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FERRITE WOOD FIBROUS COMPOSITE MATERIALS FOR ELECTROMAGNETIC WAVE PROTECTION

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Abstract

Ferrite wood fibrous composite materials represent a great interest in the production of special articles with electromagnetic wave absorpton for different applications in electronics, electrotechics, office equiqments and many other rooms with high electromagnetic concentration.The present investigations are connected with development of new method for preparation of ferrite-containing lignocellulose fibrous material by treatment with mixture of Fe^{2+}/Fe^{3+} and on this basis ferrite wood fibrous composite materials have been produced.

The new ferrite wood fibrous composite materials are very usful for different application.

Key words: *Ferrite wood fibrous materials, composites, electromagnetic wave protection*

1. INTRODUCTION

The fast developing science and engineering, particularly production of new materials, continuously change the quality of life. The greater part of industry as product generates also problems for the society. The natural fibers and the wastes of the agricultural industry are used as fillers in polymer matrixes of specific properties. Particular interest present composites on the base of thermoplastic matrices reinforced by lignocellulose materials such as: wood, wheat, straw, almond peels and rice husks. These fillers introduce some advantages compared to the conventional inorganic fillers which contribute to their regenerative character (Bakar 2005). The modification of cellulose and cellulose fibers (Boufil 2006, Zhang 2008, Kitkulnumchai 2008, Pasquini 2008, Majumdar 2005) gives many new opportunities of application which makes it a very important product. Its use in composite materials (Pasquini 2008, Majumdar 2005) as regenerative material is one more reason to consider this product singular.

Particular interest present the magnetic fibers prepared through magnetic powder introduction in the lignocellulose matrix and the subsequent production of nonwoven textile materials for magnetic protection (Rubacha 2007).

There is carried out modification of cellulose fibers and microcrystalline cellulose (MCC) with Fe for preparation of materials with thermal and electrical properties. It is found that the thermal stability decreases while high electrical conductivity is achieved in the modified materials (Sundar 2011).

A considerable number of researches are devoted to the modification of cellulose fibers by ferrite powder (Leonowicz 2004, Kaszuwara 2004, Rubacha 2004) with the purpose to produce composites of magnetic properties.

There are investigations on modified polysaccharides that acquire magnetic properties when treated by Fe^{+2} in insoluble polysaccharide matrix (Raymond 1995). The materials produced are suitable for use in the production of composites for electromagnetic wave protection.

Interest present the researches related to the development of adequate methods for modification of lignocelluloses by copper-sulphur containing reduction systems to impart new properties and subsequent production of wood polymer composites for electromagnetic wave protection (Nenkova 2011).

The present researches are connected with preparation and study of ferrite containing lignocelluloses by treatment with two-component Fe^{+2} and Fe^{+3} system and on their basis production of ferrite wood fibrous composite materials for engineering and household purposes.

2. MATERIALS

Wood fibers are used – high yield fiber materials (HYFM), obtained during processing of broad-leaf wood splinters with the purpose to produce thermo mechanical mass that is used for the manufacture of wood fibrous plates. They are delivered from Lesoplast Ltd, town of Troyan. As binding agent for preparation of the wood-polymer composites phenolformaldehyde resin is used – content 0,1% compared to the fibers. The following are used as modifying reagents: $FeCl_2x4H_2O$ - SIGMA ALDRICH Chemie GmbH, M 198,881 g/mol, $FeCl_3x6H_2O$ - SIGMA ALDRICH Chemie GmbH, M 270,33 g/mol.

3. EXPERIMENTAL

3.1 Wood fibers modification.

Table 1 presents the modification conditions of the wood fibers.

The lignocellulose material - HYFM is modified by ferrite system which contains water solutions of $FeCl_2.4H_2O$, and $FeCl_3.6H_2O$, mixed in molar ratio 1:2. The solution thus prepared is diluted with water in proportion from 1:2 to 1:10, then it is mixed with the lignocellulose material at constant hydromodule (M=1:8), stirred and a definite quantity of NH_4OH is added. The modification time is varied from 5 to 30 minutes. The temperature of performing the modification is room temperature (from 20°C to 25°C). In alkaline medium of high pH the ferrous chlorides hydrolyze with formation of magnetite (Hunger 2006).

