GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

BIOLOGICAL ORIGIN FILLERS AND METAL NANOPARTICLES EFFECT ON DIELECTRIC AND ELECTRICAL PROPERTIES OF LDPE+X VOL%FB BIOCOMPOSITES

Gojayev E.M.[1], Aliyeva Sh.V.[2], Mammadova S.I.[3], Babayev U.T.[4] & Aliyeva B.V.[5]

[*1] Professor. Department of Physics, Azerbaijan Technical University, Baki, Azerbaijan
[2] Doctorant,. Department of Physics, Azerbaijan Technical University, Baki, Azerbaijan
[3] PhD. Department of Physics, Azerbaijan Technical University, Baki, Azerbaijan
[4] Master,. Department of Physics, Azerbaijan Technical University, Baki, Azerbaijan
[5] Doctorant,. Department of Informatics, University Land of fire , Baki, Azerbaijan

ABSTRACT

The presented work presents the results of studying the temperature dependences of the dielectric constant and tangent of the dielectric loss angle and specific volume resistance of biocomposites LDPE + x vol% FB and bionanocomposites LDPE + x vol% FB +1 vol% Cu in the temperature range 290 - 390K.It was revealed that with an increase in the volume content of a bio-filler, the dielectric constant increases, and the specific resistance and dielectric loss decreases. It was revealed that with a change in the volume content of the filler of biological origin of the metal nano particle and temperature, it is possible to control the optimal values of the dielectric and electrical parameters of the studied biocomposites.

Keywords: *Fishbone, dielectrical permittivity, biological origin, low density polyethylene, volume resistance, dielectric loss, temperature dependence, biofillers*

I. INTRODUCTION

There is information on the preparation of novel composite materials based on polymers with fillers of different kinds of wastes including biological origin.The choice of such fillers is not accidental. The analysis of periodic literature shows that fillers of biological origin are sufficiently strong natural polymers against external influences. In addition, their use has great economic benefits. Because in the course of economic difficulties, the study and application of materials that are completely natural and have cheap costs have become one of the urgent problems of our time. Studies have shown that fish waste is a complex multicomponent system, consisting mainly of minerals and collagen. It is known that a large proportion of the waste of commercial fish mainly consists of bones, leather and scales, which in real conditions of the processing enterprises were mainly directed to the production of feed meal. This waste belongs to collagen-containing raw materials that are promising to produce natural-forming structures, which has a wide range of uses in various sectors of the food industry and national economy.

In particular, gelatin obtained by processing collagen-containing raw materials is a hydrolyzed collagen solution. It has a number of features and is a unique substance with specific chemical and amino acid composition and physico-chemical characteristics, which are widely used in the food industry, medicine, cosmetology and other sectors of the national economy [1-8]. By its nature, collagen - a connective tissue protein is considered as a valuable source of dietary fiber [5, 7], its composition is not inferior to terrestrial sources of ballast substances. Membranes, monolayers, and multilayer structures can be made from collagen material. Films (monolayer, multilayer, three-dimensional matrices) [3,4], prepared from collagen materials, are among the most interesting materials from the point of view of both practical use and theoretical research. Such films are interesting for biomedical applications [5]. Using nanorods and nanowires (for example, carbon nanotubes or silver / gold nanowires) and other additives (for example, sulfonic liquid crystals), one can modify the optical and electromagnetic properties of collagen films. On the other hand, to meet the requirements of the rapidly developing modern technology, it is necessary to search for and obtain materials with a new complex of physicochemical properties. In this respect composite materials, the main advantage of which is that materials and structures are created simultaneously,

ISSN 2348 – 8034
Impact Factor- 5.070

and the properties of materials are controlled by variation of the content and composition of the matrix and filler have enormous advantages. The properties of composite substantially depend on the material of filler. In the modern literature there are numerous works devoted to the preparation and study of composite materials with various fillers [9]. In this work, to obtain new type composites, we used fillers of the biological origin of fish bone (FB) as filler.

In light of the foregoing, the purpose of this work is to obtain new nanocomposites with biological fillers and to study the effect on the surface structure and dielectric properties of metal nanoparticles.

II. METHOD & MATERIAL

Electrical parameters of composites LDPE+x vol. % FB and nanocomposites LDPE + x vol.% FB + 1vol.% Cu we measure on the equipment which scheme shown in fig.1 where, 1- measuring cell, 2 – sample, 3 - thermocouple,4 - heater, 5 - immitance meter, 6– termometer,7 – three phase LATR (laboratory transformer) system.Temperature adjustment was performed using a tri-LATR system. Measurement of the dielectric constant and the tangent of the dielectric loss angle were carried out using an automatic bridge E8-4 at a frequency of 1 kHz in the temperature range 300-500K on the installation shown in Fig.1 [11].

