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# COMPARATIVE EVALUATION OF CHITOSAN-BASED HYDROGELS IN THE IMPROVEMENT OF AGRONOMIC PROPERTIES

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## 1. Introduction

The urgent need for **sustainable agricultural practices** has driven the development of novel materials to address key challenges such as **excessive fertilizer use**, **inefficient water management**, and **soil degradation** [1]. Among emerging biopolymers, **chitosan (CTS)**—a biodegradable and biocompatible derivative of chitin—stands out for its versatility. It shows **antimicrobial activity**, **enhances nutrient uptake** and **root growth**, and **activates plant defense mechanisms**, making it suitable for eco-efficient crop management [2]. Building on these features, this work employs **1st generation interpenetrated polymeric networks (IPN) based on CTS** crosslinked with **tris(cyclic carbonate) (TrisCC)**, designed as controlled-release biostimulant delivery systems (BDS) [3].

## 2. Preparation of CTS-based 1st generation-IPN

The **IPN syntheses** employed **TrisCC**, prepared via **click thiol–ene** chemistry, as crosslinker. Three IPN systems were obtained through the aminolysis of **TrisCC** by the amine groups of chitosan (CTS), using **different CTS concentrations (2–6% w/v)** to modulate the network characteristics (Figure 1).

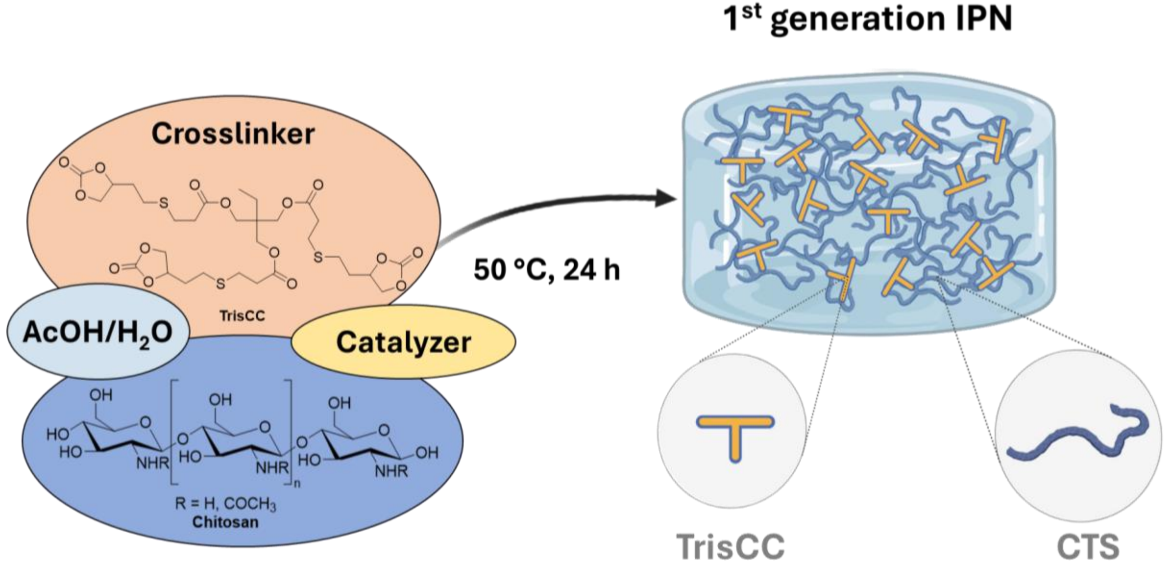


**Figure 1.** Preparation of 1st generation IPN by NIPU methodology. CTS concentration 2, 4 or 6% (w/v); crosslinking degree 30%.

