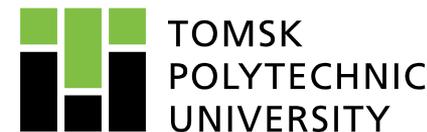




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Polyhedral graphite particles ambient air direct current arc plasma synthesis

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Tomsk, 2020

Tomsk Polytechnic University

TPU was established in 1896 year by the Emperor Nicolay The Second



TPU number 301-305 in the World
TPU number 3 in the Eurasia

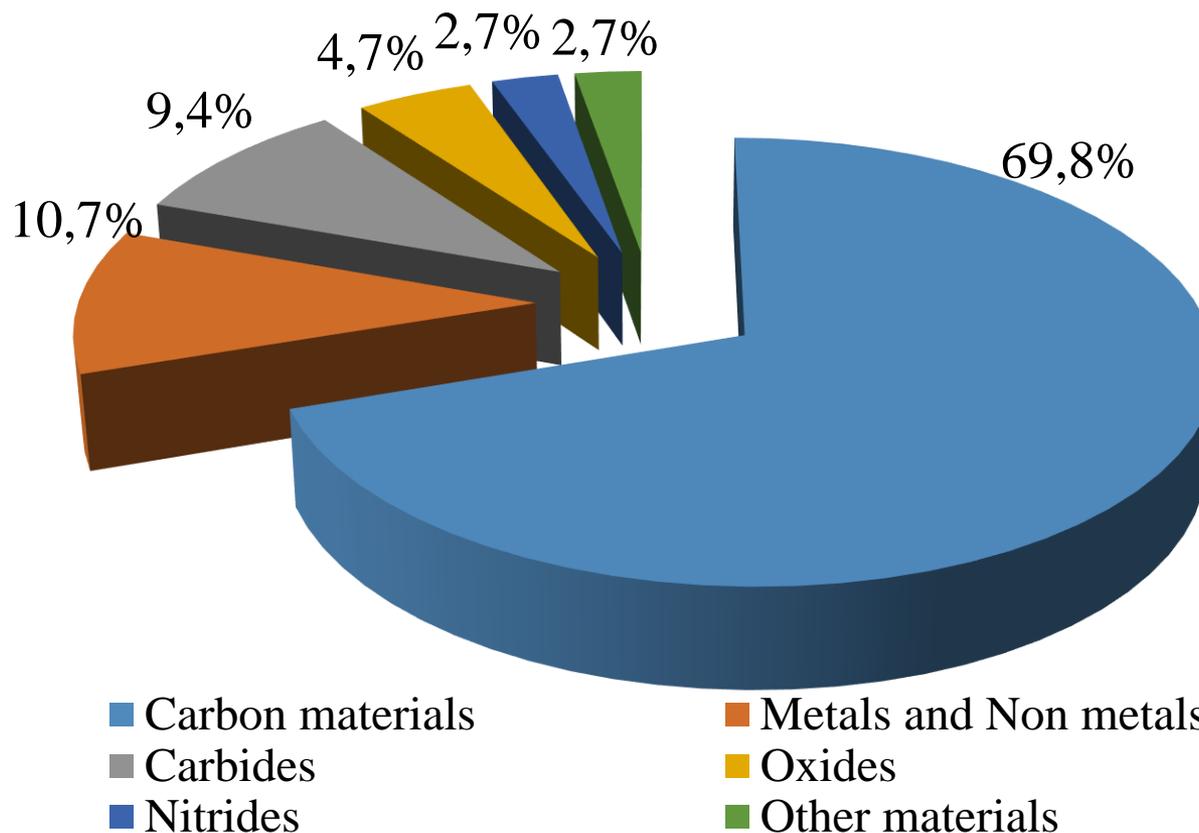


TPU number 373 in the World
TPU number 10 in BRICS



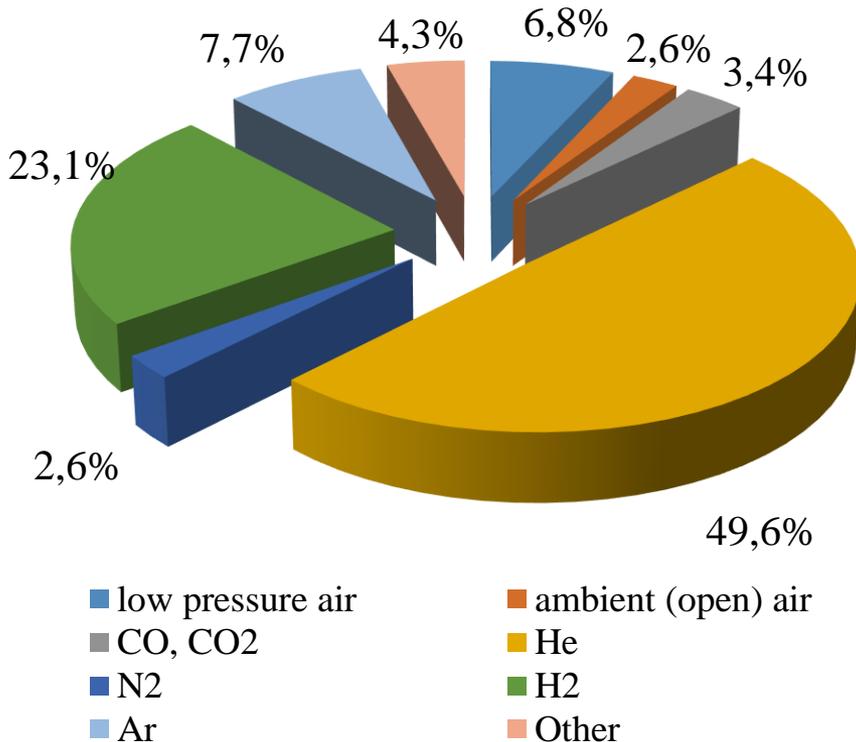
Arc discharge method

Arc discharge method according to the literature data is used for different micro and nanomaterials synthesis. Most of them are carbon nanomaterials.