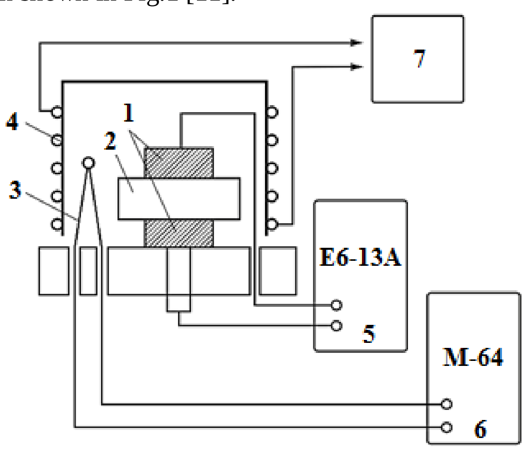


Fig. 1. Block diagram of the installation for measuring the temperature dependence of the dielectric constant and dielectric loss.

The measurement of the ρ of the samples was carried out using an E6-13A teraohmmeter in the temperature range 300-500K with linear heating.

III. RESULTS AND DISCUSSION

The results of the study of temperature dependences of the dielectric constant and dielectric loss of biocomposites LDPE+x vol.% FB with fillers 3, 5, 7,10 and 15 vol%FB are presented in fig. 2. Studies were conducted in temperature interval 300-380K. As follows from Fig.2a characteristic of all studied composites, there is a relatively weak increase in the dielectric constant. In particular, for composites with fillers 3, 5, 7, 10 and 15 vol% FB at room temperature $\varepsilon$is 11.49, 11.74, 12.06, 12.22, and 12. 97 at 373K, these values are 11.55, 11.95,

