Modified Cellulose Nanocrystals compounded with phosphorus-based flame retardants to improve the flame retardant properties and mechanical properties of PLA

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Background

- Green flame retardants have attracted widespread attention with the increase in public awareness of environmental protection. Cellulose nanocrystals (CNCs) can be used as the bio-based carbon source in intumescent systems.
- At the same time, CNCs have excellent mechanical strength, stiffness, and an ideal length-diameter ratio.
- Adding them to the matrix is conducive to improving the mechanical properties of composites.

Question and Method

The low initial decomposition temperature of CNCs limits their application

In order to improve their thermal stability, modification agents containing phosphazene or triazine group , which were used for surface modification of CNCs to obtain a flame retardant cellulose nanocrystal containing phosphazene group (P/N-CNCs) or containing triazine group (C/N-CNCs) (Fig. 1).

Synthetic route and Characterization

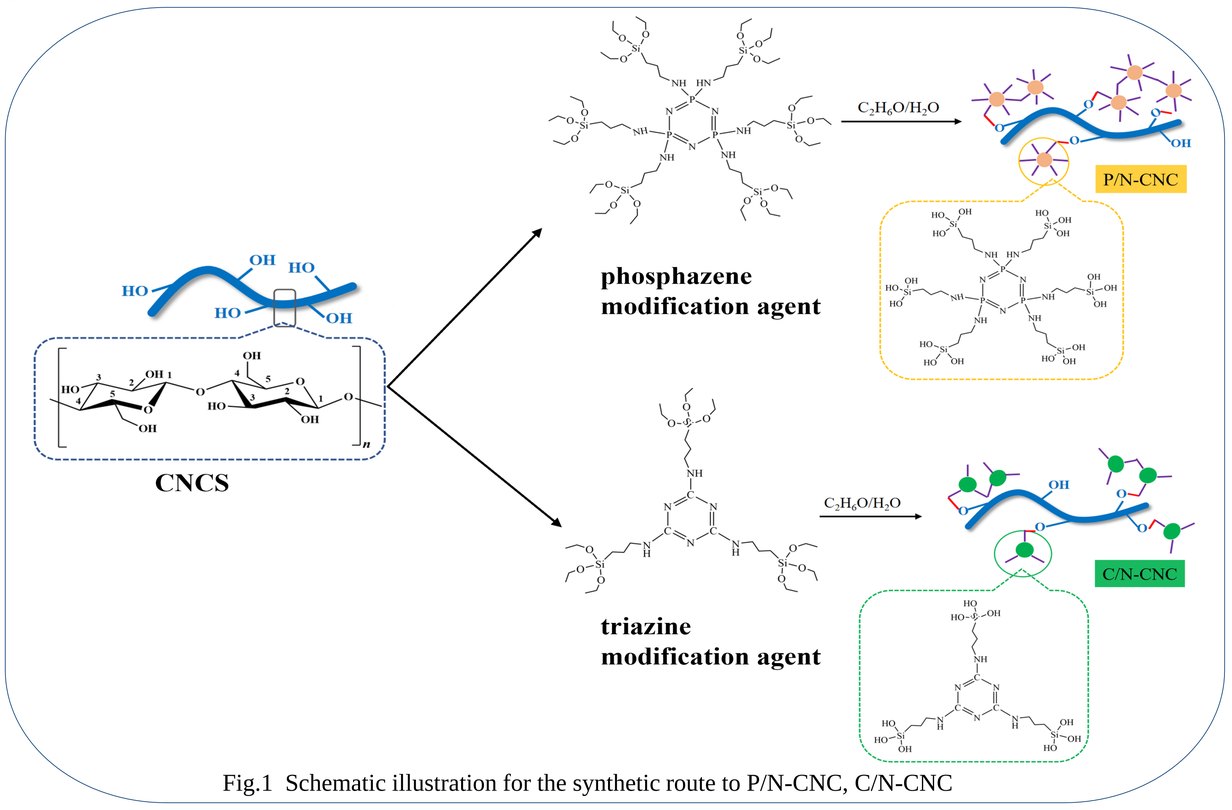

Fig.1 Schematic illustration for the synthetic route to P/N-CNC, C/N-CNC

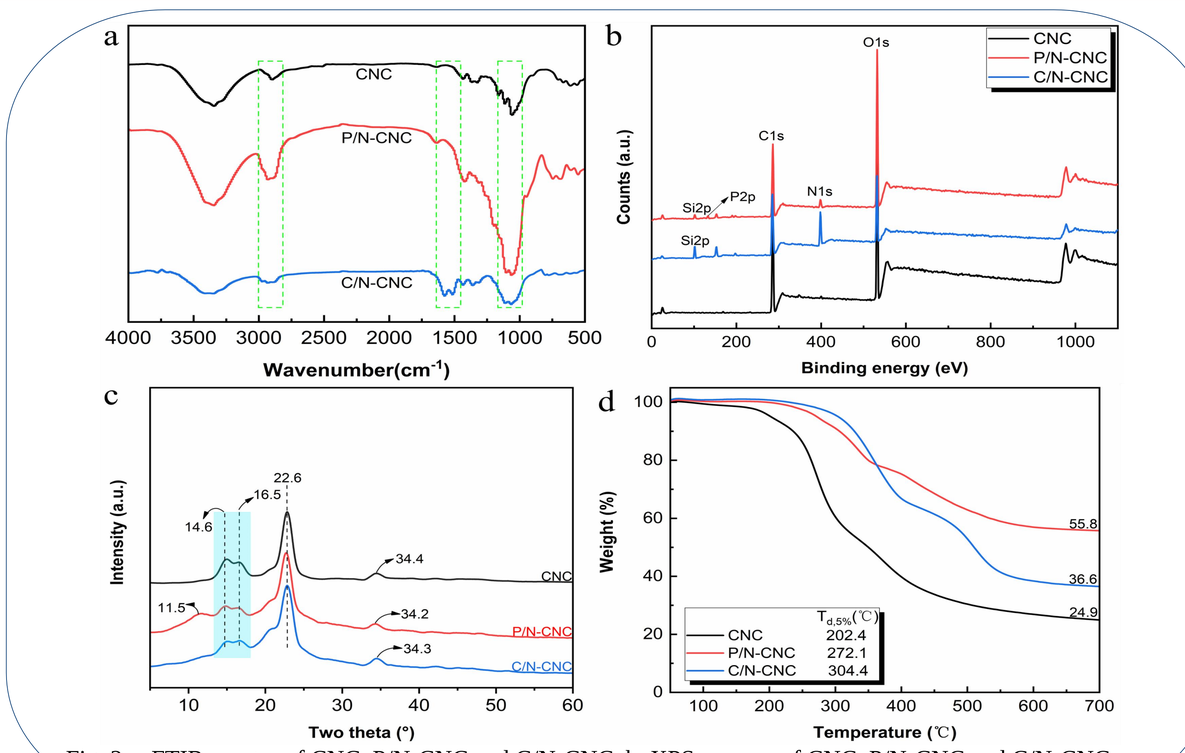

Fig. 2 a. FTIR spectra of CNC, P/N-CNC and C/N-CNC, b. XPS surveys of CNC, P/N-CNC and C/N-CNC, c. XRD patterns of CNC, P/N-CNC and C/N-CNC d. TGA curves of CNC, P/N-CNC and C/N-CNC

Results

Table 1 LOI value and UL 94 rating of PLA and PLA composites

Samples	LOI (%)	UL 94				
		t_1 (s)	t_2 (s)	Dripping	Ignition	Rating
Pure PLA	20.1	48.1	-	Y	Y	NR
PLA/10APP	24.6	4.8	0.9	Y	N	V-0
PLA/7APP/3CNC	25.2	4.3	0.7	Y	Y	V-2
PLA/7APP/3P/N-CNC	28.1	1.8	0.3	Y	N	V-0
PLA/7MPP/3P/N-CNC	22.4	8.1	2.2	Y	Y	V-2
PLA/7AHP/3P/N-CNC	22.7	11.7	3.1	Y	Y	V-2
PLA/7PPAP/3P/N-CNC	23.7	5.9	5.8	Y	Y	V-2

