



## ANTIBACTERIAL AND DIELECTRIC PROPERTIES OF TEXTILE MATERIALS MODIFIED WITH HERBAL EXTRACT OF *Picea omorika* AND THE COPPER FERRITE NANOPARTICLES

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### ABSTRACT

**Abstract:** In this paper, cotton, polyester and cotton/polyester fabrics were modified by using herbal extract of *Picea omorika* and copper ferrite nanoparticles and their antibacterial and dielectric properties were investigated. Antibacterial activities of all samples were examined against *Escherichia coli* and *Staphylococcus aureus*. The most of the fabrics modified by copper ferrite showed antibacterial activities against *Escherichia coli*, while the addition of the herbal extract improved their antibacterial protection. Dielectric properties were measured in frequency range from 24 Hz to 75 kHz at room temperature and the results showed that the modification of all three fabrics with copper ferrite caused increase in their AC conductivity. The obtained results point to the possibility of using investigated fabrics for antibacterial protection as well as for the electromagnetic shielding application.

**Keywords:** Antibacterial properties, Dielectric properties, Fabrics, Herbal extract of *Picea omorika*, Copper ferrite nanoparticles.



Figure 1. Experimental setup for a measuring of the dielectric properties.



Figure 2. LD-3 Rigid Dielectric Cell for dielectrical measurements.

