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New Technologies For Processing Coal Using Universal Module Industrial Disintegrators/Activators

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ABSTRACT:*The operating principle of the patented by authors device model named "Universal Module Industrial Disintegrators/Activators" (UMID/A), which is a high-performance mill and activator of physical and chemical processes, is considered. A number of UMID/A uses at the enterprises of coal industry to get new nanocomposite materials from coal was analyzed: boiler furnace fuel; diesel fuel; lubricating preparations; preparation of the cheap nano-cements, durable and resistant to sea water, made from wastes of mining and metallurgy. Modification of coal for the purpose of obtaining cheap carbon nanotubes was given special attention.*

KEYWORDS:*Universal Module Industrial Disintegrators/Activators (UMID/A), high-performance mill, activator of chemical and physical processes, turbulent ferromagnetic layer, nanocomposite materials, boiler furnace fuel, diesel fuel, lubricating preparations, alkaline nano-cements, cheap carbon nanotubes.*

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I. INTRODUCTION.UNIVERSAL MODULE INDUSTRIAL DISINTEGRATORS/ACTIVATORS

Device model "Universal Module Industrial Disintegrators/Activators (UMID/A), patented by the authors [1], refers to the area of chopping and mixing of bulk/liquid mediums and can be used in continuous industrial technologies such as:

- high-performance mill giving grinding of materials to nano-sized, regardless of their strength;
- mixer;
- activator of chemical and physical processes.

This allows us to apply UMID/A in various fields of industrial production, for example, in the production of new types of construction and structural composite materials, paints, perfumes composites, various suspensions, as well as in the production of nano-powders, and as the main link for environmental technological chains.

Description of UMID/A and some results of the application of this apparatus in the food industry was shows in the article [2].

UMID/A is an induction device with turbulent ferromagnetic layer in the working area, located at the center of the stainless steel pipes. Impact on processed material occurs when passing it through the ferromagnetic layer. UMID/A versatility and high performance are due to the following factors:

- many processes in its working area, and their activity:
  a) crushing with the help of «constrained blow»;
  b) electromagnetic erosion;
  c) plasma effect;
  d) ultrasound (when handling in liquid medium);
- high energy density of magnetic induction in a working area (when magnetic induction is B ~ 10^4TOS, specific energy density is W ~ 0.4 J/cm^3 = 4 10^5 J/m^3), hundreds of times higher than the energy density in the work areas of other similar devices;
- close to 100% efficiency;

- lowmaterials consumption.

The task of the proposed utility UMID/A model is:
1) avoid the disadvantages of selected authors device from prototypes;
2) many times increase the efficiency of processes occurring in the working area of the UMID/A, by consistent articulation of modules in a single chain, repeatedly thereby increasing the length of the working area;
3) a significant increase in energy density of the magnetic field in the working areas of the UMID/A sequence;
4) improving grinding efficiency of various materials;
5) improving the efficiency of mixing and activation of composites of various materials in a variety of mediums;
6) reduction of specific consumption of materials;
7) improving the conditions of assembling, operational maintenance and repair of the device during operation;
8) enhancing the overall economic efficiency of the totality of disintegrators/activators.

The proposed model UMID/A, compared to its previous versions, have a more efficient mixing and grinding of various mediums. This is achieved by increasing the energy density of the magnetic field in the working area of the UMID/A by increasing of attitudes of the length of the working area to its diameter, and thereby by significant reduction of provincial ambient of magnetic induction flow of magnetic field. We received the value of magnetic induction in work areas up to ~ 10^4Gs, which corresponds to the ~ 4 10^5J/m^3 energy density in an active zone.

The effectiveness of the proposed devices is due to the fact that effect of high magnetic induction with frequency of ~ 1 kHz leads to a significant weakening of the forces of interaction in solid crystalline material, for example, in rocks on the cleaved, and, therefore, to better of their dispersing, as well as to physical-chemical activation of the particles obtained in this case. The material used for the actuating elements was selected as magnetic hard alloy with large coercive force to increase the energy density in the working area.

UMID/A design features much easier carrying out of its maintenance and the current repairs compared to other devices.