Table 1. Modification conditions of HYFM.

Sample	Dilution of modified solution	NH_4OH (ml)	Time min.	Fe content in solution, %	Fe content in fibers, %	Fe loss in fibers after modification, %
M.1	01:01	20	5	93	7.2	85.8
M.2	01:02	20	5	62	8.3	53.7
M.3	01:10	20	5	18	8.8	9.2
M,4	01:20	20	5	9	1.3	7.7
M,5	01:01	20	30	93	6.5	86.5
M.6	01:02	20	30	62	5.8	56.2
M.7	01:10	20	30	18	3.7	14.3
M.8	01:20	20	30	9	4.9	4.1

The modified high yield fibrous materials (HYFM) are characterized with respect to infrared spectroscopy and iron content.

3.2 Determination of the iron content after modification of the fibrous materials

The iron content is determined according to ICP, after thermal and acidic decomposition of the samples. The study is performed in the Central Research Laboratory of the University of Chemical Technology and Metallurgy. Figure 1 and Fig. 2 present graphically the results.

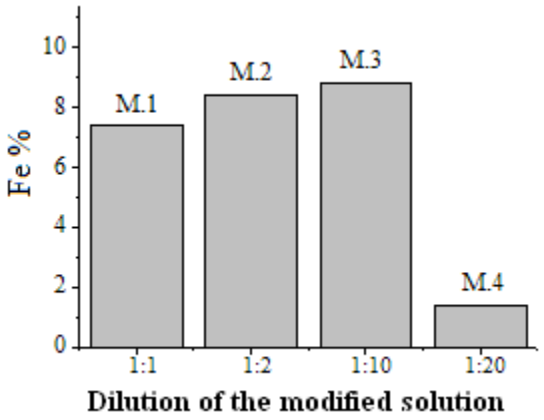


Fig.1. Fe content (%) after fiber modification, duration 5 minutes.

In these modification conditions the following dependences are observed:

- When the process duration is 5 minutes (Fig. 1) with increase of the degree of modified solution dilution the quantity of iron in the fibers increases and the loss is the smallest for proportion 1:10.

- When the process duration is 30 minutes (Fig. 2) with increase of the degree of modified solution dilution the quantity of iron in the fibers increases and the loss particularly for proportion 1:20 is considerably smaller.

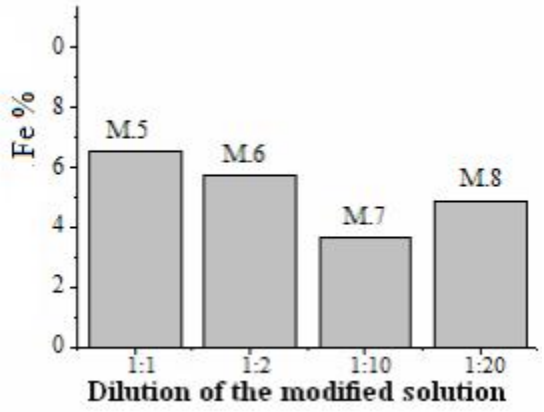


Fig.2. Fe content after fiber modification, duration 30 minutes

Comparing the data in figures 1 and 2 and Table 1, as optimum modification conditions we recommend: process duration 5 minutes and degree of modifying solution dilution 1:10.

3.3. Iron losses after fibrous material modification.

Figure 3 presents graphically the results of iron content in the wood fibers.

