

A robust polyimine vitrimer/nanocellulose hybrid film as plastic alternatives

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Abstract: Plastic because of its low price, excellent organic solvent resistance and other advantages, has become an indispensable material in daily life. Plastic production in 2018 was about 360 million metric tons. The best way to solve "white pollution" is waste plastic recycling, but the complexity and high cost of treatment have seriously hindered its development. Therefore, the use of sustainable and biodegradable materials as novel plastic alternatives is necessary. Dynamic imine polymers have exchangeable dynamic network structure and reversible cross-linking bonds, so they can be easily reprocessing, chemical degradation and closed-loop cycle can reduce environmental pollution, have very broad application prospects, and are a promising alternative to traditional plastics. However, the dynamic imine polymer network is prone to low-temperature creep with poor dimensional stability and low mechanical strength. In addition, most of the synthetic raw materials of polymers are non-degradable petroleum groups, which still pose a serious threat to the environment. Thus, the integration of bio-based materials in dynamic imine polymer networks is a pioneering combination that is crucial to the development of sustainable materials as well as the optimization of bioplastics. In a variety of bio-based materials, cellulose especially nano cellulose, because of its unique structure and properties, and natural richness, is considered as a promising advanced reinforced materials of components, not only has natural cellulose renewable, biodegradable characteristics also has high strength, high young's modulus, high tensile strength, length ratio can be used as green high performance composite material enhancer, used for the preparation of lightweight, high strength composite material. Therefore, in order to overcome these defects, composite materials with high mechanical properties and simple recovery are prepared using renewable resources nanocellulose (cellulose nanofibrils CNFs) and dynamic imino polymers (PI). PI/CNFs can form multiple hydrogen bond interactions to enhance the interface affinity, thus improving the mechanical properties of PI/CNFs membranes (tensile strength 71.00 MPa, Young's modulus 1.4 GPa). Meanwhile, because of PI, PI/CNFs have good thermal induced repair, excellent water resistance and organic solvents, high thermal stability, and good degradability and recyclability. Furthermore, the PI/CNFs-1% composites can be easily recovered by excess imine closed loop. Our study provides a novel approach to produce highly durable, consistent, and environmentally friendly traditional plastic alternatives with great implications for both environmental protection and social sustainability.

一种可作为塑料替代品的坚固聚亚胺玻璃体分子/纳米纤维素混合膜

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摘要: 塑料因其价格低廉、优良的耐有机溶剂性等优点, 已成为现代生活各个角落不可或缺的材料。2018 年的塑料产量约为 3.6 亿公吨。解决“白色污染”的最佳途径是垃圾塑料回收, 但处理的复杂性和高成本严重阻碍了它的发展。因此, 使用可持续和可降解材料作为新型塑料替代品是必要的。动态亚胺聚合物具有可交换的动态网络结构和可逆的交联键, 因此可以很容易地进行再处理、化学降解和闭环循环可以减少环境污染, 具有非常广阔的应用前景, 是传统塑料的一种很有前途的替代品。然而, 动态亚胺聚合物网络易于发生低温蠕变且尺寸稳定性较差, 机械强度低。此外, 大部分聚合物的合成原料是不可降解的石油基, 这依然会对环境造成严重的威胁。因此, 在动态亚胺聚合物网络中整合生物基材料是一种开创性的组合, 这对可持续材料的发展以及生物塑料的优化都具有至关重要的作用。在各种生物基材料中, 纤维素特别是纳米纤维素, 由于其独特的结构和性能, 以及天然的丰富度, 被认为是一种很有前途的先进功能材料的纳米构件, 不仅具有天然纤维素可再生、可生物降解等特性还具有强度高、杨氏模量高、抗拉伸强度高、长径比大等优点可做为绿色高性能复合材料的增强剂, 用于制备轻量、高强度的复合材料。因此, 为了克服这些缺陷, 利用可再生资源纳米纤维素(纤维素纳米原纤维 CNFs)和动态亚胺聚合物(PI)制备了高机械性能和简单可回收的复合材料, 即 CNFs 增强聚亚胺复合材料(PI/CNFs)。PI/CNFs 可以形成多个氢键相互作用来增强界面亲和力, 从而提高了 PI/CNFs 膜的力学性能(拉伸强度 71.00 MPa, 杨氏模量 1.4 GPa)。同时, 由于 PI 的存在, PI/CNFs 与传统玻璃体一样具有良好的热诱导修复性、优良的耐水和有机溶剂性、较高的热稳定性以及良好的降解性和可回收性。此外, PI/CNFs-1%的复合材料可以很容易地被过量亚胺闭环回收。我们的研究提供了一种新的方法, 以生产高度耐用, 一致, 和环保的传统塑料替代品对环境保护和社会可持续发展都具有重大意义。