

# Synthesis and Characterization of Films Based on Poly(lactic acid), PLA with Nanoparticles of Chitosan-encapsulated Oregano Essential Oil †

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**Abstract:** In recent years, the development of novel films based on polymeric materials which combine biodegradability with improved properties, such as antioxidant and/or antimicrobial action, has acquired a special interest in food packaging. One of the most promising bio-derived polymers is poly(lactic acid), PLA. As natural antioxidants, chemical compounds contained in the essential oil of plants, such as oregano, which are abundant in Greece, could be used. The aim is to create the most suitable conditions for encapsulating the essential oil in the polymeric matrix to avoid its complete removal before use. In this study, encapsulation of oregano essential oil into chitosan nanoparticles was prepared by a two-step method; oil-in-water emulsion and ionic gelation of chitosan with sodium tripolyphosphate, using different amounts of essential oregano oil. FTIR spectroscopy was performed to confirm the success of the encapsulation, and Thermogravimetric Analysis (TGA) to estimate the percentage of encapsulated oregano essential oil to chitosan. Subsequently, the nanoparticles were added to poly(lactic acid), and films containing PLA with chitosan-encapsulated essential oil nanoparticles were prepared using different additive contents (1%, 5%, and 10%). The antioxidant activity of the film samples was evaluated using DPPH (2,2-diphenyl-1-picrylhydrazyl) method and a UV-vis spectrometer. The DPPH method showed that nanoparticles increase the antioxidant activity of PLA. Results of FT-IR showed that nanoparticles were absorbed on the chitosan surface. TGA showed that the presence of nanoparticles improves the thermal stability of PLA. Finally, Differential Scanning Calorimetry was used to calculate the glass transition point, T<sub>g</sub>, and the melting point, T<sub>m</sub> of prepared films.

**Keywords:** poly(lactic acid); PLA; chitosan; nanoparticles; essential oils; oregano.

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## **Conflicts of Interest**

The authors declare no conflict of interest.