

Novel Paper Sheets Containing Kapok Fibers

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Abstract

The focus of this present work is to develop a novel paper sheet which includes Kapok fibers containing Solid fluorescence particles inside. The Kapok fiber is natural half-transparent hollow tube whose inner and outer diameters are 18 and 20 μm respectively. This fibers exhibit superior water repellent properties and absorb oil due to capillary force. Furthermore, the fibers have a high hollow rate. In general, synthetic fibers have a hollow rate of under 50%, however, those of Kapok fibers are about 90%. In this paper, we made Kapok fibers containing Solid fluorescence particles inside, and a paper sheet containing the composite fibers as described above. We found that the paper sheet exhibits strong luminescent and high solvent resistance. The Kapok fibers including Solid fluorescence particles have a beneficial effect on anti-counterfeit technologies.

1. Introduction

Security paper sheets such as banknote often include fluorescence fibers as shown in Figure 1. The fluorescence fibers used for security technologies are generally dyed with fluorescence dyes which have poor repellence against water and/or oil. Whereas these fibers can be easily dyed, they easily lose the dye. By contrast, there are Solid fluorescence materials which have high solvent resistance. However, it seems be difficult to keep Solid fluorescence particles with fibers. Therefore, we utilize Kapok fibers to keep these Solid fluorescence particles. In present work, we report the Kapok fibers containing Solid fluorescence particles and paper sheets including Kapok fibers containing them.

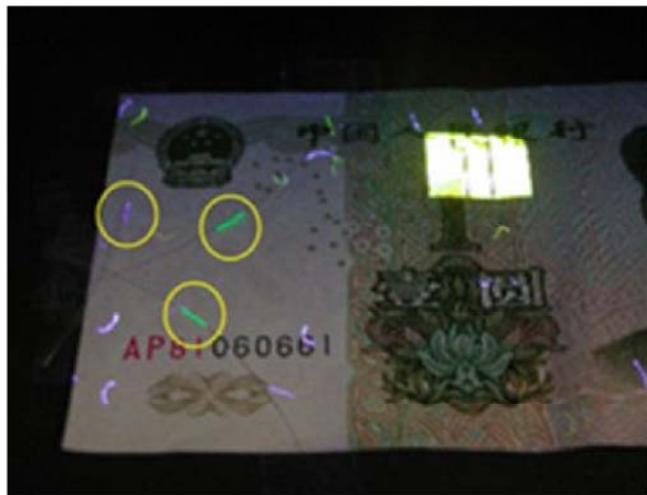


Figure 1 Chinese banknote under UV light.

2. Kapok fiber

We can see Kapok trees in forests of south-eastern Asia, especially Indonesia and Philippines. The Kapok fibers can be said as environment-friendly materials, because the Kapok fibers are fruits of Kapok trees. The Kapok fiber is natural half-transparent hollow tube whose inner and outer diameters are 18 and 20 μm respectively. This fibers exhibit superior water repellent properties and absorb oil due to capillary force. Furthermore, the fibers have high hollow rate. In general, synthetic fibers have hollow rate of under 50%, however, those of Kapok fibers are about 90%. The Kapok fibers are applied to pads for life jackets and pillows, because the material has large number of porosities and then specific gravity is quite low.



Figure 2 Fruit of Kapok Tree.

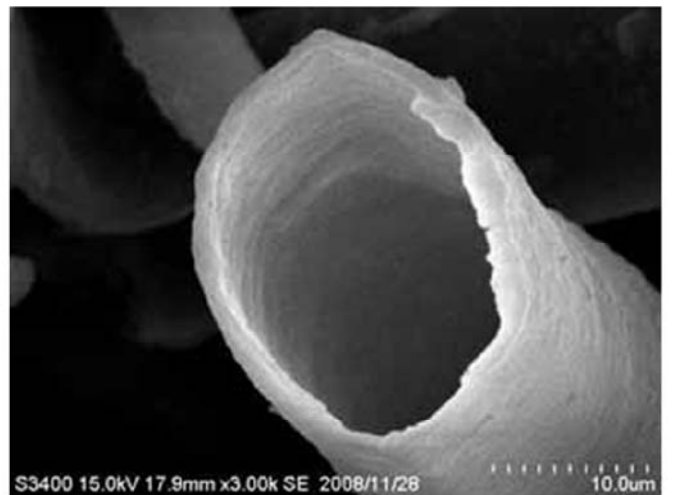


Figure 3 SEM Image of Kapok fiber.

