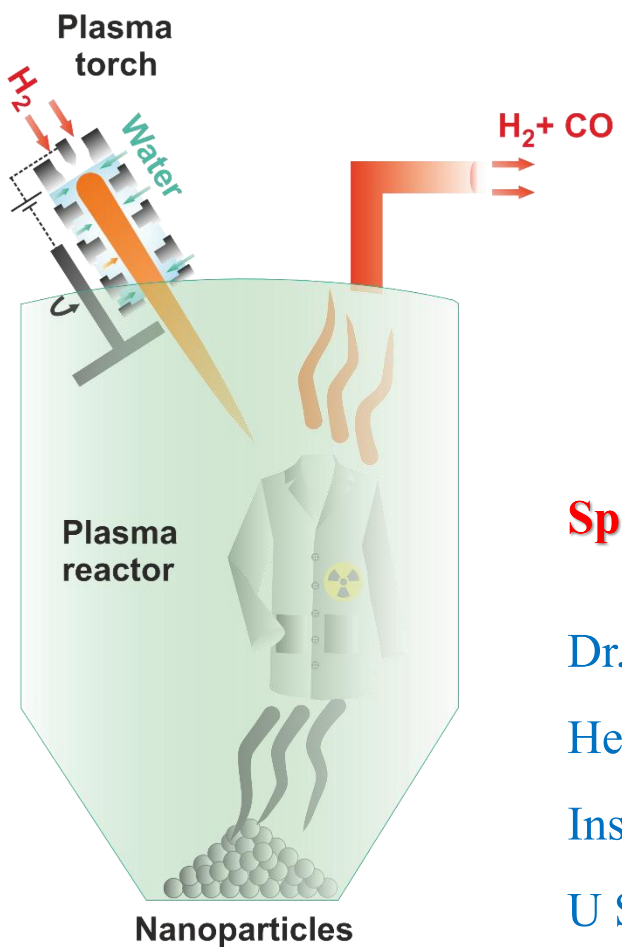
Plasma Chemical Technologies



Refuse Derived Fuel - from Waste to Hydrogen and Carbon Nanoparticles

Speaker:

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Refuse derived fuel (RDF) Tuhé alternativní palivo (TAP)

Refused Derived Fuel (RDF) is a type of alternative fuel made from various types of waste. It's primarily used in **cement kilns**, **power plants**, and **industrial boilers** to reduce the use of fossil fuels

These materials are **processed and shredded** to a specific size and sometimes **dried or pelletized** to make them suitable for combustion.

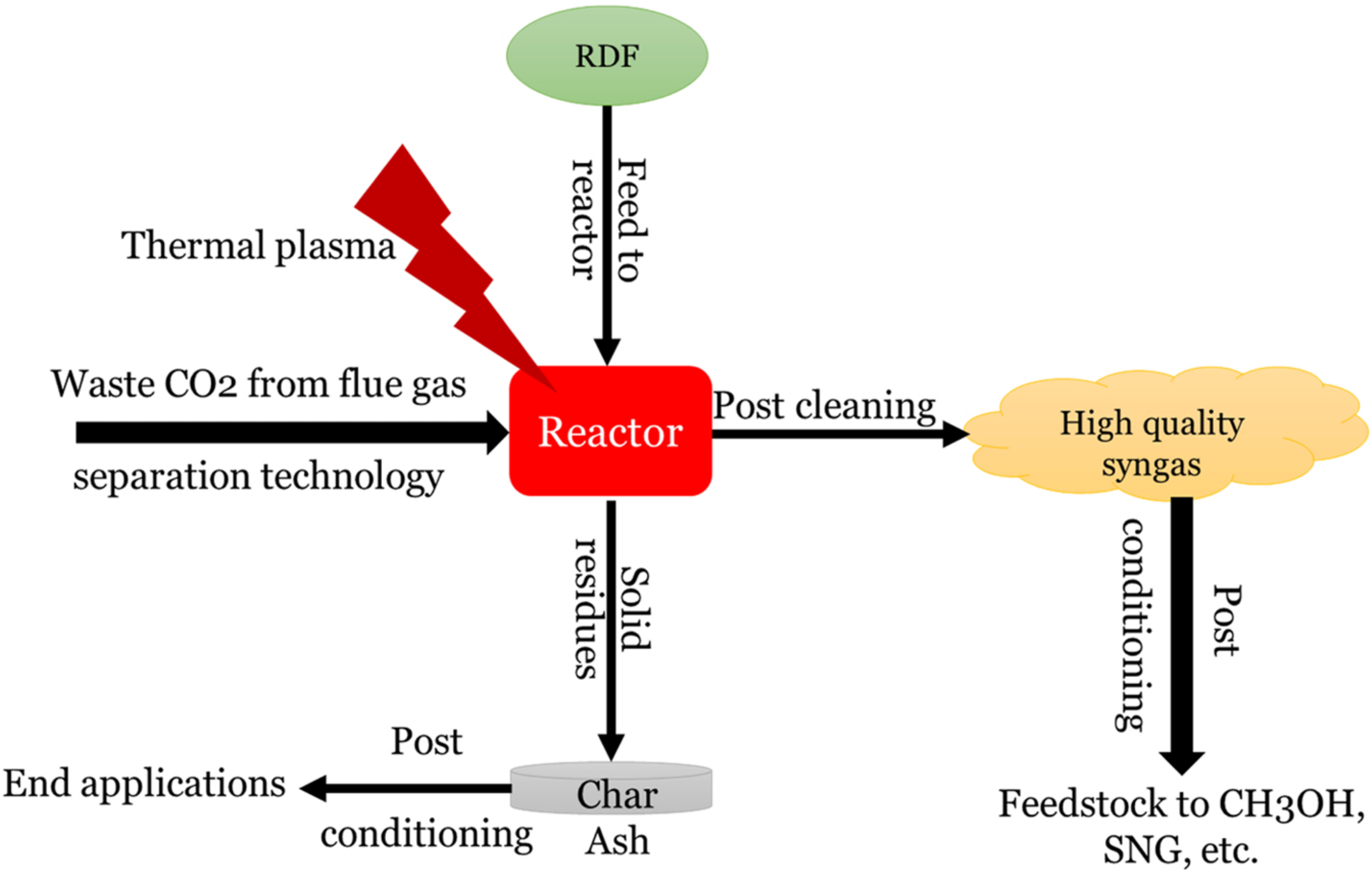
- Plastics (non-recyclable)
- Paper and cardboard (not suitable for recycling)
- Textiles
- Wood waste
- Rubber
- Packaging materials

