NANODISPERSED CARBON BLACK PRODUCTION BY PYROLYSIS OF HYDROCARBONS

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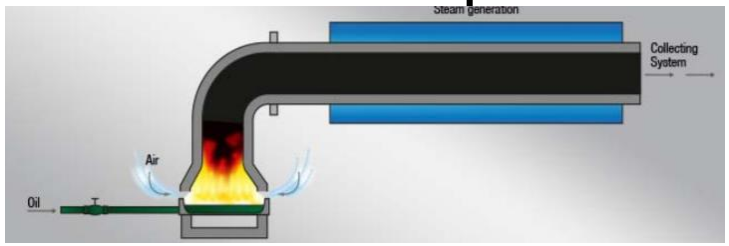
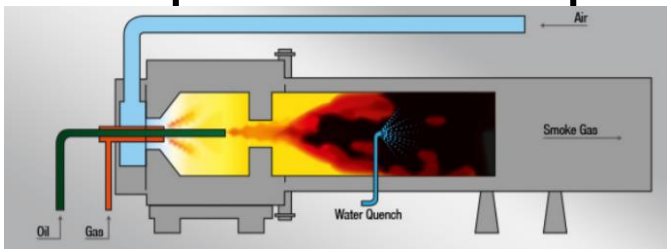
Relevant issue

