STUDY OF THE ORGANIC-INORGANIC INTERFACES AND THE EFFECT OF ADDITIVES IN PIEZOELECTRIC COMPOSITES

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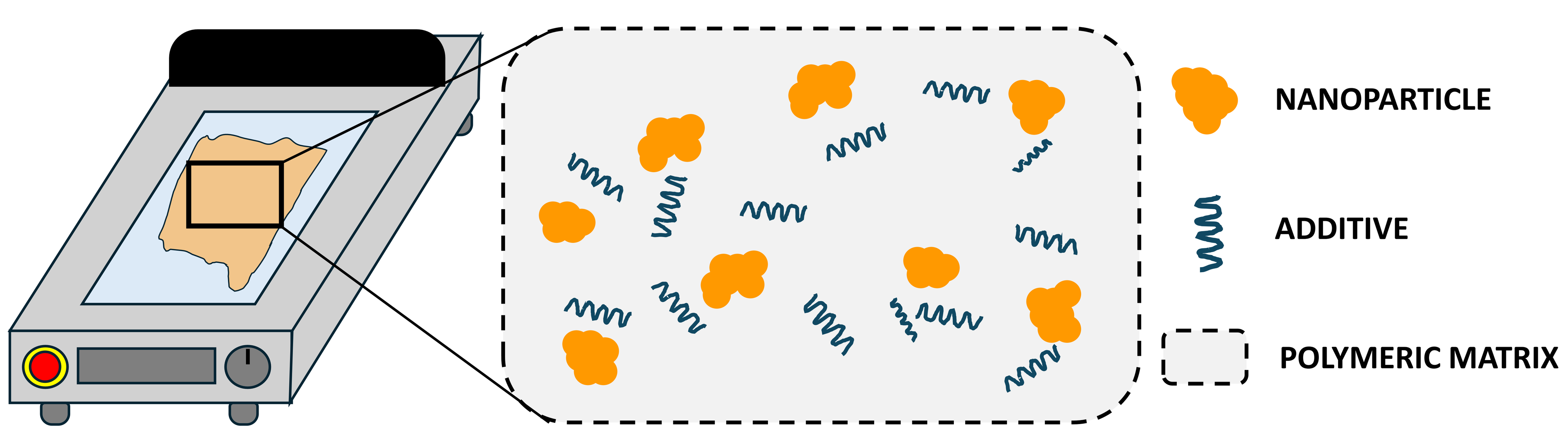
DIELECTRIC PROPERTIES ANALYSIS

Piezoelectric materials, which convert electrical energy into mechanical energy and vice versa, are widely used in actuators, sensors and energy harvesters. Although ceramics offer high performance, their rigidity restricts their applications.[1] Polymers are flexible but less efficient. Piezoelectric composites aim to combine the advantages of both types of material, though achieving good particle dispersion and strong organic–inorganic interfaces remains challenging.[2] Enhancing these interfaces with additives or coupling agents is therefore crucial for improving composite performance.[3] This work presents piezoelectric hybrid composites prepared by tape casting using different types of perovskite as fillers in a poly(L-lactide) (PLLA) matrix. The effect of different additive combinations on interface quality is evaluated through dielectric property analysis.

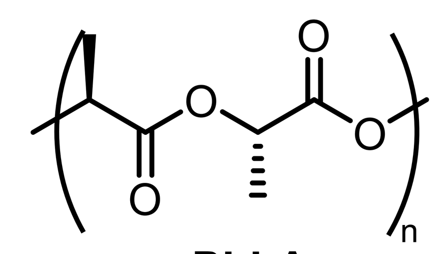


NANOPARTICLES

- Barium titanate (BTO)

POLYMERIC MATRIX

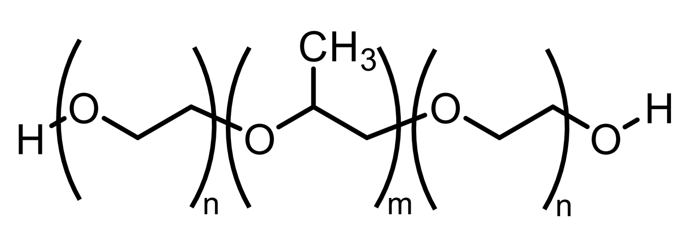
- Poly-*L*-lactic acid (PLLA)