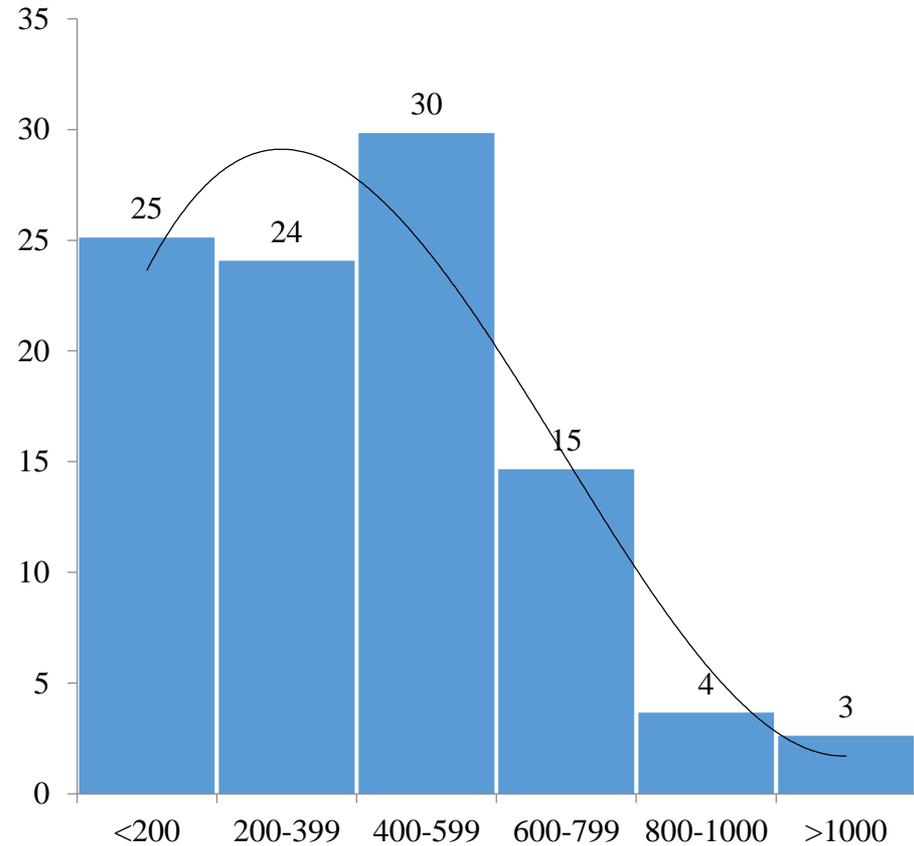


Experimental parameters: review

Nitrogen, argon, helium and other gases are used as a working gas medium; at the same time, less than 3% of experimental works implement the synthesis of the desired materials in air at normal pressure.