### RESULTS AND DISCUSSION

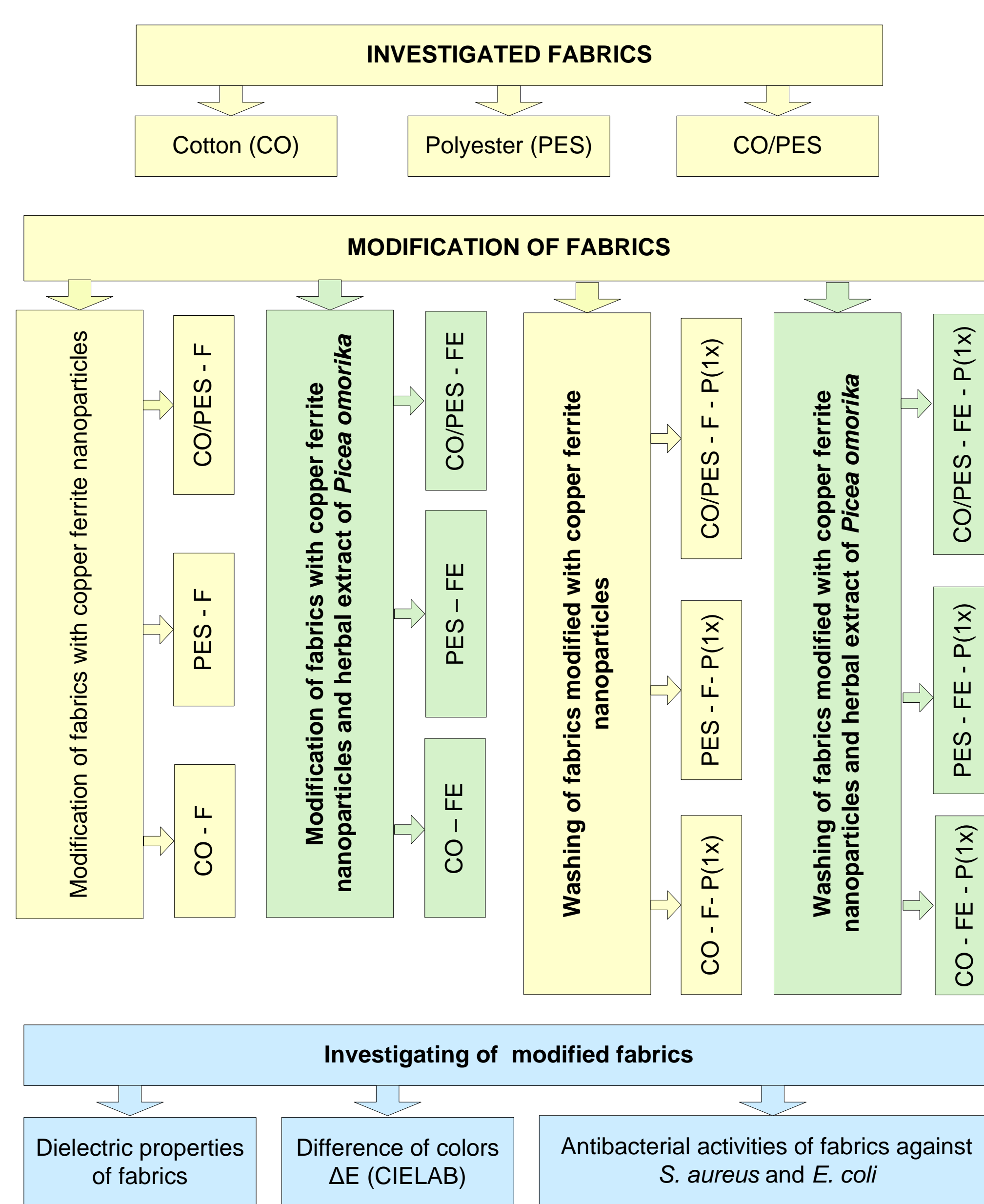


Figure 3. Experimental details

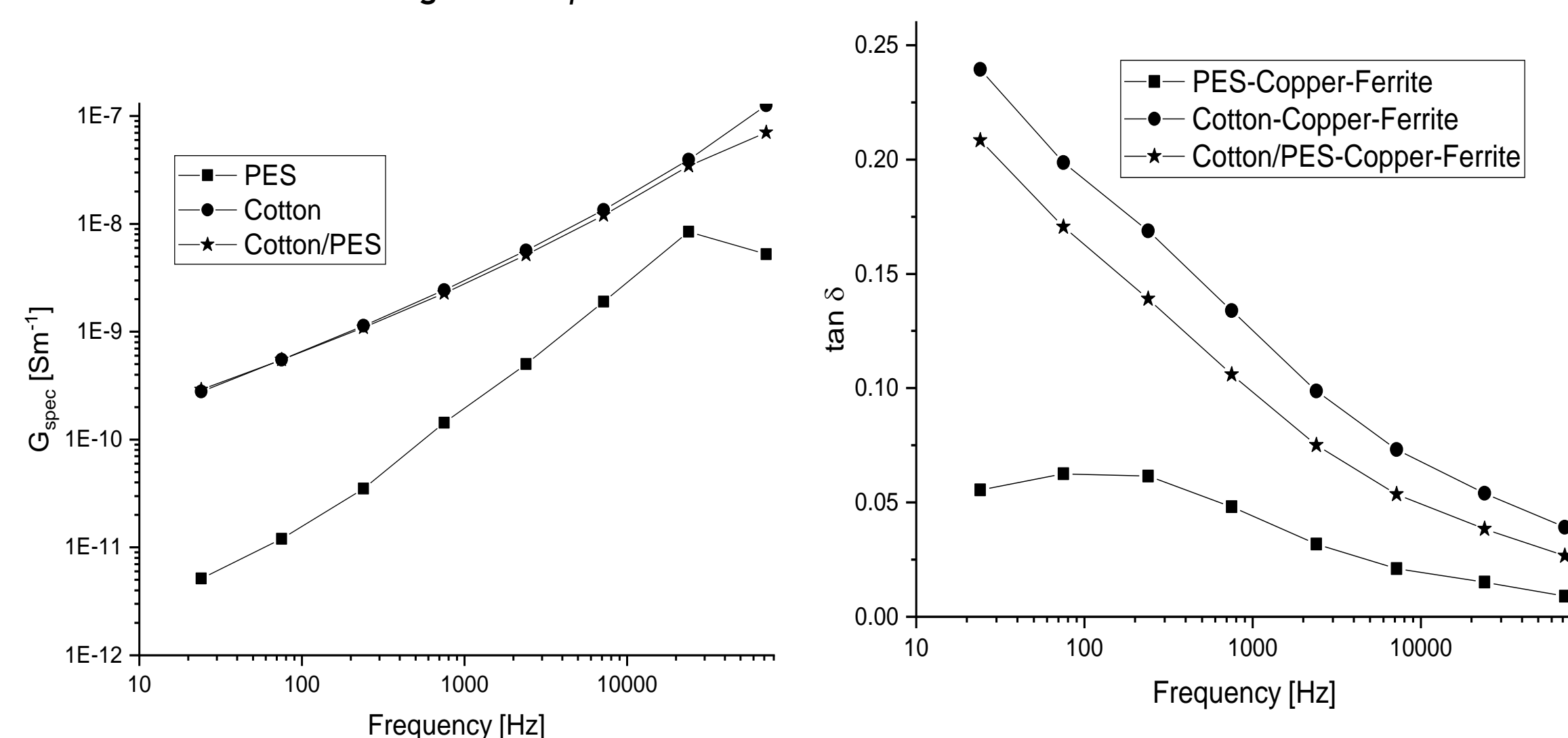


Figure 4. Frequency dependence of specific conductance of unmodified cotton, polyester and cotton/polyester fabrics at room temperature.

