Textile material-based grid structure for EM attenuation

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ABSTRACT – REZUMAT

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This paper presents several aspects concerning materials with potential applications for electromagnetic shields. For this objective, grid structures coated by ultrasound treatments in conductive polymeric dispersions were designed to obtain appropriate models for electromagnetic attenuation. To anticipate the potential use of these samples in EM shields, the samples were analysed to observe the values for electrical resistance.

Keywords: *textile, electromagnetic attenuation, resistance, conductive, EM shields*

Material textil pe bază de structură tip reţea pentru atenuare EM

Această lucrare prezintă câteva aspecte privind materialele cu aplicaţii potenţiale pentru ecranare electromagnetică. Pentru realizarea acestui obiectiv, structurile tip reţea au fost tratate prin ultrasonare utilizând dispersii polimerice conductive concepute pentru a obţine modelele adecvate pentru atenuare electromagnetică. Pentru a anticipa potenţialul de utilizare a acestor probe în cadrul ecranelor EM, probele au fost analizate pentru a observa valorile rezistenței electrice.

Cuvinte-cheie*: textil, atenuare electromagnetică, rezistenţă, conductiv, ecran EM*

INTRODUCTION

All electrical and electronic equipment are sources of electromagnetic disturbances so that they can cause problems for other electrical/electronic devices. Electrical interference can also affect them, which means they are receivers. In general, shielding systems are expensive and increase the weight of the equipment [1].

Electromagnetic inferences/disturbances and pulses affecting aircraft, medical equipment, navigational instruments and signalling systems are classified as health and safety hazards [1–3].

Familiar sources for electromagnetic pulses are radio, TV, radar equipment, power lines, electronic circuits, light intensity control devices, electric arc welding machines, electric motors, storms with electrical discharges and enormous solar flares, and weapons with electromagnetic pulses. The principal receivers (potential victims) are radio and TV receivers, home devices, computers, and phones. In general, sources and receivers have no problem as long as they are not connected, and by eliminating the coupling, protection against electromagnetic fields can be obtained [1–3].

The primary way to transmit the electromagnetic pulses can be obtained through [1]:

- Transmitted coupling path – electromagnetic disturbance travels through cables and pipes. The coupling can be inductive magnetic or capacitive electrical coupling [1–3].
- Radiated coupling path – the electromagnetic disturbance travels through the air as waves. Its energy is absorbed and generates a current flow in the receiving cable/pipe or the electronic equipment [1–3].

Electromagnetic protection can be achieved by electromagnetic attenuation through reflection. The electromagnetic wave represents the incident electromagnetic field that propagates in the direction of the screen, undergoes a reflection in contact with the screen and repeated internal reflections inside the screen, and part of the wave is also sent into the screened space. At low frequencies, magnetic materials can channel magnetic fields in a specific area of space [1, 2, 4–7].

Electromagnetic protection can be achieved by electromagnetic attenuation through absorption [1, 2].

At the incidence of an electromagnetic wave with a surface separating two media with different electrical properties – the first being free space and the second – the screen (textile surface with conductive or magnetic properties), the two components, the electric field and the magnetic field, transmitted to the screen, undergo changes that can be appreciated by comparing the surface impedances Zs of the two media [1–3].

$$Zs = E / H \tag{1}$$

where H is the magnetic field intensity and E is the electric field intensity.

For EM shielding, materials based on polymer matrices containing carbon, copper (Cu), nickel (Ni), aluminium (Al), iron, and carbon nanotubes (CNTs) as well as conductive polymers (e.g., PEDOT PSS –