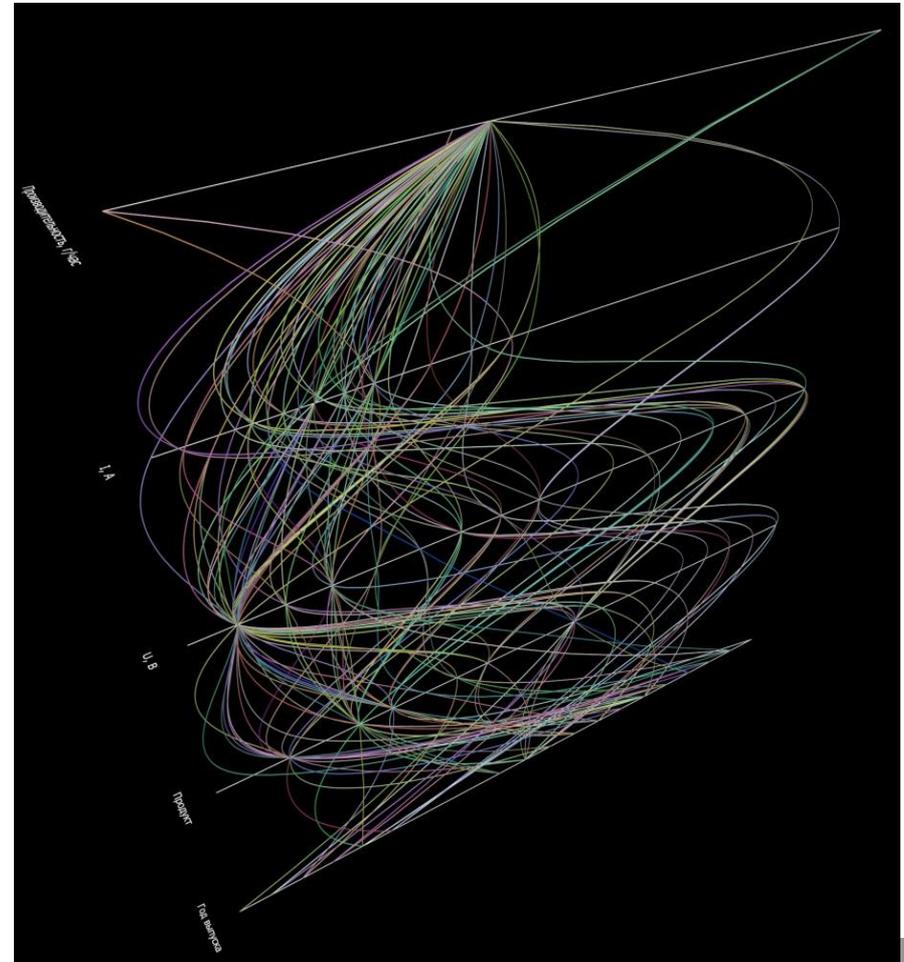
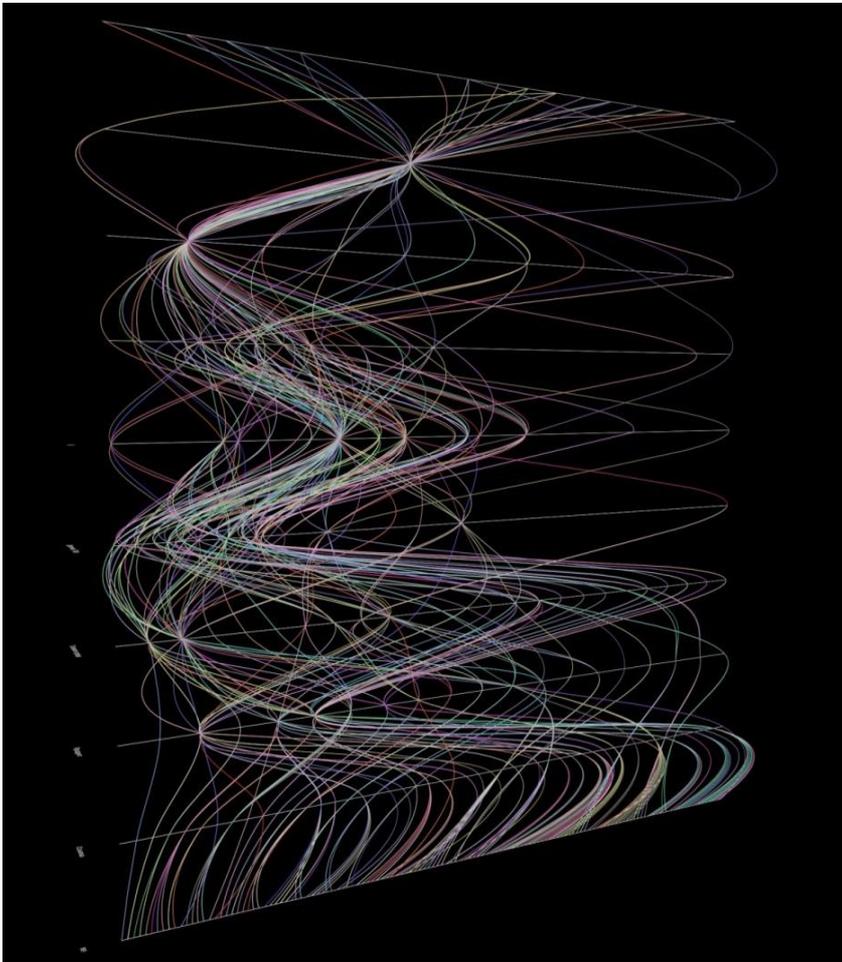
Gas atmosphere content



Gas pressure parameters

The Arc discharge method (literature analysis)

For carbon materials synthesis 3D multidimension data modeling is used. Names of materials, parameters of the synthesis process (current, voltage, gas pressure, gas type), dates (years) are visualised (about 150 papers).





Relevance:



- Polyhedral graphite nanoparticles (PGPs) have the potential for application as an electron field emitter and as a material for electrical energy supercapacitors because of their unique morphology.

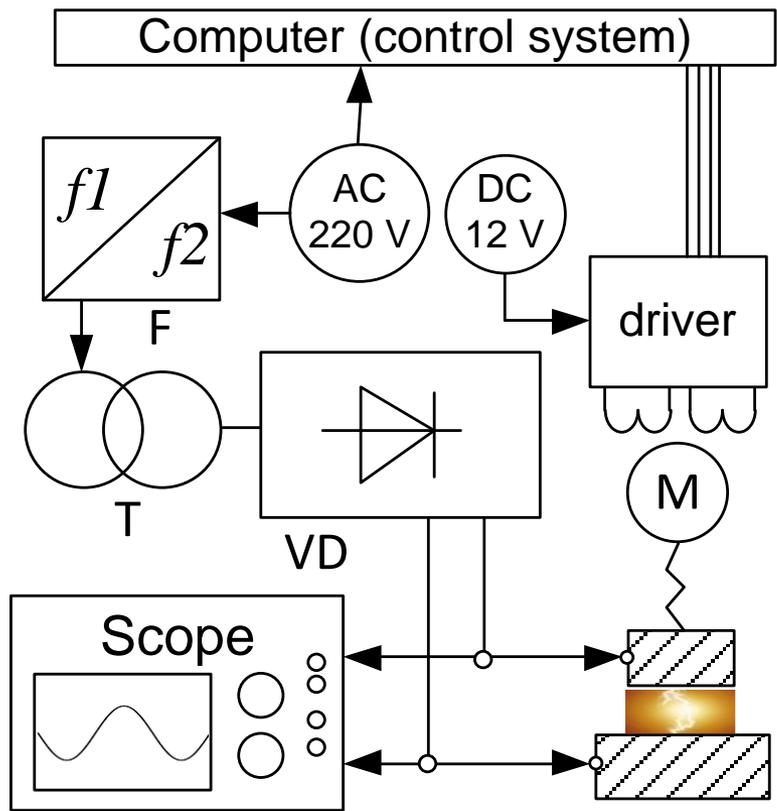


- Molybdenum carbides are known materials suitable for creating catalysts for the generation of hydrogen from water.

