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PVA/PEG-Based Films Incorporating *Clitoria ternatea* Extract for pH-Responsive Smart Food Packaging

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Introduction

Intelligent food packaging can monitor food quality through visual pH changes. ternatin from *Clitoria ternatea* (Fig. 1a) are promising natural indicators due to their color response. PVA/PEG films provide a flexible matrix for developing sustainable pH-responsive packaging, Fig. 1b – Structure of a ternatin; Fig. 1c – Structure of PEG.

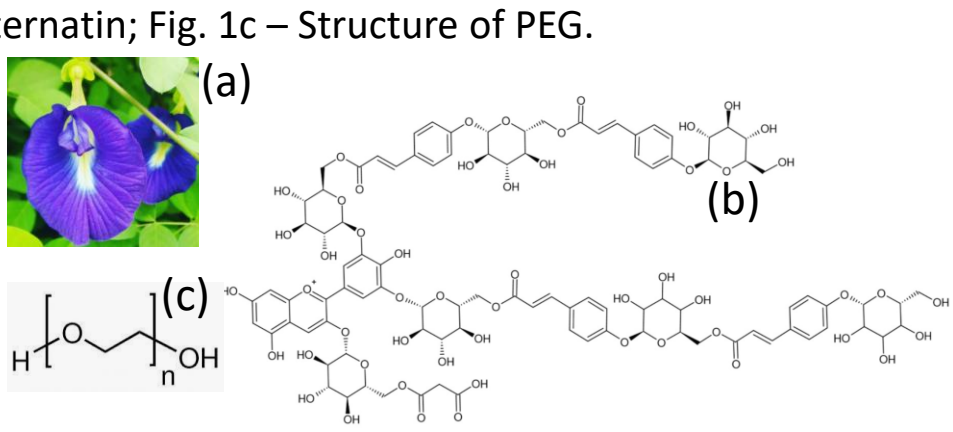


Figure 1. (a) *Clitoria ternatea* flower, (b) ternatin and (c) PEG.

Objectives

To develop PVA/PEG films containing Clitoria ternatea extract and evaluate their thermal and molecular properties by TGA, DSC, and ATR-FTIR, aiming to assess their potential as sustainable pH-responsive materials for intelligent food packaging.

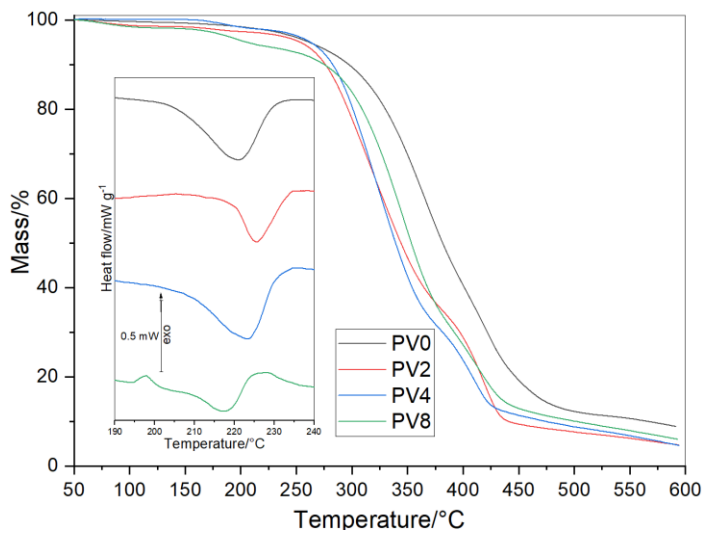
Metodology

Film preparation: PVA/PEG (70:30) films containing *Clitoria ternatea* extract were prepared by casting and designated PV0, PV2, PV4 and PV8, corresponding to 0, 0.3, 0.6 and 1.2 µg of extract, respectively.

Characterization: TGA/DSC analyses were performed using a STA 6000 (PerkinElmer, USA), from 50–700 °C at 20 °C min^{-1} under N_2 (20 cm^3 min^{-1}), using 10 mg samples. ATR-FTIR spectra were recorded using a Frontier PerkinElmer FTIR spectrometer, from 4000–650 cm^{-1}, with 4 scans and 4 cm^{-1}

Results and Discussion

Thermogravimetric and DSC analysis (Fig. 2) shows the TG curves and DSC thermograms of the PVA/PEG films containing different concentrations of extract. TG curves exhibited similar degradation profiles for all formulations, with an initial mass loss at low temperatures, mainly associated with the removal of water and volatile components, followed by the main degradation stage. PV0 showed higher thermal stability, while the incorporation of the extract caused a slight shift toward lower degradation temperatures, particularly for PV2 and PV4.



igure 2. TG/DSC curves of PV0, PV2, PV4 and PV8.

DSC thermograms (Fig. 2, inset) exhibited endothermic events in the approximately 210–230 °C range, associated with thermal transitions of the PVA/PEG matrix. The incorporation of the extract produced slight changes in the position and intensity of these events, suggesting modifications in intermolecular interactions and polymer-chain organization.

FTIR spectra (Fig. 3) showed characteristic bands at ~1730, 1640, 1450, 1320–1370, 1250–1300 and 1080–1150 cm^{-1}, mainly related to C=O, C=C/O–H, CH_2 and C–O vibrations. PV4 and PV8 showed more pronounced intensity changes, indicating interactions with the extract.

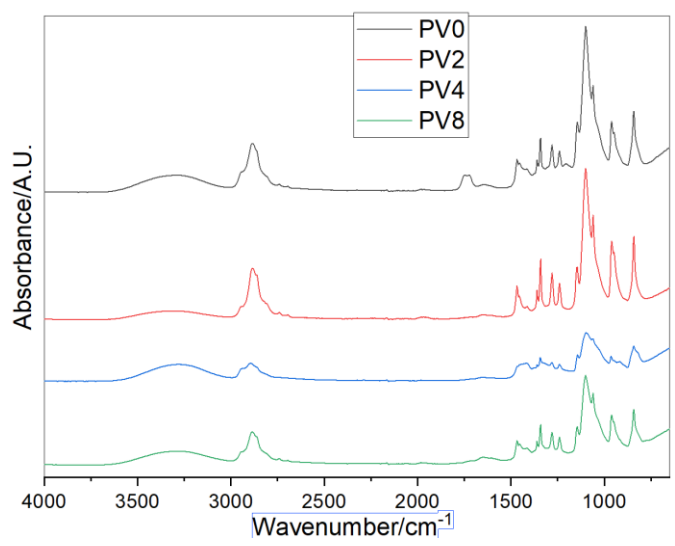


Figure 3. FTIR spectra of of PV0, PV2, PV4 and PV8.

Conclusions

The results demonstrated that Clitoria ternatea extract can be successfully incorporated into PVA/PEG films without significantly compromising their thermal stability. TGA and DSC indicated only minor changes in thermal behavior, while FTIR confirmed the preservation of the main polymeric bands and suggested interactions between the extract and polymer matrix. These findings support the potential of PVA/PEG–C. ternatea films as sustainable pH-responsive materials for intelligent food-packaging applications.

References and acknowledgements

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