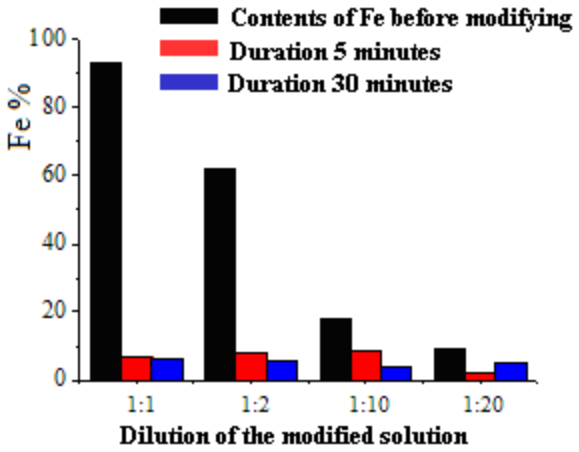


Fig.3. Iron losses after fibrous material modification

The optimum results in relation to iron content in the fibers and the losses in the solution are achieved during modification under the following conditions: ratio 1:10 and duration 5 minutes.

3.4. Preparation of ferrite fibrous composite samples.

In the preparation of wood fibrous composite samples the following is used:

- Ferrite wood fibers modified by the above described method and the specified optimum conditions as follows: proportion 1:10 and duration 5 minutes.
- Wood fiber mass (12% dry substance), submitted by the production line of Lesoplast Ltd., Troyan town.

The composite materials have been produced in Lesoplast Ltd., by laboratory press under the conditions and parameters given in Table 2.

Table 2. *Conditions and parameters of composite samples production.*

Sample	Fiber quantity Troyan, (%)	Modified fiber quantity, (%)	Time (min)	Mass (g)	Temperature (^{o}C)
0	100	-	10	250	180
1	87,5	12,5	10	250	180
2	75	25	10	250	180
3	50	50	10	250	180

The composites are produced under conditions and parameters accepted for the production of wood materials by the aqueous method: the Phenol formaldehyde resin (PF) quantity compared to fibers 1%; paraffin emulsion content 10%; degree of grinding (DS) 18 sec., mass pH 5,5. The composites are pressed for 1,30 minutes under specific pressure of 50 kg/cm^2 and 8,30 minutes under 12,5 kg/cm^2. Degree of grinding (DS) 18 sec., mass pH 5,5.

3.5. Characterization of the composite samples.

The composite materials are characterized in relation to: X-ray diffraction, physical-mechanical characteristics, infrared spectroscopy, electrical conductivity and electromagnetic absorption.

3.5.1 X-ray Diffraction

The analysis is performed by apparatus Brucker D8 diffractometer in the Institute of Inorganic Chemistry of the Bulgarian Academy of Sciences. Figure 4 shows the roentgenogram.

