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# Improvement of electret properties of polylactide by loading mineral fillers

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## Introduction

Polymer electrets are applied in different industries and there is a problem of disposal after use. One of the solutions is to make them from biodegradable polymers, e.g. polylactide (PLA) that is produced from renewable plant sources and degrades under composting conditions for 3 months. However, corona electrets made from pure PLA didn't show sufficient for practical use electret properties. Search for the increase of the properties revealed that optimal solution is loading of fine fillers into the polymer matrix [1-3].

**The objective of the paper was studying the effect of fine mineral fillers on the properties of electret materials based on polylactide.**

## Materials

Four different fillers were loaded into the D-polylactide (ρ=1.24 g/cm$^3$, $T_g$=60 ºC, $T_m$=165 ºC) in the quantities of 2, 4 and 6 vol.% :

- talc grade ПМК-27 (ρ=2.75 g/cm$^3$),
- mica grade СМЭ-315 (ρ=2.76 g/cm$^3$),
- Fumed silica (aerosil) grade A-175 (ρ=2.15 g/cm$^3$)
- bentonite (ρ= 0.78 g/cm$^3$)

## Methods

The polymer and the fillers were mixed by Brabender Mixer W 50 EHT. Mixing was performed at temperature of 180 ˚ C for 300 s at blades rotation of 150 rpm. Samples were compression molded as 0.5 mm films using Gotech GT-7014-H10C according to GOST 12019-66 (Russian standard). Molding parameters were as follows: temperature 180 ˚ C, pressure – 15 MPa, preheating time – 5 min, holding-pressure time – 5 min, cooling time – 5 min.

*Charging* of the films was done using corona discharge system. It consists of 196 sharp needles uniformly distributed at a square of 49 cm$^3$. Space between a sample and the charging electrode was 20 mm, polarization voltage 30 kV, polarization time 30 s. Before charging samples were preheated in a heating chamber at 90 ˚ C for 10 min. Samples were stored in paper envelops under the ambient conditions.

*Surface potential $V_s$, electric field strength E and effective surface charge density $\sigma_{eff}$* were measured by IPEP-1 fieldmeter. Measurement error of the electret properties didn't exceed 3 %. The results given were average values of 5 trials.

*Differential scanning calorimeter* Q-200TA was used to assess the effect of fine filler addition on its transition temperatures. Heating rate was 10 ˚ C/min.

*Melt flow index* was measured according to GOST 11645-73 using IIRT instrument.

Measurement and calculation of *the specific volume resistivity $\rho_v$* were made according to GOST 6433.2-71.

*Infrared spectra* of the composite materials were obtained by ATR-FTIR spectrometer InfraLUM FT-08 within the range of 600-4000 cm$^{-1}$.

*Stress-strain behavior* of the samples was measured according to GOST 11262-80 using universal testing machine Test P 108.

## Results

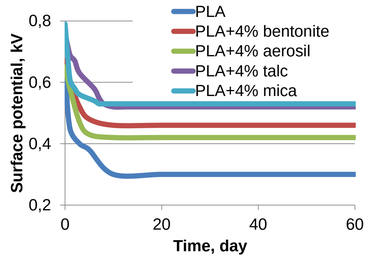


*Figure 2. Surface potential of PLA and PLA composite electrets over time*

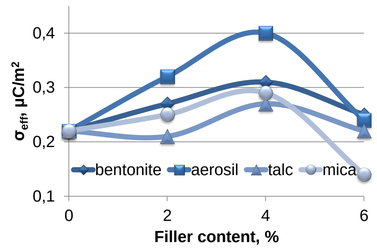


*Figure 1. Effective surface charge density of PLA composite electrets vs. filler content at 60$^{th}$ day*