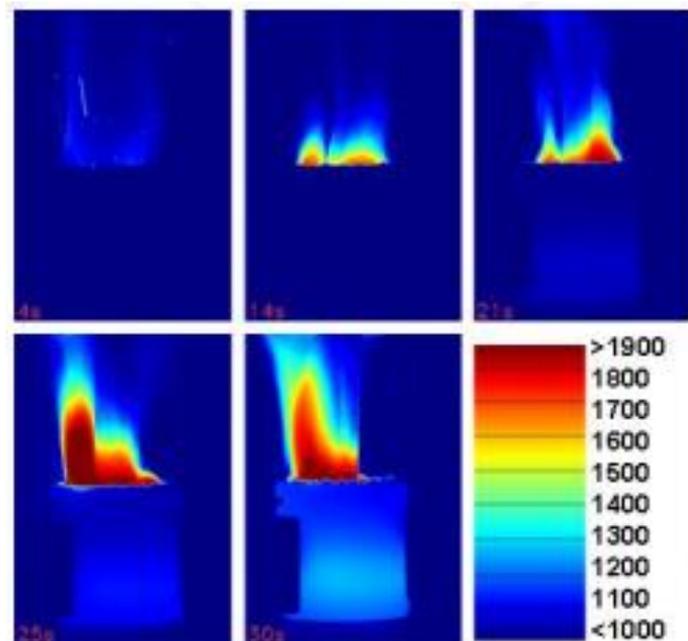


- PDPs synthesis using self-shielding ambient air direct current arc plasma and molybdenum catalyst. This approach is very promising due to the potential energy and cost efficiency and simplicity.

Experiment

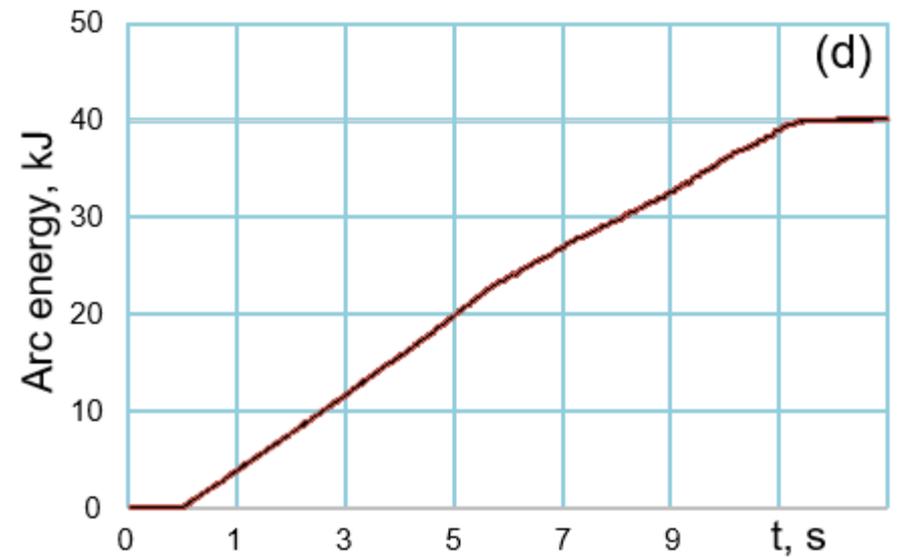
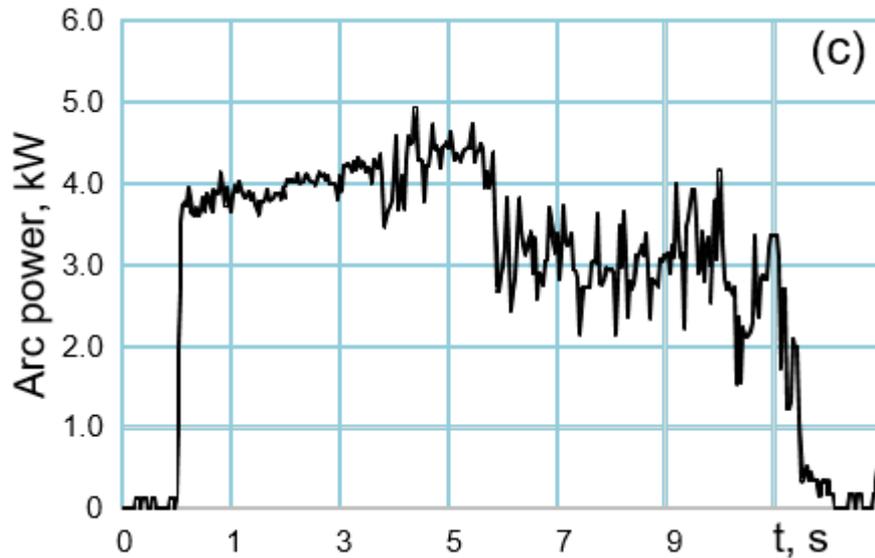
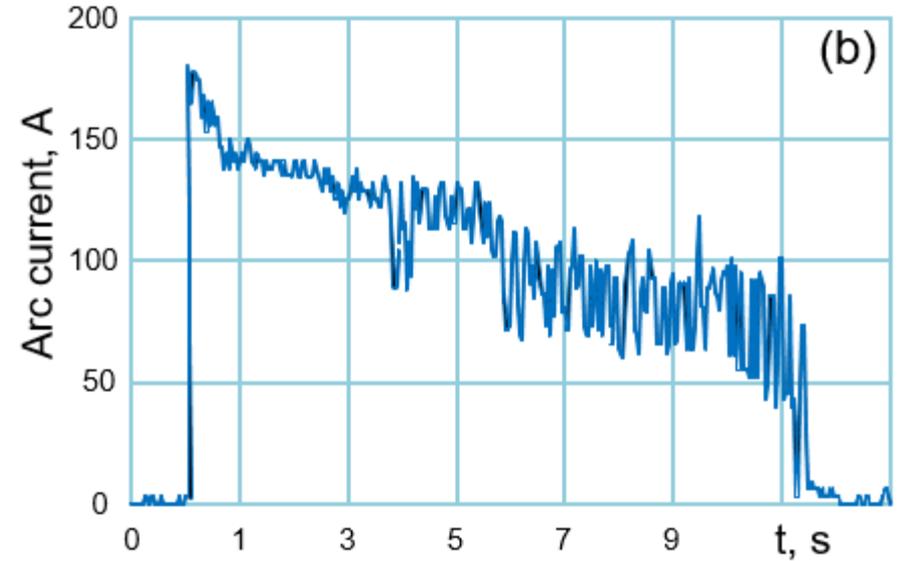
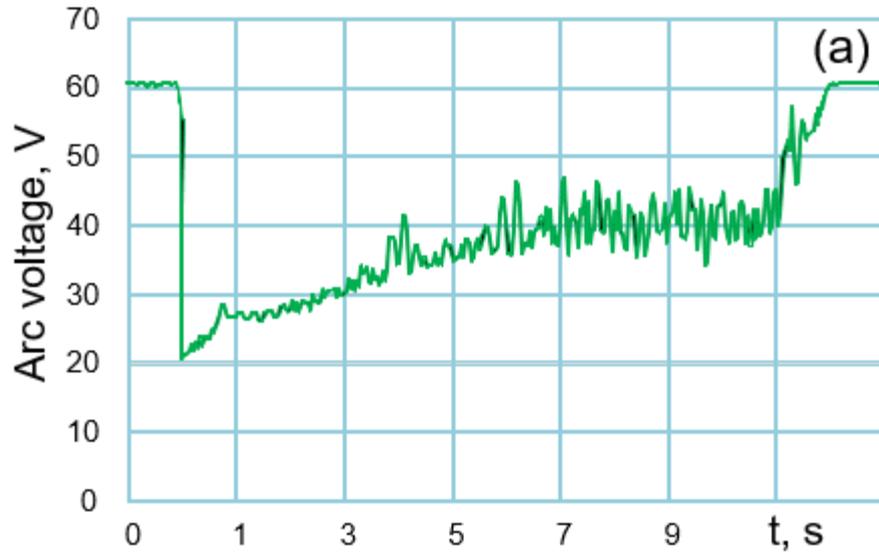