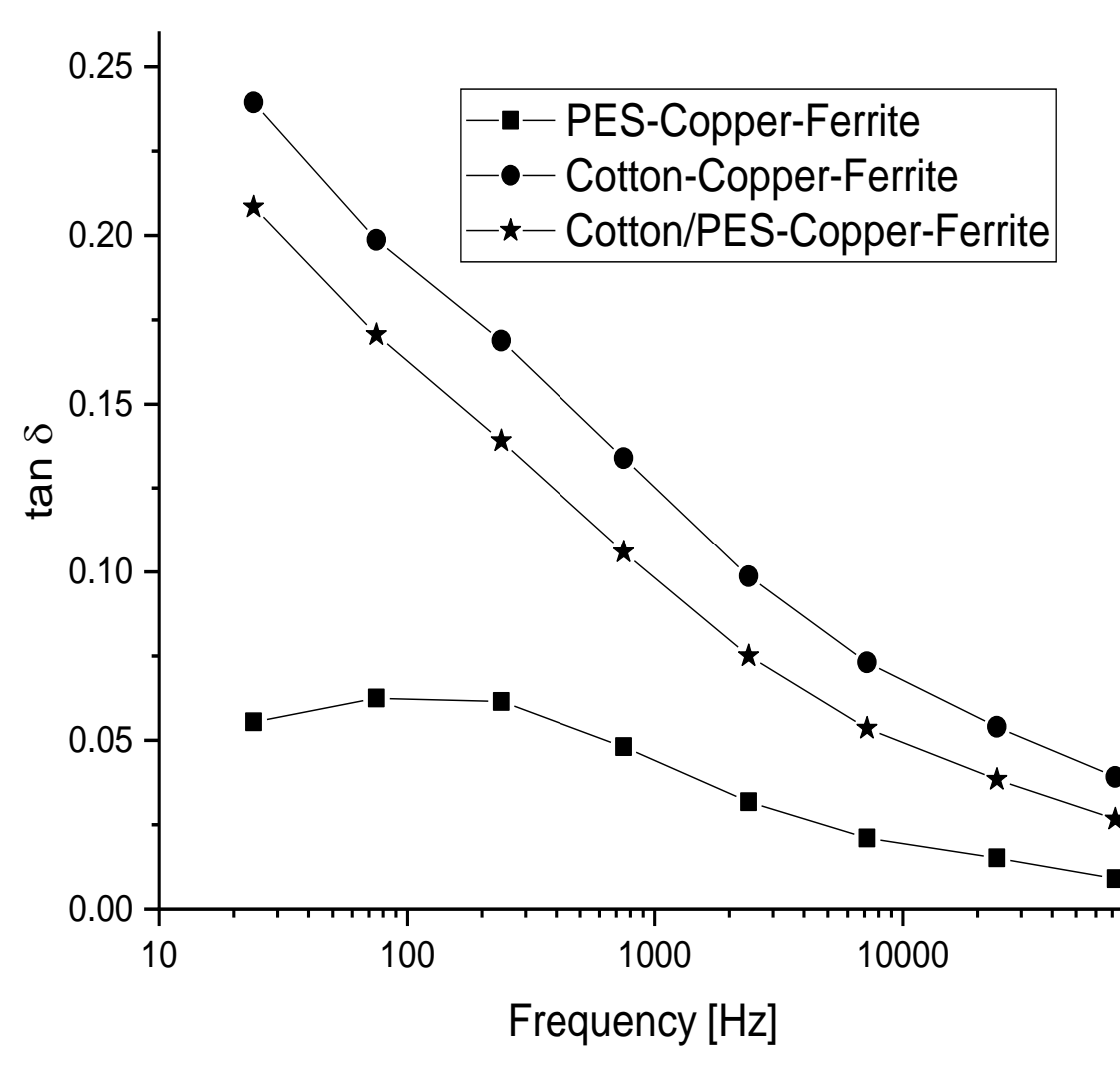


Figure 7. The  $\tan \delta$  as a function of frequency for all the samples modified with copper ferrite nanoparticles at room temperature.