One of the technical results of UMID/A is that the magnitude of the electromagnetic induction and its frequency response lead to a preliminary decrease in the strength of the material being processed, which contributes to an increase in the efficiency of the processes of dispersing solid crystalline materials, reducing the energy costs of the process and the specific wear and tear of the equipment. The grinding of solid materials in the working area of the module is due to a "constrained blow", as a result of which the grains of the powders obtained have very sharp edges, which increases both their physical and chemical activity. This allows us to get a lot of activity of the "binder" materials, obtained by shutting them with solutions of alkali or soda, and a higher activity when using them in powder chemistry.This same characteristic also contributes to the activation of the process of obtaining suspensions from these powders. The module can be effectively used to produce emulsions of practically immiscible liquids, due to the powerful turbulent movement of the mixture of liquids in the working area.

The processes of grinding materials in the working area of the module are superficial, and therefore these processes become more active, the higher the specific area of the initial product.There is no "caking" of powders in UMID/A under the conditions of the ongoing processing of the material, so the efficiency of the process does not decrease, but on the contrary increases with increasing fineness of the powders. Since there are no bearings or rubbing structural elements in the working area of the module, in principle, the device cannot jam and stop the equipment.The equipment is low-noise, with a low material-intensity compared to other similar equipment of this purpose.Only the walls of the sleeve restricting the working areas and the elements of the working substance that are easily replaced during the current maintenance of the equipment are exposed to wear.The durability of the sleeve of the working zone made of stainless alloy is ~ 1000 hours.

II. POSSIBLE APPLICATION OF UMID/A AT COAL INDUSTRY ENTERPRISES

Based on technological capabilities, UMID/A with high efficiency can be applied in all sectors of coal mining firms. So, for example, in the mining sector of such firms, the UMID/A can be used:

- as a high-efficiency mill, which allows to obtain finely divided powders (up to nano-sizes) of mined coal and minerals (UMID/A as a mill 180 times more effective than a ball mill per unit of work volume);
- as a high-performance mixer and activator, allowing to obtain from the above-mentioned powders various high-quality homogeneous suspensions.

Since the UMID/A blocks are optimized modules, their geometric parameters cannot be arbitrarily changed, i.e. it is impossible to increase, for example, the productivity of the machine, to change the cross-section of the pipe of its working area, because this will lead to a sharp decrease in its economic indicators. The fact is that the price of obtaining a high value of the strength of the magnetic field in a large diameter pipe is very high. When production is necessary to achieve this goal, it is necessary to put as many UMID/A blocks in the form of parallel chains in the technological process, how many times it is necessary to increase the final output of the finished product of one chain in this technology.

To increase the efficiency and intensification of any technological process with the use of UMID/A, it is necessary to set the necessary number of modules in each technological chain in sequence, which, in fact, is equivalent to the corresponding increase in the total length of the active working zone of such a chain. Thus, the total machine in any technological process using the UMID/A modules is a series of parallel technological chains, each of which consists of separate sequentially connected UMID/A blocks.

The method of obtaining new nanocomposite materials using UMID/A is know-how and is based on the authors' work on super-exchange quantum forces in condensed media and the water droplet potential [3-9].

1. Preparation of boiler/furnace fuel from coal

If the coal ground on ordinary mills to 50-100 microns is ground in water to a fine state in UMID/A plants, the resulting high-quality, homogeneous and poorly settling suspension that can effectively be used as a furnace or boiler fuel for urban thermal power plants. Such fuel is freely pumped from producer to consumer through pipes.

2. Preparation of diesel fuel from coal

If, when stitching in the UMID/A pre-ground coal by conventional mills, use diesel fuel instead of water, then we get a diesel fuel for powerful diesels of small power plants or powerful barker/quarry diesels (quarry dump trucks, tractors, excavators, and also cargo ships and port tugs). Such diesel fuel is a fine-dispersed suspension of fine-dispersed coal in diesel fuel with a mass content of suspension particles up to 30-50%. Preparation of such diesel fuel can be carried out in advance at special enterprises. However, the restoration of homogeneity of such fuel and its additional activation should be carried out immediately before it is injected into the working cylinders of diesel engines. A specially designed UMID/A model for each such particular diesel can be powered by a three-phase generator of the same diesel engine.

3. Preparation of lubricants from coal

Preparation of a suspension of diesel fuel and coal, very finely ground in the UMID/A, gives a lubricating oil such as nigrol (gearbox oil), which is suitable for lubrication of friction parts of diesel machines.

All these three above mentioned technologies will allow:
- to reduce costs (by tens of percent) of firm for purchase of diesel fuel and lubricants for the powerful career dump trucks and powerful ship diesels;
- increase the power and efficiency of these diesels;
- facilitate their maintenance.