Productions methods

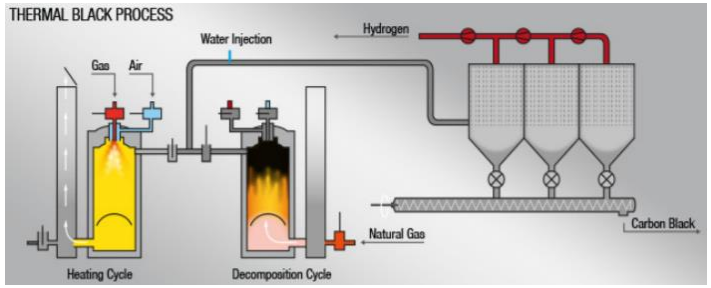
- Furnace black process



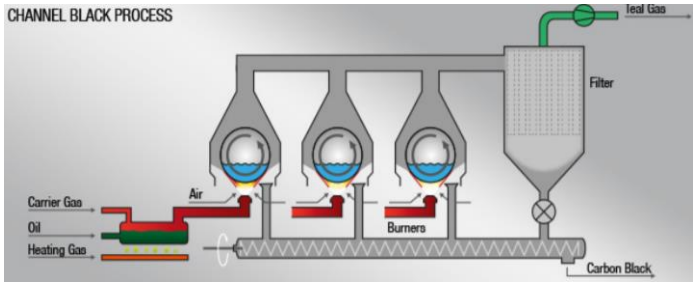
- Lampblack black process



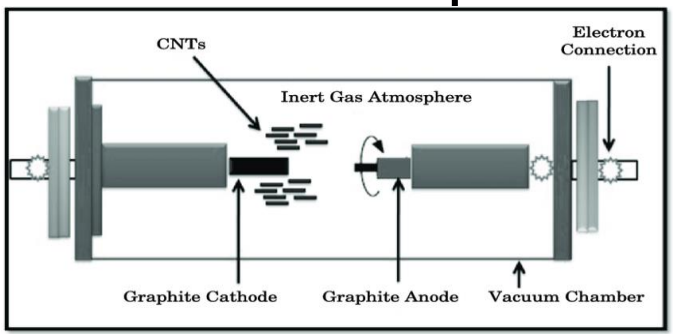
- Thermal black process



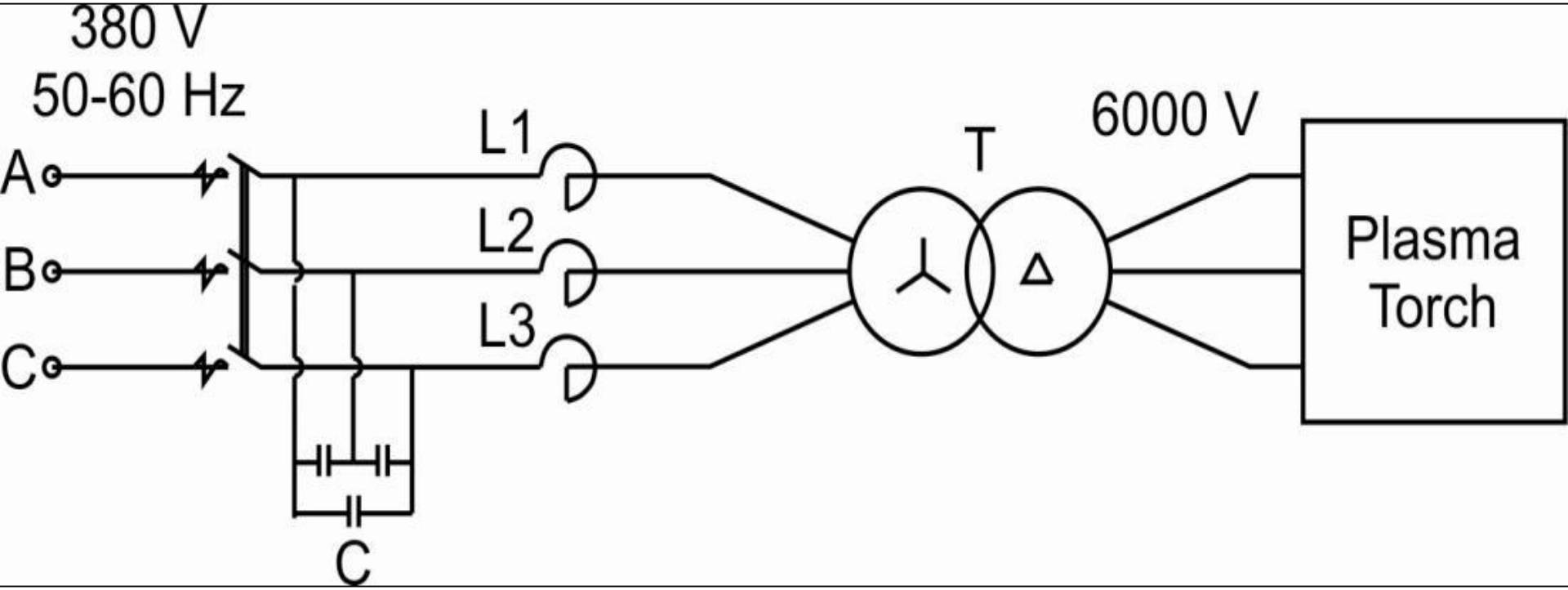
- Channel black process



- Electric arc process



Plasmatron high voltage power supply scheme (6 kW, 50 Hz)



The high-voltage power supply (6 kV, 50 Hz) consists of three current-limiting reactors, a reactive power compensator, a step-up transformer and a system for measuring and recording electrical parameters.

Goal and tasks

Goal:

Producing the finely dispersed Carbon Black using a plasma-chemical reactor based on a three-phase AC plasmatron operating on orthoxylene and argon.

Tasks:

1. Study the electric arc pyrolysis of orthoxylene;
2. Physical and chemical analysis of the resulting Carbon Black .

Mechanism with three-phase AC plasma torch

Producing Carbon Black from hydrocarbons

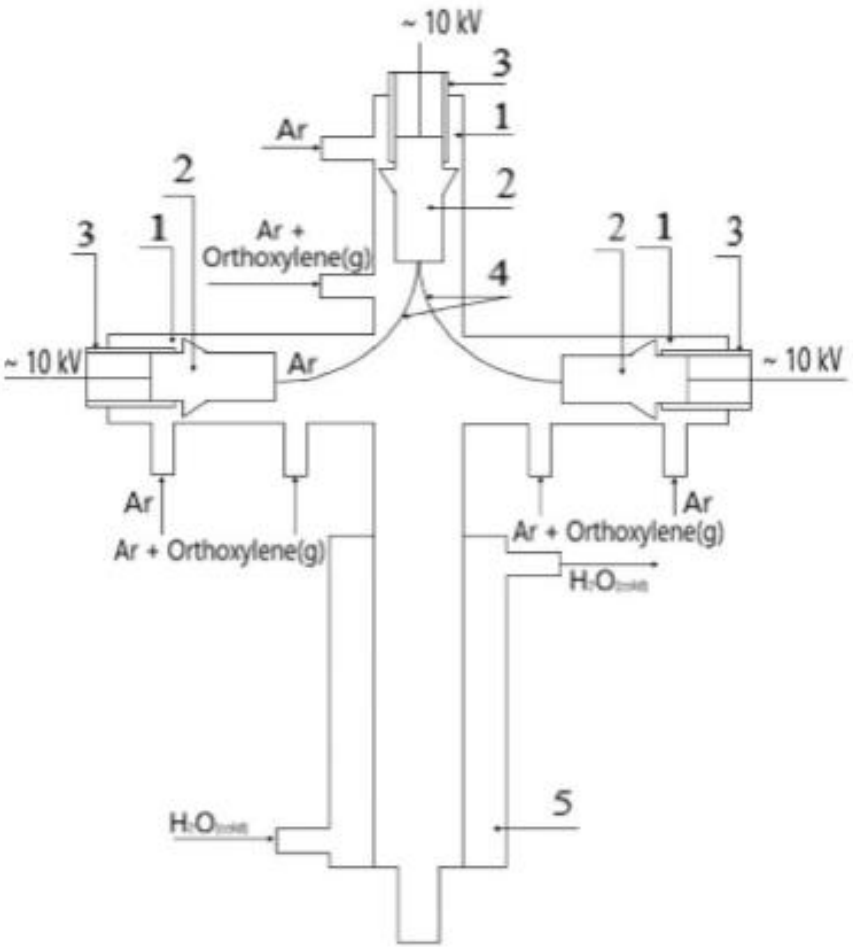
High performance

Using AC, 50 Hz

Limited environmental impact (there is no direct CO_2 emission)

The ability to provide and (adjust) the enthalpy and or temperature by an external energy supply with temperatures

Synthesis description



Electric power 10 kV (thermal efficiency - 95%)

The mass flow rate of argon G_{Ar} = 3 g/s (in a gas discharge chamber) and 0,5 g/s (to the arc burning zone)

The plant worked on technical orthoxelene and argon

The mass flow rate of orthoxelene $G_{orthoxelene}$ – 0,05 g/s
(gas was supplied to the arc zone)

1 - electric arc channel, 2 - electrode, 3 - fluoroplastic insulator, 4 - electric arc paths, 5 - water refrigerator

Adsorption isotherms

To determine the specific surface area and porosity of highly dispersed solids or systems having developed porosity, adsorption isotherms are used.

