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"Antibacterial Properties of Biobased Polyester Composites Achieved through Modification with a Thermally Treated Waste Scallop Shell"

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Abstract

New antibacterial properties of a composite made from thermally treated white scallop shell powder (TWWSSP) and modified polylactide (MPLA) are described. The carbonate waste was calcined at 1000 °C to produce calcium oxide (CaO) and calcium hydroxide (Ca(OH)2). The content and structure of the calcined product were examined using energy dispersive spectrometry, Fourier transform infrared spectroscopy and X-ray diffraction. TWWSSP was tested to establish its efficacy as a bactericidal component when combined with MPLA to produce composites. Infrared spectroscopy, tensile, and morphological research revealed that TWWSSP and PLA adhered better to composites and were more compatible than PLA/WWSSP composites. The results of the MTT assay and cell adhesion test of composites revealed that the relative growth rate of Mus dunni fibroblast (MDFB) cells rose with increasing TWWSSP concentration in the composites, indicating that the composites were not cytotoxic. Aside from that, MPLA composites including TWWSSP demonstrated significantly increased antibacterial activity of TWWSSP and MPLA, with the highest results obtained with MPLA and TWWSSP. MPLA/TWWSSP and PLA/WWSSP composites have excellent antibacterial and biodegradable qualities, making them ideal for a wide range of applications, particularly food packaging and biomedical products.

Introduction

- There is an urgent need for alternatives to petrochemical plastics due to fossil fuel depletion, rising costs, and environmental concerns.
- Focus on sustainability drives research towards advanced bio-based polymers to reduce reliance on resources and minimize environmental impacts.
- Bio-based polymers offer eco-friendly, renewable, and biodegradable solutions to reduce carbon footprint and promote ecological health.
- Versatile aliphatic and aromatic polyesters are gaining popularity for various applications such as food packaging and medical devices.

Synthesis

Scheme 1. Schematic Diagram of Polylactide Modified with Thermally Treated Waste White Scallop Shell Powder and the Fabrication of Composites

