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ELECTROMAGNETIC RADIATION SHIELDING PROPERTIES OF COPPER CONTAINING ACTIVATED CARBON

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Abstract. It's proposed to modify the consist and electromagnetic radiation shielding properties of powdery activated carbon by the method of chemical deposition of copper clusters on the surface of fractions of such material. The choice of these element caused by it resistance to the environment conditions, which could determines the stability of the shielding properties of materials including of these elements. Regularities of electromagnetic radiation interaction with powdery activated carbon modified by the proposed method were researched. According to the results of this research it's established that electromagnetic radiation reflection coefficient in frequency range 8...12 GHz of shields made with powdery activated carbon decreases from -2 to -14 dB after modification of such material consist.

Keywords: activated carbon, copper, chemical deposition, shielding of electromagnetic radiation.

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**Electromagnetic radiation shielding properties
of copper containing activated carbon**

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Introduction

Carbon containing materials are widely used for production of electromagnetic radiation shields nowadays. It's caused by them electroconducting properties which due to the energy losses of electromagnetic radiation interacted with such materials. It was established that the shields based on composite materials with carbon filler might be characterized by the electromagnetic radiation attenuation more than 40 dB in radiofrequency range [1]. But as a rule this shields have high cost due the complex technology of carbon materials production. Moreover shields based on carbon containing composite materials are unsubstantial, because more part of such materials are characterized by low adsorption capacity due to their low porosity. As a result the searching of new types of electroconducting materials for electromagnetic radiation shields is rather actual. Powdery activated carbon is one of such materials. It porosity value reaches 97.5 %. As a result it's possible to form strong composite materials based on powdery activated carbon for creation of electromagnetic radiation shields [2]. Electromagnetic properties of such shields might be changed by the way of modification of activated carbon consist. As a rule modification of carbon containing materials consist is actual in cases when it's necessary to reduce them electromagnetic radiation reflection coefficient which determines their ability to create passive electromagnetic interferences.

Objective of presented work was the research of effect of metals deposition on the surface of activated carbon on it's electromagnetic radiation reflection characteristics.

Experimental methods

Modification of consist of powdery activated carbon have been realized by the way of chemical deposition of copper clusters from water solutions on it's surface. The chose of such method is due to the comparatively low temperature required to it's realization. Moreover copper

clusters deposited from water solution are characterized by low porosity and high resistance to the environment conditions. Copper is electroconductive material. The structure of fine grid formed by the fractions of powdery activated carbon might be changed after the chemical deposition of copper clusters on them surface. As a result the amplitude of electromagnetic waves dissipated on this grid might be changed.

Water solution used for copper clusters deposition included potassium-sodium tartrate, copper sulphate (crystalline hydrate) and sodium hydroxide. It's pH value was 12,8. Formalin (40 %) was reducing agent. Solutions' temperature required for flow of reactions of copper clusters deposition was 60...65 °C.

The process of chemical deposition included the next steps.

1. Washing of powdery activated carbon with use of distilled water.
2. Mixing of components for obtaining necessary water solution.
3. Heating of water solution to the temperature required for flow of reactions of clusters deposition.
4. Dipping of powdery activated carbon in heated water solution and carrying out the reaction of metal clusters reduction.
5. Extracting of modified powdery activated carbon from water solution.
6. Carrying out the reaction of stabilization of deposited metal clusters on the surface of fractions of powdery activated carbon with use of surface-active substance.
7. Washing of modified powdery activated carbon with use of distilled water and drying it in the standard conditions [3].

Electromagnetic radiation properties (reflection coefficient and attenuation) of the samples of powdery activated carbon were researched with use of panoramic standing wave ratio and attenuation meter. It includes sweep generator, waveguide paths, detector of incident and reflected waves, indicator of standing wave ratio and attenuation.

Connection diagrams of the devices for measuring the standing wave ratio and electromagnetic radiation attenuation values of the samples are shown in Fig. 1 and 2.