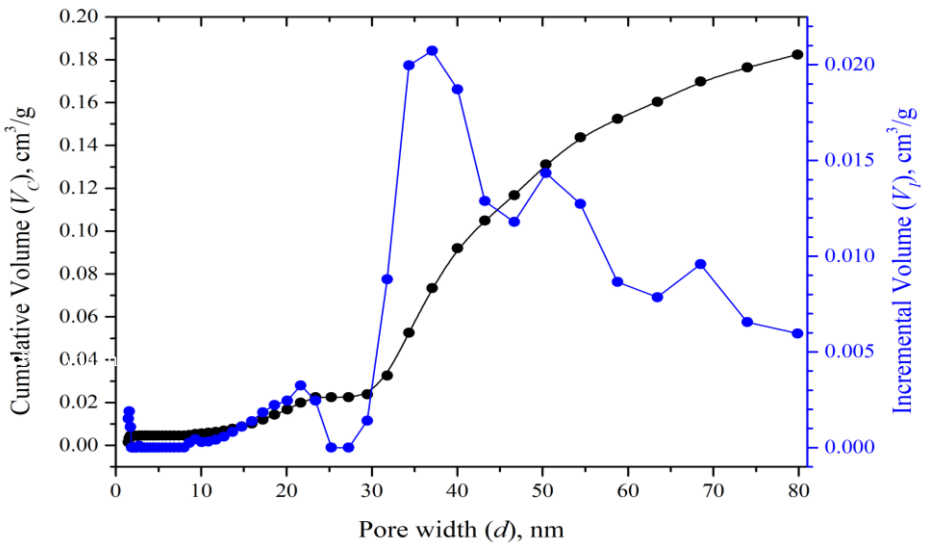


Fig. 1 **-** Pore volume dependence on width

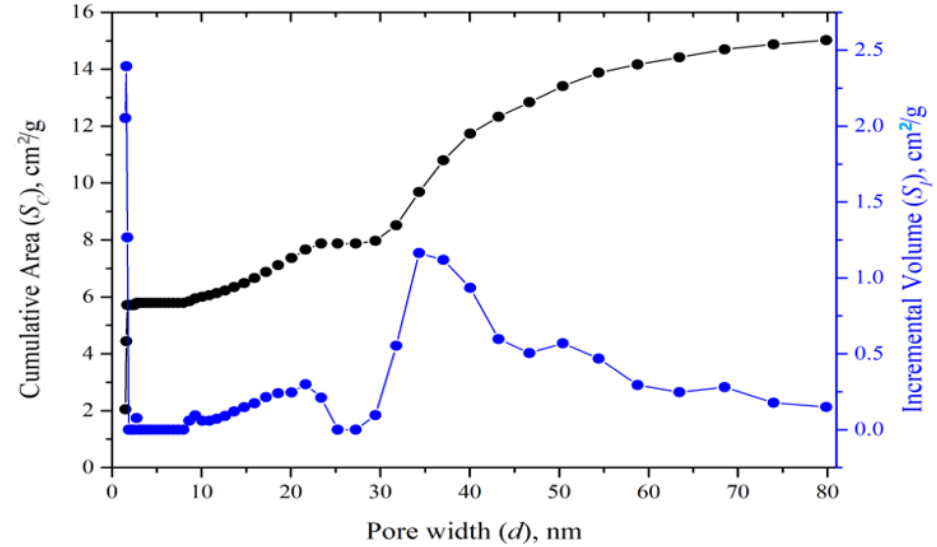


Fig. 2 **-** Pore surface area dependence on width

The total pore volume($P / P_0 = 0.98$) = 0.252624 cm^3/g ;
The average BET pore width– 16.7 nm;
The Density Functional Theory (DFT) method the total volume and total pore area of 0.18284 cm^3/g and 37.760 m^2/g.

Specific surface area :
- to the single-point method: 58.7 m^2/g;
- the BET method : 60.4 m^2/g;