Composition (before treatment)

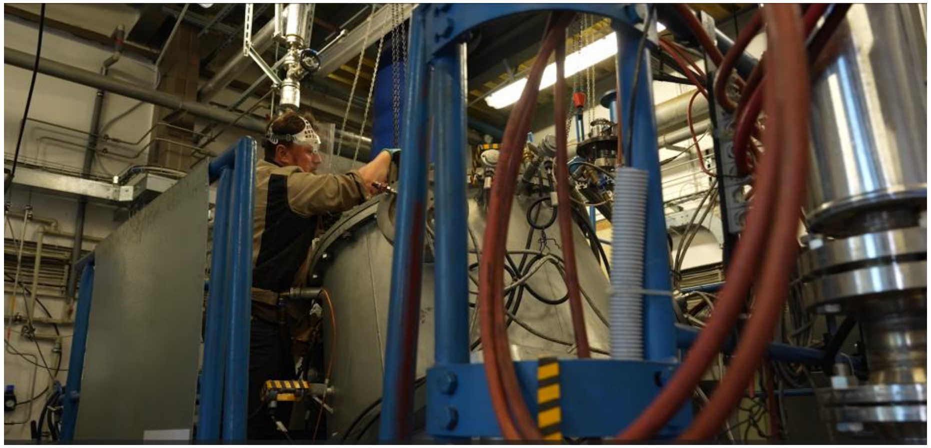
Table 1
The composition of the feed material (RDF) used in experimental runs.

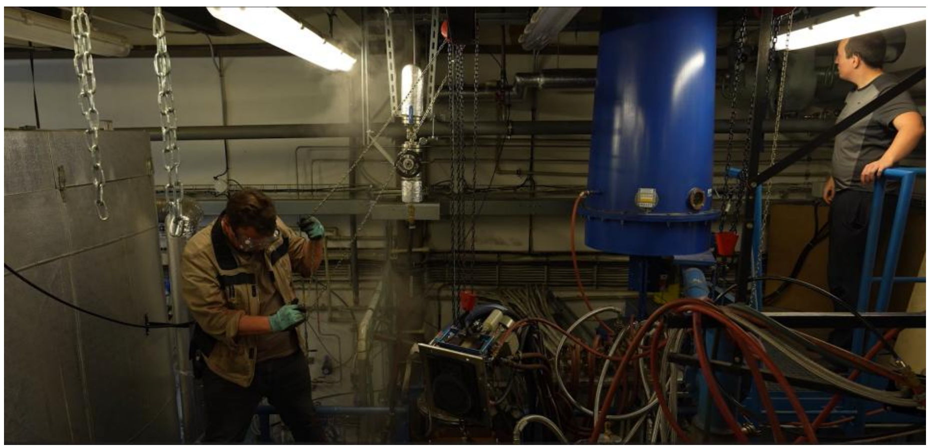
Parameter	Dry and ash-free (daf)	Dry	As received (ar)
Water (wt%)			1.5
Ash (wt%)		9.3	9.1
Volatiles (wt%)	90	81.4	80.3
Fixed carbon (wt%)	10	9.3	9.1
C (wt%)	70	63	62
H (wt%)	9.1	8.2	8.1
N (wt%)	0.67	0.61	0.60
O (wt%)	20	18	18
S_{comb} (mg/kg)	380	350	340
Cl (mg/kg)	2700	2400	2400
F (mg/kg)	82	74	73
Br (mg/kg)	39	36	35
Lower heating value (MJ/kg)			24