These technologies for the production of liquid fuels and lubricants from coal can already be attributed to the use of UMID/A machines in the energy sector.

4. Preparation of strong and resistant in sea water alkaline cements from the waste of mining and metallurgical sectors of the company

It is known that all mining enterprises give a lot of waste dumps. We have developed the basis of technologies for the production of alkaline cements (AC) from metallurgical slag, volcanic or rocks without additional annealing, but with small corrective mineral additives, "mixing" in sea water, a solution of alkali or table salt and passing an electric current through the mass of concrete prepared on the basis of this AC.

Such concretes:
- they can have a strength of up to ~2000 kg/cm^2 and they are waterproof, which allows them to be used in the creation of containers for reliable preservation and disposal of radioactive waste underground in special storage facilities, since they are not afraid of groundwater and earthquakes;
- they are resistant to sea water, which, together with the previous point, makes them an ideal material for the construction of sea piers, breakwaters and other port facilities;
- they are cheap, because their creation requires energy only for crushing slag or rocks, for coarse and fine grinding.

They allow:
- to build not only cities, but also ports (which is very important for far Eastern companies);
- to completely solve the issue of preserving the environment at metallurgical and mining and processing plants, because the waste of these industries are used to obtain the above mentioned alkaline binders;
- to solve the problem of affordable housing;
- to solve the problems of cheap construction of highways, railways and urban development in general.

The technology of producing AC from metallurgical slag, volcanic or rocks has several stages:

- pre-crushing of local mountain/volcanic rocks to obtain crushed stone, sand and inactive powder with grain

size up to 100÷50 μm;
- up-grinding of powder to grain size up to 1000÷100 nm in UMID/A;
- mixing in a concrete mixer in a certain proportion with sand and corrective additives (depending on the composition of the rock);
- "mixing" with seawater or alkaline/saline solution;
- additional activation of the mass by passing it several times through the working zone of the UMID/A at a certain speed;
- mixing in the mixer with the granite gravel of different degrees of crushing;
- fill in the formwork and seal with vibrators, and with vacuum in the factory.

5. Modification of coal in order to obtain cheap carbon nanotubes

Modern industrial technologies are inconceivable without the use of nanocomposite materials. One of the most promising nanomaterials is carbon nanotubes (CNT), the modern production of which is inefficient and expensive. To create new technologies of composite nano-materials requires: high performance of nanoparticles; low cost of their production; the ability to manage the processes of formation of structures from them.

CNT (single-wall, multi-layer, telescopically embedded and various fragments of them) are best suited for these purposes, because of their unique physical and chemical properties, having, in one way or another, magnetic susceptibility. The presence of a small amount of impurities of iron group in CNT is allowed for the application of this material in the technologies. In our studies, the initial charge containing ~12% of coking coal (COC) from the total ash mass was used, the composition of which is shown in the Table 1.

Table1

SiO_2	CaO	MgO	Fe_2O_3	Al_2O_3	P_2O_5	SO_3	K_2O	Na_2O	TiO_2
54,04	5,85	1,13	9,28	22	0,66	3,07	1,65	1,04	1,21

To obtain of CNT from COC, we have developed a special method of thermal modification of COC, which includes several identical cycles in the ferromagnetic turbulent layer in UMID/A. This method was determined by the fact that CNT are usually obtained in electrical discharges in an atmosphere of inert gases on graphite electrodes in the presence of an additive from iron group elements as a catalyst for the CNT formation process. Uniform distribution of small additives of metal in the charge is guaranteed up-grinding it each cycle in the UMID/A.

The original COC did not exhibit any magnetic properties at room temperature. After modification, it acquired magnetic permeability up to μ ~2, which is ~0.5 of the magnetic permeability of Fe_2O_3; this is difficult to explain due to a small admixture of iron oxide ~1.1%. The magnetic permeability of the samples appeared during repeated cycles of modification of the initial coking coal. The COC modified by us had such a magnetic permeability, like it's on 50% consisted of Fe_3O_4. The modified COC has a density approximately half the density of the original.

The analysis of microscopic images of natural COC was carried out with the help of scanning electron microscope JSM-35CF, thermally modified by the method of multi-level dynamic contrast, developed by V.A.Rantsev-Kartinov. Elemental analysis of the modified COC was performed using the same microscope. It turned out that the impurities in the samples are distributed locally as separate particles of micron size (1-50 μm), which are well allocated in the electronic image and make an average of ~10-15% in the density of atoms. Metal films of iron in carbon structures are ~1.0-1.5%. The micron size of the impurities grains due to the fact that coal quickly up-grinding, and iron grain during milling did not have time to grind to the nano range.