3. Solid fluorescence material

Solid fluorescence material, 5,5'-Bis[4-(N-carbazolyl)phenyl]-3-dimesitylboryl-2,2'-bithiophene, which we used in this present work, is highly emissive organic solid with fluorescence. It was produced by using 3-boryl-2,2'-bithiophene as a core skeleton.

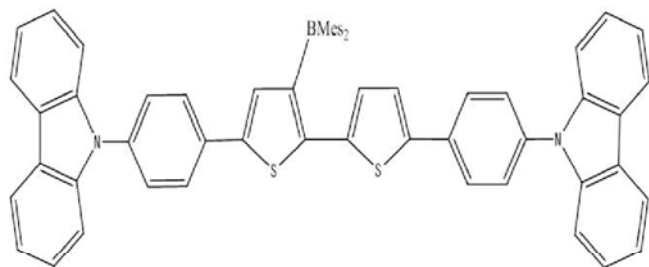


Figure 4 Solid fluorescence material structural formula.

4. Experiment method

4-1. Kapok fibers containing Solid fluorescence particles

The Kapok fibers containing Solid fluorescence particles were prepared as follows: 0.01 g of Solid fluorescence particles were dissolved in 1.0 g of ethanol in 50 ml beaker. Then 0.12 g of Kapok fibers were dropped gradually into the beaker. The Solid fluorescence particles solution were absorbed into Kapok fibers due to the capillary force.



Figure 5 A Schematic diagram showing a Kapok fiber containing Solid fluorescence particles.

4-2. Paper sheets including Kapok fibers containing Solid fluorescence particles

Paper sheets including Kapok fibers containing Solid fluorescence particles were prepared as follows: 12g of pulp were mixed with 500ml of water by the mixer, 10g of PVA were added after that, and pulp liquid was prepared. Pulp liquid was poured into simple handsheet making kit, then Kapok fibers containing Solid fluorescence particles were included within the pulp liquid. Finally, drying process was performed for the above thing, and paper sheet including Kapok fibers containing Solid fluorescence particles was obtained.

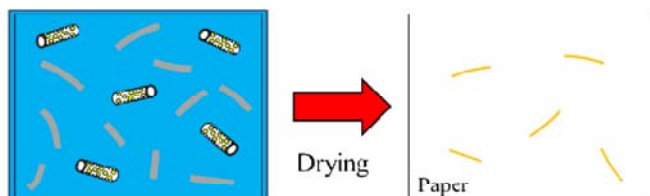


Figure 6 A model of paper sheets including Kapok fibers containing Solid fluorescence particles.

4-3. $L^*a^*b^*$ measurements by colorimeter

The picture under UV light of paper sheet including Kapok fibers containing Solid fluorescence particles was printed out with the inkjet printer. This picture measurements are $L^*a^*b^*$ between Kapok part and Pulp part by colorimeter. We measured about paper sheet including Kapok fibers with Fluorescein sodium in previous works in the same way.

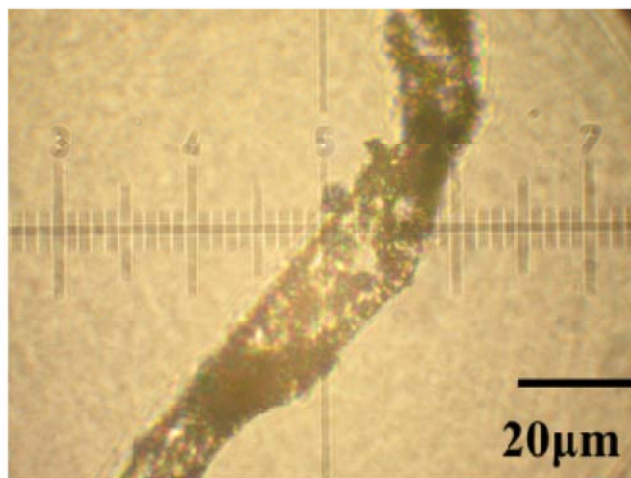
4-4. Paper sheets made from only Kapok fibers

The paper sheet made from only Kapok fibers was prepared as follows: 2g of Kapok fibers were mixed with 500ml of water by the mixer, 10g of PVA were added after that, and Kapok liquid was prepared. Kapok liquid was poured into simple handsheet making kit. Finally, drying process was performed to the above thing, and paper sheet made from only Kapok fibers obtained.