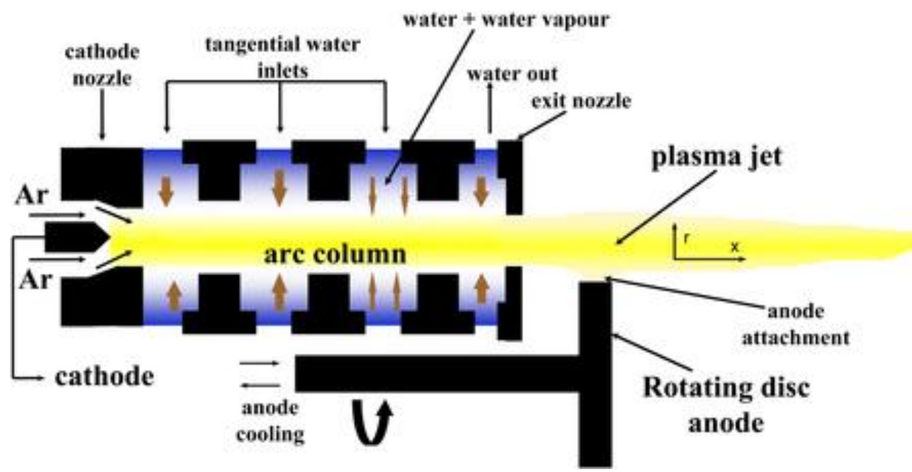
Scheme of treatment

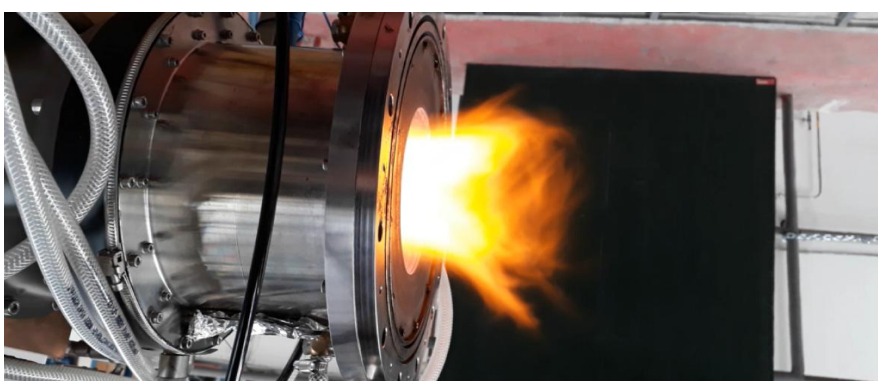


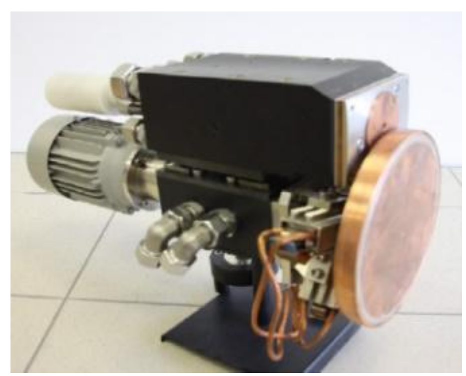
Plasma reactors. PlasGas reactor



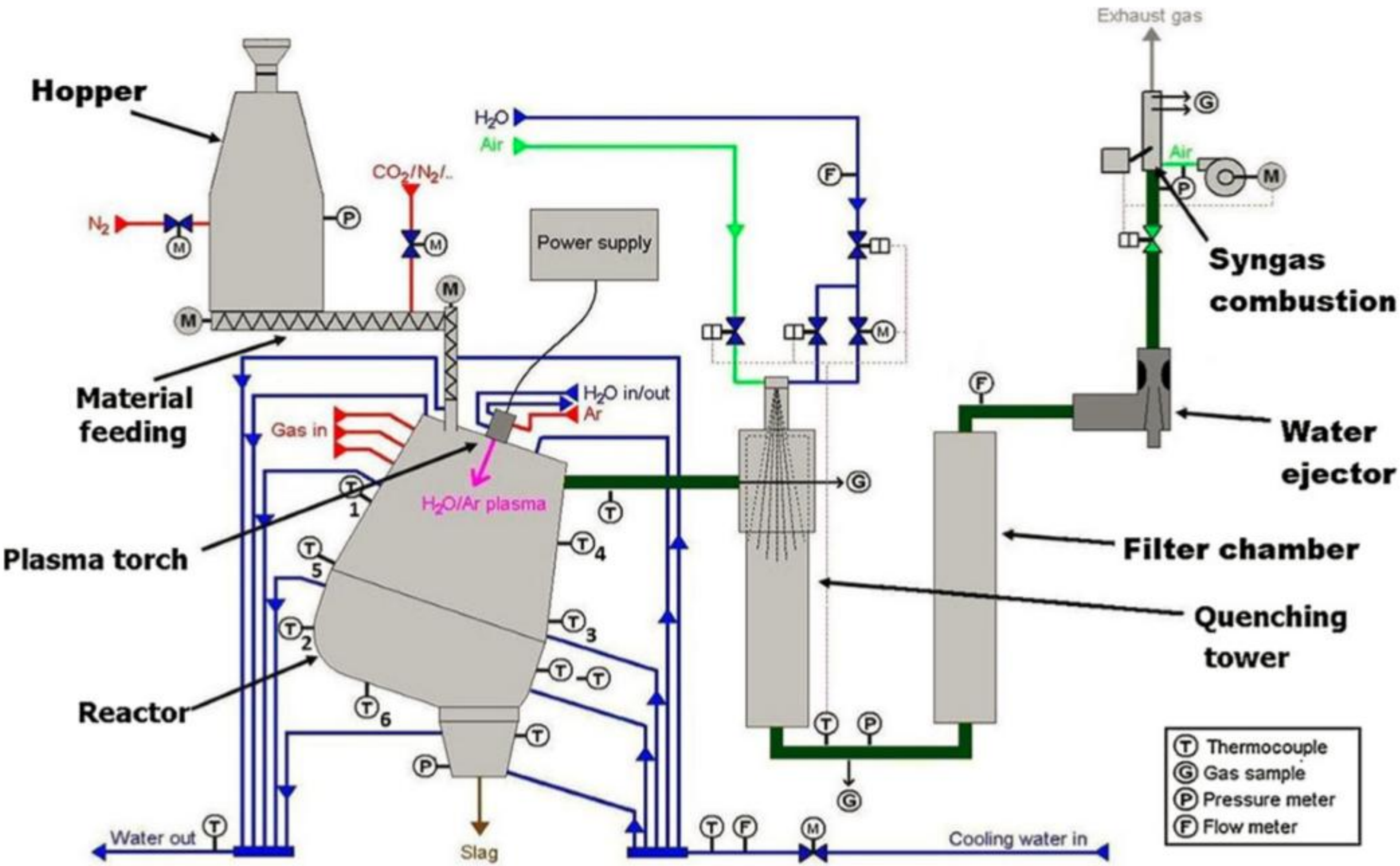








Plasma reactors. PlasGas reactor scheme

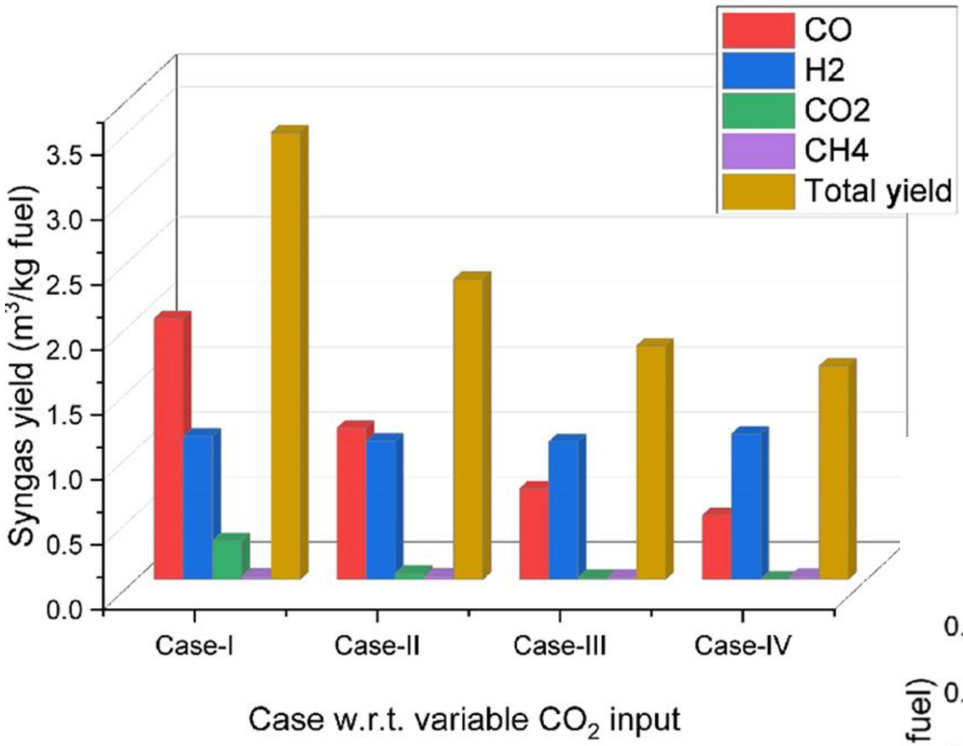


Experiment input

Table 2
Experimental parameters for four different cases.

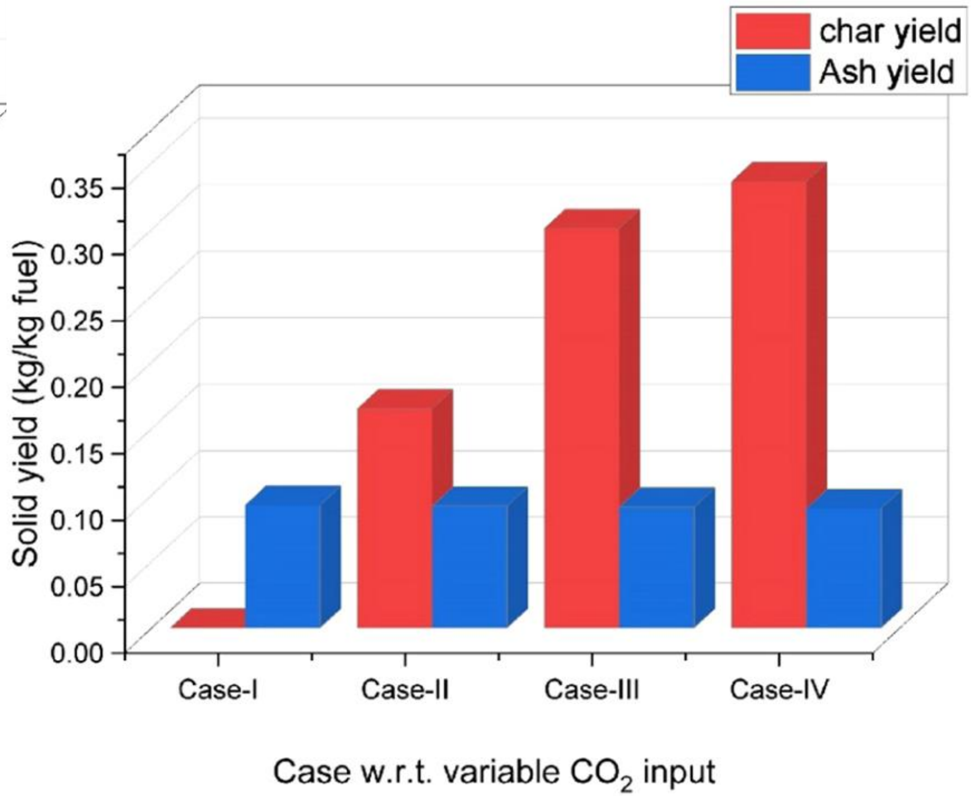
Parameters	Case-I	Case-II	Case-III	Case-IV
Fuel (kg/h)	10	10	11	8.9
CO_2 input (L/m)	170	62	26	0
Gasification ratio (GR)	1.04	0.80	0.60	0.40
Power of the plasma torch (kW)	120	110	95	80
Electric efficiency of the plasma torch (%)	69	68	67	67
H_2O input to the plasma torch (g/m)	28	28	28	28
Ar input to plasma torch (L/m)	11	11	11	11
Supplementary addition of Ar (L/m)	110	110	110	110

Experiment output (gases)



Syngas yields in m^3/kg of fuel

Production of solids (char and ash)