Fig.1, on the left, the location of iron in the sample is presented, and the spectrum of impurities taken from the window field in this image is given; on the right, the location of the spectrum capture point on the impurity spot in the modified angle and its spectrum is given.

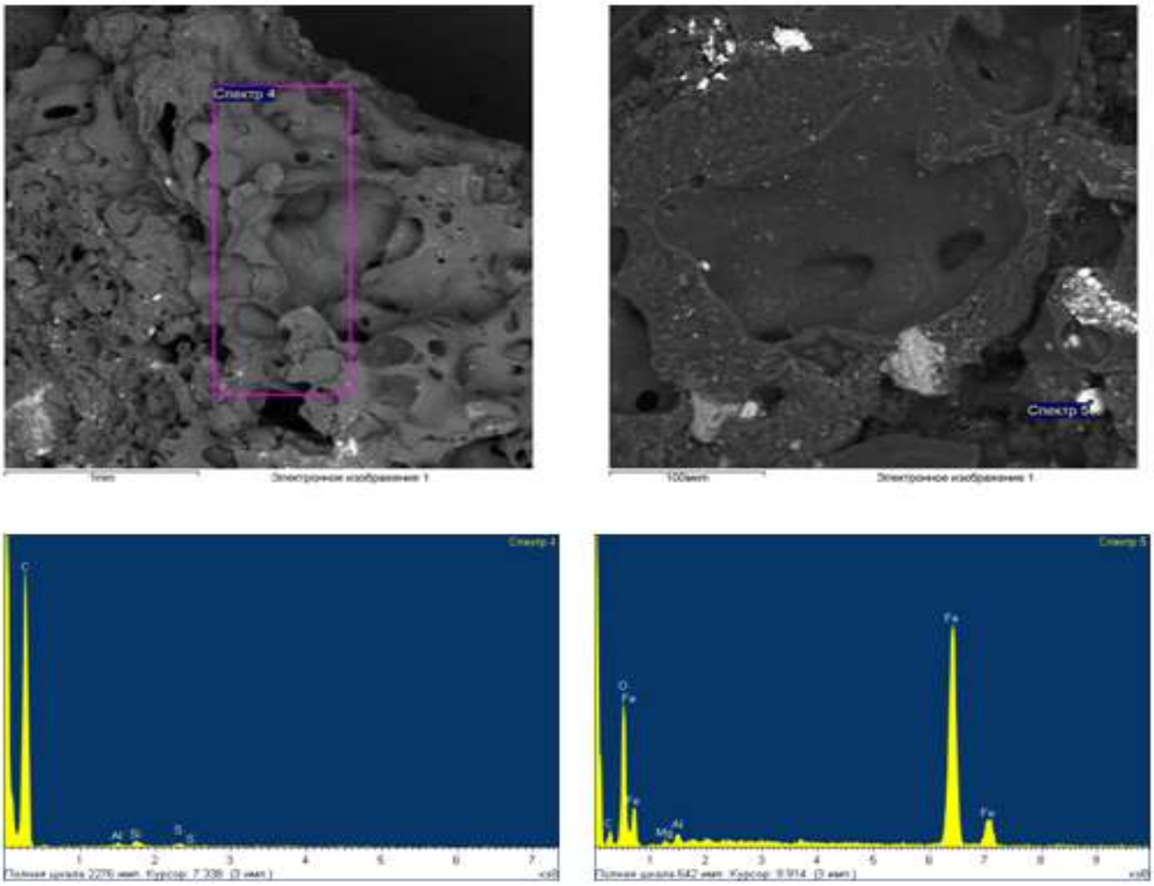

Fig.1. Iron in the sample and range of impurities

The structure of the COC has plate blocks, which are a pressure-crushed structure of wood subjected to pyrolysis (Fig.2); the electronic image of the COC is given in Fig.3.