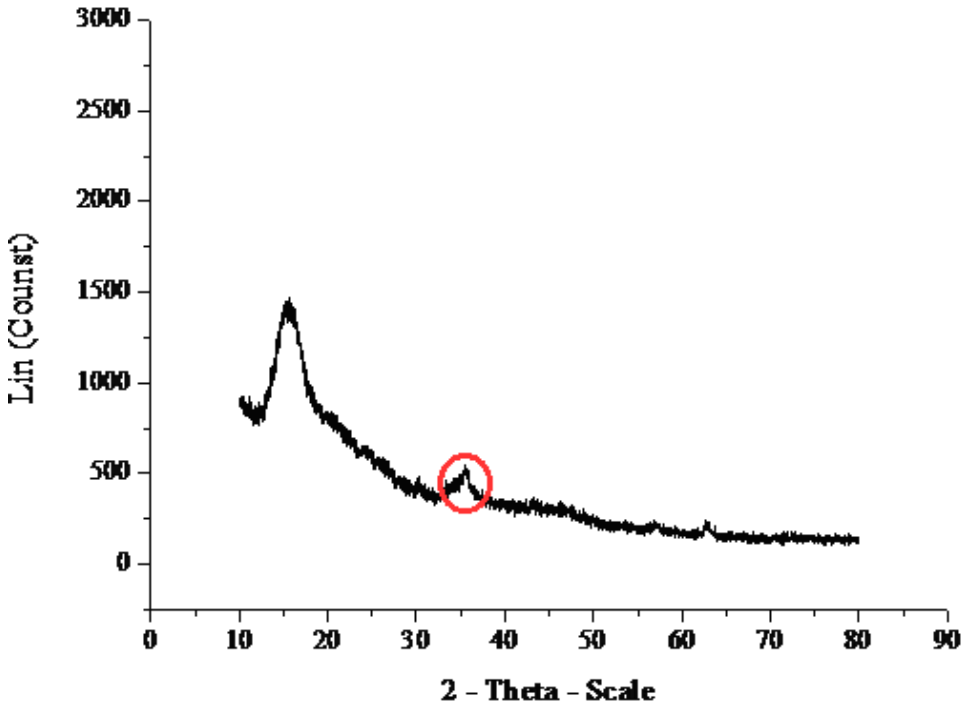


Fig.4. X-ray diffraction analysis of composite produced of modified wood fibers

The X-ray analysis shows the presence of magnetite in the modified fibrous composite. The first peak is due to the fibrous material and the considerable presence of cellulose in it, the second peak which shows the magnetite is clearly expressed that confirms the successful modification of the wood fibers. The composite of the lowest modified fibers content is used. The research made has also specified the size of the magnetite particles: =10nm.

3.5.2. Physical-mechanical characteristics

3.5.2.1 Three-point bending

Figure 5 presents graphically the three-point bending strength depending on the modified fiber content in the composite.

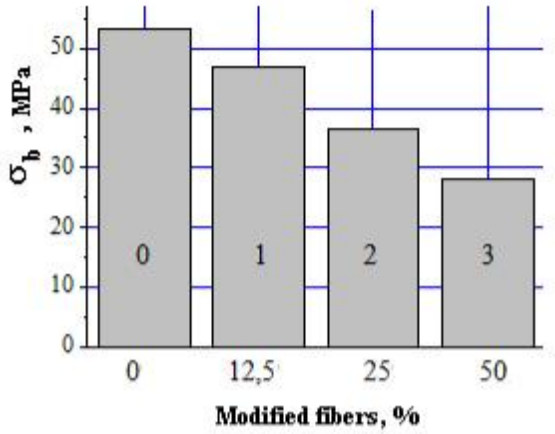


Fig 5. Three-point bending strength depending on the percentage of introduced modified fibers

Figure 5 clearly shows that the highest indicator of three-point bending strength has the sample without modified fibers. With the increase of the percentage of introduced modified fibers the strength value decreases in three-point bending.

3.5.2.2 Tensile strength

The tensile strength results of the composites are graphically presented in Fig. 6 and Fig. 7, respectively: tensile strength and tensile elasticity modulus.

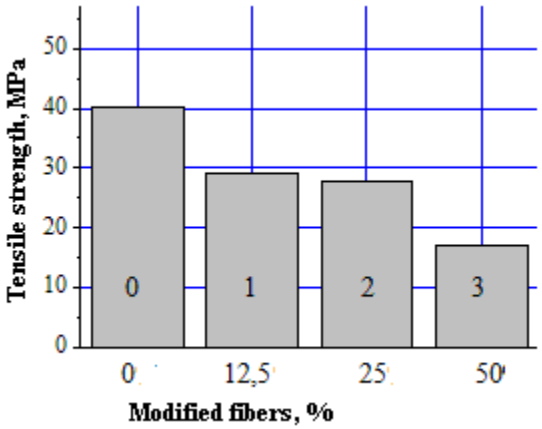


Fig.6. Tensile strength depending on the percentage of introduced modified fibers

Figure 6 indicates that all the samples containing modified fibers show lower values for tensile strength compared to the zero one. The lowest value has the sample which contains 50% of modified wood fibers. The cited above dependences of tensile strength refer also to the elasticity modulus indicator (Fig. 7)

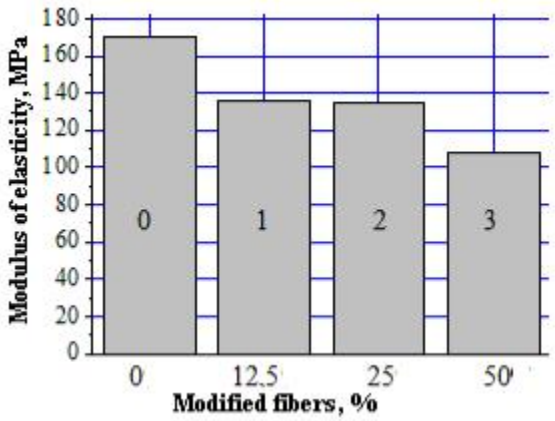


Fig.7. Elasticity modulus in tension depending on the quantity (%) of introduced modified fibers