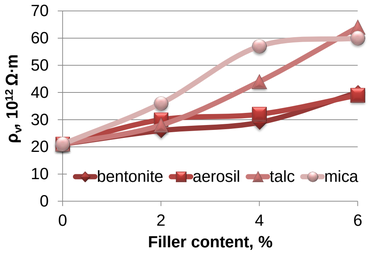


*Figure 3. Specific volume resistivity of PLA composites*

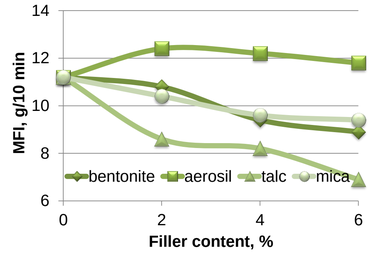


*Figure 4. Melt flow index of PLA composites as a function of filler content*

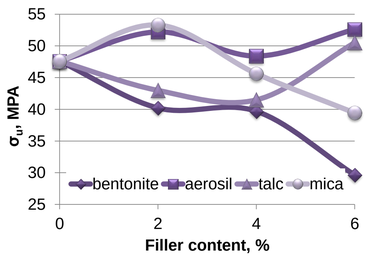


*Figure 5. Ultimate strength of PLA composites*

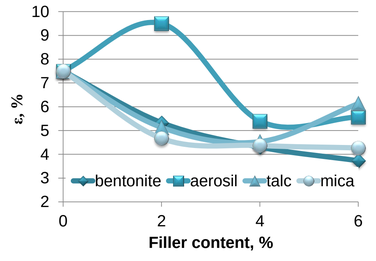


*Figure 6. Elongation at a break of PLA composites*

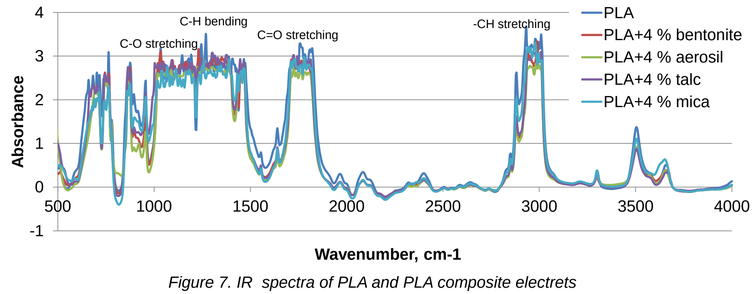


*Figure 7. IR spectra of PLA and PLA composite electrets*

Fillers significantly affected the electret properties of PLA. Figure 1 illustrates that all fillers enhanced them. Talc and mica demonstrated the greatest effect. Figure 2 shows that the best electret properties were shown by the compositions with 4 % filler load. Surface potential and electric field strength of the compositions had the same behavior pattern as effective surface charge density. Properties enhancement after loading can be explained by appearance of new charge traps at polymer-filler interface boundary.

Filler content increase slightly rises specific volume resistivity ($\rho_v$) of the compositions (figure 3). It is the second reason of the electret properties growth after loading.

Figure 4 demonstrates that the higher filler content in the PLA matrix is, the higher viscosity of the composition melt is, that is evidenced by the reduction of values of melt flow index (MFI). Loading of the fillers didn't influenced significantly on mechanical properties of the compositions – ultimate strength (figure 5) and elongation at a break (figure 6).

IR-spectroscopy didn't detect significant changes in PLA structure after filler addition and/or corona charging (figure 7).

Filler loading didn't affect the transition temperatures ( of the polymer that were studied by differential scanning calorimetry.

## References

1. Guzhova, A.A., Galikhanov, M.F., Gorokhovatsky, Y.A,, Temnov, D.E., Fomicheva E.E., Karulina, E.A., Yovcheva, T.A. Improvement of polylactic acid electret properties by addition of fine barium titanate. *Journal of Electrostatics, 2016, Vol.*79, pp. 1-6.
2. Zagidullina, I.A., Galikhanov, M.F., Kamalova, R.I., Sharipova, G.F., Khairullin, R.Z. The study of the electret properties of polylactic acid and mineral fillers. AIP Conference Proceedings, 2020, Vol. 2313, pp. 050048
3. Kamalova, R.I., Minzagirova, A.M., Galikhanov, M.F., Spiridonova R.R., Guzhova, A.A., Khairullin, R.Z. Electret properties of polylactic acid - montmorillonite composites. AIP Conference Proceedingsthis, 2019, Vol. 2174, pp. 020026

## Conclusion

Thus, loading of 2-4 % mineral fillers into the polylactide resulted in enhancement of its electret properties and didn't affected PLA operational performance. Compositions of polylactide and 4 % talc or mica showed the best properties.

## Acknowledgements

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