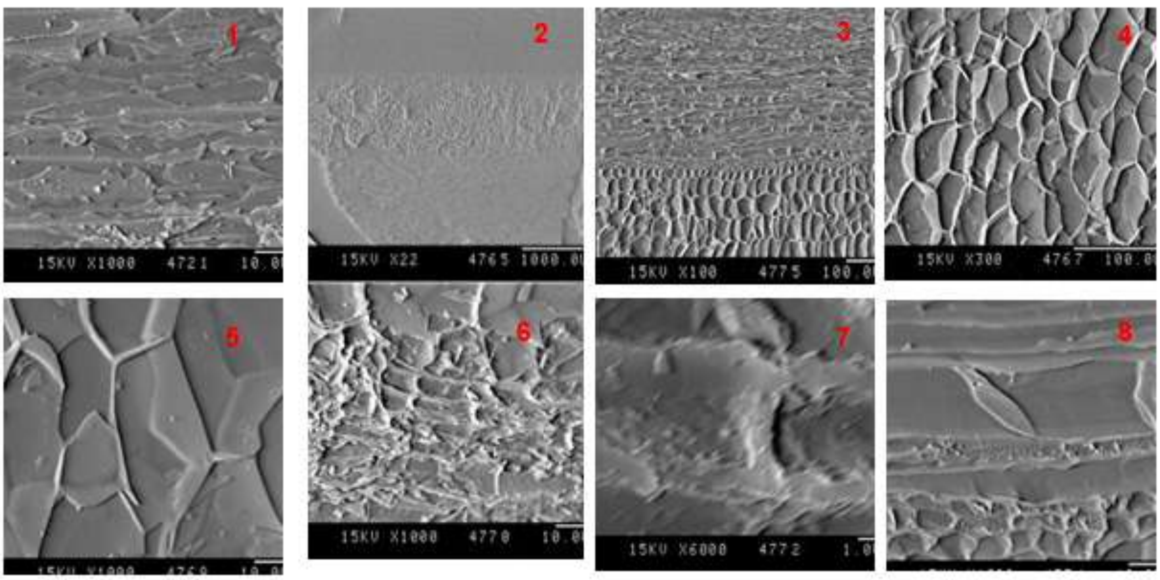

Fig.2. Structures of pyrolyzed wood: 1 – longitudinal structure of the outer layer of pyrolyzed wood; 2, 3 – longitudinal fracture of pyrolyzed wood with different magnification (DM); 4, 5 – longitudinal fracture of the core of pyrolyzed wood with DM; 6, 7, 8 – longitudinal fracture of the annual rings of pyrolyzed wood with DM

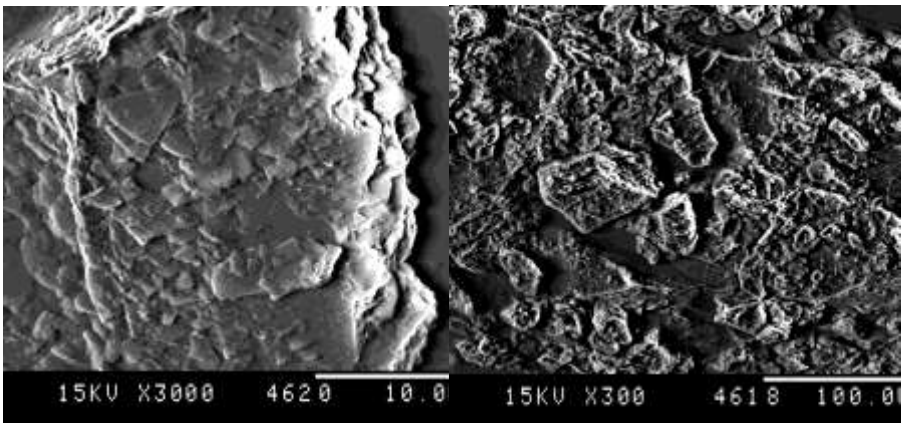

Fig.3. Structure of coal

As a result of the chosen type of volumetric action, tubular skeletal structures were revealed in the mass of the processed and studied samples.

We demonstrate the result of the modification of the charge of the COC after several identical cycles on the technology developed by the authors. Fig.4, on the left, the image of the original charge obtained by JSM-35CF is given, on the right is the corresponding image of the thermally modified COC after the fifth modification cycle; the scale of the image is given below the figure. The result of the modification is clearly visible.