Result and discussion

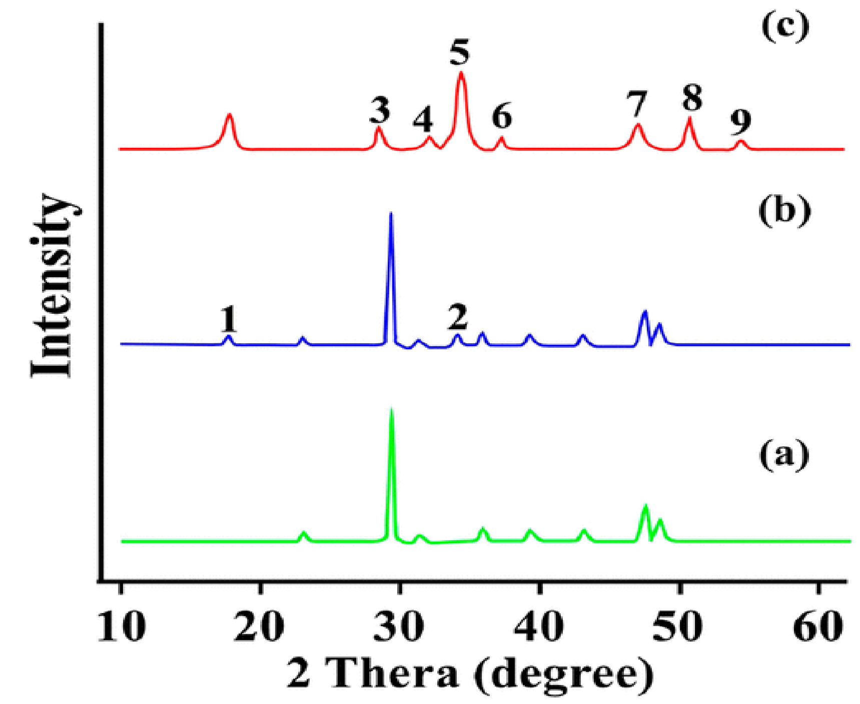

Figure 1. Wide-angle X-ray diffraction patterns

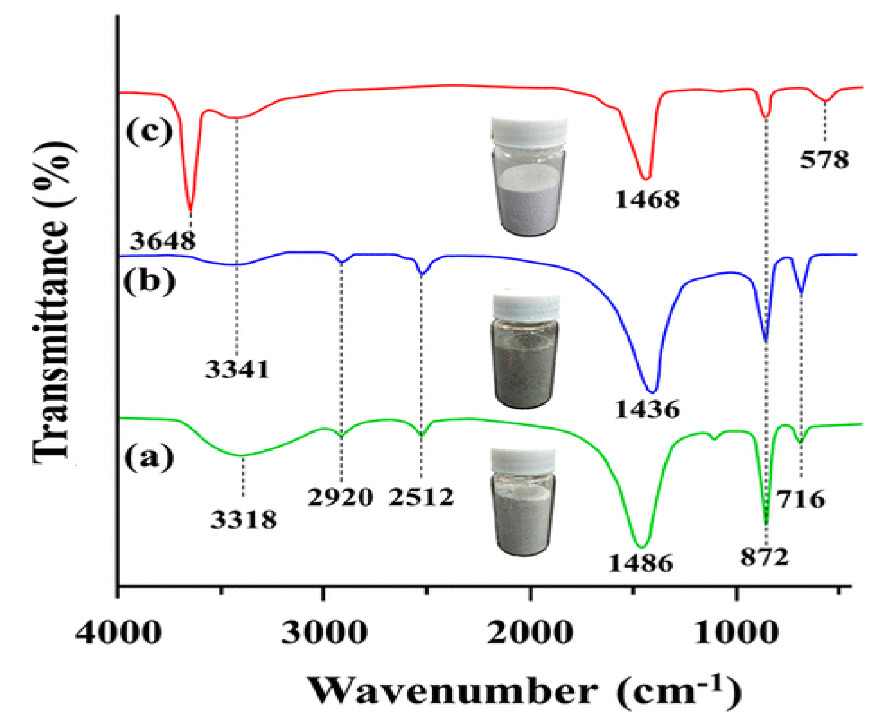

Figure 2. Fourier transform infrared spectra of (a) untreated WWSSP and TWWSSP formed at (b) 500 and (c) 1000 °C

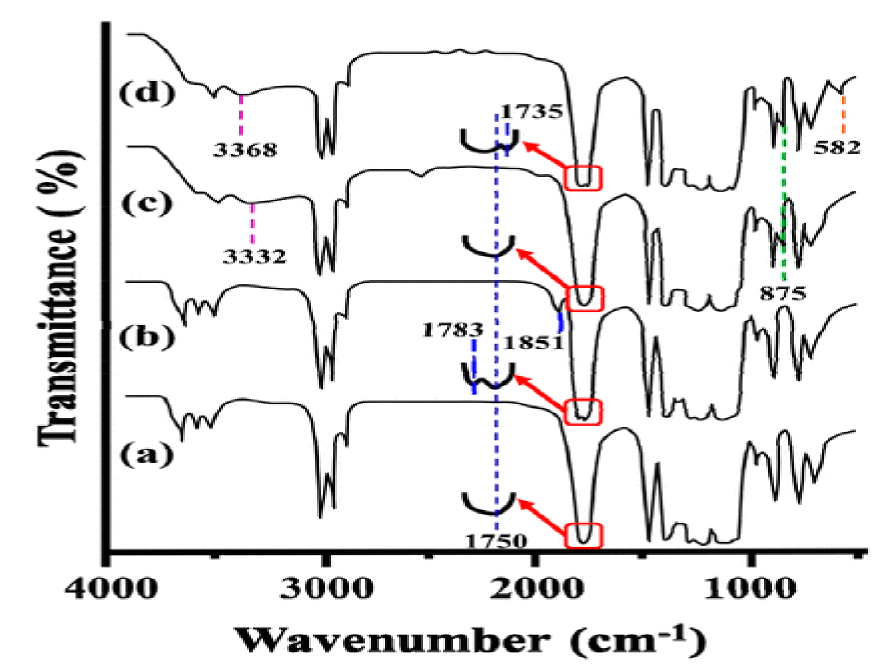

Figure 3. Fourier transform infrared spectra of (a) polylactide (PLA), (b) modified polylactide (MPLA), (c) PLA/WWSSP (3 wt %), and (d) MPLA/TWWSSP (3 wt %).