Scanning electron microscopy

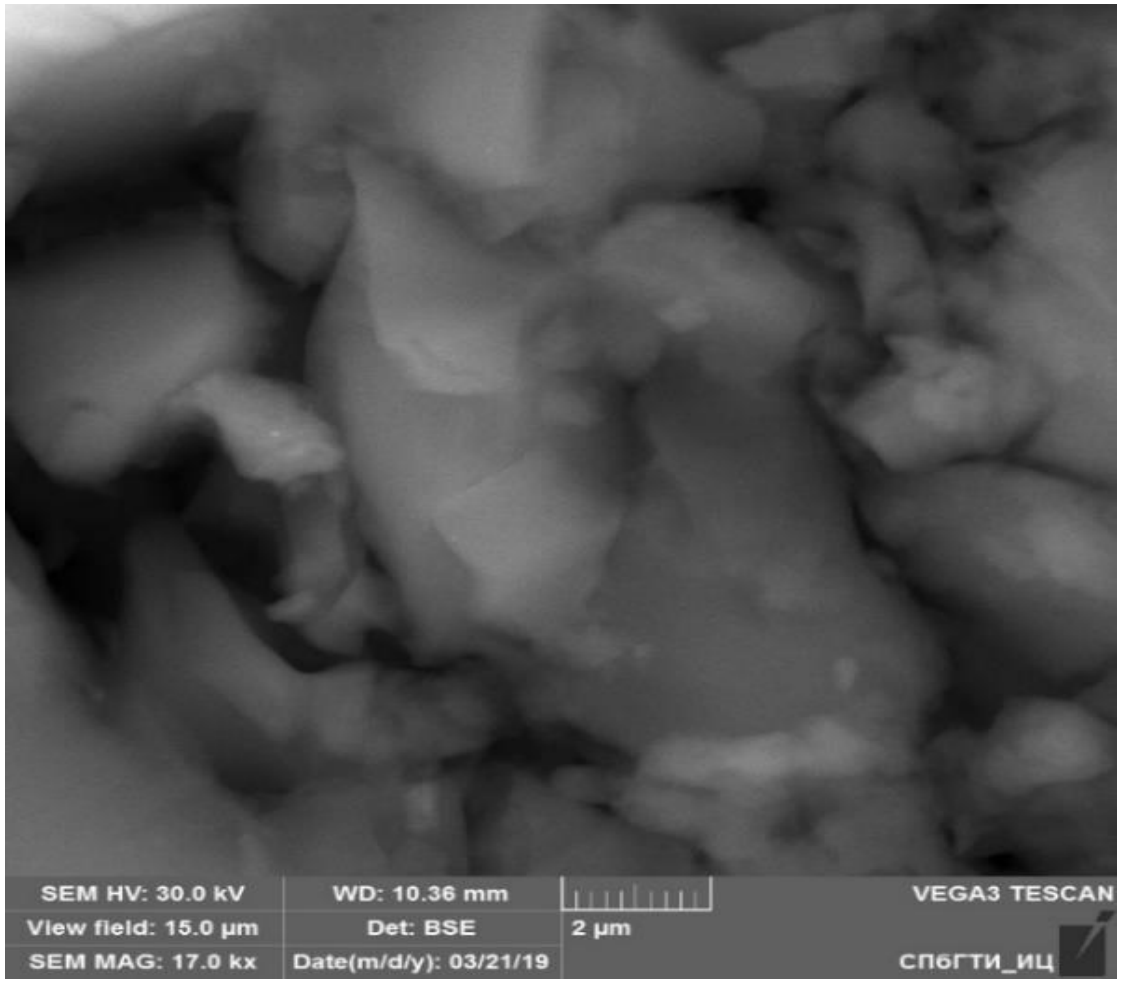


Fig. 3 **-** SEM micrograph of soot

Dynamic light scattering

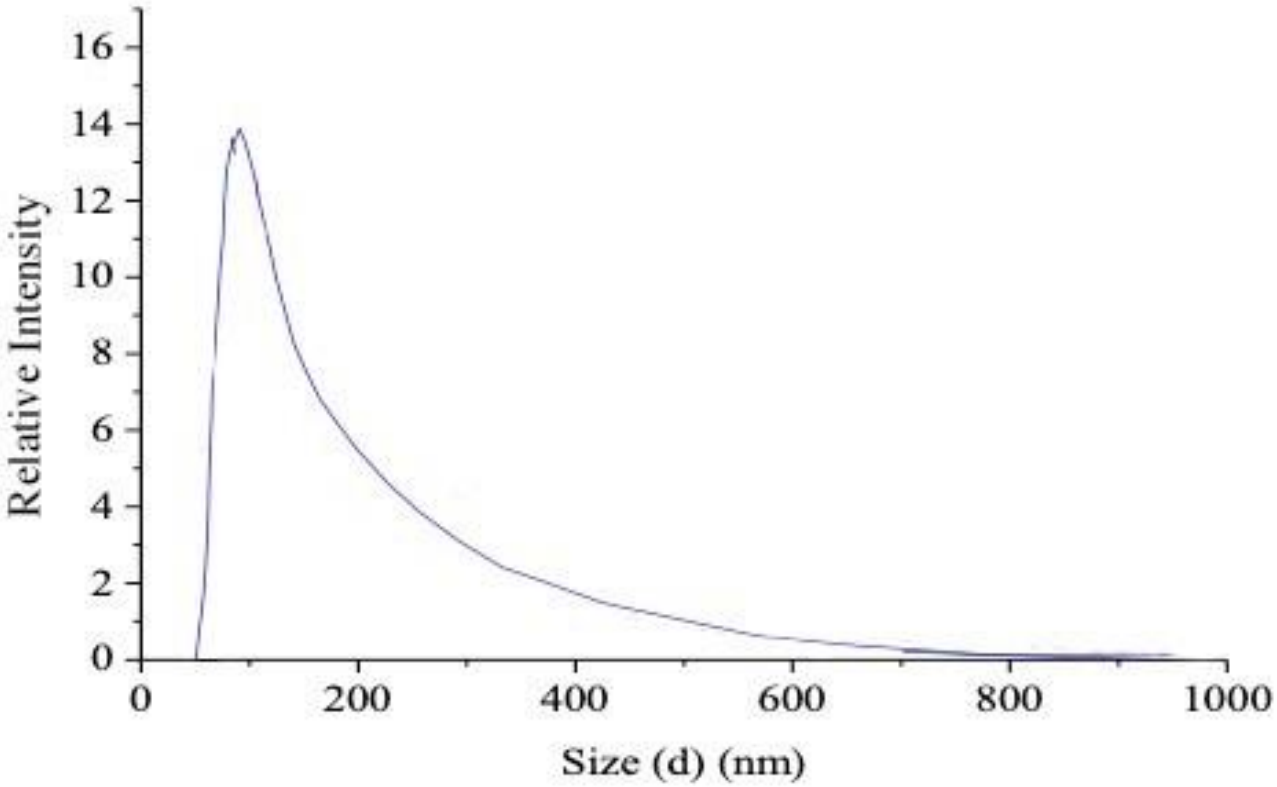