3.5.2.3 Impact strength according to Izod

The results of this characteristic are graphically presented in Fig. 8

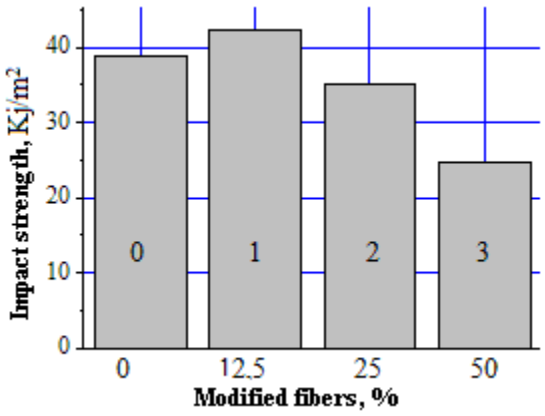


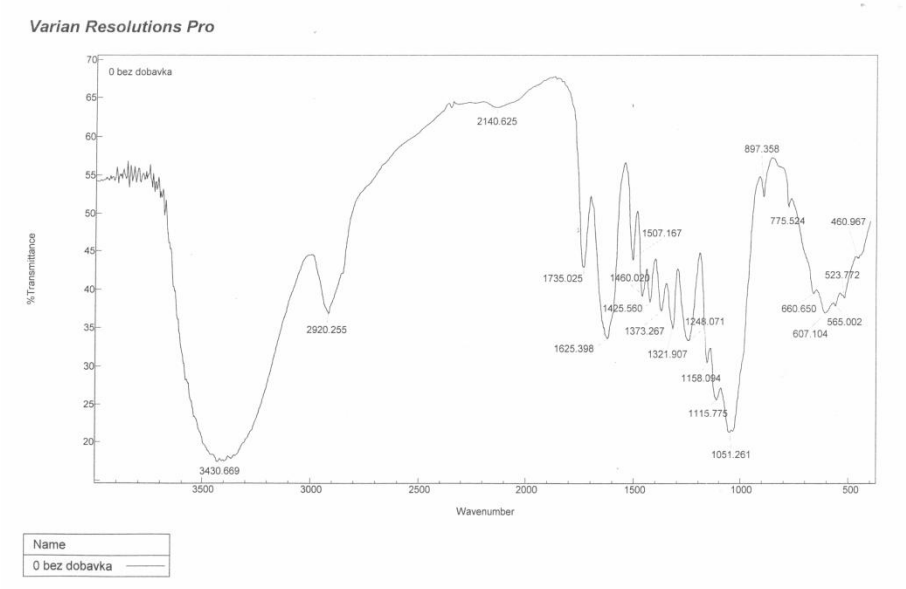
Fig.8. Impact strength according to Izod depending on the percentage of introduced modified fibers

It is obvious that with the increase of the modified fiber percentage above 12,5% the impact strength decreases.