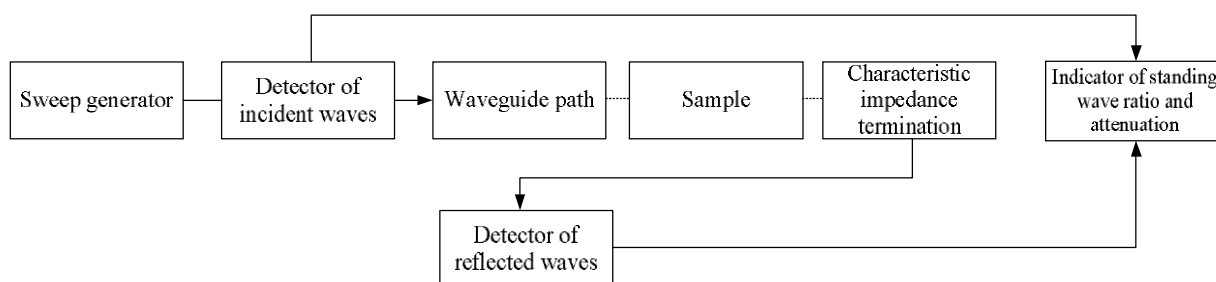


Fig. 1. Connection diagrams of the devices for measuring the standing wave ratio of the sample

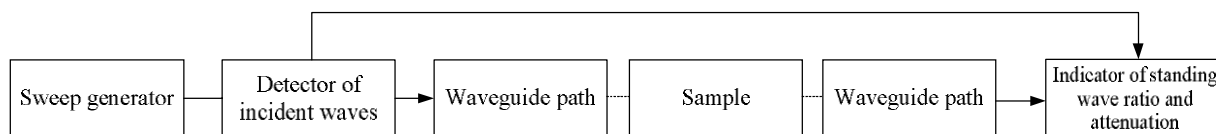


Fig. 2. Connection diagrams of the devices for measuring the electromagnetic radiation attenuation of the sample

The samples were made as cases filled by the powdered activated carbon. These cases produced from hard polymer radiotransparent material. The thickness of such material was 0.2 mm. The thickness of samples was 3 mm.

Samples consist was studied by the analysis of them diffractograms obtained by the X-ray diffraction method with use of $\text{CuK}\alpha$ -radiation (wavelength (λ) was 1,5417737 Å). Special software MATCH! was used for determination and identification of diffractograms' X-ray maximums. It realized the comparing of maximums of analyzed diffractograms with maximums of diffractograms stored in the free database «Crystallography Open Database». It's possible also to analyze the content of substances in the researched samples.

There were researched two samples. Sample 1 was made from non-modified powdery activated carbon, samples 2 was made from activated carbon containing copper clusters.

Results of the research

It was established that modification of consist of powdery activated carbon by the method of chemical deposition of metal clusters influences to it electromagnetic radiation reflection coefficient in frequency range 8...12 GHz. Electromagnetic radiation attenuation of non-modified and modified powdery activated carbon is more than 40 dB in radiofrequency range.

Electromagnetic radiation reflection characteristics in frequency range 8...12 GHz of the samples are given in Fig. 3. According to the Fig. 3 powdery activated carbon is characterized by the electromagnetic radiation reflection coefficient equaled to -2 dB. Chemical deposition of copper clusters from water solutions led to decreasing of electromagnetic radiation reflection coefficient of powdery activated carbon on 5...7 dB respectively. This is due to the fact that modified activated carbon contains less carbon elements as compared with non-modified (Fig. 4, 5). As a result it conductivity and wave resistance are lower.

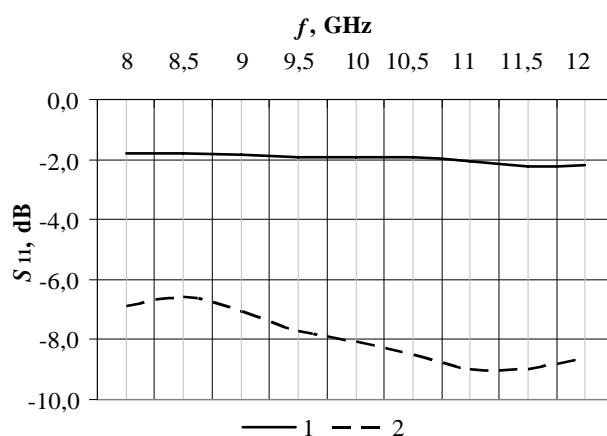


Fig. 3. Electromagnetic radiation reflection characteristics in frequency range 8...12 GHz of the samples: 1 – sample 1; 2 – samples 2