## 3. Results

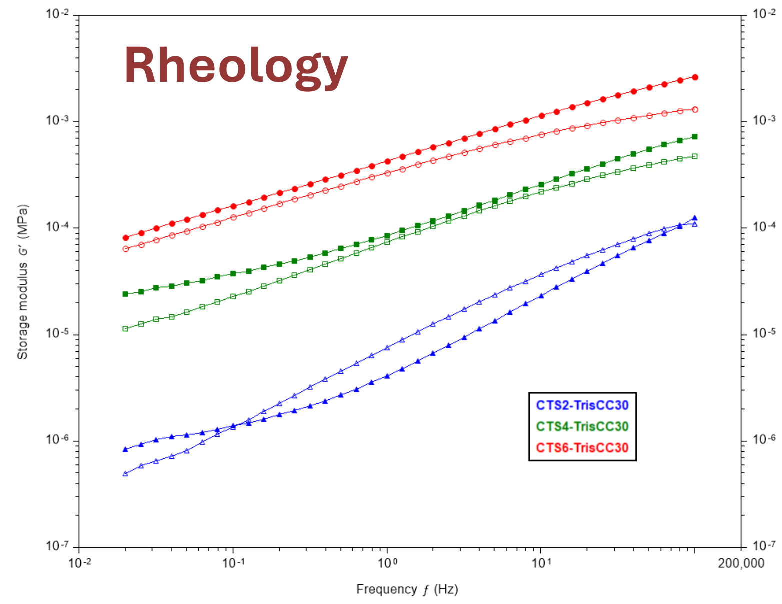
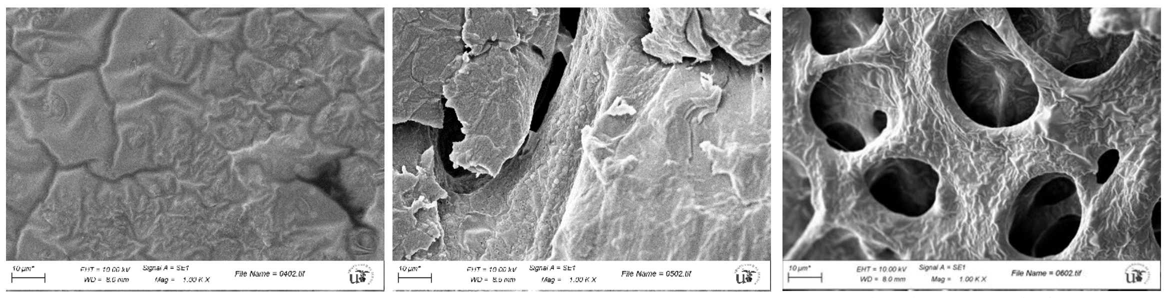


**Figure 2.** Frequency sweep of IPN synthesized at 2, 4, 6% CTS, with 30% TrisCC. Filled symbol: G'; empty symbol: G''.

**Crosslinking**: ↑ **rigidity** & **elasticity**
**Higher [CTS]:**↑ **G', G'', and η***
**Highest $G_n^0$ in $CTS_6$–$TrisCC_{30}$: strongest IPN**