### Dielectric measurement

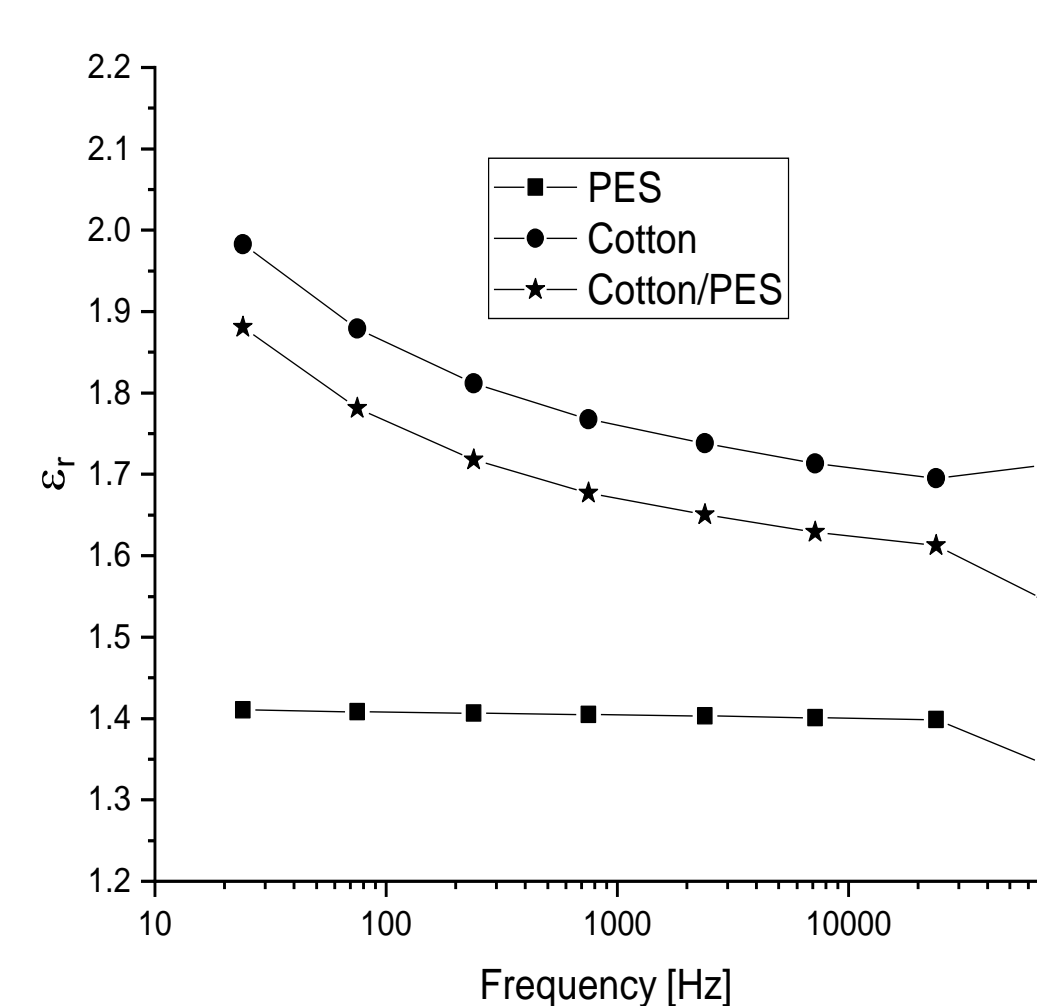


Figure 5. The dielectric permittivity as a function of frequency for the samples: cotton, polyester and cotton/polyester fabrics without modification at room temperature.