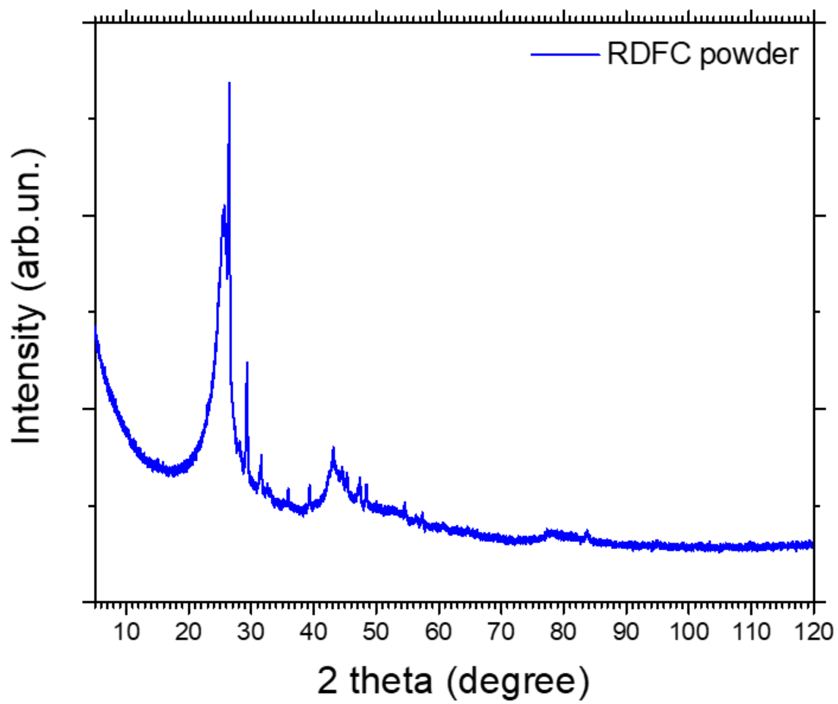
Experiment output (contaminants)

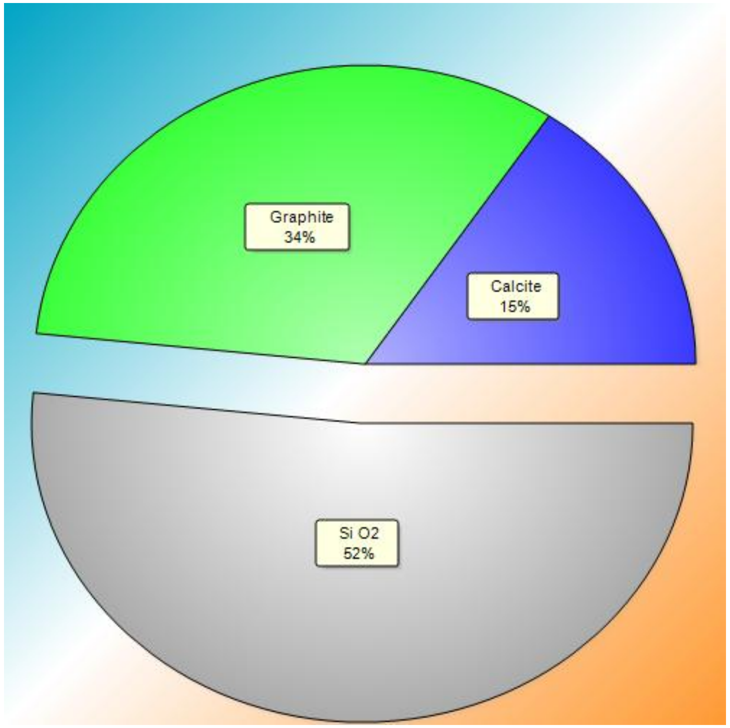
Table 3

Contaminants with respect to four cases and limits for methanol synthesis.

Contaminant	Case-I (max; ppm)	Case-II (max; ppm)	Case-III (max; ppm)	Case-IV (max; ppm)	Limits for methanol synthesis in ppm[34]
NH_3	2349	3236	3850	3913	< 0.0001
H_2S	58	80	96	97	< 0.001
HCl	371	511	608	618	< 0.0001
HF	21	29	35	35	< 0.0001
HBr	2	3	4	4	< 0.0001

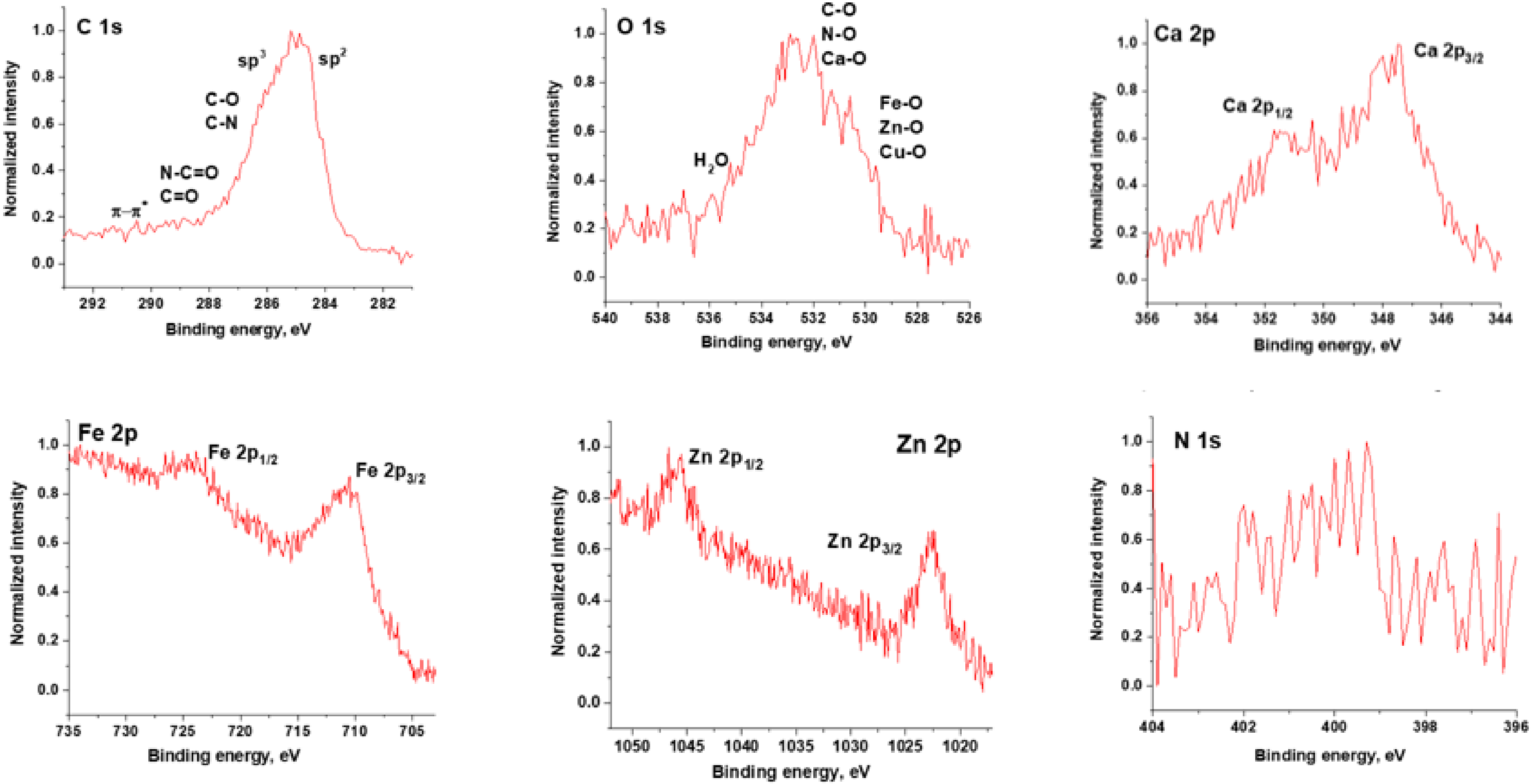
Experiment output (carbon nanoparticles). XRD