### Microstructure



$CTS_2$-$TrisCC_{30}$ $CTS_4$-$TrisCC_{30}$ $CTS_6$-$TrisCC_{30}$

**Figure 3.** SEM images (x1000)

### Swelling

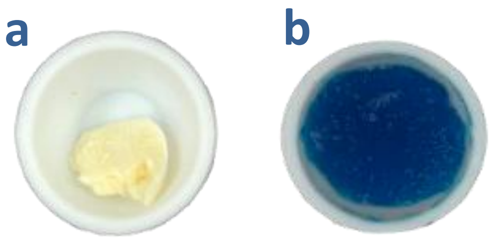


**Figure 4.** IPN $CTS_6$ $TrisCC_{30}$ before (a), and after (b) swelling assay.

$CTS_6$-$TrisCC_{30}$ increases its weight **44 times;**
**SI > 44,000 %**

### Biodegradation

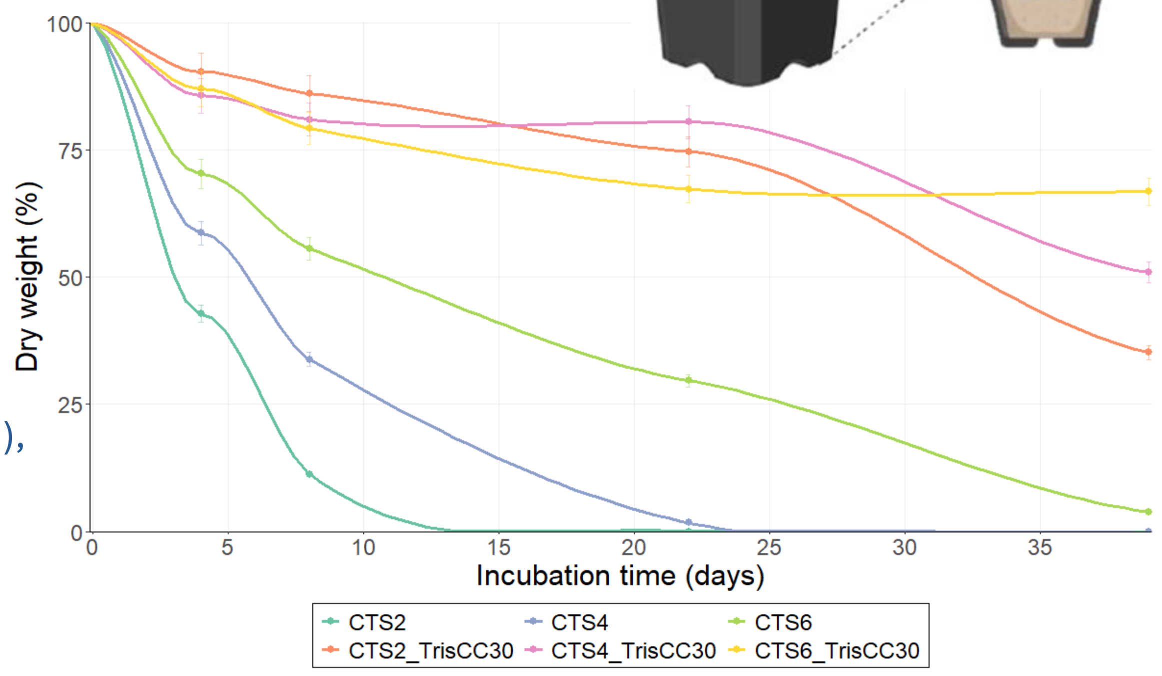


**Figure 5.** Biodegradation of CTS-based hydrogels by soil burial test.

### *In vitro* release studies of BDS

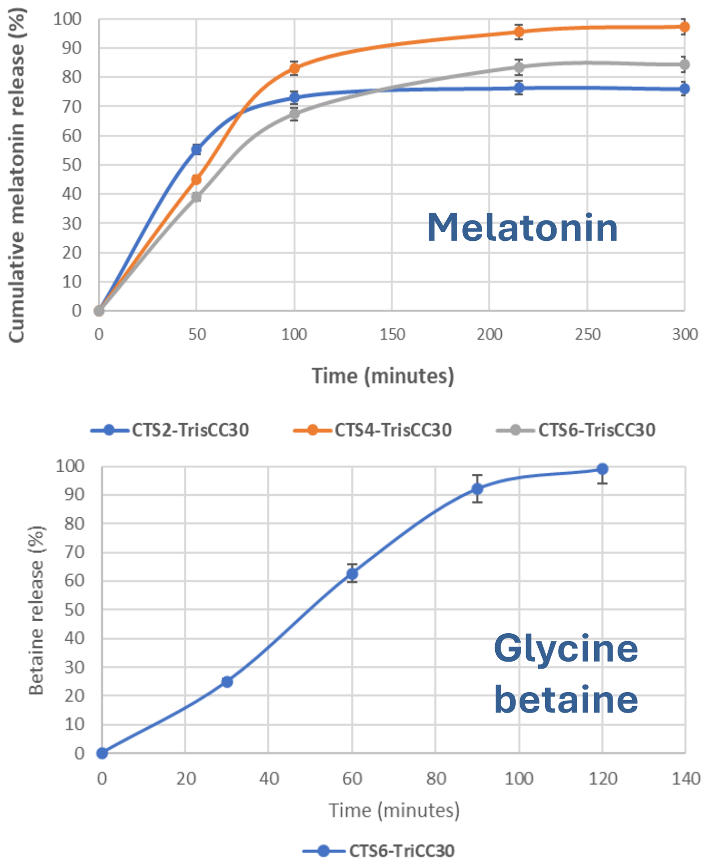


**Figure 6**. Cumulative melatonin and glycine betaine release from CTS-based hydrogels.

## 4. Conclusions

- **CTS-based hydrogels** showed **enhanced mechanical strength**, **controlled biodegradation**, and **superior water absorption**.
- Enabled **sustained release of melatonin and glycine betaine**, reaching **bioactive levels in water**.
- **$CTS_6$–$TrisCC_{30}$** displayed **the best overall** performance in **structure, swelling, and release control**.
- **Future perspective: validation under abiotic stress** and expansion **to other bioactive compounds** for crop applications.

## References

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[3] Nangia, S.; Warkar, S.; Katyal, D. J. Macromol. Sci., Part A **2018**, 55, 747.

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