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Functional nanoparticles for preventing wool yellowing

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Abstract. Core-shell $TiO_2@SiO_2$ nanoparticles (NPs) were fabricated and characterized in this study. This novel structure endowed TiO_2 NPs with high transmittance, strong UV-shielding ability, and low photocatalysis properties, which are ideal for protecting wool against photoyellowing from sunlight.

Introduction

Wool fiber is well known as a superior natural textile material, but the photodegradation caused by sunlight makes the fiber weak and yellow [1]. To solve the problem, UV absorbers have been applied to wool. However the protection of wool against photoyellowing under sunlight has not been satisfactory so far due to the limitations of UV absorbers. For inorganic UV absorbers, such as ZnO and TiO_2 NPs, the photoyellowing process of wool treated with ZnO/TiO_2 can be accelerated by reactive radicals due to their strong photocatalysis [2]. Therefore ZnO/TiO_2 is not suitable for application to wool directly though they are less toxic, more stable and effective than the organic ones.

This study aims at fabricating core-shell structured $TiO_2@SiO_2$ material with high UV absorbance and low photocatalytic activity, which will improve the photostability of wool greatly.

Experiments and results

In this work mono-dispersed rutile TiO_2 NPs were prepared by a hydrolysis process of tetrabutyl titanate firstly. And then silica shells were coated onto the surfaces of synthesized particles by stöber method (Figure 1).

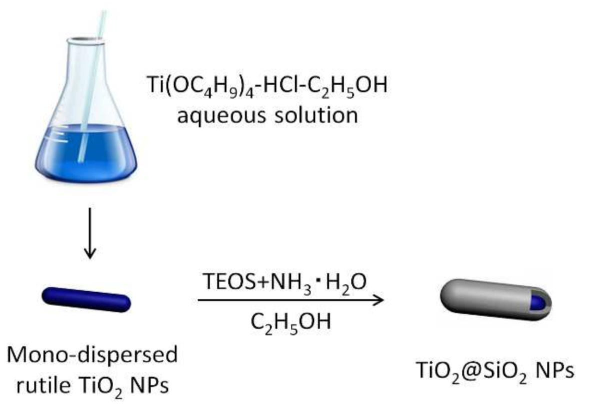

Figure 1. Schematic of the preparation of $TiO_2@SiO_2$ NPs.

The average size of generated TiO_2 NPs was around 25 nm in diameter and 100 nm in length as shown in the TEM image below (Figure 2), and the rutile crystal-type was proved by XRD.

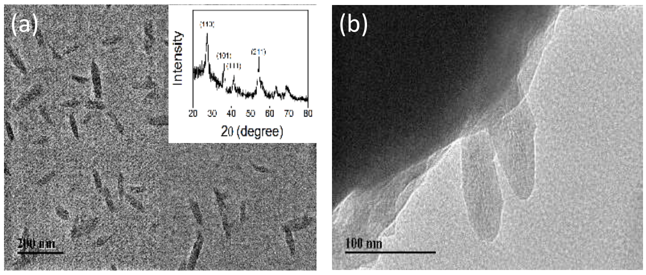

Figure 2. TEM images of (a) mono-dispersed rodlike rutile TiO_2 NPs and (b) $TiO_2@SiO_2$ NPs. The insert is the XRD spectrum of synthesized TiO_2 NPs.

These TiO_2 NPs exhibited higher UV absorption and transmittance, and much lower photocatalytic activity than that of commercial TiO_2 NPs (e.g. P25). Their photocatalytic activity was further reduced at subsequent silica coating step, while the UV absorption and transmittance were slightly decreased. The treatment of $TiO_2@SiO_2$ NPs indeed retarded the yellowing rate of wool fabrics, and the whiteness was improved along with the increase of NPs concentration (Figure 3).

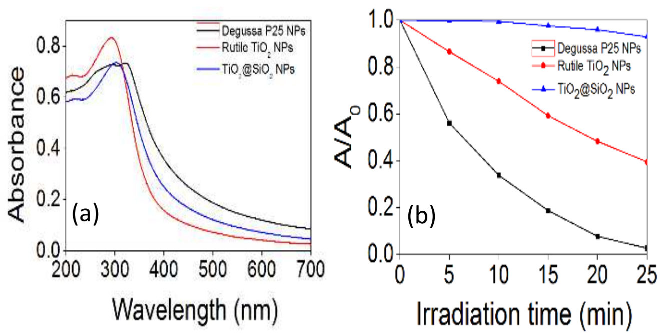

Figure 3. a) UV-Vis spectra and b) photocatalytic activity of Degussa P25 NPs as well as the mono-dispersed rodlike rutile TiO_2 NPs before and after silica coating.

The treatment of $TiO_2@SiO_2$ NPs indeed retards the yellowing process of woolen fabrics over untreated fabric, and the whiteness is improved along with the increase of consumption (Figure 4).

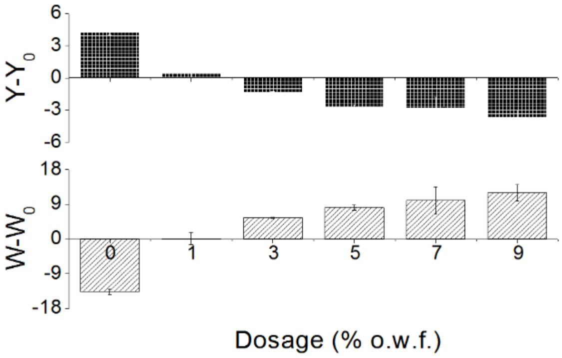

Figure 4. Yellowness and Whiteness of wool fabrics treated with $TiO_2@SiO_2$ NPs before and after 240 h simulated solar irradiation.

Conclusion

Core-shell structured rutile type $TiO_2@SiO_2$ NPs have been prepared successfully. These structured nanoparticles have high UV absorbing ability and low photocatalytic activity, as well as good transparency. After 240h simulated solar irradiation, they have been found to greatly retard the photoyellowing rate of wool fabrics.

References

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