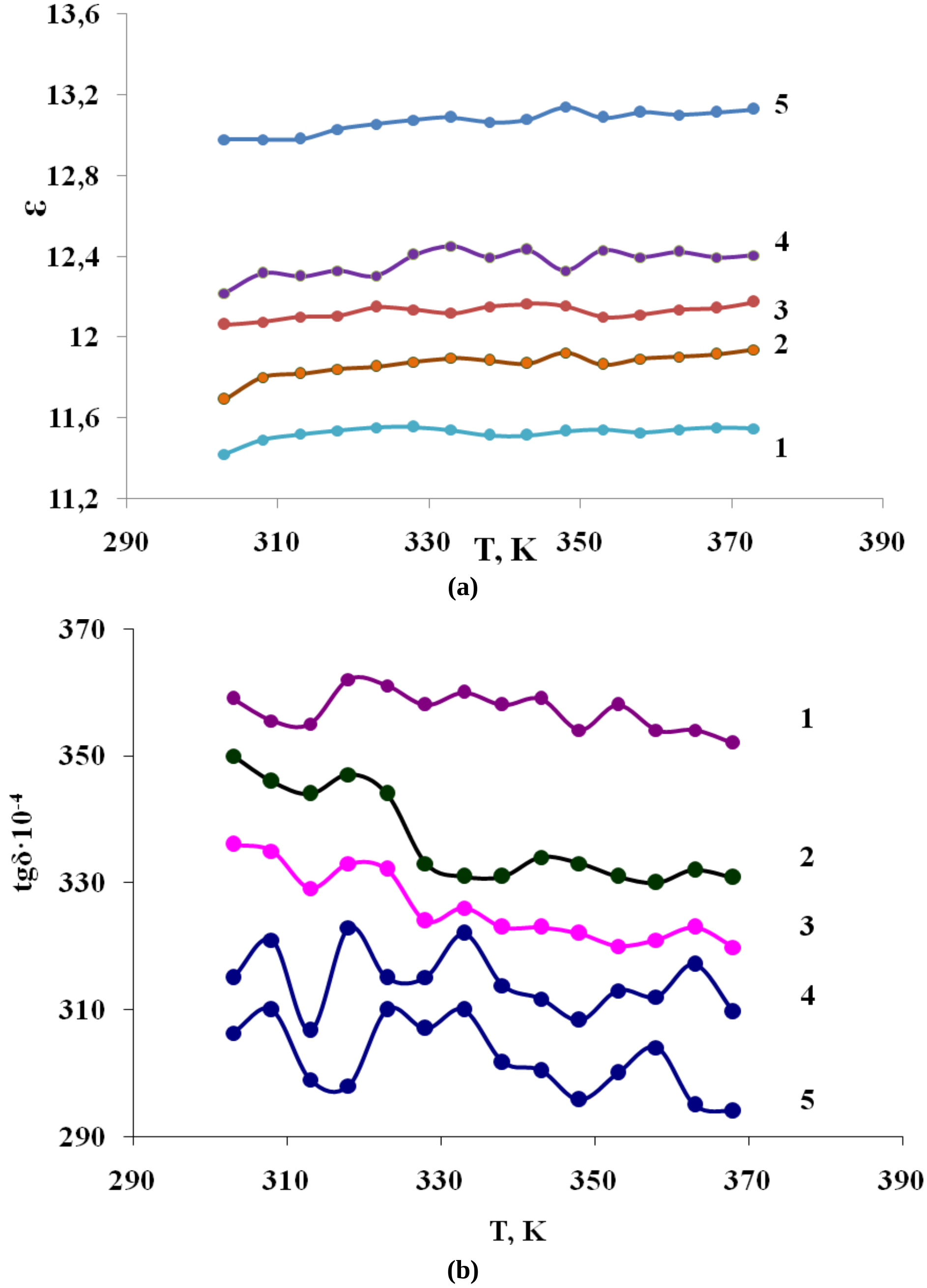


Fig. 2.The temperature dependences of the dielectric constant (a) and dielectric loss (b) of biocomposites LDPE+x vol.% FB where, 1-x-3, 2-x-5, 3 -x- 7, 4 -x -10, 5 -x-15 vol%FB

12.173, 12.4, and 13.13 respectively. An increase in the dielectric constant was also observed with an increase in the volume content of the fish bone filler. In general, the character of ε(T) dependences in the studied biocomposites are almost the same.

Temperature dependence study results of the dielectric loss of LDPE+ x vol.%FB biocomposites with fillers 3,5,7,10 and 15 vol% FB are shown in fig. 2b. As follows from fig. 2b. the character of the *tgδ (T)* change for composites with the bulk content of fillers 3 and 5vol.%FB is slightly different,there are weak maximum on the *tgδ(T)* curves. For composites with fillers 7, 10, and 15vol.%FB, the character of the change *tgδ(T)* is almost the same, a slight decrease in dielectric loss is observed with increasing temperature. With an increase in the volume content of the filler, *tgδ* decreases over the entire temperature range studied.

Also investigated temperature dependence of volume resistivity composites LDPE +x vol.% FB with fillers 3, 5, 7 vol.%FB. The results are presented in Fig. 3, from which it follows that at low temperatures it is characteristic of all investigated composites that a slight decrease in ρ_v is observed , and with a further increase in temperature ρ_v practically unchanged. In investigated composites LDPE + x vol .% FB with an increase in the volume content of the filler, a decrease in the value of the volume resistance is observed.

Figure 4 shows the temperature dependence of the permittivity *(ε)*, dielectric loss tangent *(tgδ)* and volume resistivity of nano composites LDPE + x vol.% FB + 1vol.%Cu. Studies were conducted in composites LDPE + x vol.% FB with fillers 3; 5; 10 and 15vol.% FB and 1vol. %Cu. As follows from figure 4a. on the curve *ε (T)* dependences of the composite LDPE+3vol.%FB+ 1vol.%Cu. There is a single maximum at a temperature of 328K and two weak minimum at 323 and 333K, respectively. In general, as the temperature increases from room temperature to 393K, the dielectric constant increases from 13.49 to 13.64.
On the curve temperature dependent and permittivity nanocomposites LDPE+10 vol.% FB+1vol.%Cu significant responses are not detected, and to this composite with increasing temperature from room temperature to 383K *ε* increases from 13.56 to 13.91. The variation of the dielectric constant of the composite with 15%vol.FB filler and 1vol.%.Cu depending on temperature is a

