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Obtaining Environmentally Friendly Trace Element Preparations for Crop Production via the Electric Spark Treatment of Metals

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INTRODUCTION & AIM

Over the past two decades, in connection with the search for new technological solutions to environmental and resource problems, a new scientific direction has begun to "gain momentum" all over the world, related to the integration of modern nanotechnological developments in various fields, such as instrumentation, micro- and optoelectronics, chemical technologies, medicine and biotechnology.

Traditional technological approaches used for the cultivation of field crops using many mineral fertilizers and chemical plant protection products are becoming costly, as well as environmentally and economically irrational.

An example of the rational use of available resources can be demonstrated by solving the problems of ecologization of modern production, especially in the fields of agricultural production. Therefore, the physicochemical properties and reactivity of the material in the nanoscale state are of interest to researchers, since such materials can be used in various technological processes, in particular in the chemical, processing and food industries.

An alternative direction is the use of modern technological approaches, including nanomaterials.

The article presents the method of obtaining a biologically acceptable and effective form of trace elements in the form of aqueous dispersions of metals.

METHOD

During the research process, we studied the regularities of the electro-spark dispersion of metals, which determines the synthesis of nanoparticles of biogenic elements. Electron microscopy (SEM and TEM) and the X-ray diffraction analysis of the metal phase of colloidal solutions were used to research the composition, structure, and average sizes of the obtained nanoparticles of various metals. A complex compound was prepared, which includes metal nanoparticles, in particular, such as iron (Fe)—1800 ppm; copper (Cu)—400 ppm; zinc (Zn)—1000 ppm; and manganese (Mn)—800 ppm. The compounds were tested in the field during the cultivation of winter wheat at different stages of organogenesis.

Parameters: 8000 – 12000 C; Metal granules: 5-10 mm; 40-220V.; 30-150A.

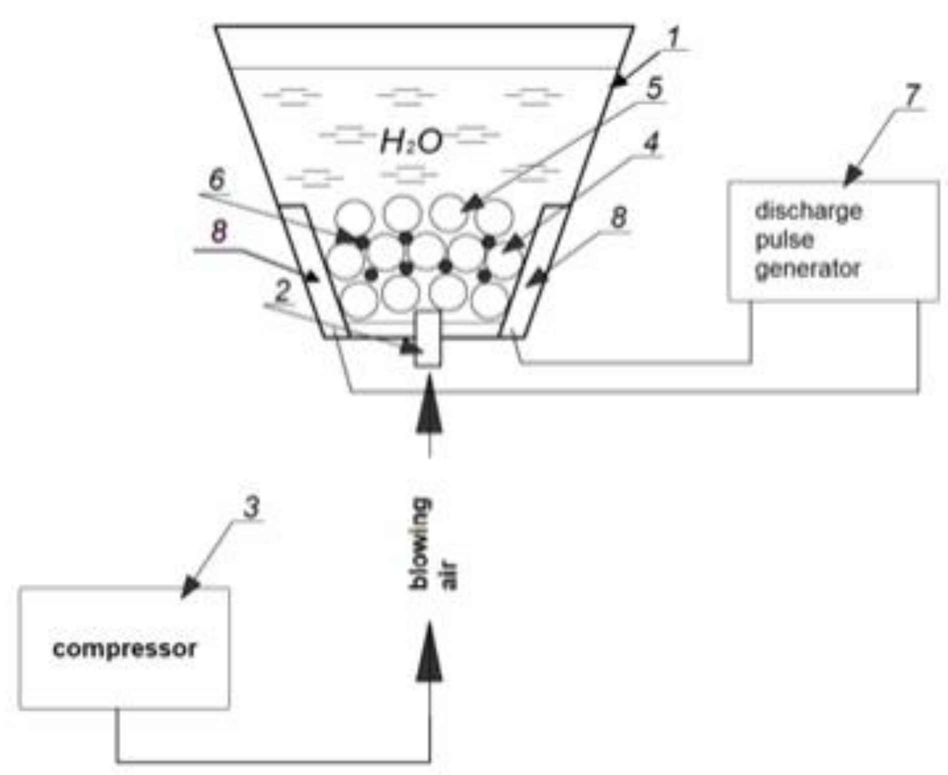

Figure 1. Scheme of the device for obtaining metal nanoparticles.

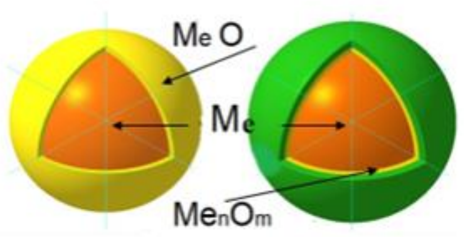

Figure 1.2 Diagram of the general structure of metal nanoparticles obtained by electrospark dispersion in an aqueous dispersion medium.

RESULTS & DISCUSSION

The obtained preparations of metal nanoparticles: Zn, Fe, Mn, Cu were studied by X-ray diffraction analysis, scanning and transmission electron microscopy (Figure 2). Physical methods were used to isolate the dispersed phase of nanoparticles from the dispersion medium. The study took into account the fact that the substance in the dispersed state is prone to consolidation.

All detected metal nanoparticles with a size of 5 - 100 nm acquire the characteristics of 3D nanomaterials according to the international classification.