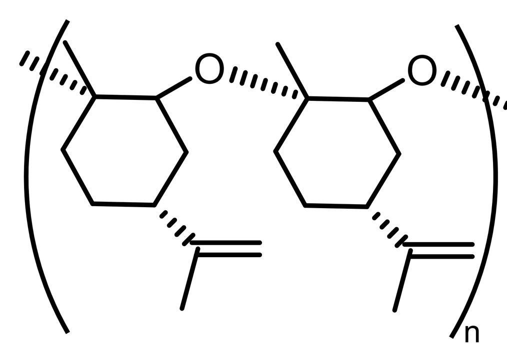
PLLA

ADDITIVE

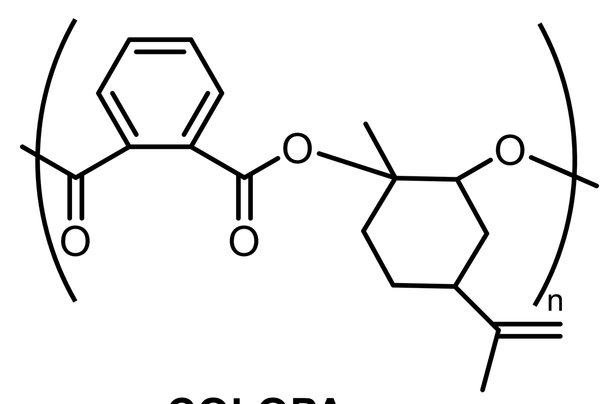
- Copolymer of polyethylene-polypropylene-polyethylene glicol (Kolliphor® P407) M_n= 10-14 KDa
- Polyoxylimonene (PLO) M_n= 5.1 KDa
- Copolymer of limonene oxide and a phtalic anhydride (COLOPA) M_n= 1.6 KDa