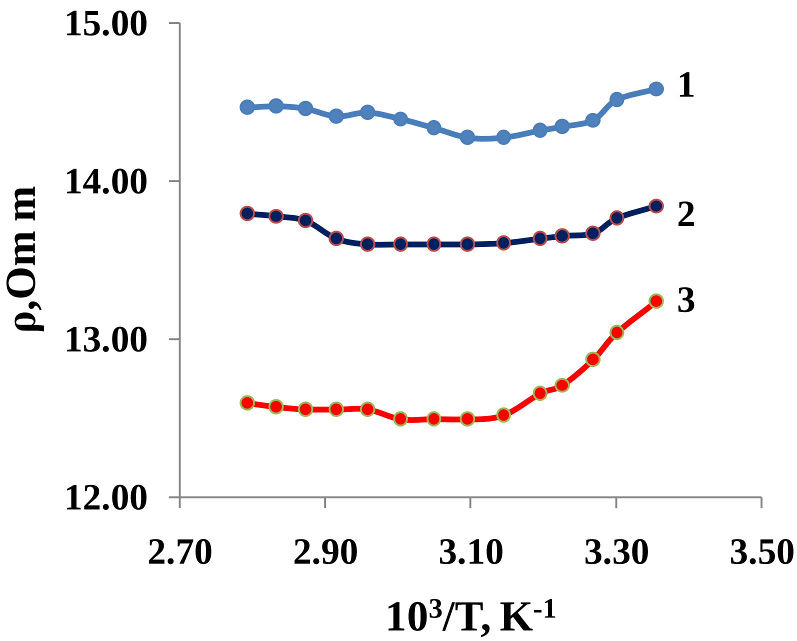


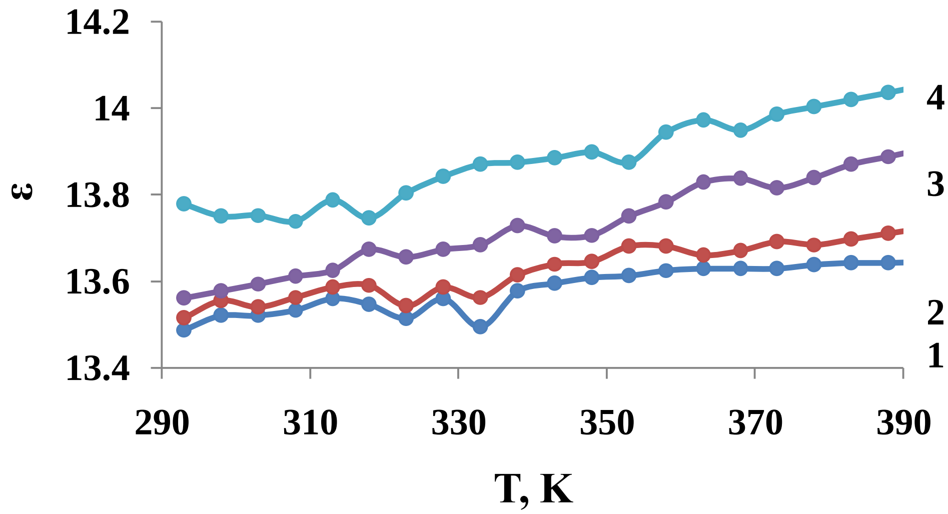
Fig. 3.The temperature dependence of volume resistivity composites LDPE +x vol.% FB with fillers 1-x-3, 2-x-5, 3-x-7vol.%FB.

similar nature, i.e. with increasing temperature from room temperature to 383K *ε* increases from 13.78 to 14.05 .
An increase in the dielectric constant is observed with increasing volume content fishbone in the composite, with the same content of metallic nanoparticles. Temperature dependence study results of the tangent of the dielectric loss angle of LDPE+ xvol.%FB +1vol.%Cu composites are given in fig.4b. As follows from fig.4b in composites with volumetric contents of fillers 10 and 15vol.% FB, the character of the change in *tan δ* with temperature does not differ significantly. At the curves at 323K, weak maximums are observed, and in general, in the temperature

