Industrial Production of Poly(L-Lactide) Piezoelectric Films: From Fundamental Process-Structure-Properties Relationships to Emerging Applications

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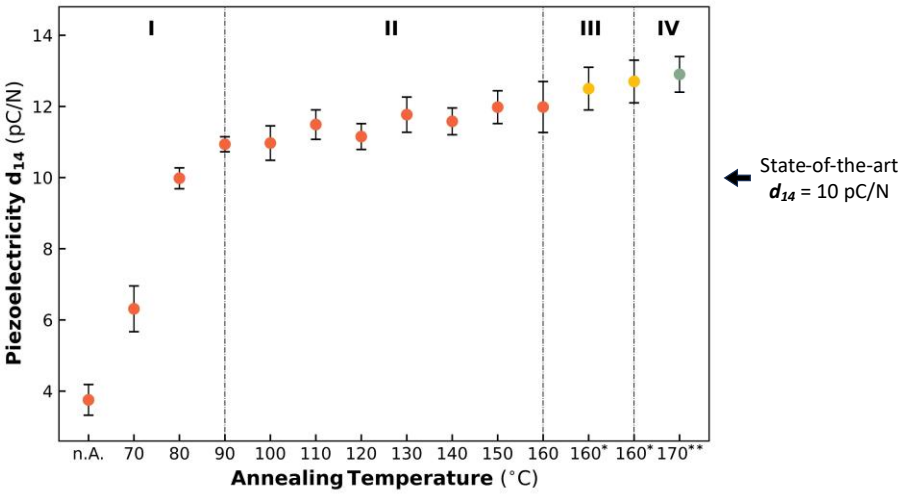
Résumé : This work focuses on improving the piezoelectric performances of poly(L-Lactide) (PLA) films for replacing conventional electroactive ceramics and fluoropolymers in emerging applications. Notably, the piezoelectricity of optically active PLA films arises from uniaxial orientation, eliminating the need for energy-intensive electrical poling. An industrially-relevant extrusion-orientation process (machine-direction orientation, MDO) coupled to post-annealing treatments is under investigation for several years which enables an efficient production of piezoelectric PLA films with high orientation state. The primary study was focused on linking structure-property relationships with processing conditions. Precise piezoelectric measurements coupled to specific structural analysis (polarized infrared spectroscopy and x-ray diffractions) were conducted. A predictive model was proposed [1] to decouple the piezoelectricity of PLA into contributions of crystalline, meso-, and amorphous phases. This work revealed that the oriented amorphous phase is indispensable with an extrapolated piezoelectric contribution up to 7 pC/N. The MDO was proved effective for the amorphous orientation because its high deformation rate prohibits amorphous relaxation. Oriented crystals are attested with the highest piezoelectric contribution [2]. This research revealed that post-annealing treatments under tension above 100°C is fundamental to significantly produce fully-oriented crystals. Annealing temperatures up to 160 – 170°C are helpful to boost fully-oriented crystals up to 52% and obtain densified alpha crystals. This crystal has marginally elevated piezoelectric coefficient than the conventional disordered alpha' crystals. Overall, PLA films produced by MDO and post-annealing displayed higher shear piezoelectricity (13 pC/N) than the state-of-the-art value with a 30% enhancement. Finally, our studies are focused on emerging applications of these piezoelectric films such as vibrational energy harvesters and water remediation under ultrasound stimulations.



n.A. Non -annealing * Increase annealing dura α c

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