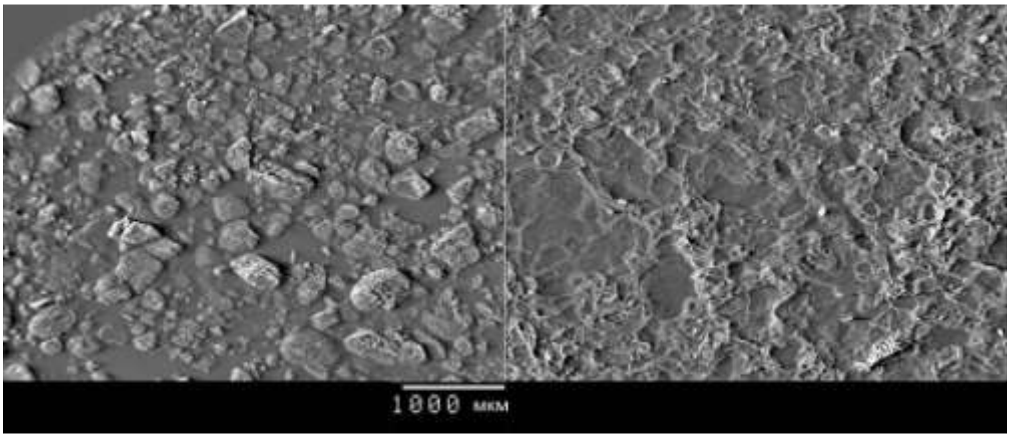

Fig.4. Modification of the charge of the COC

Fig.5 an enlarged image of a fragment of the modified coal structure marked with a frame is presented.

The width of the figure is 632 microns. Fore floors of tubular structures with a diameter of ~100-150 µm can be seen. Some tubes are telescopically nested. The minimum observed diameters of the tubes are ~8.5 µm, the rods are ~3 µm. It can be seen that almost all carbon is contained in these structures.

It is interesting to note that the walls of microscopic CNT are collected from similar tubes of the previous generation. Further analysis on the electron microscope showed that the structure of the modified coal is a fractal collected from coaxial-tubular blocks (KTB) with radial spokes-bonds (fig.6).

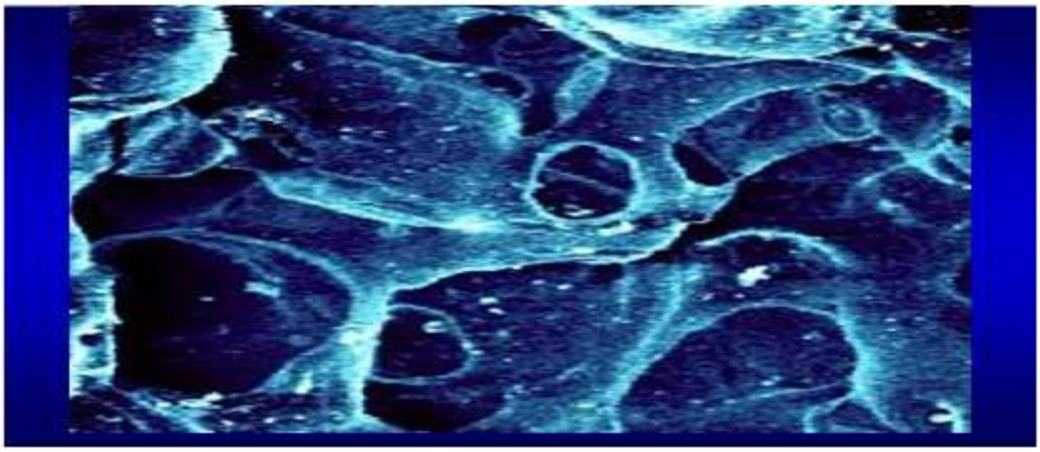

Fig.5. A magnified image of a modification of the charge of the COC

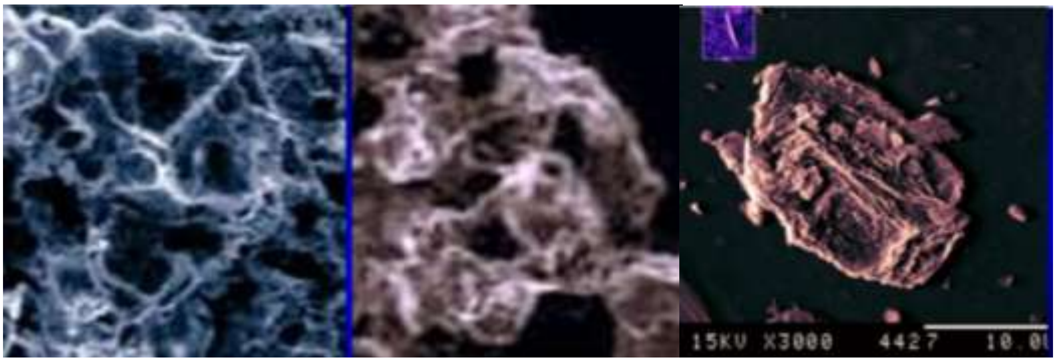

Fig.6. KTB type structures in modified COC: left width is 1.1 mm, in the middle width is 0.8 mm; right shows the structure with a diameter of 20 microns