Simplified installation diagram



Operating mode thermogram

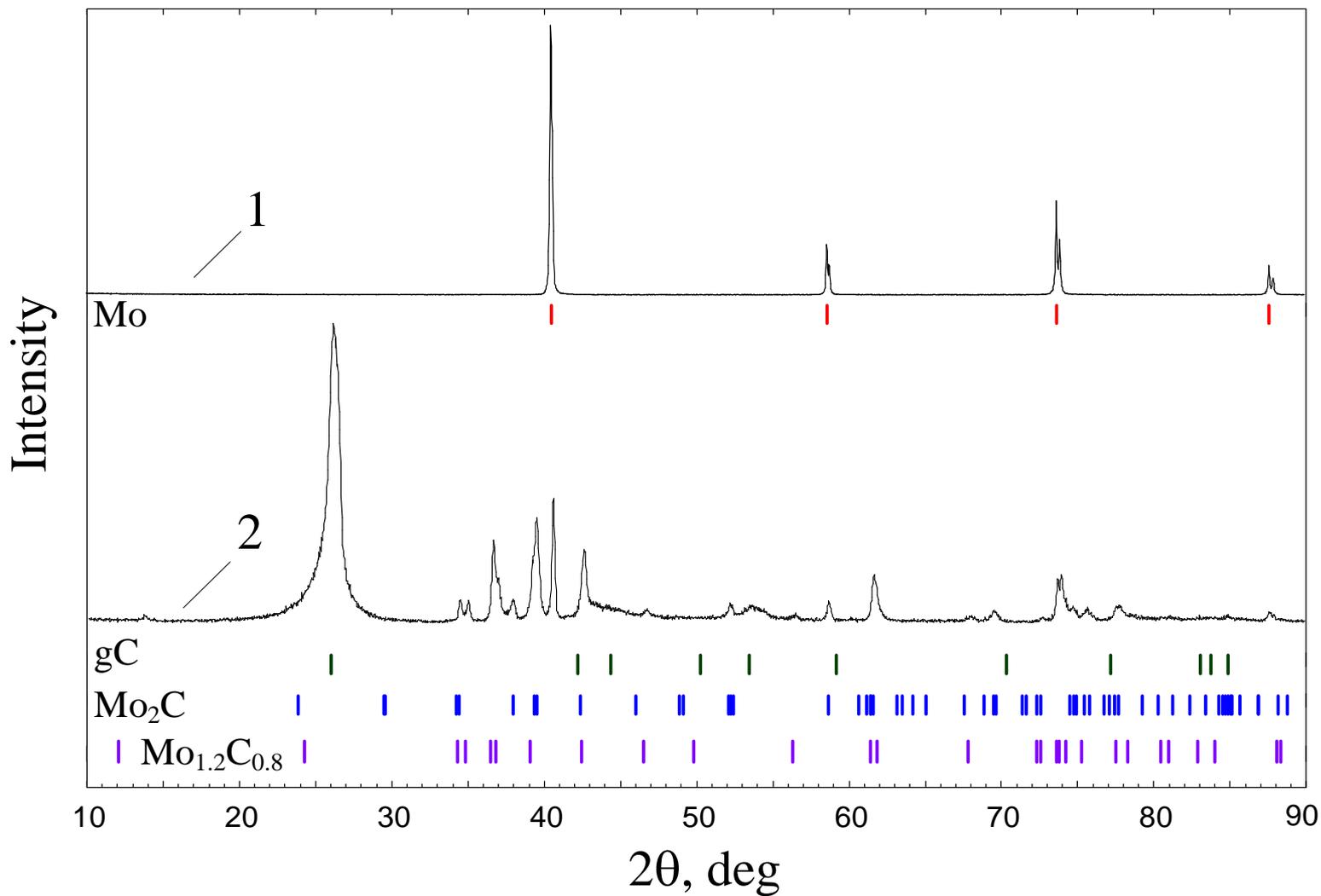
- | | |
|----------------------------|----------------------------|
| 1. AC source | 6. Constant current source |
| 2. Frequency converter | 7. Electric drive |
| 3. A step-down transformer | 8. Stepper motor |
| 4. Oscilloscope | 9. Graphite electrodes |
| 5. Rectifier | |