KOLLIPHOR P407



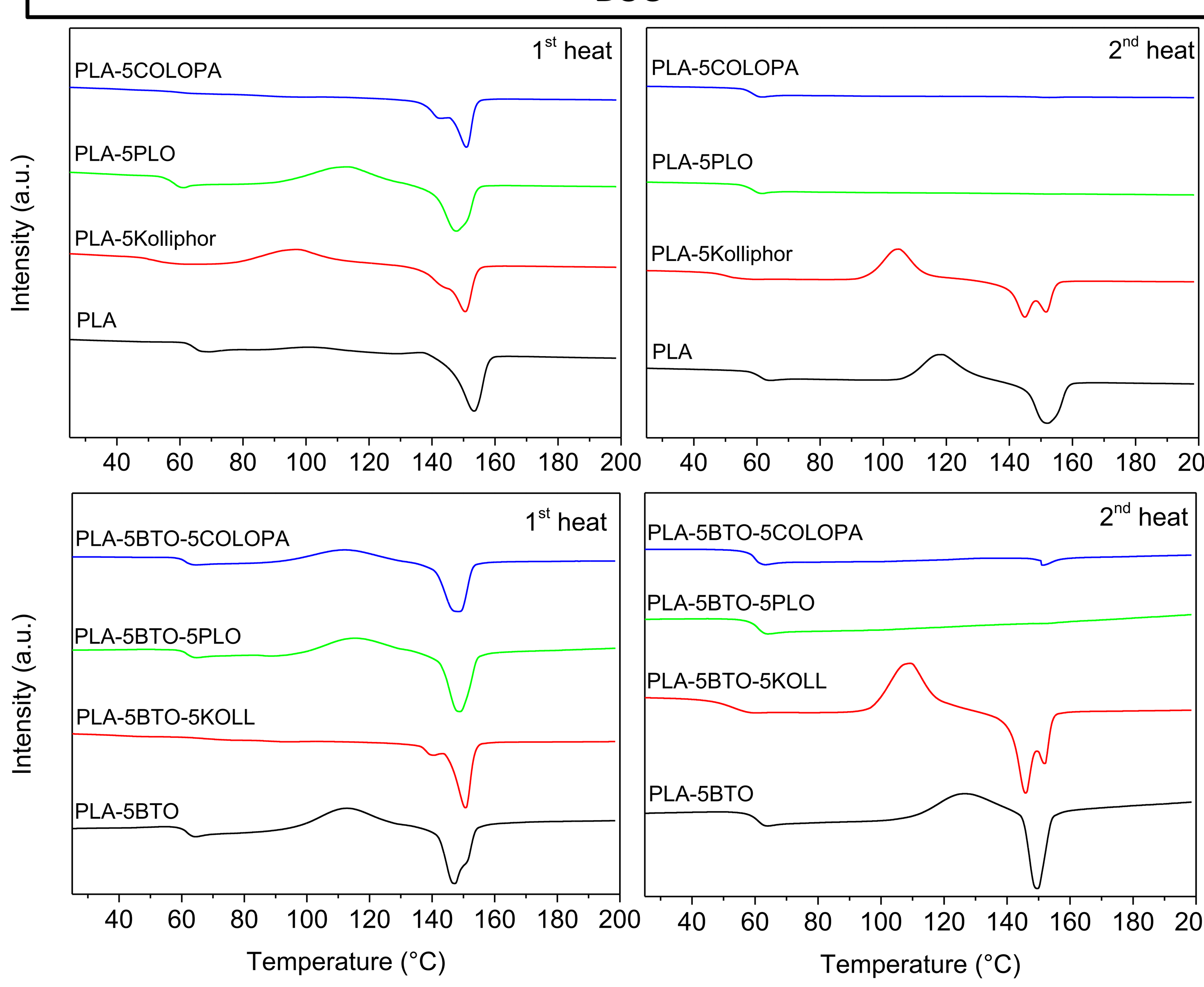
PLO



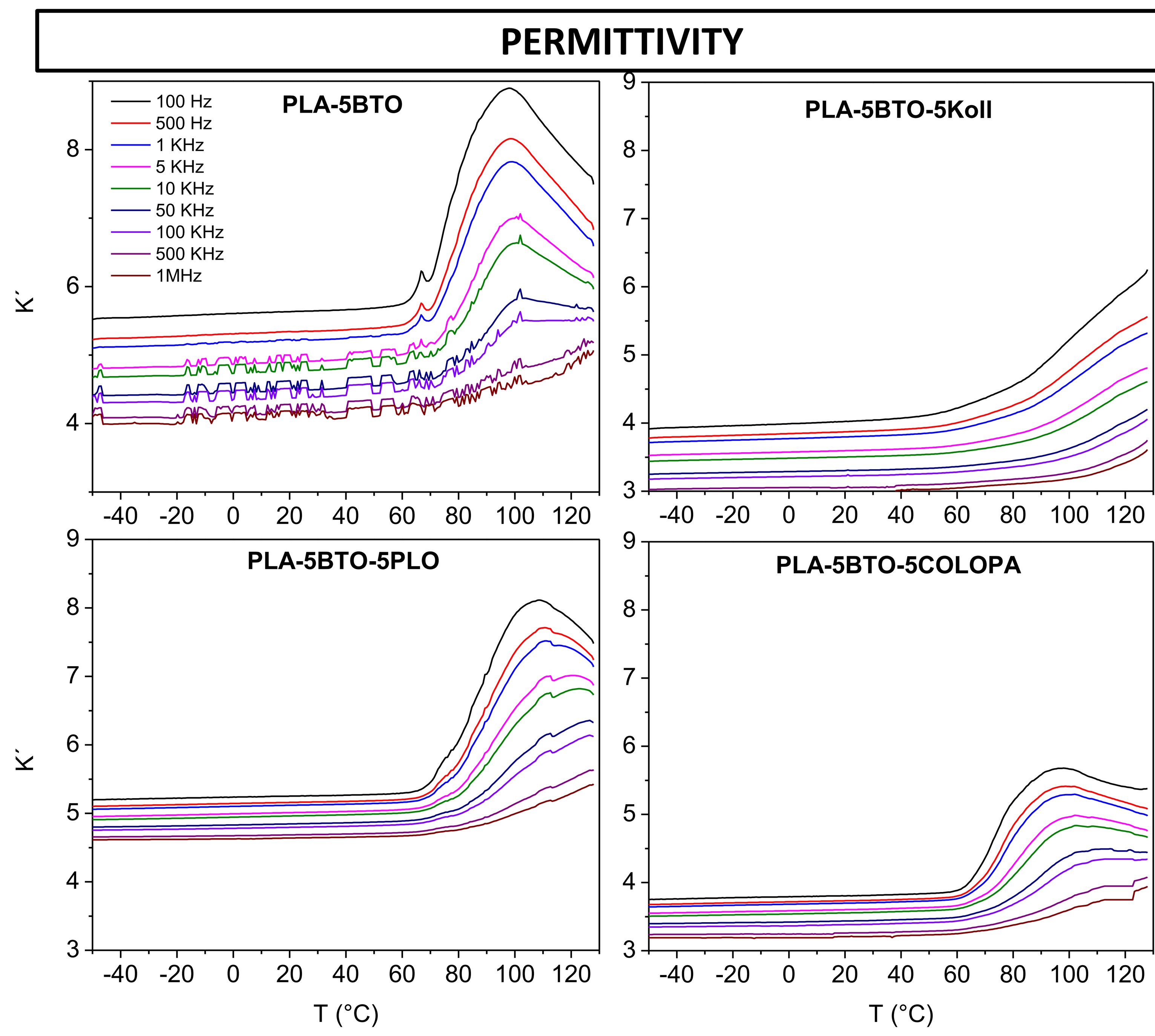
COLOPA

CHARACTERIZATION

DSC



PERMITTIVITY



	$T_{g\,1h}$ (°C)	$X_{c\,1h}$ (%)	$T_{g\,2h}$ (°C)	$X_{c\,2h}$ (%)		$T_{g\,1h}$ (°C)	$X_{c\,1h}$ (%)	$T_{g\,2h}$ (°C)	$X_{c\,2h}$ (%)	$\varepsilon'_{1\,KHz\,1h}$	$\Delta\varepsilon_{100\,Hz\,-\,1\,MHz\,1h}$	tan δ 1 KHz 1h
PLA	63.7	23.4	60.3	0.4	PLA-5BTO	61.1	1.7	60.1	2.7	5.22	5.64-4.03= 1.61	0.055
PLA-5Koll	52.0	2.7	50.5	0.1	PLA-5BTO-5Koll	67.2	28.2	52.8	0.1	3.81	4.04-2.95= 1.07	0.047
PLA-PLO	56.8	0.1	57.3	0.0	PLA-5BTO-5PLO	61.6	10.4	60.3	0.0	5.12	5.26-4.64= 0.62	0.019
PLA-COLOPA	58.8	30.2	57.6	0.5	PLA-5BTO-5COLOPA	60.9	6.3	59.4	0.9	3.70	3.81-3.21= 0.6	0.023

1h: First heating; 2h: Second heating

Measurements are taken at 300 K (27 °C)

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CONCLUSION

- Without BTO particles, the addition of additives reduces the glass transition temperature (T_g) of PLLA, indicating a higher chain mobility, whereas the degree of crystallinity (X_c) significantly decreased in all cases for the second heating, indicating the positive impact of tape casting processing method to achieve high crystallinity.
- The inclusion of BTO modify these trends. T_g maintains similar or even above that of PLLA, while X_c is totally influenced by the strong combined effect of the additive and the particles.
- Compared to pure PLLA (ε′ ≈ 3), BTO enhances the dielectric permittivity, with a cold crystallization process observed in the mostly amorphous composites.. Dielectric losses and frequency dispersion decrease with the addition of additives, indicating improved interface compatibility between PLLA and BTO.

REFERENCES

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