

Reduction of Ag^+ by spherical nanocellulose and its applications

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Abstract: Spherical nanocellulose, a new type of nanocellulose, has received widespread attention due to its unique structure and properties. However, its key properties, such as surface reduction properties, have not been fully elucidated, limiting its development in practical applications. For this reason, the surface reduction properties of spherical nanocellulose and its potential applications were thoroughly investigated in this study. Spherical nanocellulose and silver nitrate were used as raw materials to reduce Ag^+ to silver nanoparticles by a simple comingling reaction at 65°C, and the reduction effect of spherical nanocellulose on Ag^+ was assessed by determining the loss rate of Ag^+ . The antibacterial activity of the spherical nanocellulose/silver nanoparticle composites prepared after reduction against the model microbes *E. coli* and *S. aureus* and the catalytic degradation performance of p-nitrophenol was also investigated. The results showed that the spherical nanocellulose reduction of the Ag^+ reaction was carried out for 3 h. The loss rate of Ag^+ reached about 90%, which could efficiently reduce Ag^+ in silver nitrate solution to monolithic silver nanoparticles. The nanosphere morphology, cellulose type II crystalline structure, and low degree of polymerization of the spherical nanocellulose endowed its high surface hydroxyl density, which made it highly reducible. The spherical nanocellulose/silver nanoparticle composites prepared after reduction have a novel structure, which is a conjugate of large nanorods (spherical nanocellulose, with an average particle size of 41 ± 9.7 nm) and small nanorods (silver nanoparticles, with an average particle size of 12 ± 6.3 nm). The large nanorods not only act as reducing agents but also as unique nanorod surface carriers to keep the small nanorods well dispersed. Thanks to this novel structure, the composites exhibited excellent antimicrobial performance against the model microbes *E. coli* and *S. aureus* with minimum inhibitory concentrations of 18.75 $\mu\text{g/mL}$ and 150 $\mu\text{g/mL}$, respectively. Meanwhile, the composite as a catalyst catalyzed p-nitrophenol with an apparent rate constant k_{app} value of 1.6514 min^{-1} and a catalytic activity factor k value of 4792.0 $\text{min}^{-1} \text{g}^{-1}$, which were higher than most of the catalysts of the same type, indicating that it has high catalytic activity.

球状纳米纤维素对 Ag^+ 的还原及其应用研究

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摘要: 球状纳米纤维素作为一种新型的纳米纤维素, 因其独特的结构和性质受到广泛关注。但其表面还原特性等关键性质尚未完全阐明, 限制了其在实际应用中的发展。为此本研究对球状纳米纤维素的表面还原特性及其潜在应用进行了深入的探究。以球状纳米纤维素和硝酸银为原料, 在 65°C 下通过简单的共混反应将 Ag^+ 还原为银纳米颗粒, 通过测定 Ag^+ 的损失率评估球状纳米纤维素对 Ag^+ 的还原效果。并研究了还原后制备的球状纳米纤维素/银纳米颗粒复合材料对模式微生物大肠杆菌和金黄色葡萄球菌的抗菌活性, 以及对对硝基苯酚的催化降解性能。结果表明: 球状纳米纤维素还原 Ag^+ 反应进行 3 h 后, Ag^+ 的损失率约达到 90%, 可以高效地将硝酸银溶液中的 Ag^+ 还原为单质银纳米颗粒。球状纳米纤维素的纳米球形貌、纤维素 II 型结晶结构和低聚合度赋予其高表面羟基密度, 使其具有较高的还原性。还原后制备的球状纳米纤维素/银纳米颗粒复合材料具有新型结构, 是大纳米球 (球状纳米纤维素, 平均粒径 $41 \pm 9.7 \text{ nm}$) 和小纳米球 (银纳米颗粒, 平均粒径 $12 \pm 6.3 \text{ nm}$) 的共轭物。大纳米球不仅充当还原剂, 同时作为独特的纳米球表面载体, 使小纳米球分散良好。得益于这种新颖的结构, 该复合材料对模式微生物大肠杆菌和金黄色葡萄球菌的最小抑菌浓度分别为 $18.75 \text{ }\mu\text{g/mL}$ 和 $150 \text{ }\mu\text{g/mL}$, 具有优异的抗菌性能。同时该复合材料作为催化剂催化对硝基苯酚的表观速率常数 k_{app} 值达到了 1.6514 min^{-1} , 催化活性因子 k 值达到了 $4792.0 \text{ min}^{-1} \text{ g}^{-1}$, 高于多数同类型催化剂, 表明其具有较高的催化活性。