Fig. 4 **-** The diagrams of particle size distribution

Dynamic light scattering

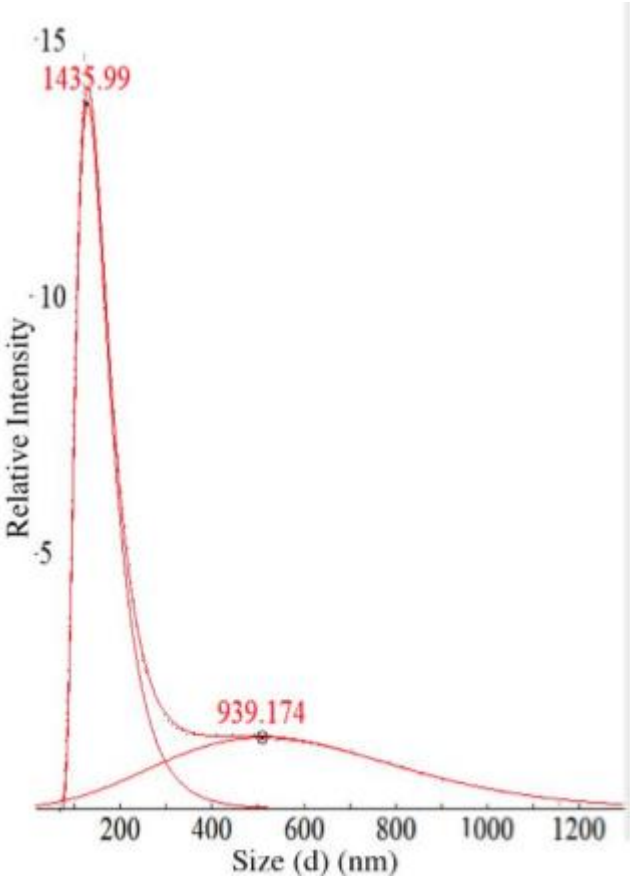


Fig. 5 **-** Approximation of spectrums using the OriginLab program (Lorentz distribution).