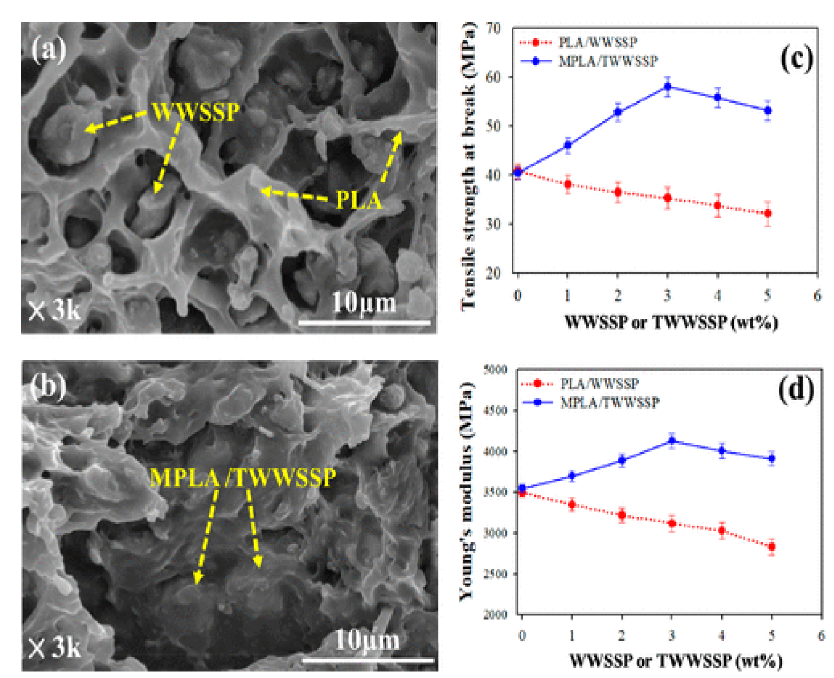

Figure 4. Scanning electron microscopy images showing the distribution and wetting

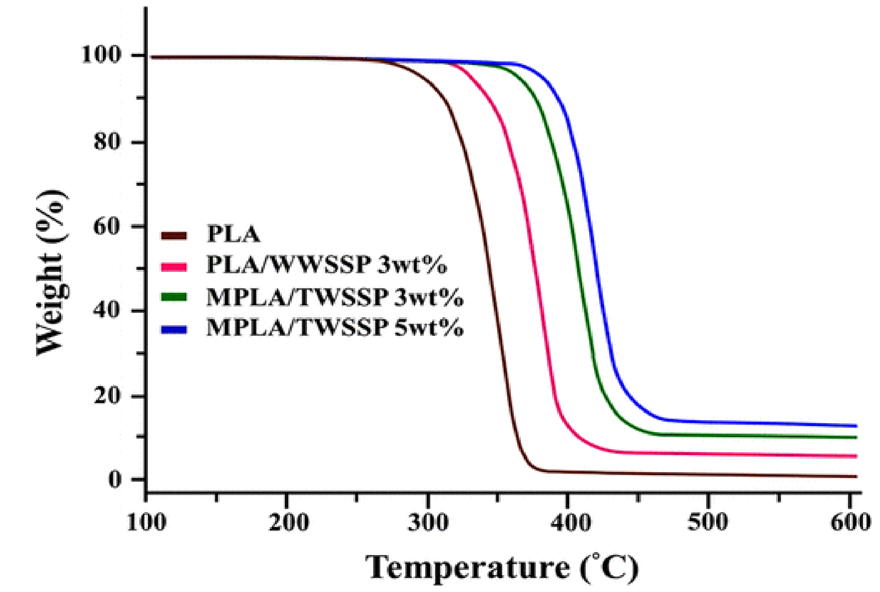

Figure 5. Thermogravimetric curves for PLA, PLA/WWSSP, and MPLA/TWWSSP composites.