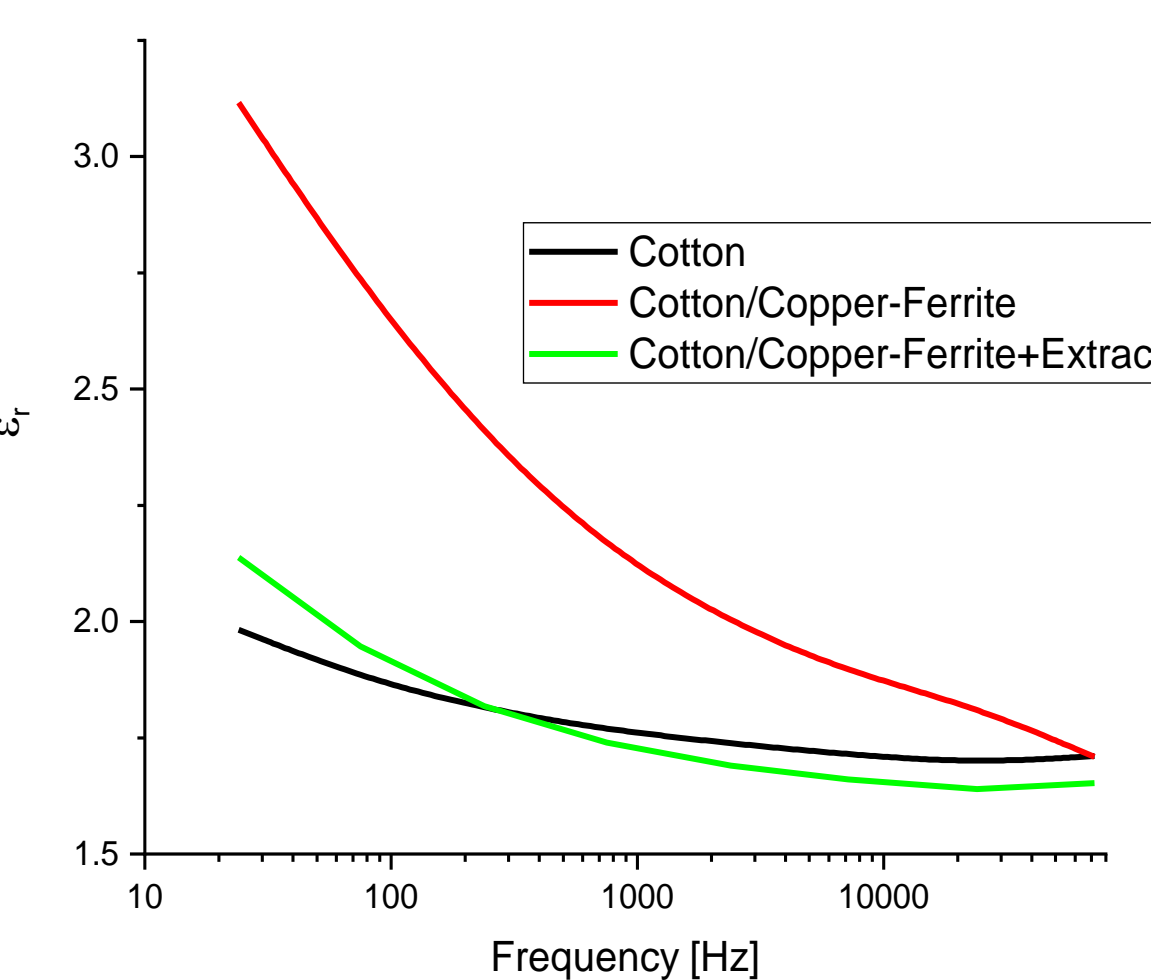


Figure 6. The dielectric permittivity as a function of frequency for the samples: cotton fabric, cotton fabric modified with copper ferrite nanoparticles and cotton fabric modified with copper ferrite nanoparticles and herbal extract of *Picea omorika*.