The sample contains two fractions are distinguished: with a maximum of about 150 nm and 500 nm.
The largest particles have size about 2 micron;

This is probably due to different mechanisms of formation of these particles. Smaller soot is formed during the pyrolysis of o-xylene, and larger soot is formed during erosion of graphite electrodes.

X-ray diffraction

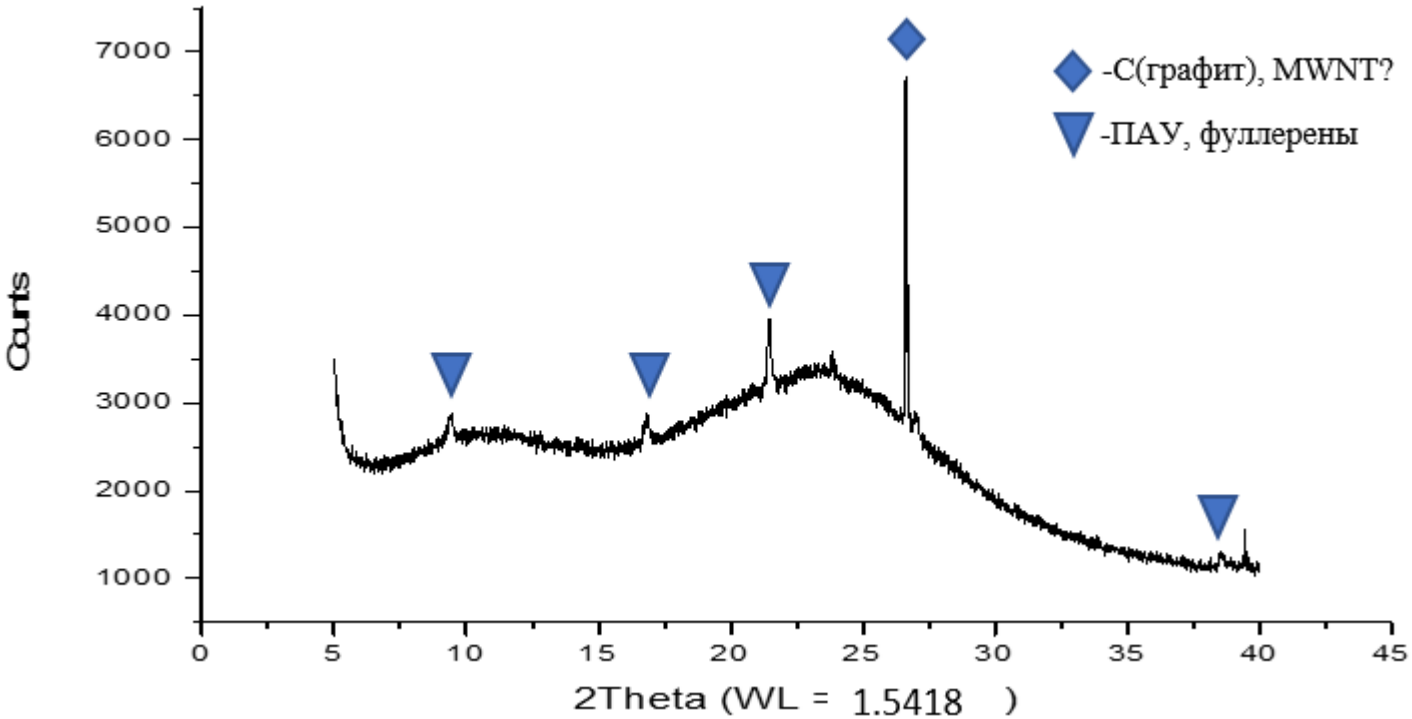


Fig. 6 **-** X-ray diffraction of soot

The diffractogram has peaks of weak intensity appear, poorly identifiable and presumably related to polyaromatic hydrocarbons and, possibly, fullerenes or fulleroid substances. The highly intense peak is attributed to graphite residues.