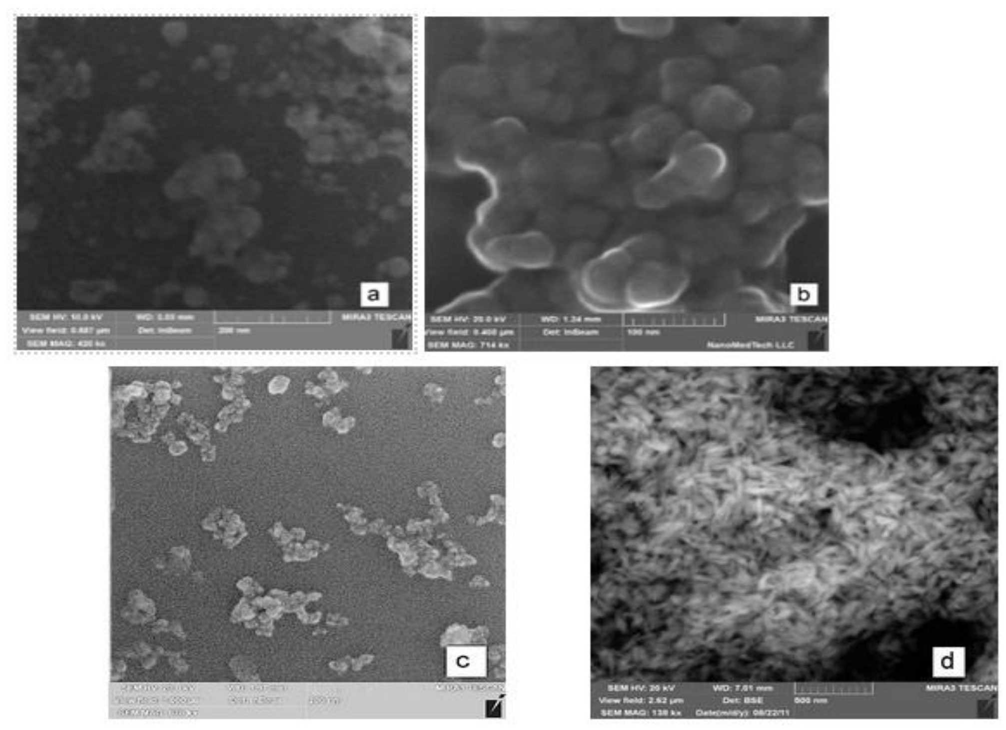

Figure 2. SEM of the nanoparticles of zinc Zn (a), iron Fe (b), manganese Mn (c), copper Cu (d)

Copper nanoparticles with sizes in the longitudinal direction from 100 nm and 30-50 nm in the transverse direction are formed in the form of elongated grains with sharp ends.

Nanoparticles of iron group metals, in particular iron Fe and manganese Mn, have a similar morphology of the dispersed phase in different size ranges and form crystal-like particles of regular shape in the range of 20 - 50 nm (Fig 3).

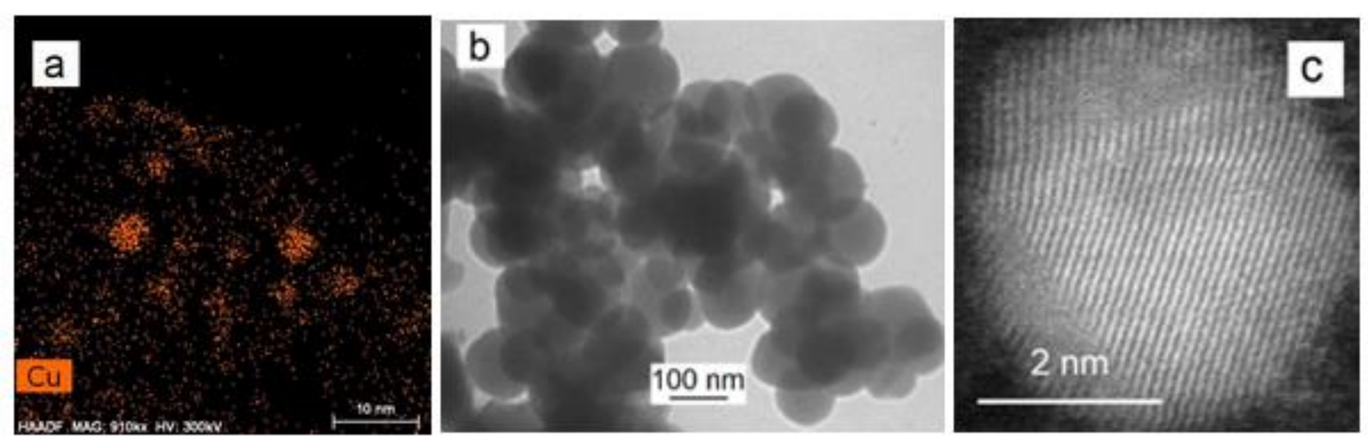

Figure 3. TEM of the particles of copper Cu (a, c), iron Fe (b)

It is important to note a change in the quality indicators or nutritional value of the harvest grain – an increase in gluten by more than two times, which can be considered a significant result of using metal nanoparticles in the cultivation of cereal crops, particularly winter wheat.

Figure 4. Plants in the tillering phase (a) - experiment, (b) - control and the phase of full maturity of wheat (c) - control, (d) – experiment.

CONCLUSION

The application rate of the prepared compound was 1-1.5 l/ha, and 1.0-1.5 liters of the compound were diluted in 250 liters of water. It has been established that the proposed technology increases grain yield and its quality indicators. The presented technology for growing grain crops is cost-effective and provides an increase in wheat cultivation profitability by 10-15%. The presented technology (electric spark method) can be considered ecologically and environmentally safe. It does not pose a threat to the environment, the agricultural sphere, and humans due to their probable biodegradation.