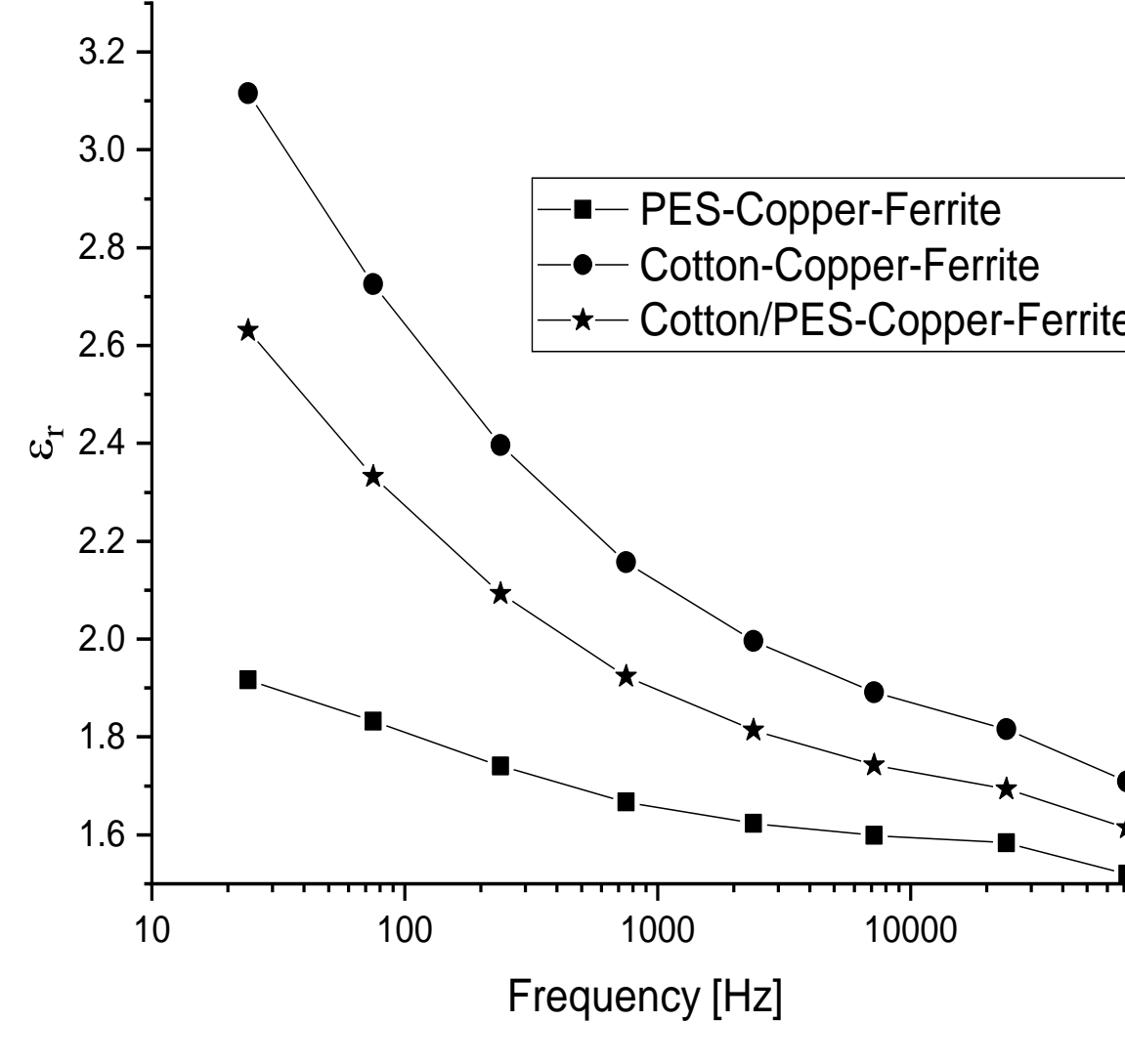


Figure 8. The dielectric permittivity as a function of frequency for all the samples modified with copper ferrite nanoparticles at room temperature.

