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Cellulose is the most abundant renewable polymer on earth, which has long-time applications as energy source, paper, cellulose derivatives and so on. Recently, with the popularity of environment-friendly awareness, cellulose as biorenewable and biodegradable material source, has been developed to prepare high-valued materials. Due to the biorenewablibity and biodegradability, as well as superior stiffness and high transparency, TEMPO-oxidized cellulose nanofiber (TOCN) has been developed as a high potential nanofiller for the polymer nanocomposites in order to expand the application fields of transportation sectors, sports products and so on. The dispersion and alignment of TOCNs are significantly important for the reinforcing properties of the TOCN-based polymer nanocomposites.

In chapter 2, polystyrene/TOCN (PS/TOCN) nanocomposites with TOCNs were successfully prepared and the structural, thermal, optical and mechanical properties were evaluated. The surface of TOCN was modified TOCNs with PS-NH_2 in order to improve the dispersion of TOCN in PS matrix. The results indicated that better dispersion of TOCNs in PS matrix were achieved by surface modification of TOCN with PS-NH_2. Thus, comparing with PS/TOCN nanocomposites, PS/mTOCN nanocomposites maintained higher transmittance over around 90% in the visible light region, and better mechanical properties with 36% improvement of tensile strength and 38% improvement of Young's modulus. With the addition of TOCN, the thermal stability of PS/TOCN nanocomposites, PS/mTOCN nanocomposites was largely improved. The highly transparent PS/mTOCN nanocomposites with better mechanical properties and thermal stability show the broader applications in the industrial materials and consumer goods. The surface modification of TOCN by simple method are beneficial for the improvement of properties for TOCN-based polymer nanocomposites.

In chapter 3, PMMA/TOCN nanocomposites with high transparency and improved mechanical properties were prepared. Owning to the surface modification with PEG-NH_2, the TOCNs were homogenously dispersed in the PMMA matrix, even with a 10 wt% content of TOCN. The optical transmittances of PMMA/TOCN nanocomposites were as high as around 90%. Moreover, because of the opposite signs of the birefringence of PMMA and TOCN, the birefringence of PMMA/TOCN

nanocomposites is controllable by adjusting the TOCN content, and even zero-birefringence, which is significant for the application in optical devices. More importantly, the tensile strength had a 30% increase and Young's modulus had a 150% increase after the addition of 10 wt% TOCNs. Therefore, the PMMA/TOCN nanocomposites show high potential for the application in the engineering field and in optical devices because they exhibit with excellent transparency, thermal stability, adjustable birefringence and improved mechanical properties.

In chapter 4, PMMA/TOCN nanocomposites with various weight ratios of TOCNs by *in situ* polymerization were prepared, which have high transparency, improved tensile strength and Young's modulus, as well as controllable birefringence due to the good dispersion of TOCNs in PMMA matrix. TOCNs were homogenously dispersed in the PMMA matrix without aggregation due to *in situ* polymerization. Moreover, the nanocomposites were highly transparent with transmittance as high as approximately 90%. Furthermore, the birefringence of the nanocomposite could be controlled by the amount of TOCN addition, even achieving zero birefringence. More importantly, the tensile strength and Young's modulus of PMMA were significantly improved with the addition of TOCN. Such well-dispersed TOCN-based nanocomposites with high transparency, controllable birefringence and enhanced mechanical properties exhibit great potential for the applications in the engineering field.

In chapter 5, we successfully achieved the alignment of TOCN by polymerizable liquid crystal of LC242. The baking temperature and time are critical for the alignment of LC242 on PAL. With the higher baking temperature during the liquid crystal state, the alignment process of LC242 was faster, while the dewetting would occur after baking for long time. During the baking process, the order parameter of LC242 firstly increased to a peak, then kept constant, finally decreased due to dewetting. The alignment of TOCNs was achieved by taking the advantages of the alignment of LC242. During the alignment of TOCNs, the TOCNs aggregated during the baking process, forming some TOCN aggregates. And the TOCN aggregates were largely aligned in the direction of LC242. This alignment method could be also applied to other nanocellulose materials in the polymer matrix. The results pave a new way to prepare the aligned

cellulose nanofiber in polymer matrix for the fabrication of polymer nanocomposites with superior mechanical or optical properties.