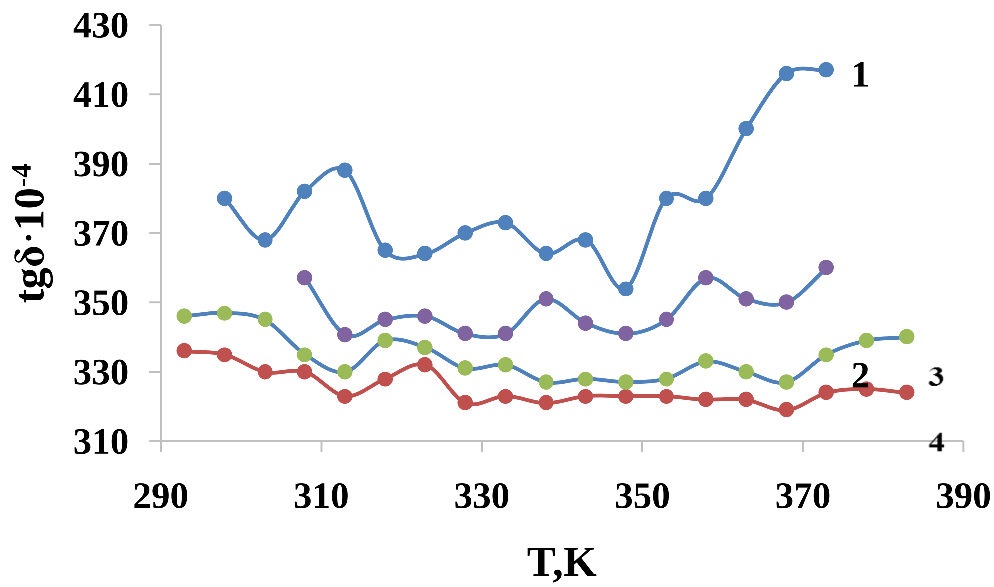
ISSN 2348 – 8034
Impact Factor- 5.070

range 293-383K *tgδ* for the composite with 15vol.% FB filler does not decrease significantly from 336 to 324. The decrease in *tgδ* for the composite with filler 10 (curve 3) and 15vol.%FB it was from 346 to 340.

Temperature dependences of *tgδ* composites with carbon aggregates of 10 (curve3) and 15vol.%FB (curve 4) is relatively complex. As follows from fig.4b (curve3) on the curve *tgδ (T)* at temperatures of 308K, 338K, 357K and 368K, weak maximum are observed. On the *tgδ (T)* curve of the LDPE+15vol.%FB+ 1vol.%Cu composite at 313 K, a clear maximum and weak maxima at 339K, 343K are observed. *tgδ* this composite from room temperature to 373K increases from 380 to 417. Note that *tgδ* in the studied composites with an increase in the volume content of the filler decreases.



(a)



(b)

Fig.4. The temperature dependences of the dielectric constant (a) and dielectric loss (b) of biocomposites LDPE+x vol.% FB+1 vol%Cu where, 1-x-3, 2-x-5, 3 -x- 10, 4 -x -15vol%FB.

[Gojayev, 6(1): January 2019] ISSN 2348 – 8034
DOI- 10.5281/zenodo.2531588 Impact Factor- 5.070

In Fig.5. presented the dependence lg ρv = f (1/T) for LDPE film and its modifications. Studies were conducted in nanocomposites LDPE+vol.%FB+1vol.%Cu, where, x = 3,5,7,10,15. As can be seen from Fig. 5 (curve 1), the specific volume resistance of a pure LDPE sample is linearly decreases with increasing temperature, after the introduction of the fish bone additives into the LDPE, the values ρ_v of the composites increase over the entire temperature range (curves 2,3,4,5).

The study results of the dielectric and electrical properties of composites LDPE + x vol .% FB and LDPE nanocomposites + 15 vol.% FB + 1 vol.% Cu can be explained as follows.

It is likely that an increase in the volume content of the filler in the composition of the composites studied leads to the growth of fish bone particles in the total thickness of the sample. Clusters closed on each other in the sample thickness can be considered as active resistance included between the electrodes.

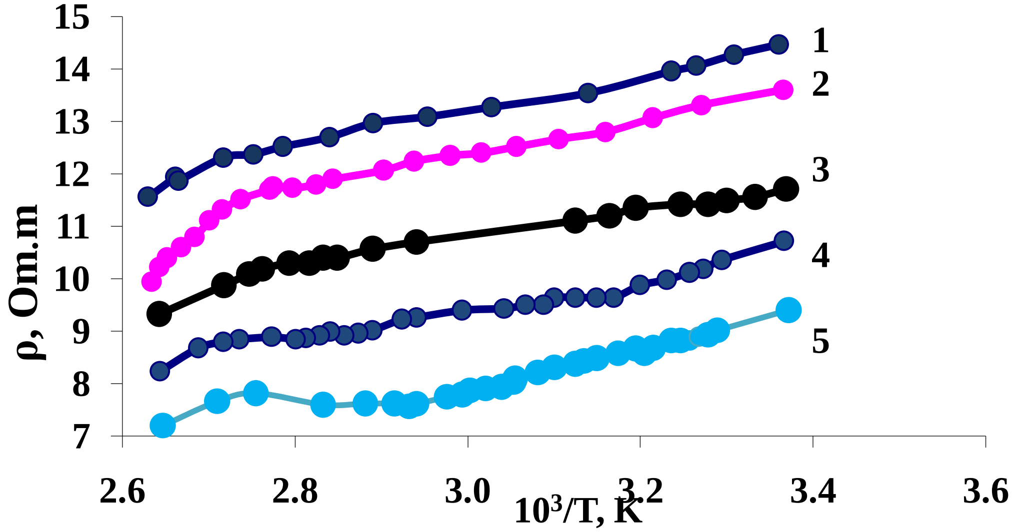


Fig.5.The temperature dependence of volume resistivity composites LDPE +x vol.% FB+1 vol%Cu with fillers 1-x-3, 2-x-5, 3-x-7, 4 -x -10, 5 -x-15 vol%FB.