### Antibacterial properties

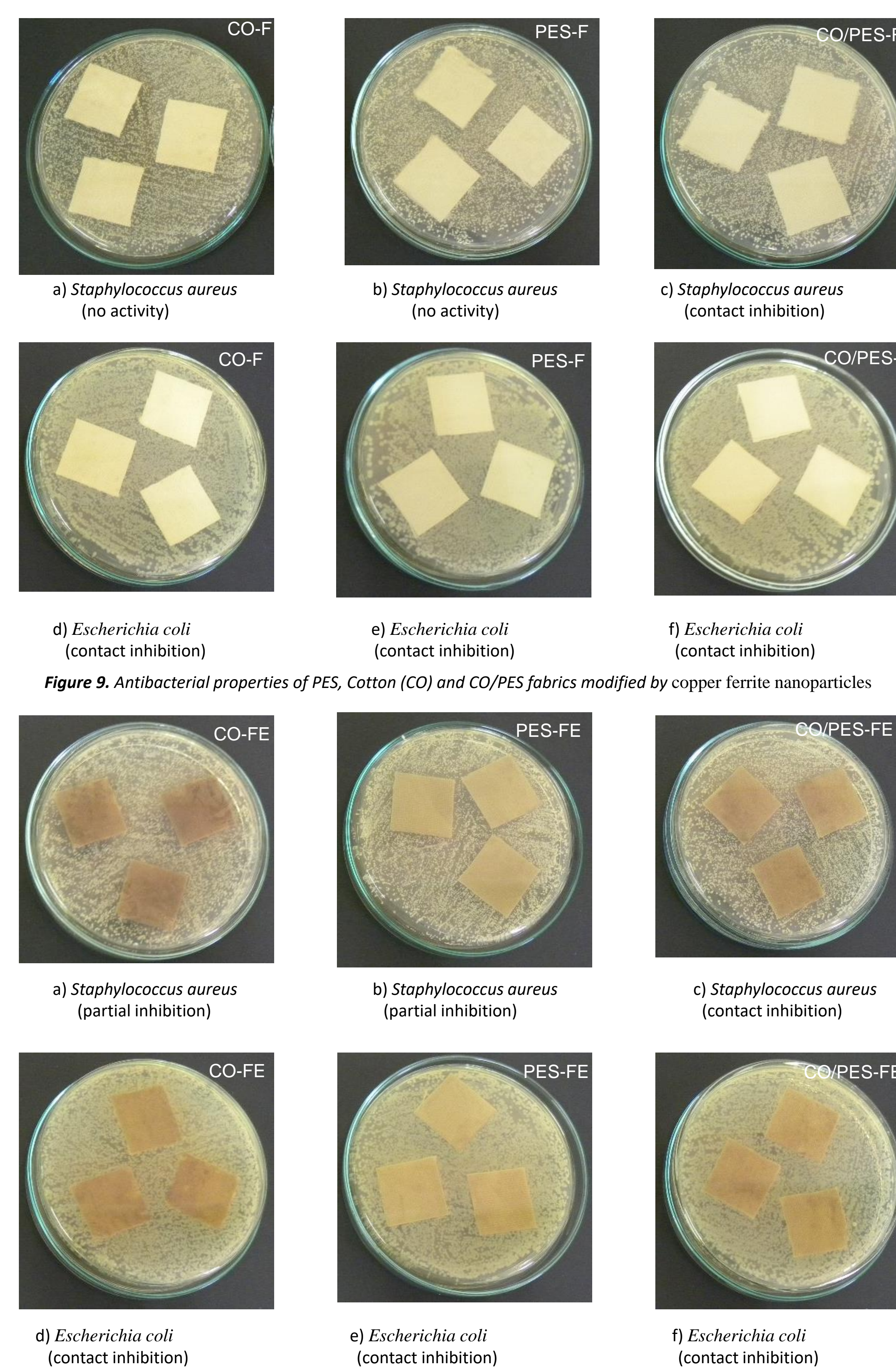


Figure 9. Antibacterial properties of PES, Cotton (CO) and CO/PES fabrics modified by copper ferrite nanoparticles

Figure 10. Antibacterial properties of PES, Cotton (CO) and CO/PES fabrics modified by copper ferrite nanoparticles and herbal extract of *Picea omorika*.

### CONCLUSIONS

After the study of the dielectric and antibacterial properties of unmodified fabrics and fabrics modified with copper-ferrite nanoparticles and herbal extract of the *Picea omorika*, it was found that:

- All fabrics modified with copper-ferrite nanoparticles show antibacterial activity, which acts as contact inhibition against *Escherichia coli*, while against *Staphylococcus aureus* antibacterial activity was observed only in the CO/PES fabric modified with copper-ferrite nanoparticles.
- Antibacterial activity against *Staphylococcus aureus* and *Escherichia coli* was observed in all fabrics modified with copper-ferrite nanoparticles and alcoholic herbal extract of the *Picea omorika*.
- Cotton and PES fabrics modified with copper-ferrite nanoparticles and alcoholic herbal extract of the *Picea omorika* show an enhanced antibacterial activity, which acts as partial inhibition on *S. aureus*. This is explained by the presence of herbal extract of the *Picea omorika* in the solution of copper-ferrite nanoparticles, because the herbal extract shows a good effect against gram-positive bacteria, which includes *S. aureus*.
- The results of the antibacterial activities of the modified fabrics after washing also showed better antibacterial activities against *E. coli*, except in cotton fabrics in which no activity was observed.
- Specific conductance of cotton and cotton/polyester fabrics are about one order of magnitude higher than value of specific conductance of polyester sample. At lower frequency there are no significant differences between specific conductance of cotton and cotton/polyester samples, while at higher frequency specific conductance of cotton is 78% higher than for cotton/polyester sample.
- As expected, based on conductivity of the copper ferrite nanoparticles, the specific conductance of the all samples increases by sample modification with copper ferrite nanoparticles. The values of specific conductance of samples additionally modified with herbal extract of *Picea omorika* are between the values of unmodified samples and samples modified with copper ferrite nanoparticles.
- At frequency of 24 Hz, unmodified cotton fabric has value of the dielectric permittivity 2, while cotton modified with copper ferrite nanoparticles has value of 3.2. The dielectric permittivity of all samples decreases with increase in frequency.
- It was found that the values of  $\tan \delta$  for all samples modified with copper ferrite nanoparticles decrease with increasing frequency. Additionally, for the PES sample modified with copper ferrite nanoparticles it was recorded the peak at frequency about 200 Hz.
- All results indicated that cotton fabrics modified with copper ferrite nanoparticles showed more pronounced increase in conductance than other fabrics, also if one want to develop material with good antibacterial properties and better conductivity than pure fabrics the best choice is cotton fabric modified with both, copper ferrite nanoparticles and herbal extract of *Picea omorika*.