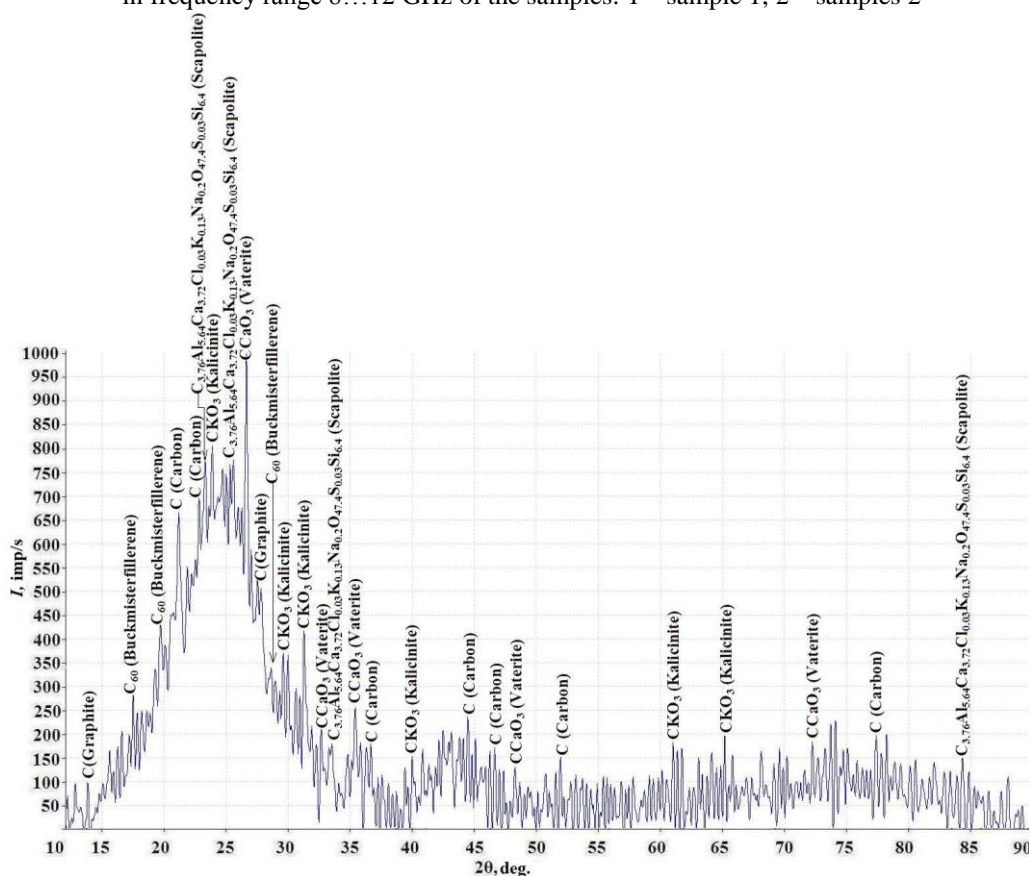


Fig. 4. Diffractogram of activated carbon

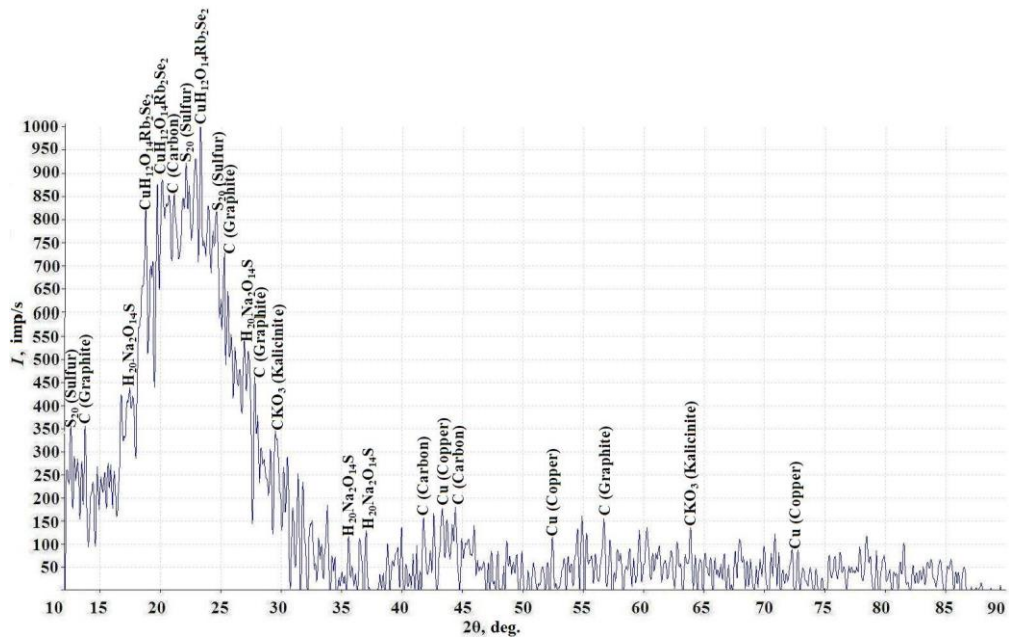


Fig. 5. Diffractogram of activated carbon containing copper clusters

It was established that non-modified powdery activated carbon contains 100 % of carbon elements. There were formed copper clusters on the surface of fractions of powdery activated carbon (1.9 wt. %) after the chemical deposition of copper. There were also 26.3 wt. % of kalicinite, 51.4 wt. % of sulfur and sulfur containing element ($H_{20}Na_2O_{14}S$), 10.8 wt. % of copper containing compound ($CuH_{12}O_{14}Rb_2Se_2$), 9.2 wt. % graphite on the consist of powdery activated carbon modified by the method of chemical deposition of copper clusters.

There were carried out the measurements of electromagnetic radiation reflection coefficient of the samles fixed on metal plates. The results of such experiments were nessesary to estimate the possibility of the researched samples to decrease the energy of electromagnetic radiation, reflected from the metal materials. Occurrence of electromagnetic radiation's reflection from metal materials might lead of forming of standable waves due to the passive interferences in practice cases.

Electromagnetic radiation reflection characteristics in frequency range 8...12 GHz of the samples fixed on metal plates are given in Fig. 8. Fixing of samples on metal plates was realizing with use of sprayable glue.

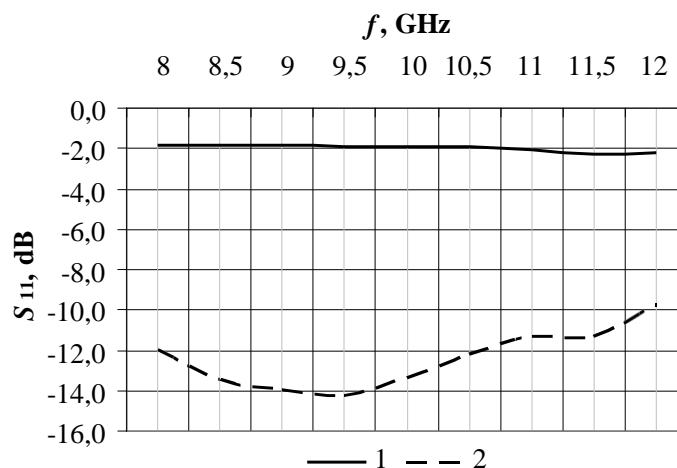


Fig. 6. Electromagnetic radiation reflection characteristics in frequency range 8...12 GHz of the samples, fixed on metal plates: 1 – sample 1; 2 – sample 2

According to the results of analysis of characteristics given in Fig. 8 it was established that electromagnetic radiation reflection coefficient of sample 1 hasn't changed after the fixing of such

sample in the metal plate. This is due to the most part of electromagnetic waves interacted with this sample reflected by its surface made from non-modified powdery activated carbon. Such speciality aligned with the significant difference between wave resistances of air and carbon [4].