Fig.7 is given an enlarged image of a light window (top left) with a graphical drawing of the joints of the observed structures

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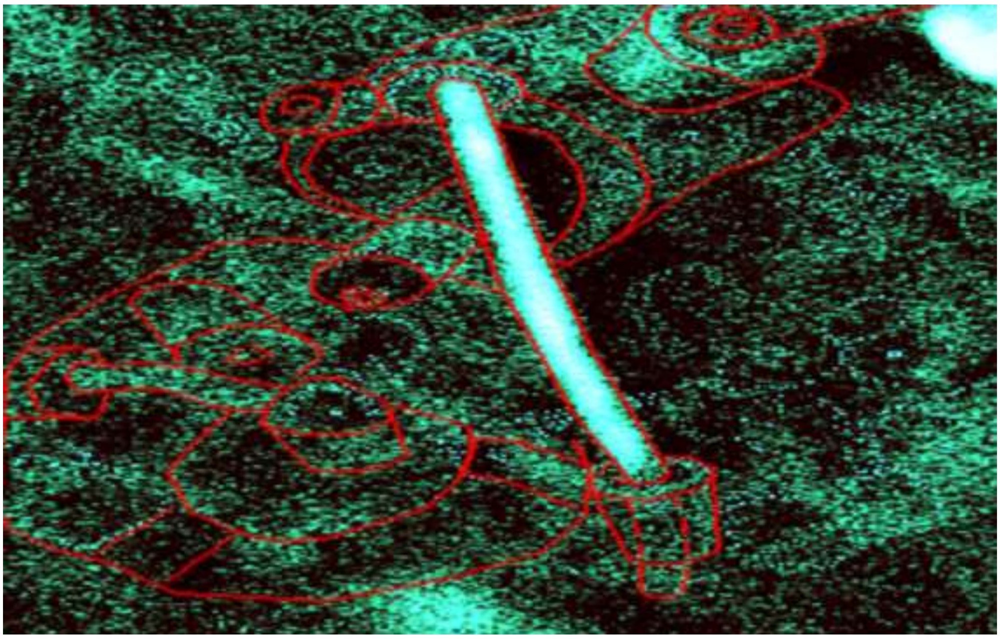

Fig.7. Increased light window: width of fig. is ~6.4 μm; light cylindrical structure with a diameter of ~0.46 μm and a length of ~4 μm; tubular structures with a diameter of ~0.3-0.7 μm are visible; the minimum observed diameter is ~30 nm

Sometimes in the images there are long carbon tubular structures with a diameter up to 10 µm, densely clogged with amorphous carbon; their image is presented in fig.8.

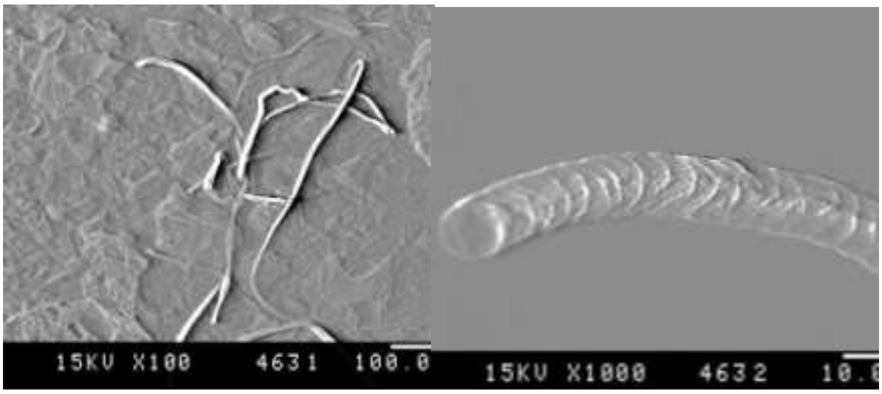

Fig.8. Long CNT (left) and increased CNT (right)

Fig.9 an image of an image fragment with an almost limiting magnification for this electron microscope is presented.