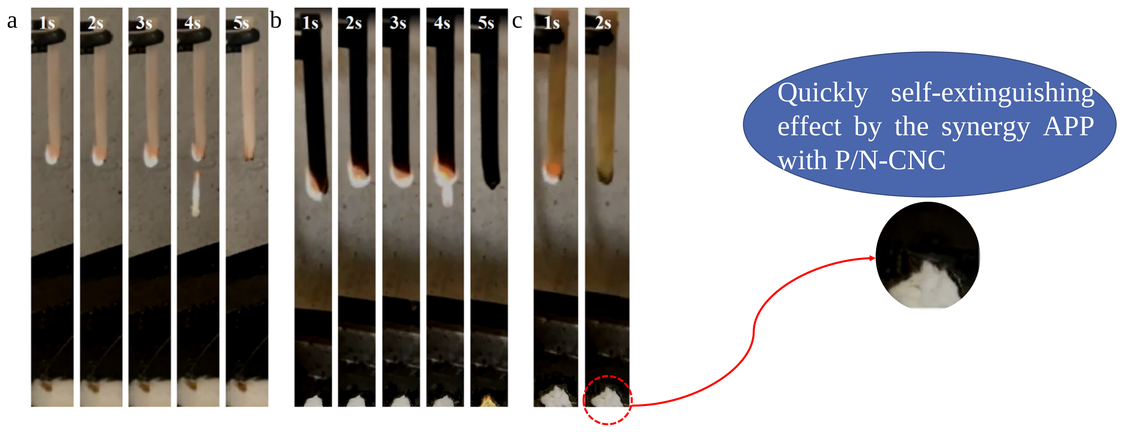

Fig.3 Digital photo of PLA composites in vertical combustion test PLA/10APP (a), PLA/7APP/3CNC (b), and PLA/7APP/3P/N-CNC (c)

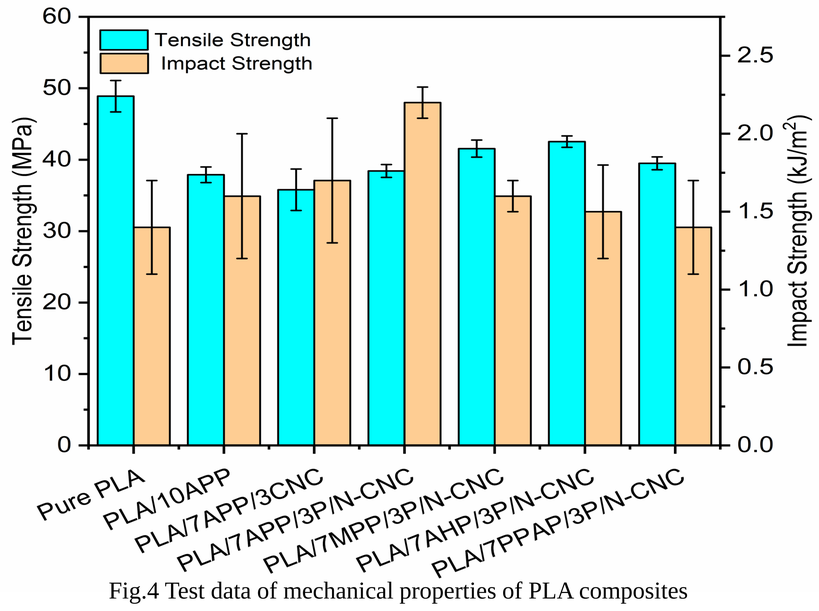

Fig.4 Test data of mechanical properties of PLA composites

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Conclusions

- P/N-CNC and C/N-CNC were obtained by chemical surface modification of CNC. Results showed that P/N-CNC had better char forming ability than C/N-CNC.
- P/N-CNC was compounded with several common phosphorus flame retardants and used for PLA flame retardant. The test results showed that PLA/7APP/3P/N-CNC had the highest LOI and achieved UL 94 V-0 rating, and it had the highest impact strength.
- This study provides a new idea for designing cellulose nanocrystals with flame retardant groups and high thermal stability.

References

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