Typical XRD results

Typical X-ray diffraction pattern of the synthesis product ($\lambda = 1.54060 \text{ \AA}$)

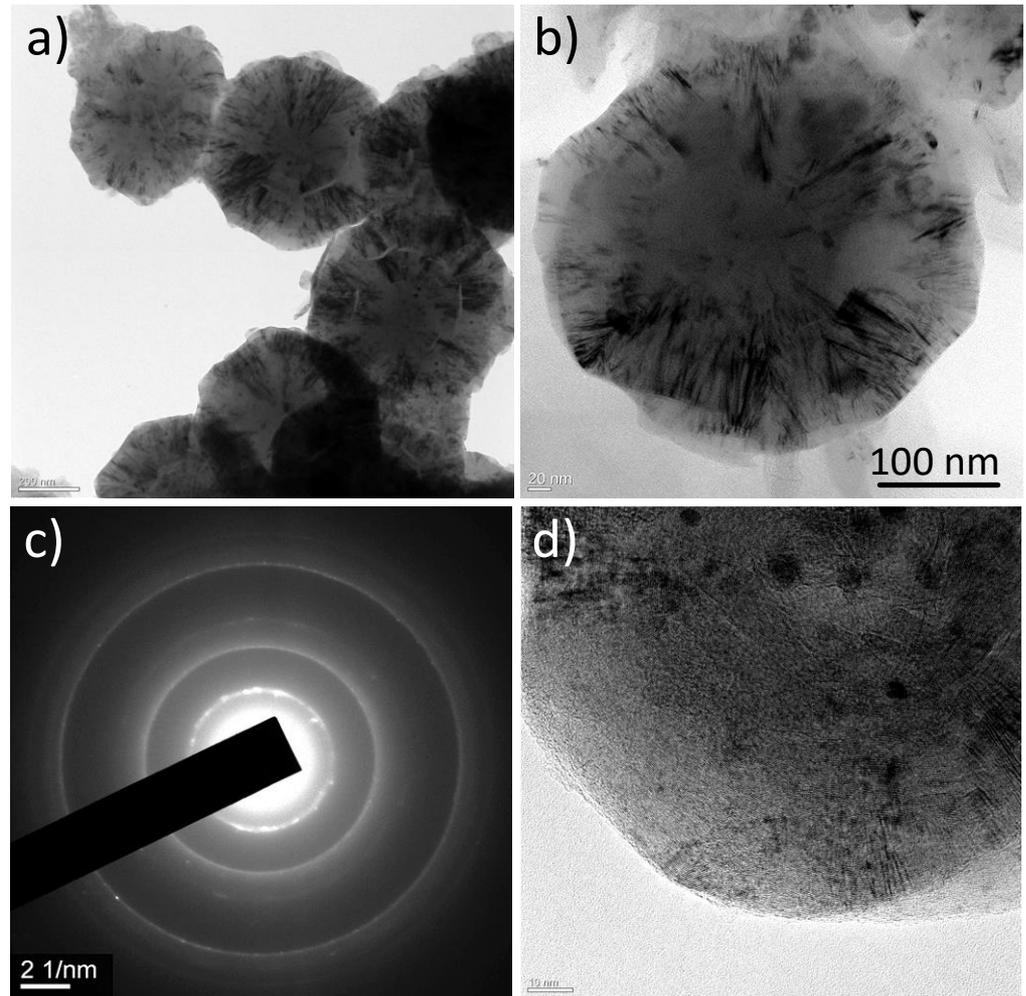




Typical TEM results

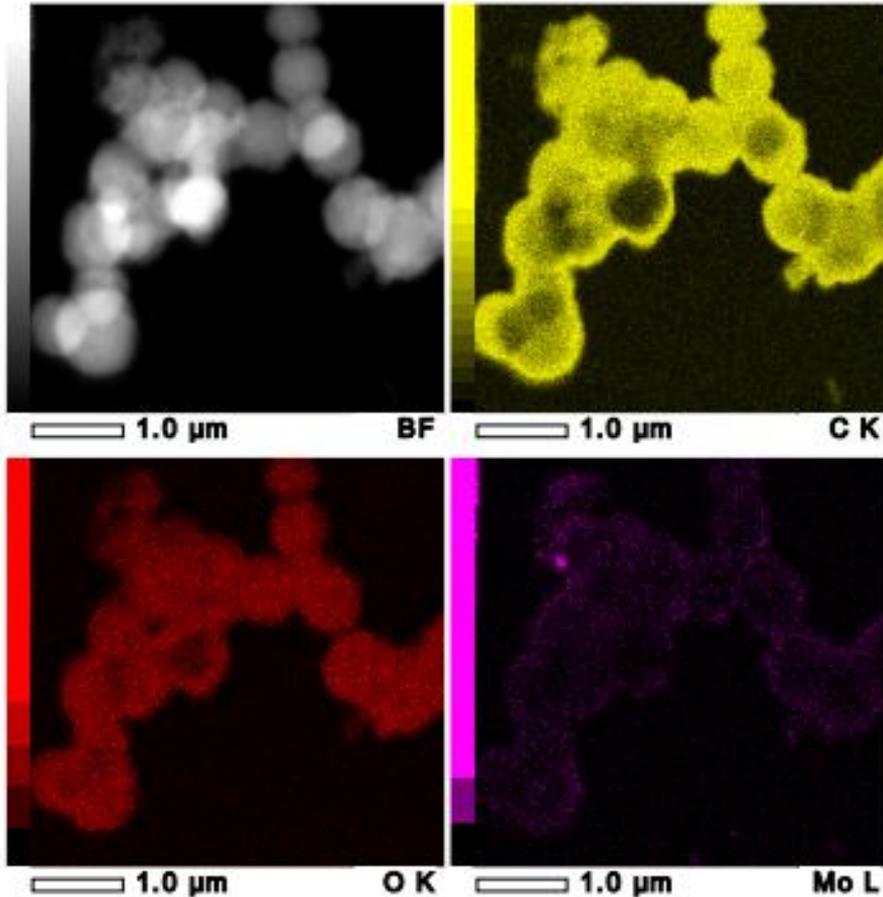
Transmission electron microscopy of the obtained powder product:

- a) HRTEM image of the PGP;
- b) selected area electron diffraction pattern,
- c) electron diffraction pattern,
- d) direct resolution image