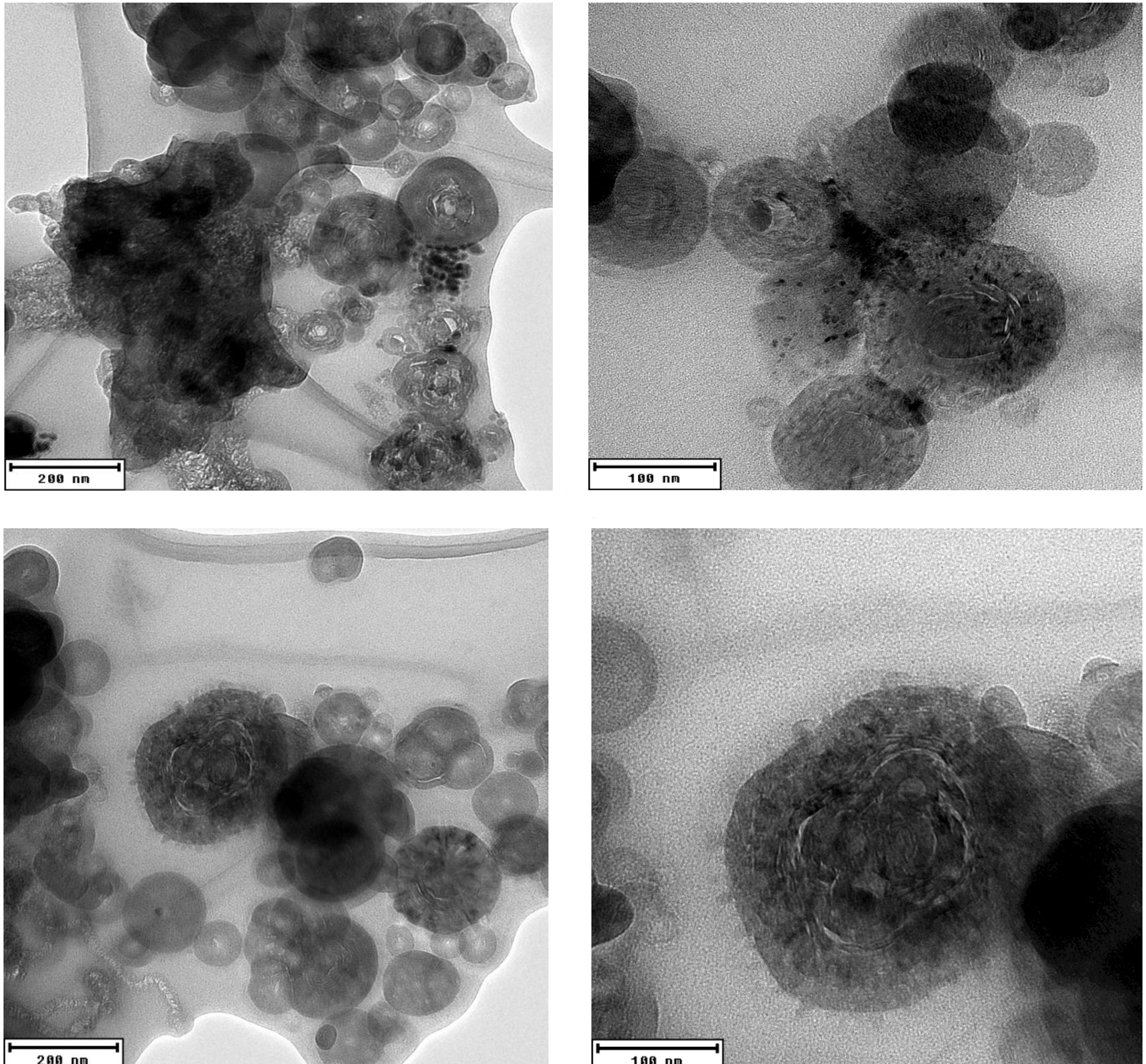
Visible	Ref.Code	Score	Compound Name	Displ.[°2θ]	Scale Fac.	Chem. Formula
*	96-900-0968	49	Calcite	0.000	0.332	Ca6.00 C6.00 O18.00
*	96-901-1578	37	Graphite	0.000	0.595	C4.00
*	96-412-4075	44	Si O2	0.000	0.650	Si16.00 O32.00

