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POLYLACTIDE FILMS WITH INCREASED OPTICAL BARRIER PROPERTIES THROUGH THE USE OF BIXIN

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1. Introduction

The use of carotenoids as yellow-red colorants for polymeric materials represents a sustainable way of obtaining colored packaging. The introduction of bixin, a carotenoid with coloring and antioxidant properties, could be used to increase the barrier properties of poly(lactide) (PLA) films, turning the biodegradable polymer more suitable to protect light- and oxygen-sensitive food products. **The present study aimed to evaluate the influence of bixin on the optical and oxygen barrier properties of PLA films. The thermal properties of films were also evaluated.**

2. Materials and Methods

Films production

- Bixin was extracted from annatto seeds (*Bixa orellana*) with dichloromethane.
- Bixin extracts were added to PLA solution (7%w/w in dichloromethane) in order to achieve different bixin concentrations (w/w):

0% 0.01% 0.05% 0.10% 1.0%

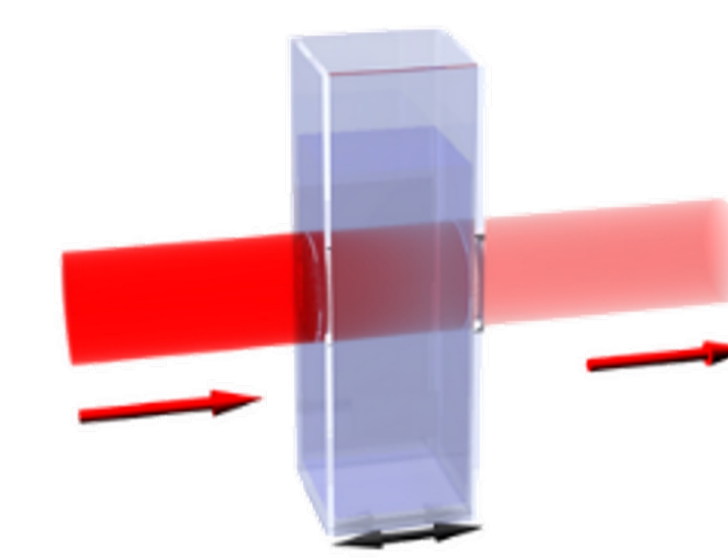
- Solutions were poured into Teflon plates and dried at ambient temperature for 48h.
- Films were peeled and thermo-pressed (160 °C, 6 min) to remove the residual solvent.

Films characterization

The **optical barrier properties** were measured by placing the films in quartz test cells. Samples were scanned from 200 to 800 nm in a UV-Vis spectrophotometer.

Films **oxygen permeability** was determined in a GDP-C permeameter (25 °C). The permeability (P) was calculated by multiplying the measured oxygen transmission rate by the sample thickness (measured with a micrometer on 9 points). The diffusion (D) and sorption (S) coefficients were calculated with the help of the time-lag (t_{lag}) method.

Films **crystallinity degree (χ)** and **glass transition temperature (T_g)** were analyzed using a Q100 DSC.



3. Results and Discussion

Figure 1. PLA films produced with different bixin concentrations (0 – 1%)



- ✓ The presence of bixin reduced the light transmission of PLA films (Figure 2): **the higher the concentration of bixin, the higher the films' barrier** to ultraviolet (200–300 nm) and visible light (300–800 nm). The conjugated double bonds in bixin molecular structure serve as chromophore moieties, being responsible for its light absorption capacity.