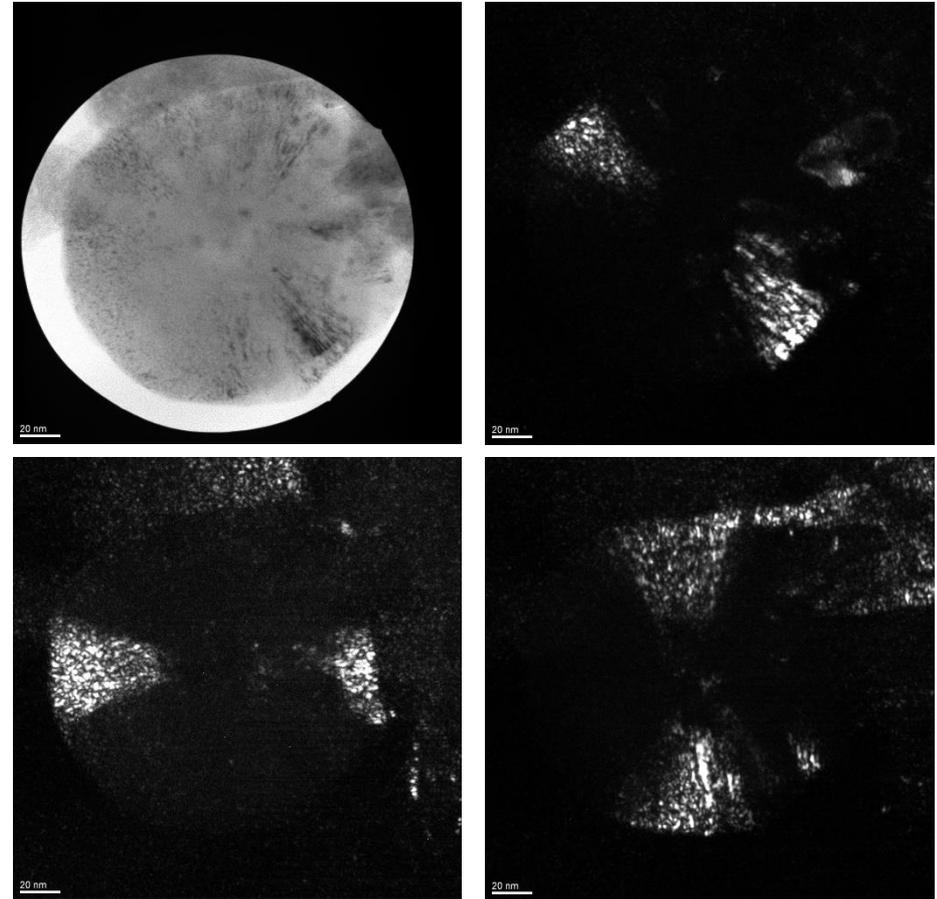


Chemical composition results

Dark-field STEM images



Dark-field TEM images



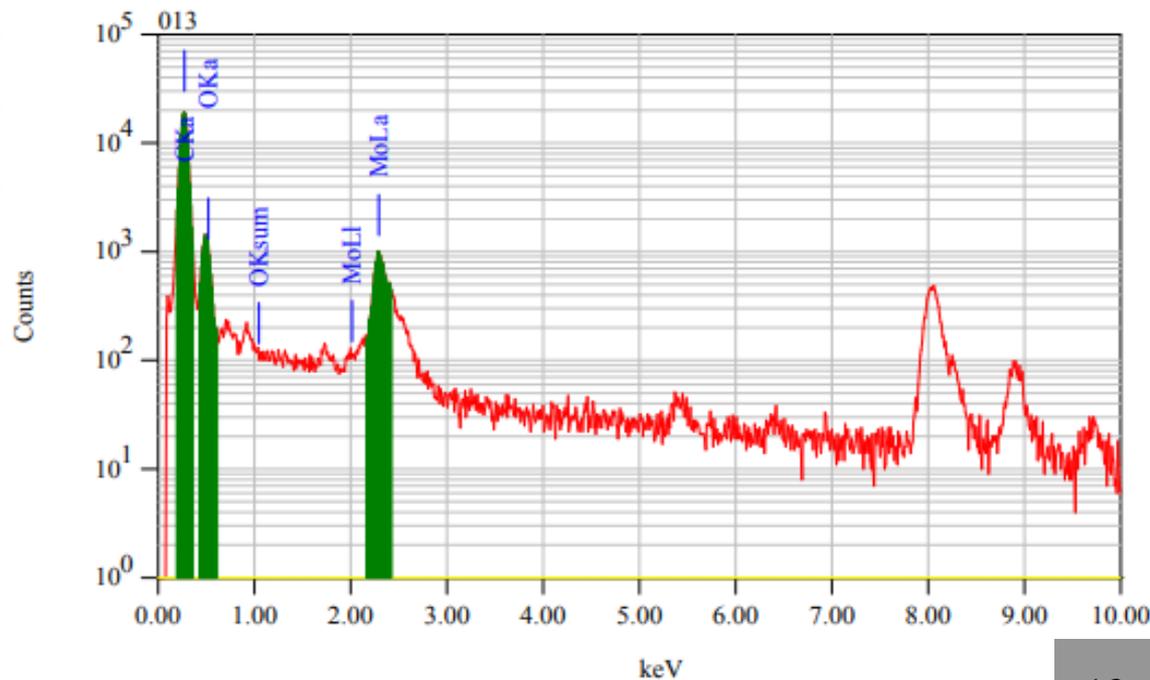
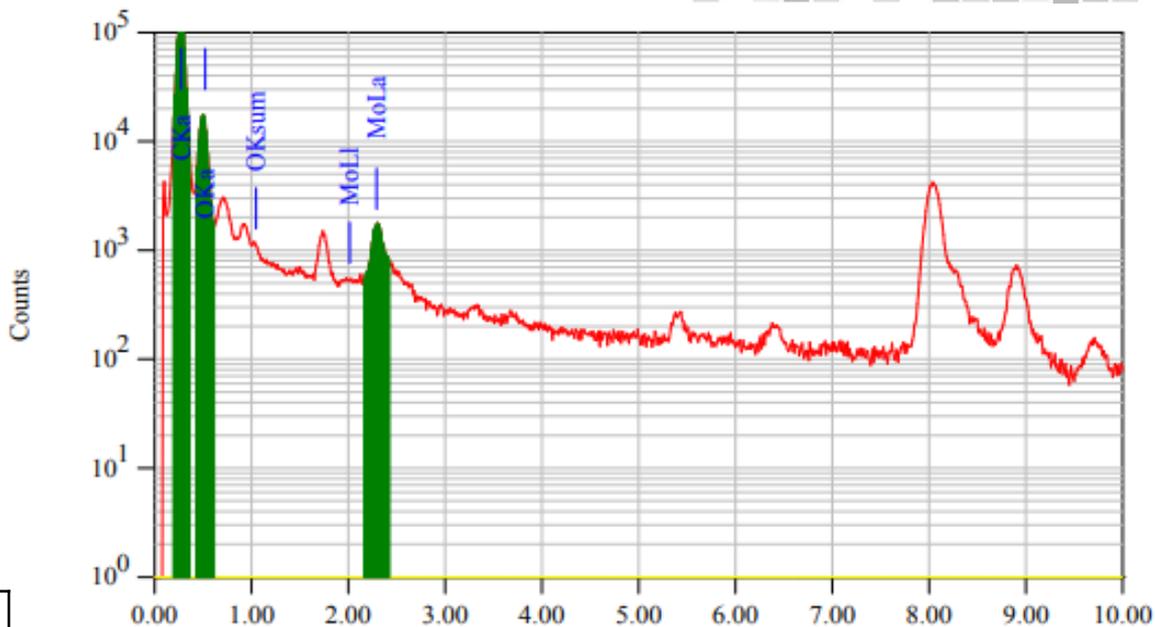


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Energy dispersive spectrum →

Averaged data of Quantitative Analysis:

Element	Energy, keV	Mass, %
C	0.277	97.09
O	0.525	1.33
Mo	2.293	1.58





Conclusion

1. The obtaining submicron particles of polyhedral graphite is possible in atmospheric electric arc plasma in the presence of molybdenum.
2. The resulting particles are characterized by sizes of the order of 100-500 nm and a typical morphology for the phase of polyhedral graphite. The crystal structure of the particles corresponds to a typical graphite structure.
3. The developed electric arc method allows the synthesis of these particles of polyhedral graphite without the use of vacuum or gas equipment, because it is realized in open air due to the effect of shielding of the reaction volume with carbon monoxide and carbon dioxide gases, the emission of which occurs during the combustion of an arc discharge.

This work was supported by the Russia President's grant for young scientists (MK-633.2019.8). The work was performed using the equipment of the Nanocenter of Tomsk Polytechnic University.



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Thanks for your attention!