Experiment output (carbon nanoparticles). XPS

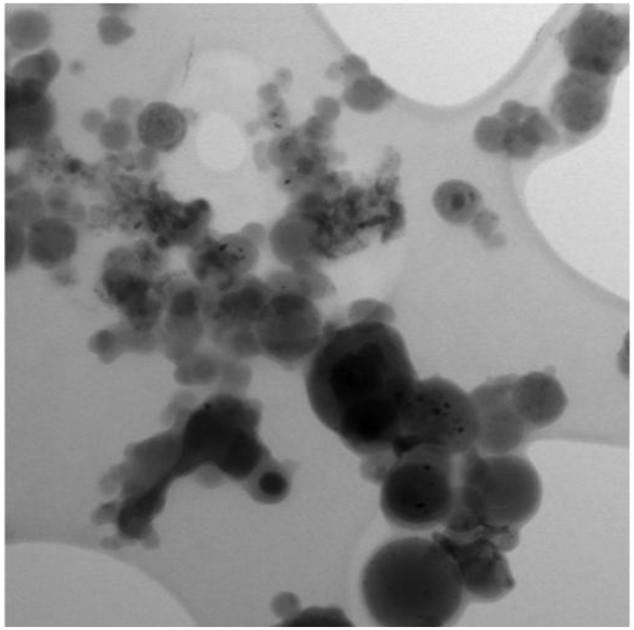


Atomic concentration, at.%						
C	O	N	Cu	Fe	Zn	Ca
31.1	56.0	2.1	1.8	2.7	1.1	5.3

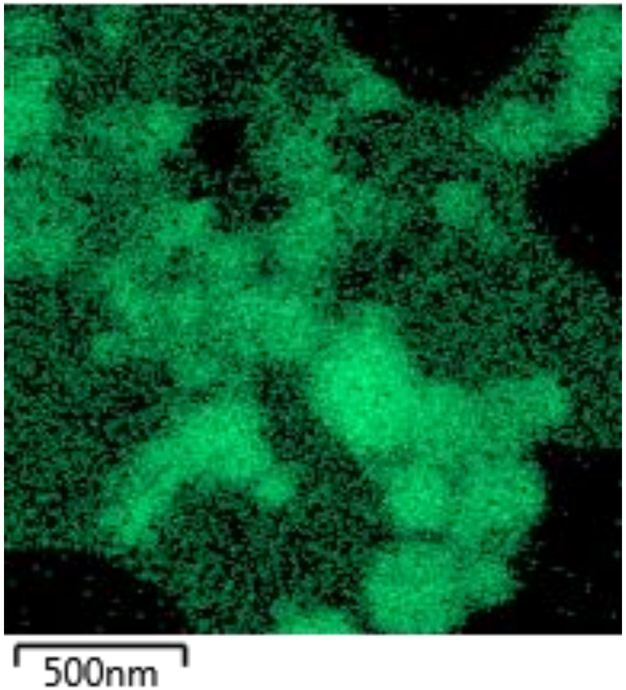
Experiment output (carbon nanoparticles). TEM



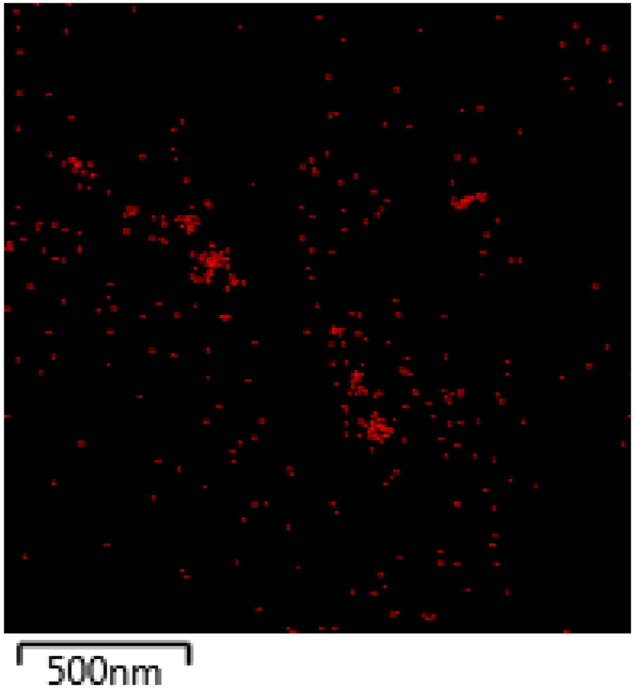
Experiment output (carbon nanoparticles). TEM