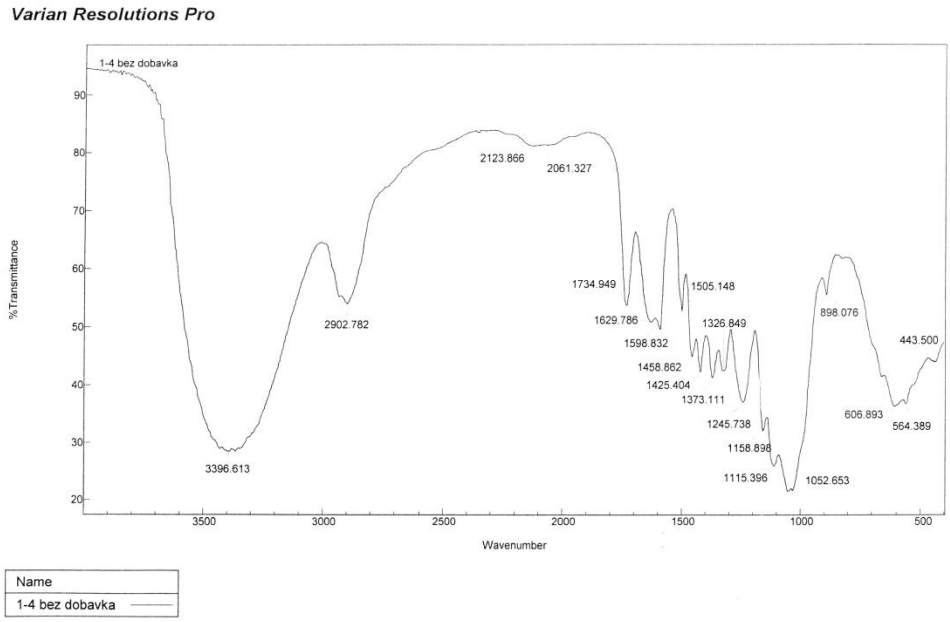
3.5.3 Infrared spectroscopy

The infrared spectra of the modified fibers (Fig. 9) show the appearance of a band at ~ 400 cm^{-1} that is characteristic for the metal-oxygen bond (Balasuria 2002). Probably, this bond is as a result of

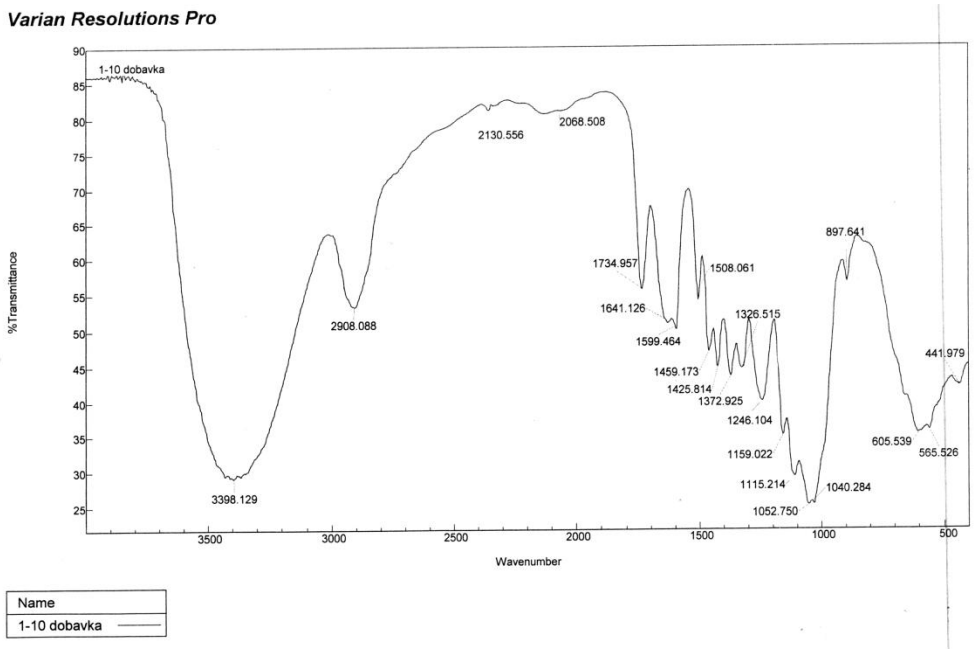
coordination bonding of the metal ions with oxygen atoms of the cellulose OH groups and the aromatic nucleus of the lignone macromolecule.



a)



b)



c)

Fig.9. Infrared spectra of: a) initial fibers; b) modified fibers; c) modified fibers with added bonding agent

3.5.4. Electric conductivity of the composites

Table 3 presents the results. All samples belong to the category of dielectrics. It is obvious that the electric resistances data of the composite samples are close between them and do not differ significantly from the zero samples.

