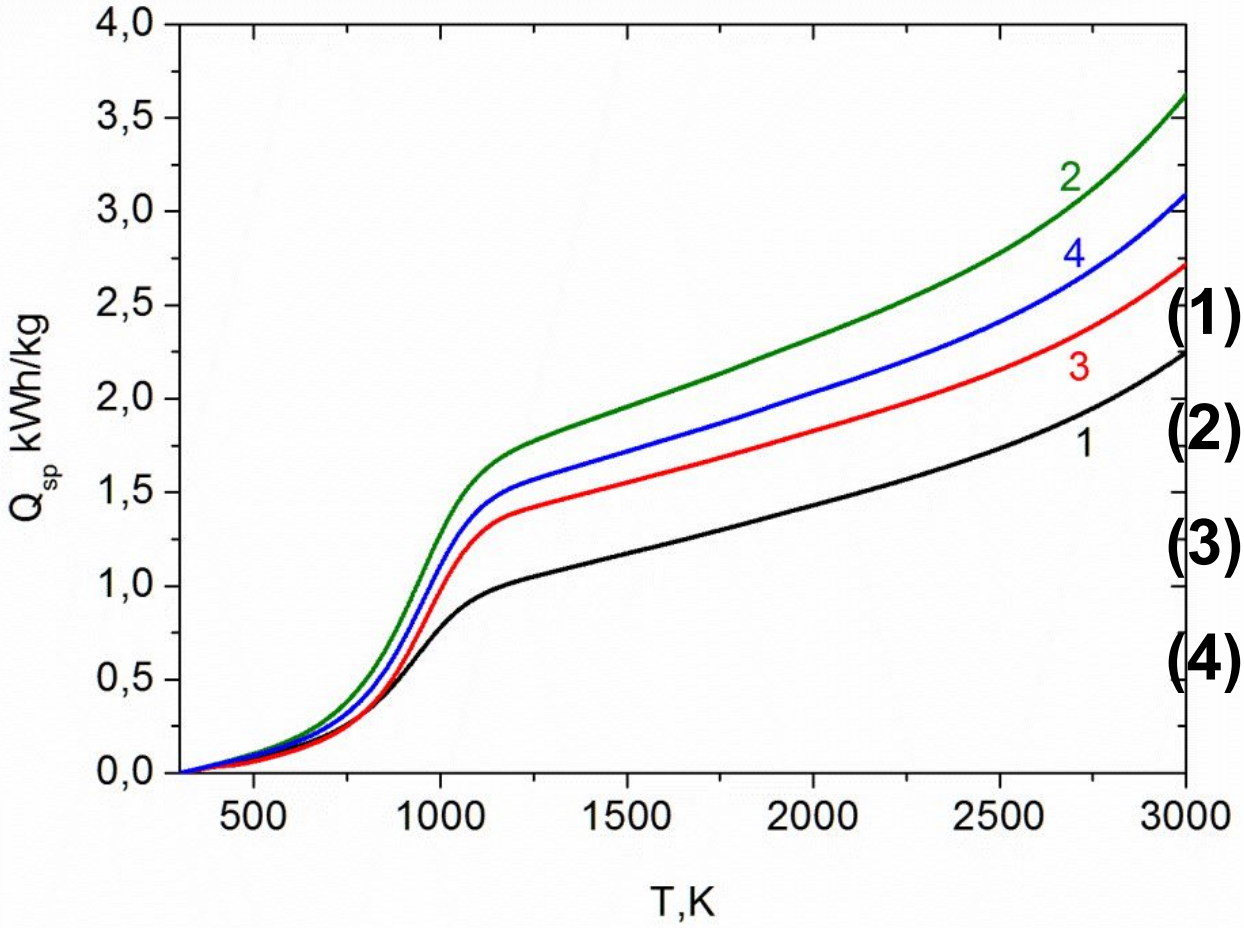


Concentration of the condensed components depending on the temperature of plasma gasification of BMW in air, steam, carbon dioxide and oxygen medium



$$X_C = \frac{C_{ini} - C_{fin}}{C_{ini}} \cdot 100\%$$

Carbon gasification degree dependence on temperature of BMW gasification: (1) – air; (2) – steam; (3) – carbon dioxide; (4) – oxygen



T = 1600 K:

(1) Q_{sp} – 1.22 kWh/kg

(2) Q_{sp} – 2.02 kWh/kg

(3) Q_{sp} – 1.6 kWh/kg

(4) Q_{sp} – 1.78 kWh/kg

Specific power consumption dependence on temperature of BMW plasma gasification:

(1) – air; (2) – steam; (3) – carbon dioxide; (4) – oxygen

Conclusions

- **Thermodynamic calculations showed that the maximum yield of synthesis gas during plasma gasification of biomedical waste in various gasification agents is achieved at a temperature of 1600 K.**
- **The maximum yield of synthesis gas is achieved with plasma-steam gasification and is 96.6%. During plasma gasification using carbon dioxide and oxygen as gasifying agents, the synthesis gas output reaches 95.6%.**
- **The minimum specific energy consumption at a temperature of 1600 K for plasma-air gasification is 1.22 kWh/kg, but the synthesis gas output is relatively small (68.1%) compared with other gasifying agents (steam, oxygen, carbon dioxide).**
- **Thermodynamic calculations showed that with plasma-carbon dioxide gasification of the BMW with a significant synthesis gas output (95.6%), the specific energy consumption for the process is relatively small (1.6 kWh/kg). Note that the use of carbon dioxide as a gasifying agent contributes to reducing the greenhouse effect.**


Thanks !