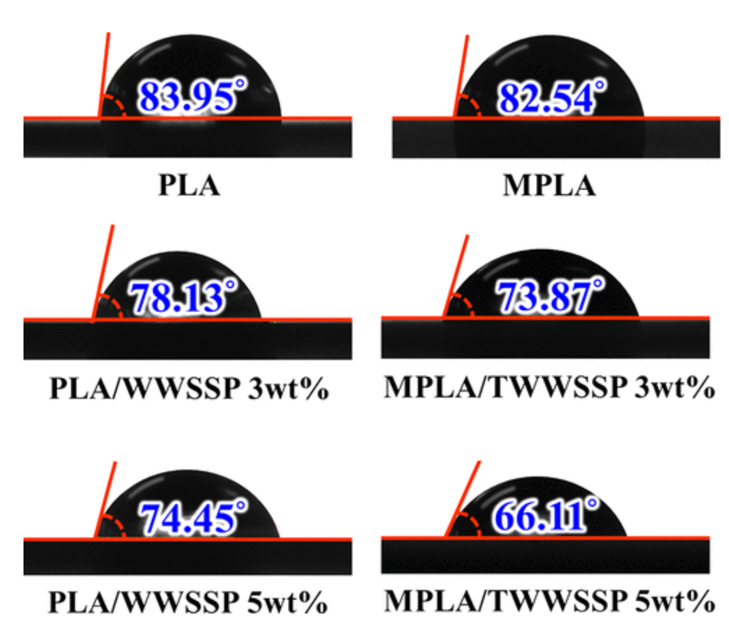

Figure 6. Contact angle profiles for PLA, MPLA, PLA/WWSSP, and MPLA/TWWSSP composites.

Conclusion:

- **TWWSSP, especially when calcined at 1000°C, shows antibacterial properties alone and in blends with MPLA.**
- **Structural analysis confirms chemical interactions between TWWSSP and MPLA, improving adhesion and mechanical properties.**
- **Increased TWWSSP content enhances cell growth and exhibits strong antibacterial effects.**
- **Composites demonstrate accelerated biodegradation rates compared to pure PLA or MPLA.**
- **Suitable for applications in tissue engineering, antibacterial materials, and air filtration membranes.**

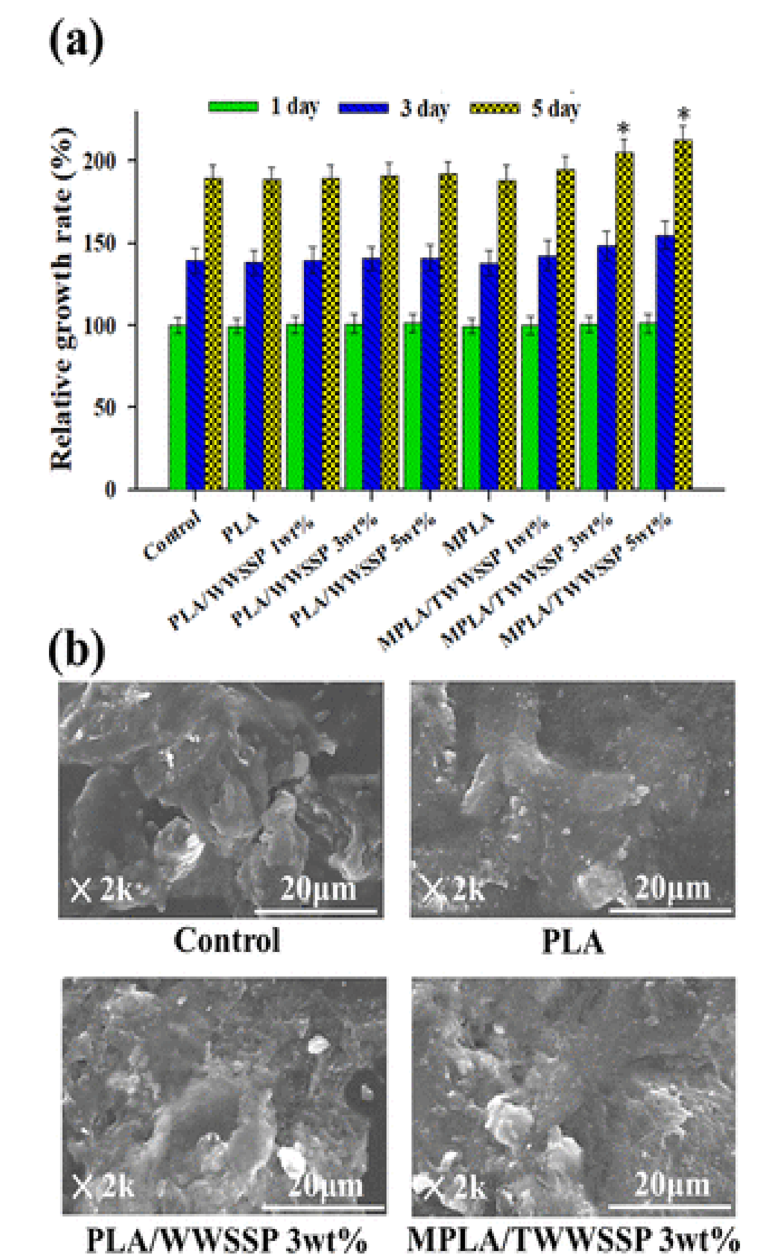

Figure 7. (a) Cell viability of *Mus dunni*. (b) Scanning electron microscope images

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