Since fish bones have higher conductivity (10^{10} Ohm $^{-1}$) compared with LDPE (10^{15} Ohm $^{-1}$) [12], it can be considered that the resistance of the composite will mainly be determined by contacts between the fish bone particles. The accumulation and redistribution of free electric charges (Maxwell Wagner's volume polarization), which distorts its original internal electric field, occurs at the cluster boundaries in an alternating electric field. It is known [13] that at low frequencies the internal electric field is distributed according to the conductivity, and at high frequencies according to the dielectric constant. Consequently, a decrease in ε with an increase in the frequency of the measuring field can be explained by the appearance of a relatively strong internal field in the bone clusters.

REFERENCES

1. *T.H. Kao, R.G. Razumovsky. Development of optimal modes for the extraction of collagen from fish waste in the Volga-Caspian basin. // News of universities. Food technology. 2011, No. 1 (319), p. 33–36.*
2. *2. A.B. Kiladze. Fish waste - valuable raw materials // Fisheries. MGAVMiB them. K.I. Scriabin. 2004, No. 3, p. 58.*
3. *O.A. Pokusaeva, K.S. Zakharova, N.V. Dolganova, O.S. Yakubov. Development of food films on the basis of ichtiojelatin // Scientific achievements in solving actual problems of raw materials production and processing, standardization and food safety: Proc. IV Intern. scientific-practical conf. young scientists, graduate students, students. Kiev: Nat. University of Bioresources and Nature Management of Ukraine, 2014. p. 37–38.*
4. *Cisneros, D. et al., "Creating Ultrathin Nanoscopic Collagen Matrices for Biological and Biotechnological Applications", Wiley InterScience, 2007, vol. 3, No.6, pp. 956-963.*

5. V.V.Kovanov and I.A. Sychenikova.I.A. Sychenikov and others. Collagenoplasty in medicine. // Ed. M .: Medicine, 1978, 256 p.
6. Sarina Sulaiman, N. Khairudin, P. Jamal, M. Z. Alam, Zaki Zainudin, S. Azmi Characterization of Fish Bone Catalyst for Biodiesel Production World Academy of Science, Engineering and Technology International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering Vol:8, No:5, 2014, 476 -478
7. J.H.Muyonga, , Cole, C.G.B., Duodu, K.G. Extraction and physicochemical characterisation of Nile perch (Lates niloticus) skin and bone gelatine. Food Hydrocolloids, 2004,8, pp.581-592
8. S.K. Ghosh, D. Mandal. High-performance bio-piezoelectric nanogenerator made with fish scale. AppliedPhysicsLetters 109, 103701 (2016)
9. Berlin A.A. Modern polymer composite materials. - Soros Educational Journal. 1995, No. 1, pp. 57-65.
10. Yu. Ignatiev, V. Ya. Bazotov, V. F. Madyakin. The dielectric characteristics of ammonium nitrate with a moisture content of less than 0.1% // Bulletin of Kazan Technological University, № 13, vol. 16, 2013, p. 70-72
11. E. M. Gojayev N. S. Nabiyev, M. A. Ramazanov, K. Sh. Kahramanov, Sh. V. Alieva Investigations Microrelief of the Surface, Dielectric Properties and Fluorescence Spectrum of Natural Composite - Fish Scales Physical Science International Journal 6(1): 45-53, 2015, Article no.PSIJ.2015.032
12. A.B. Turik, M.Yu. Rodinin. Dielectric losses in materials with a limited region of the relaxation time distribution // letters to JTP, 2010, 36 (1), p. 37-43
13. E. M. Gojaev, Sh. V. Alieva, K. C. Gulmammadov, S. S. Osmanova Dielectric Properties of Fishbone Kutumand Composite Materials with ItsParticipation//Journal of Inorganic Non-Metallic Materials, SciRes. 2016, 6, 1-5.