Figure 2. Light transmittance (%) from 200 to 800 nm through PLA films

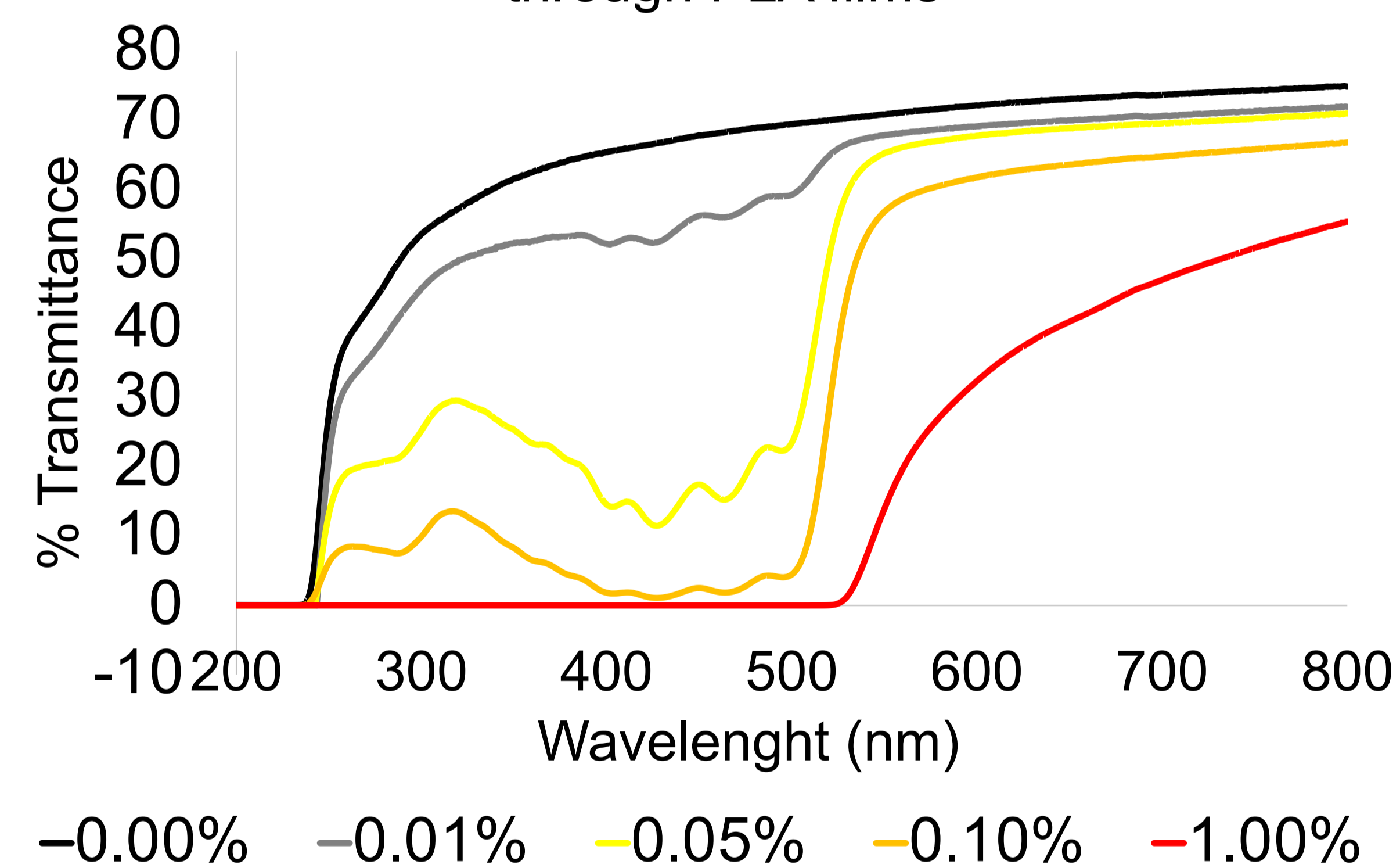


Table 1 – Oxygen barrier and thermal properties of PLA films produced with bixin.

Bixin (%)	P.10 ¹⁸ [m ³ m m ⁻² Pa ⁻¹ s ⁻¹]	D.10 ¹² [m ² s ⁻¹]	S.10 ⁶ [m ³ m ⁻³ Pa ⁻¹]	T _g (°C)	χ (%)
0.00	3.31	3.3	1.0	50.5 ± 0.7	0.8 ± 0.1
0.01	4.14	3.5	1.2	49.8 ± 1.9	1.5 ± 0.2
0.05	3.04	2.8	1.1	50.4 ± 1.7	1.0 ± 0.4
0.10	3.59	3.2	1.1	50.3 ± 0.1	1.3 ± 0.2
1.00	3.32	2.9	1.2	49.3 ± 2.3	1.3 ± 0.0

- ✓ Bixin did not affect the oxygen solubility, diffusivity and permeability of the films, neither their thermal properties, given by T_g and crystallinity degree (χ) (Table 1).

4. Conclusion

Bixin effectively increased the UV-Vis light barrier of PLA films, where the presence of 1% of the carotenoid resulted in films with nearly zero UV light transmittance. Although improvements on oxygen barrier properties are still required, the presence of bixin is expected to retard oxidation reactions in light sensitive food products.