REVIEW

DISSERTATION THESIS TITLE: Creating and Studying New Composite Materials for Microwave Absorption in the Range of 8.8-12 GHz

Scientific supervisor Doctor of Technical Sciences, professor Zharmenov Abdurassul Aldashevich. For the thesis work of Anas Houbi, "Creating and Studying New Composite Materials for Microwave Absorption in the Range of 8.8-12 GHz", submitted for the degree of Doctor of Philosophy (Ph.D.) in the specialty 8D07104 - "Chemical technology of inorganic substances".

Dissertation work A. Houbi is devoted to creating and studying new composite materials for Microwave Absorption from magnetic loss and dielectric loss materials. The aims of the work are to find optimum parameters for producing new radar absorbing materials (RAMs) characterized by low SD, strong RLmin, high SEmax and wide $B.W_{-10\ dB}$ at the frequency range of 8.8 -12 GHz. Spinel ferrites and hexagonal ferrites were prepared by the ceramic sintering method. The effect of ferrite type, substitution with several metal ions, the concentration of metal ions, and loading percentage of ferrite in the host matrix on electromagnetic interference (EMI) and microwave absorption (MA) properties were studied. The best result obtained at this stage was by using $Ni^{3+}_{0.25}Ni^{2+}_{0.375}Zn^{2+}_{0.25}Fe_2O_4$. A minimal reflection loss (RL_{min}) indicated -13.3 dB at 9.8 GHz and absorption BW-10 dB was 1.3 GHz for a thickness of 3 mm.

The effect of the different molar ratios of the metal ions to citrate acid (1:1, 2:1, and 3:1) and calcination temperatures (650, 800, and 950°C) on the properties of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ was studied. Samples were prepared with a thickness of 5 mm and a loading percentage of 65%. The results indicated that the RL attenuation peaks of samples moved to lower frequencies with increasing the metal ions to citrate acid and calcination temperature. The influence of the different loading percentages (60, 65 and 70% w/w) and thicknesses (3, 5 and 6 mm) on $Ni_{0.5}Zn_{0.5}Fe_2O_4$ – 650 properties were investigated. Figure 3.38 shows that the RL moved gradually to a lower frequency with the increased loading percentage. Also, the same phenomenon was noticed by increasing the thickness of an absorber. These results may be defined by the quarter-wavelength ($\lambda/4$) cancellation model.

EMI shielding and MA properties of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ /CI/CB nanocomposites were investigated at a loading percentage of 40% w/w with the different weight ratios of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ /CI/CB (1:1:1, 1:1:2, and 2:1:1). The results revealed the

impact of incorporating $Ni_{0.5}Zn_{0.5}Fe_2O_4$, CI (magnetic loss materials) and CB (dielectric loss material) on the SD, RL_{min}, SE_{max}, and $BW_{-10\ dB}$ of the prepared absorber. This incorporation leads to obtaining a wider BW-10 dB, lower SD absorber, and loading percentage compared to the $Ni_{0.5}Zn_{0.5}Fe_2O_4$ /CI absorber. The best result was obtained by using the F/CI/CB-211 nanocomposite sample. The results were compared with some lately reported carbon-based nanomaterials. The results of the literature show these composites are good in the C-band and Ku-band frequencies and limited in the X-band frequency. The presently prepared nanocomposites display in this research better MA in the X-band frequency. The distinct of these prepared nanocomposites have a lower loading percentage and thickness of the absorbers compared with the other literature.

The effect of PANI/$Ni^{3+}_{0.25}Ni^{2+}_{0.375}Zn^{2+}_{0.25}Fe_2O_4$ hybrid nanocomposites morphology on the RL and the SE were investigated. The mixture of agglomerated particles and rod-like morphology appeared to show the best MA and EMI shielding properties. The absorption BW_{-10dB} was 1.8 GHz with a SD of 3.04 for the PANI/F.2 nanocomposite. In contrast, the absorption BW_{-10dB} was 1.9 GHz with a SD of 3.22 for the PANI/F.1 nanocomposite. While no absorption BW_{-10dB} was noticed for PANI, $Ni^{3+}_{0.25}Ni^{2+}_{0.375}Zn^{2+}_{0.25}Fe_2O_4$ and PANI/F.3 nanocomposite.

The prepared samples were structurally characterized using XRD, FTIR, TGA, and EDX. SEM was utilized to define the morphology of the powders. Finally, the prepared samples were functionally characterized utilizing the horn antenna connected to an oscilloscope.

A. Houbi passed the internship at the Center on Complex Processing of Mineral Raw Materials. He gained good experience in synthesizing PANI-based nanocomposites.

The results obtained are of practical interest for obtaining new improved nanocomposites for absorbing EM waves at the X-band frequency. In addition, the scientific level of the presented thesis complies with international standards for research conducted in the selected field. This is evidenced by a good level of publications, the presentation and the discussion of the results of work at international conferences. I believe the results presented in this dissertation are reliable and undoubtedly arouse deep scientific interest. Nevertheless, the work meets the requirements of the modern scientific world. In connection with the above, the dissertation work of Houbi Anas, "Creating and Studying New Composite Materials for Microwave Absorption in the Range of 8.8-12 GHz", submitted for the Ph.D. degree, according to the main features - the relevance of the problem, the

novelty of the results obtained, their validity and reliability, the amount of research and practical significance - is a scientific work that has a promising direction for the development of the processes of obtaining composite materials for microwave absorption and the doctoral student deserves to be awarded a Ph.D. degree in the specialty "8D07104 Chemical technology of inorganic substances".

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