IR spectra

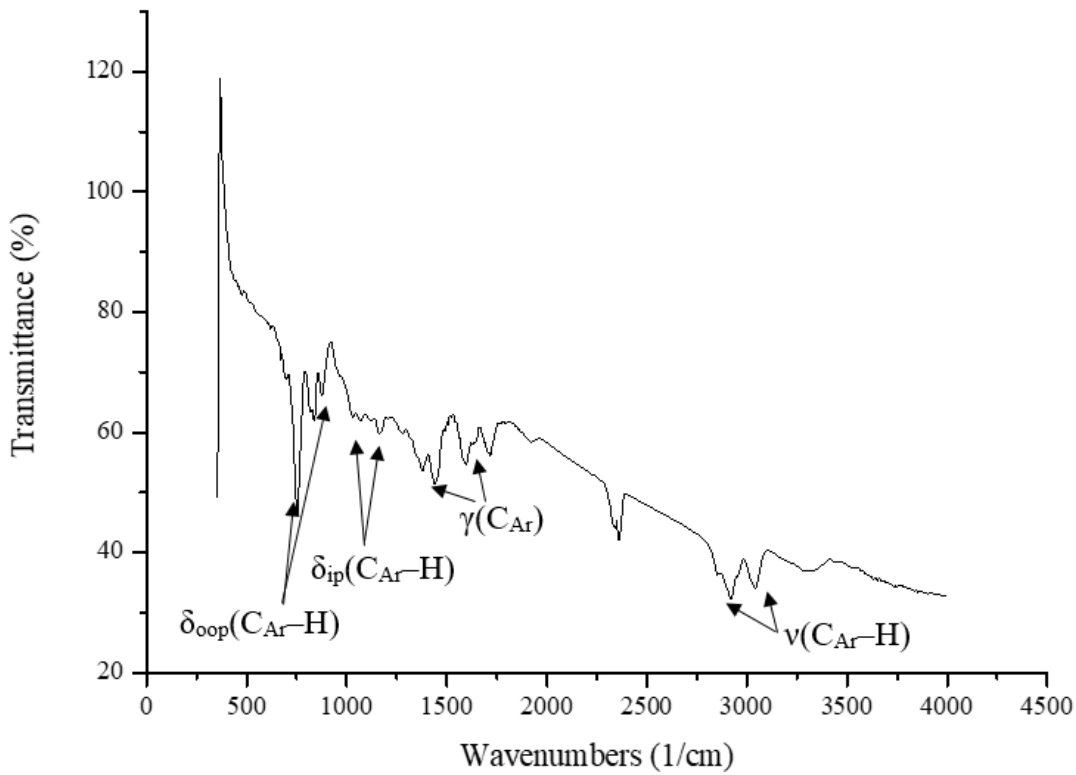


Fig. 7 – IR spectra of soot

C_{Ar} - aromatic ring carbon; ν - stretching, δ - deformation (ip - in-plane, oop - out-of-plane, γ - skeletal vibration, respectively)

CHNS analysis

Table 1. The elemental composition

	1, atom, %	2, atom, %	3, atom, %	Mole fraction, %	% wt
C	82,7	76,1	79	79,2	99,03
H	5,7	5,1	4,5	5,1	0,005
N	0,3	0,4	0,2	0,3	0,004

CHNS analysis showed that the extract does not contain any elements except carbon and hydrogen and adsorbed gases. Based on the average atomic mass fractions of elements (C:H = 1.3:1 ratio), It can be assumed that the presence of aromatic polynuclear hydrocarbons.

Conclusions

1. As a result of plasma pyrolysis of orthoxylene, carbon black sample was obtained
2. The particle size distribution by dynamic light scattering (DLS) has rather narrow distribution with two maxima at 150 and 500 nm The largest particles reach almost 2 mcm.
3. X-ray diffractometry showed the presence of graphite and amorphous carbon and probably polyaromatic compounds.
4. Based on the average atomic mass fractions of elements (C:H = 1.3:1 ratio), It can be assumed that the presence of aromatic polynuclear hydrocarbons.

Thank you for attention!