Table 3. Composite electric conductivity

Sample	0	1	2	3	4	5	6
Ω/m	6.10^8	2.10^8	$1{,}2.10^8$	6.10^8	$2{,}1.10^8$	2.10^8	8.10^8

3.5.5. Microwave absorption of the ferrite wood fibrous composites

Figure 10 presents graphically the data of the microwave absorption

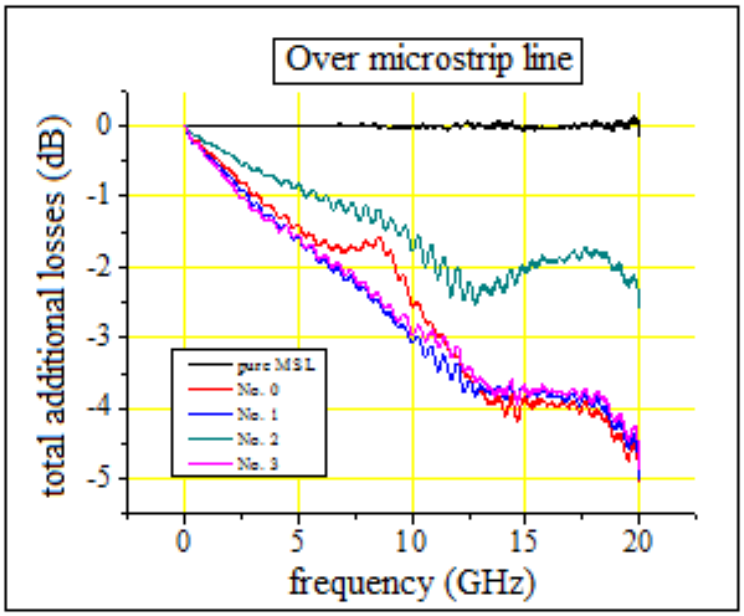


Fig. 10. Microwave losses depending on the frequency

The diagram shows that with increase of the wave frequency the losses in dB also grow as a result of the composite sample absorption (Lecheva 2008).

4. CONCLUSION

The results of the performed researches related to the development of method for production of wood ferrite fibers and on their base, respectively, composites as well as investigation of the properties of the produced new materials lead to the following summarizing and conclusions:

- Method is developed for wood fiber modification by two-component Fe^{+2} and Fe^{+3} system and the following optimum conditions for deposition in the lignocellulose matrix of suitable proportion of the two components in the ferrite system are determined.
- There are prepared, by the pressing method, wood ferrite fibrous composite materials on the base of the modified wood fibers and wood fibrous mass from the current production of Lesoplast Ltd.

On the basis of the results from the development of the method and the characterization of the produced wood fibrous ferrite composite samples in relation to iron content, physical-mechanical indicators and electrical conductivity the following dependences are defined:

1. Optimum results with respect to the iron content in the fibers and the losses in the solution are achieved when modifying wood fibers by the two-component ion Fe^{+2} and Fe^{+3} system under the following conditions: proportion 1:10 and duration 5 minutes for fibers not containing (PF) and for fibers containing (PF) at proportion 1:20 and duration 5 minutes, respectively.

2. The XRD-ray analysis has proven the presence of magnetite of particle nano-size. The peak in the roentgenogram is clearly expressed that is a proof for successfully run modification of the wood fibers.

3. High values of the physical-mechanical characteristics (three-point bending strength, tensile strength and elasticity modulus) are achieved for composites of lower percentage of modified fibers.

4. With respect to the impact strength indicator, increase of the impact strength is observed with decrease of the modified fibers for all composite samples.

5. The produced composite materials are dielectrics. The data about the electrical resistance are close between them and do not differ significantly from the initial sample.

6. The analyses of the microwave absorption have shown that the presence of magnetite particles in the samples results in adsorbing the microwaves in the composite samples.

The complete research shows that the developed ferrite wood fibrous composite materials have comparatively good physical-mechanical characteristics towards a high content of the wood component and present a new valuable product for practical application.

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