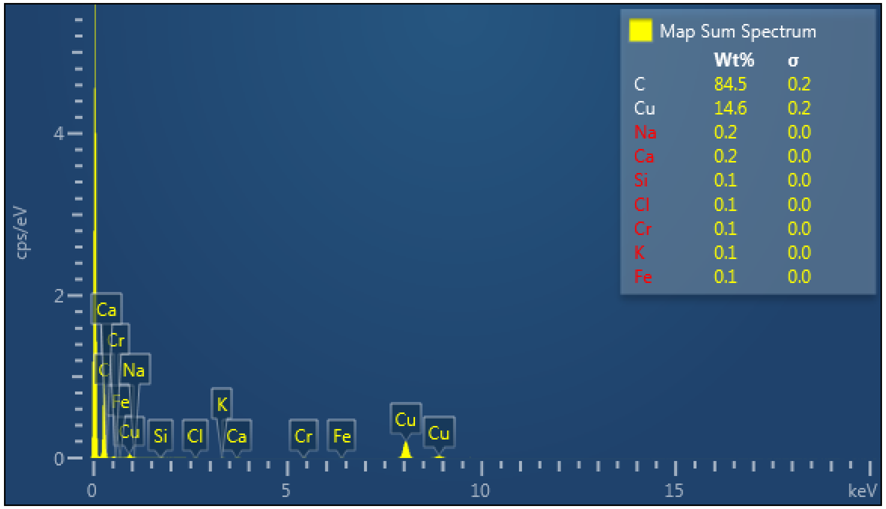


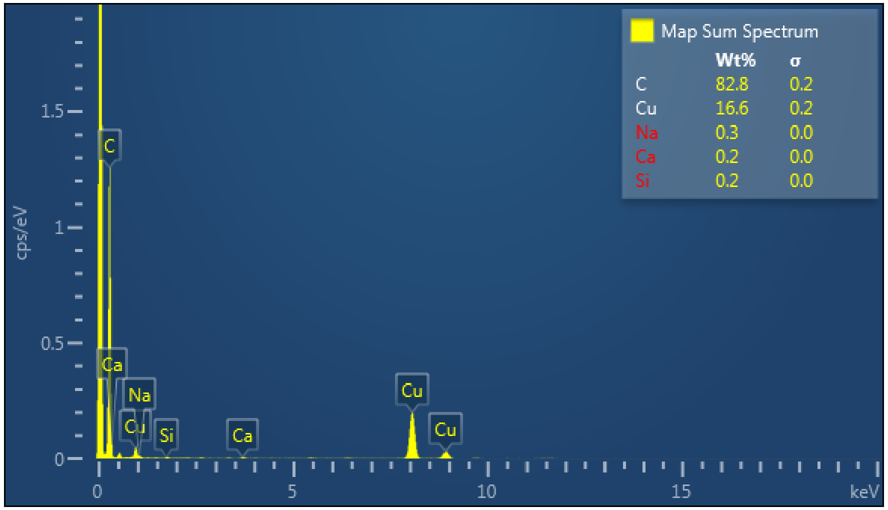
C Kα1_2



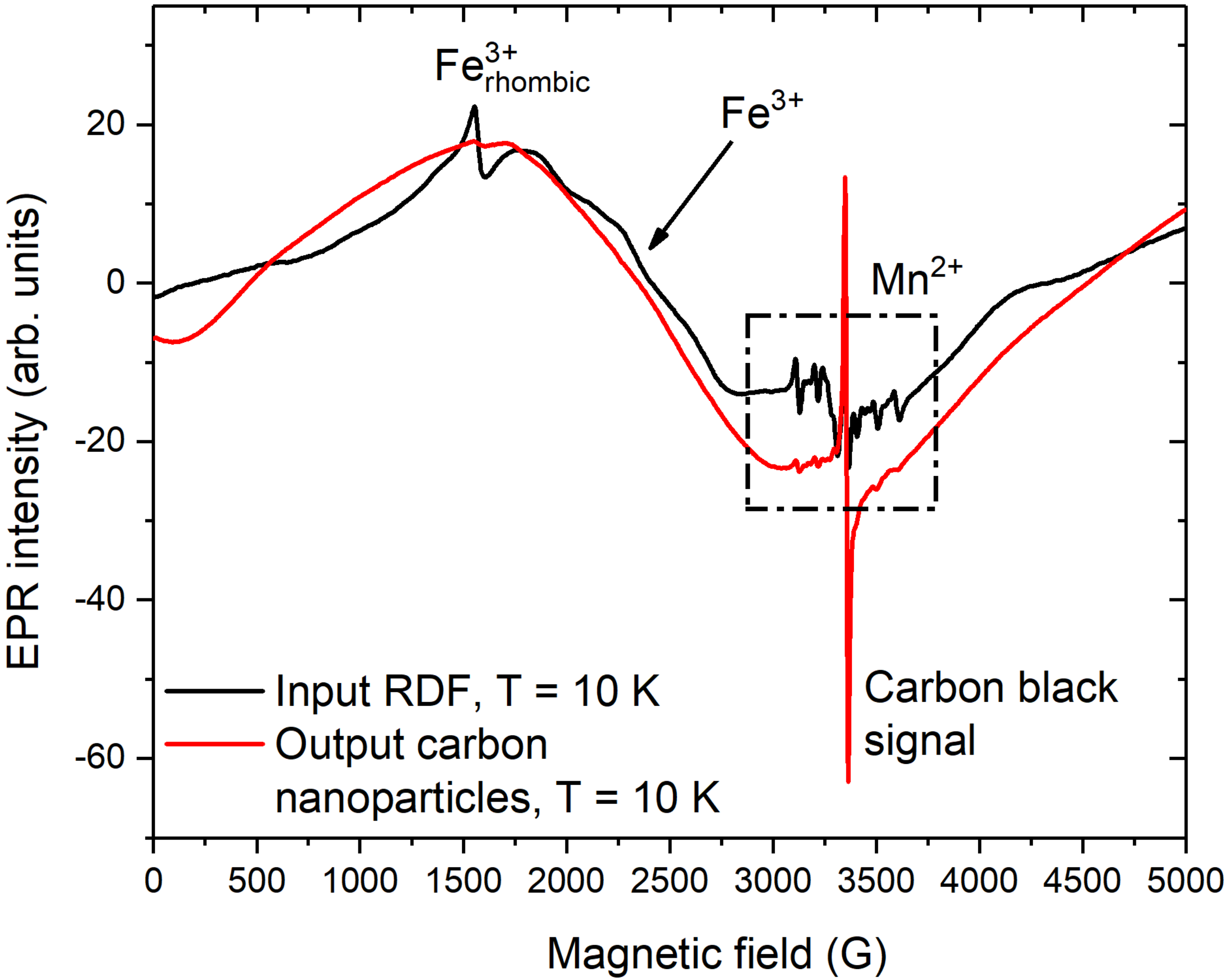
Ca Kα1







Experiment output (carbon nanoparticles). EPR



Conclusions

1. **Amorphous input becomes at the output crystallized: graphite, quartz and calciate**

2. **Oxidizing agent and power influence the output syngas composition**

3. **Toxic elements lead to the contaminants creation**

4. **Oxygen appears inside the carbon nanoparticles**

Thank you for your attention!