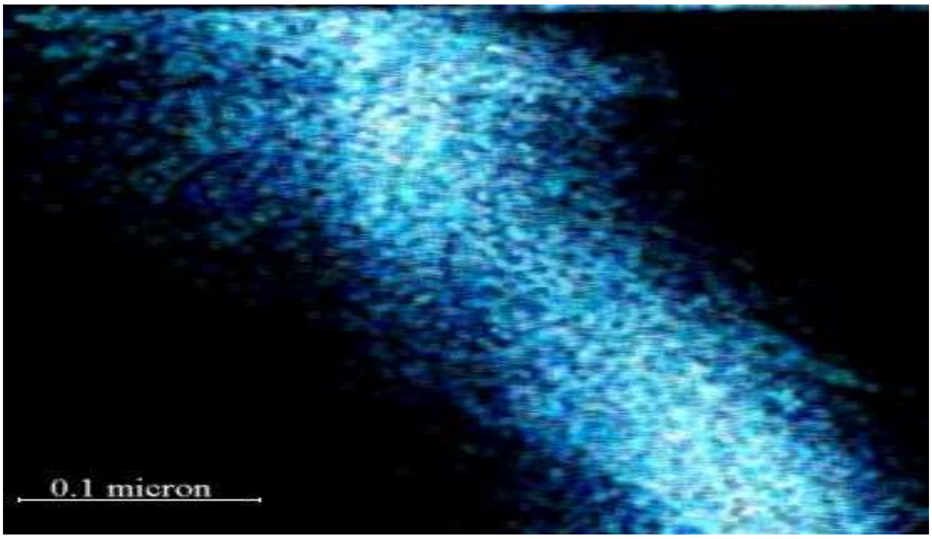

Fig.9. CNT with maximum possible increase

The minimum diameters observed on this fragment of the image of the modified COC of coaxial CNT are ~133 nm, and the cylinders are ~20 nm. To determine whether these cylinders are CNT shells, it is necessary to use a transmission electron microscope, which allows to obtain an increase up to $2 \cdot 10^6$, which allows to see individual atoms.

We also analyzed the images of micro/nano dust obtained from the mass of modified coal, which showed a small percentage of amorphous carbon in the studied samples.

As a result of the research, it can be concluded that the material of the modified COC can become the basis of various new technologies for the creation of new nano-composite materials.

III. CONCLUSION

The new technology on processing of coal on the basis of application of UMID/A offered by authors makes a breakthrough contribution to development of new technologies of the coal mining industry on all sectors of their production and defines creation of essentially new direction in science and technology: industrial production of nanocomposite materials.

REFERENCES

[1]. Rantsev-Kartinov V.A., Kulakov A.V. Universal module of industrial shredders/activators. Patent Russia. No.161751 (03.03.2015).

[2]. Kulakov A.V., Rantsev-Kartinov V.A., Tyutyunnik V.M. Application of Universal Multipurpose Modules of Industrial Disintegrators/Activators for the processing of cereals and potatoes into starch products. International Journal of Advanced Research 5(5), 1759-1762 (2017).

[3]. Kulakov A.V., Tyutyunnik V.M. New Approach to the Plasma Quantum Condensate, as a New State of Matter. International Journal of Current Research9(3), 47699-47703 (2017).
[4]. Rantsev A.A. «Waterspout» as a special type of atmospheric aerosol dusty plasma. Proc. 31-st Fur. Phys. Cos. Conf. on Plasma Phes. and Contr. Fusion, London, UK (2004). ECA 28B(4.062), 4.
[5]. Kulakov A.V., Rantsev-Kartinov V.A. Experimental confirmation of the existence of quantum plasma condensate. Izvestiya RAS. Energy1, 46-61 (2015).
[6]. Kulakov A.V., Rumyantsev A.A. Spontaneous magnetization of quantum plasma origin. Journ. of Tech. Phys. 58(4), 657-660 (1988).
[7]. Kulakov A.V. Quantum Non-Ideal Plasma as a Source of Heat Energy. Plasma Fuel Combustion. International Journal of Current Research 9(6), 53361-53365 (2017).
[8]. Kolbasov B.N., Kukushkin A.B., Rantsev-Kartinov V.A.Micro-dust frame structures in electric discharges as a new type of nanomaterial.Microsystems technology 3, 22-30(2002).
[9]. Kolbasov B.N., Kukushkin A.B., Rantsev-Kartinov V.A., Romanov P.V. New nanomaterial. Science in Russia 1, 55-59(2005).

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