Including the metal plates on the structures of the samples made from carbon-containing powdery activated carbon led to changing of their electromagnetic radiation reflection coefficient. This parameter decreased on 2...6 dB after it was fixed on the metal plate. Such attenuation due to the different phases of waves reflected from the metal plate and wave reflected from the sample surface borders with plate surface. Electromagnetic radiation reflection coefficient of the sample 4

The characteristics of electromagnetic radiation reflection of sample 2 fixed on the metal plates has a minimum point, which equaled to 9.5 GHz. The value of such parameter in this point (minimum of characteristics) is -14 dB. It is due to the changing of special aspects of interaction of electromagnetic radiation and samples. When electromagnetic waves interact with the sample fixed on the metal plate it reflects from the surface of case filled by the powdery activated carbon and from the surface of metal plate. These waves interact with each other. The phase difference between these waves depends on their frequency. The minimum value of electromagnetic radiation reflection coefficient of sample fixed on the metal plate corresponds to the maximum value of phase difference between the waves reflected from the described surfaces [4].

Conclusion

It was established the possibility of decreasing from -2 to -9 dB the electromagnetic radiation reflection coefficient of powdery activated carbon by the way of chemical deposition of copper clusters on the surface of its particles. The electromagnetic radiation attenuation of this powdery material is no less than 40 dB after modification of it consist by the described way. It was shown possibility of decreasing in 30 times the power of electromagnetic radiation reflected from metal plates by the way of their covering with material based on powdery activated carbon containing copper clusters. The obtained results might be used during the solving task of decreasing energy of standing waves in shielded rooms.

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