Improving the Filler Dispersion in Polymer Nanocomposites with Cellulose Nanocrystals

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Abstract

Cellulose nanocrystals (CNCs) have been widely used as a reinforcing component in polymer nanocomposites due to their ability to form percolation networks within a variety of matrices[1, 2]. Above the percolation threshold, the stress-transfer process is thought to be facilitated by CNC-CNC interactions resulting from hydrogen bonding between their surface hydroxyl groups. However, CNC aggregation can take place at high concentrations, which limits the amount of CNCs that can be added to a polymer and the potential reinforcement. With the aim of tackling this problem, we sought to explore the possibility of including a third component in polymer/CNC nanocomposites with the goal to improve the dispersion of CNCs at high filler contents.

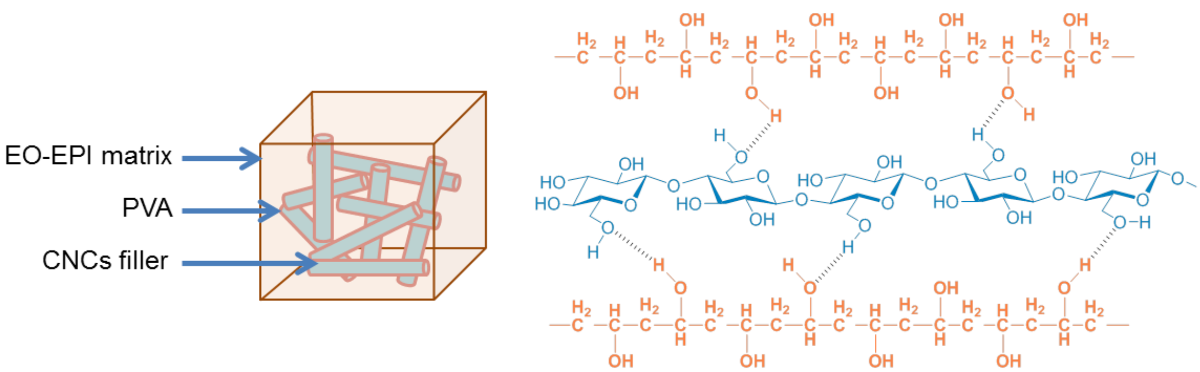
Taking a well-known poly(ethyleneoxide-*co*-epichlorohydrin) (EO-EPI)/CNC nanocomposite as a model, we explored the effect that small amounts of poly(vinyl alcohol) (PVA) have on the mechanical properties of the composites. This design was based on the assumption that PVA would interact with the CNCs through hydrogen bonding and prevent their aggregation and possibly also act as a hydrogen bonding binder, enhancing CNC-CNC stress-transfer. Indeed, the incorporation of small amounts (1 – 5% w/w) of PVA into the EO-EPI/CNC nanocomposites produced a significant enhancement of the mechanical properties for compositions with a CNC concentration above 10% w/w, i.e., above the percolation threshold, in comparison with the EO-EPI/CNC nanocomposite made without PVA. The highest strength and stiffness were obtained for composites with a PVA content of 5% w/w. Laser scanning microscopy (LSM) was used to probe the mechanistic hypothesis by labelling PVA and CNCs with fluorophores known to be capable of fluorescence resonance energy transfer (FRET) and analyzing the resulting EO-EPI/CNC nanocomposites with and without PVA. The LSM data suggest that PVA and CNCs are indeed co-localized and that this results in CNCs being more evenly distributed within the polymer matrix.

References

[1] J.R. Capadona, K. Shanmuganathan, D. Tyler, S.J. Rowan, C. Weder, *Science.* **2008**, *319*, 1370-1374.

[2] K. Shanmuganathan, J.R. Capadona, S.J. Rowan, C. Weder, *Prog. Polym. Sci*. **2010**, *35*, 212-222.

Figures



Schematic representation of the proposed system for PVA-enhanced mechanical properties of EO-EPI/CNC nanocomposite.