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学位論文題目	
Functional Modification of Bamboo Pulp Fabric Based on Nano Ag and ZnO Particles （ナノシルバーと酸化亜鉛粒子による竹布の機能改質）	
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論　文　内　容　の　要　旨

Bamboo pulp fiber is made from cellulose of bamboo in the form of dissolving pulp which is manufactured by chemical manners like alkaline hydrolysis and multistage bleaching, and then turned out via wet spinning. The processing is similar to that of traditional viscose fiber. Generally bamboo pulp fiber has lost the antibacterial property resulting from the treatment with alkali in the processing and finishing. So it is getting an important aspect to endow bamboo pulp fiber with antibacterial and UV-blocking properties.

In recent years, hyperbranched polymers has recently been of great interest due to its unique chemical and physical properties. Hyperbranched polymers can be directly used as nanoreactors for synthesis nanomaterials. The purpose of this paper is to synthesize water-soluble multi-amide compound hyperbranched polymer RSD and HSDA, and then nano Ag and ZnO particles solution were synthesized by RSD and HSDA under hydrothermal condition. In order to improve the UV protection and antimicrobial properties of bamboo pulp fabric, the synthesized Ag and ZnO particles were applied to treat the fabric. Contents and significance of this dissertation are as follows:

In chapter 2: A one-step simple synthesis of silver colloid nanoparticles with controllable sizes is presented. In this synthesis, multi-amide compound (RSD) was applied as a stabilizer and a reductant. The formation of silver colloid nanoparticles was characterized by Dynamic Light Scattering (DLS), transmission electron microscopy (TEM), UV/Visible absorption spectrophotometry and X-ray diffraction (XRD) measurements. Both particle size and the UV absorption are strongly dependent on the initial $AgNO_3$ concentrations. The silver colloid nanoparticles, prepared with 0.35 g/l $AgNO_3$ aqueous solution in the presences of 2g/l RSD, showed good antibacterial activities against Gram-negative bacteria (Escherichia coli) and Gram-positive bacteria(Staphylococcus aureus). A very low concentration of nano-silver (as low as 3.0 μg/ml)also gave excellent antibacterial performance. Furthermore, in-situ synthesis method of silver nanopartciles on the bamboo pulp fabrics was developed. The examined results confirmed that the in-situ synthesized silver nanoparticles were evenly distributed on the surface of fibers. Bamboo pulp fabric was treated by the multi-amine compound (RSD) and silver nitrate mixed solution by in-situ method. The experiment of antibacterial rate test showed that the finished fabrics had excellent antibacterial and wash-resisting property, 99.99% for S. aureus and 99.53% for E. coli, when the silver content was 97.25 mg/kg. Amazingly, even though washed 20 times, the antibacterial rate of the finished bamboo pulp fabric still remained more than 98%,

In chapter 3: ZnO particles colloidal solution were prepared in one step by mixing $Zn(NO_3)_2$ and RSD aqueous solution under hydrothermal condition. During the synthetic process, RSD served as a reactant,

dispersant and complexing agent. Due to the ZnO particles tend to agglomeration in the solution, in-situ method of synthesis ZnO nanoparticles directly on the bamboo pulp fabric was used to enhance the binding between ZnO particles and fibers. In the finishing process The results indicated that the diameter of ZnO is about 150nm, the length is about 600nm. The anti-UV property of untreated fabric is very weak, Bamboo pulp fabric treated with ZnO particles showed good anti-UV property and its UPF can reach to 83.59.After washing for 20 times, it can also keep good anti-UV property.

In chapter 4: To further enhance the stability and decrease the size of ZnO partciles, new hyperbranched polymers, HSDA-I and HSDA-II, were synthesized from the modified of hyperbranched polymer (RSD). FTIR and TGA showed that HSDA were synthesized and they had good thermal properties. ZnO nanoparticles colloidal solution was prepared in one step by mixing Zn $(NO_3)_2$ and HSDA aqueous solution under hydrothermal condition. The results of TEM and UV-vis spectra indicated that ZnO nanoparticles had been formed in colloidal solution and ZnO nanoparticles synthesized by HSDA-II have a small size and better dispersibility. The ZnO colloid nanoparticles, prepared with 0.74 g/l Zn $(NO_3)_2$ aqueous solution in the presences of 2 g/l HSDA-II, showed good antibacterial activities against Gram-negative bacteria (Escherichia coli) and Gram-positive bacteria (Staphylococcus aureus). A very low concentration of ZnO nanoparticles (as low as 5.0 μg/ml Ag) also gave excellent antibacterial performance.

In chapter 5: This research resents generic strategy to fabricate functional bamboo pulp fabric through synthesis of ZnO nanoparticles on the fabric with HSDA by in-situ synthesis and immersion method. The mechanism of the reaction process was investigated. The UV/Visible absorption spectrophotometry indicated that ZnO nanoparticles colloidal have been formed in the mixed solution. For in-situ synthesis of ZnO nanoparticles on bamboo pulp fabric, the results of SEM and X-ray photoelectron spectroscopy (XPS) techniques confirmed that ZnO nanoparticles have been fixed and well dispersed on bamboo pulp fabric.

Synthesis of ZnO nanoparticles on bamboo pulp fabric with HSDA by immersion method was also studied. The ultraviolet (UV) protective properties and antibacterial activities of the ZnO nanoparticles treated fabrics were measured. The treated bamboo pulp fabrics were characterized by SEM and X-ray spectroscopy (EDS). The results indicated that the bamboo pulp fabric treated with ZnO nanoparticles showed good anti-UV property and its UPF can reach to 90.38. Washing for 20 times, it can also keep good anti-UV properties. The ZnO nanoparticles treated fabric showed 99.91 % bacterial reduction of S. aureus and 99.97 % bacterial reduction of E. coli. The fabric was maintained at over 98.93 % reduction level even after being exposed to 20 consecutive home laundering conditions.