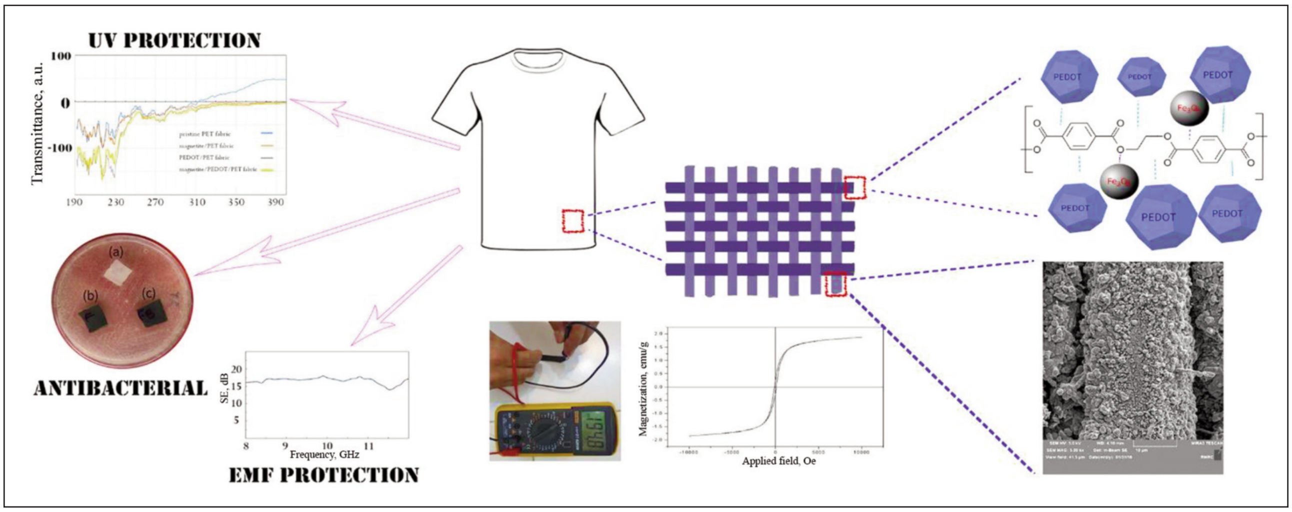


Fig. 1. Multifunctional fabric for electromagnetic shielding [11]

figure 1) are used. Other metals, such as platinum (Pt), gold (Au) and silver (Ag), are not recommended for this purpose because they are costly [7–9].

By incorporating conductive and magnetic textile materials, multifunctional, flexible and wearable substrates can be created. Some research has shown the use of magnetic nanoparticles with the PEDOT PSS polymer to create a superconductive fabric [3, 9–11].

EXPERIMENTAL PART

During the research, 15 fabric samples with electroconductive properties were made based on ultrasound technology. A 100% cotton fabric (BBC) with the following characteristics was used to make the experimental samples:

- mass per surface unit 129.38 g/m^2;
- thickness 0.824 mm;
- density in the direction of the warp 60 threads/10 cm;
- density in the weft direction 70 threads/10 cm;
- elongation at break in the warp direction 6.13%;
- elongation at break in the weft direction 8.65%;
- water vapour permeability 31.3%;
- air permeability 3298 l/m^2/sec at a pressure of 100 Pa.

For the realization of the 15 experimental samples of fabrics, (A1 – A15) functionalized by treatment in dispersions based on microparticles of nickel (Ni), copper with a particle size smaller than 63 μm, or graphite, the technology of cleaning and deposition by ultrasound was used for 60–100 minutes.

Polyvinyl alcohol (PVA), polyvinylpyrrolidone (PVP), polyethylene glycol (PEG), gelatin, citric acid and metal microparticles of Cu and Ni, respectively graphite, were used to obtain electroconductive properties.

The samples were treated by ultrasound for 60–100 minutes in dispersions based on polymer matrices (PVA, PEG, PVP) and microparticles of Cu, Ni and graphite, followed by drying at a temperature of 170–180°C for 8–10 minutes (table 1).

Table 1 shows that only samples A5 and A6 have specific characteristics of conductive materials that can be used for electromagnetic shielding.

Table 2 shows the images obtained by electron microscopy (magnitude 60x) of fabrics A0 (without ultrasound treatment) and fabrics A1 – A15 functionalized by ultrasound in dispersions based on polymers (PVA, PEG, PVP) and microparticles of Cu, Ni or graphite.

RESULTS AND DISCUSSION

In previous research to evaluate the attenuation of electromagnetic shields, the following specific equipment was used (from the INCDIE ICPE-CA endowment): coaxial cell model TEM 2000; oscilloscope Tektronix model MDO 3102; power amplifier Model SMX5; and signal generator type E8257D. The measurements were performed in the frequency range of 0.1 MHz – 1 GHz.

Analysing the experimental samples obtained for electromagnetic shielding, we observed that 2 representative samples (A5, A6) obtained by ultrasound present relevant characteristics for electromagnetic shielding such as electrical conductivity, and can lead to values of electromagnetic efficiency between 17 dB and 22.9 dB for low or high frequencies.

CONCLUSIONS

In conclusion, by analysing experimental models A1 – A15, the following can be concluded:

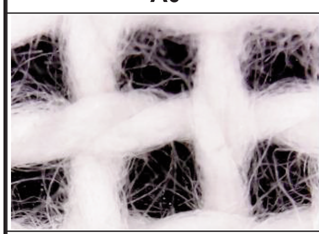
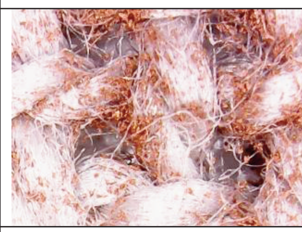
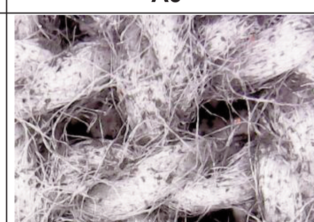
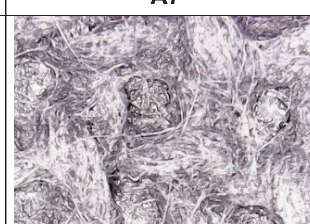
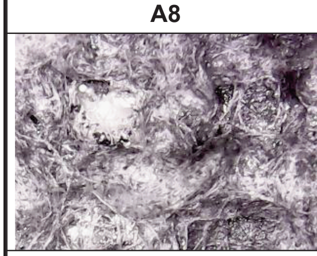
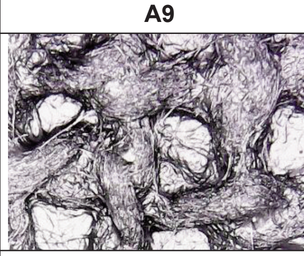
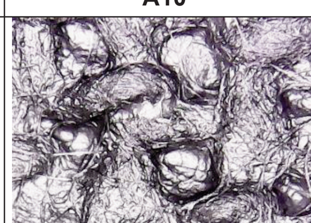
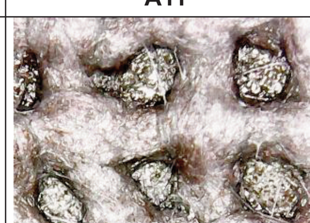
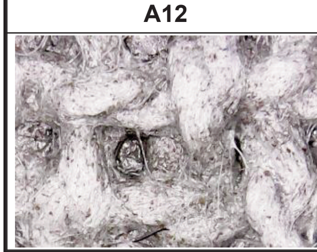
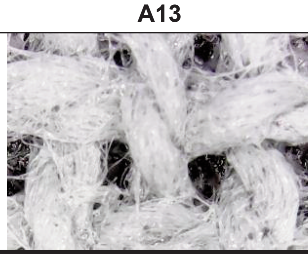
- Experimental models A1 – A4 and A13 – A15 present values of surface electric resistance specific to antistatic materials and are not recommended for use in electromagnetic shielding systems because they do not shield electromagnetic radiation;
- The experimental models A7 – A12 present values specific to semiconductor materials that cannot conduct electric current and are not recommended for electromagnetic shielding;
- The experimental models A5 – A6 based on graphite microparticles can be used for electromagnetic shielding systems because they are conductive.

Table 1

EXPERIMENTAL SAMPLES FUNCTIONALIZED IN DISPERSIONS BASED ON POLYMER MATRICES CONTAINING MICROPARTICLES OF CU, NI OR GRAPHITE												
No.	**PVA**	**PVP**	**PEG**	**Citric acid**	**H_2O**	**Gelatin**	**Ni**	**Cu**	**Grafit**	**Al**	**Rs* (Ω)**	**Electroconductive property**
A1	x	x			x			x			10^9	Antistatic
A2		x	x		x			x			10^8	Antistatic
A3	x	x			x		x				10^9	Antistatic
A4		x	x		x		x				10^8	Antistatic
A5	x	x			x				x		10^4	Conductive
A6		x	x		x				x		10^3	Conductive
A7		x	x		x	x	x				10^6	Semiconductor
A8			x		x	x	x				10^7	Semiconductor
A9			x		x	x			x		10^7	Semiconductor
A10		x	x		x	x			x		10^7	Semiconductor
A11			x		x	x		x			10^7	Semiconductor
A12		x	x		x	x		x			10^7	Semiconductor
A13		x	x	x	x	x		x			10^9	Antistatic
A14			x	x	x	x		x			10^9	Antistatic
A15		x	x	x	x	x		x			10^9	Antistatic

Note: * Rs – surface electrical resistance.

Table 2

ANALYSIS OF THE SURFACE TOPOGRAPHY OF SAMPLES A0–A15 BY DIGITAL ELECTRON MICROSCOPY WITH MAGNITUDE 60X			
A0	**A1**	**A2**	**A3**
			
A4	**A5**	**A6**	**A7**
			
A8	**A9**	**A10**	**A11**
			
A12	**A13**	**A14**	**A15**
			

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