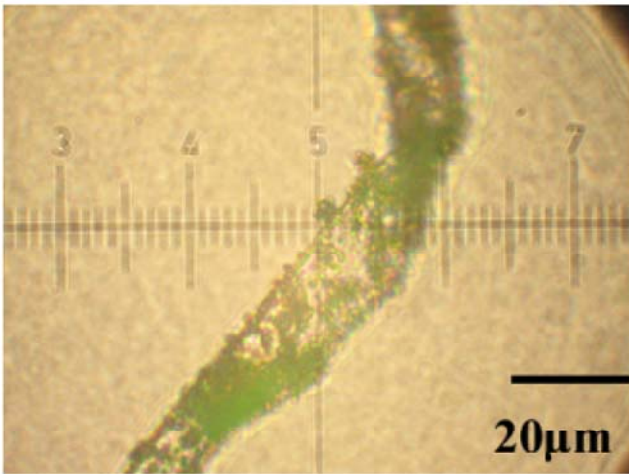
5. Results and Discussion

We found that Solid fluorescence particles in a Kapok fiber exhibit luminescent under UV light as shown in Figure 7. Therefore, it can be said that we have succeeded to make Kapok fibers containing Solid fluorescence particles. We also observed luminescence from paper sheets including Kapok fibers containing Solid fluorescence particles as shown in Figure 8. The outline made by luminescence of Kapok fibers with Fluorescein sodium is hazy as shown in Figure 9, while that of Kapok fibers containing Solid fluorescence particles is relatively clear. These results suggest that the water repellence of Solid fluorescence particles is stronger than that of Fluorescein sodium. In addition, it can be thought that the protection of Solid fluorescence particles increase the water repellence. We measured the $L^*a^*b^*$ for paper sheet including Kapok fibers containing Solid fluorescence particles and paper sheet including Kapok fibers with Fluorescein sodium using the colorimeter as shown in Table 1 and 2. Under U.V light, large color differences were observed between Kapok fiber part and pulp fiber part. We found that the paper sheet including Kapok fibers containing Solid fluorescence particles exhibits strong luminescent and high solvent resistance.

We have also succeeded to make paper sheets made from only Kapok fibers as shown in Figure 11. These paper sheets have large number of porosities, which can be used for the application such as the heat insulation and filters.



(a) Appearance under visible light.



(b) Appearance under visible and UV light.

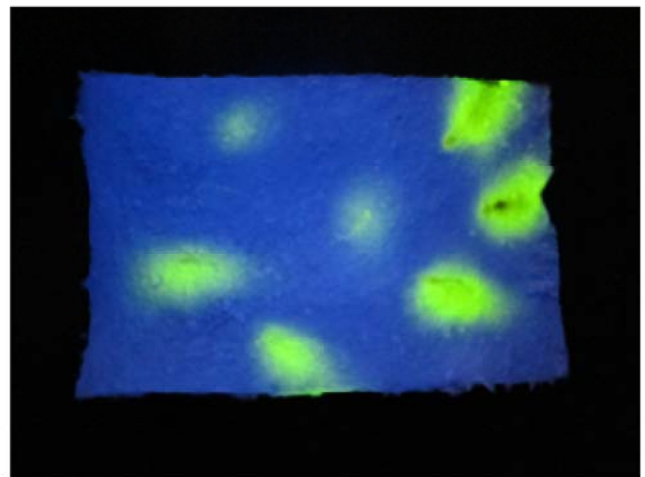
Figure 7 Kapok fiber containing Solid fluorescence particles.



(a) Appearance under visible light.

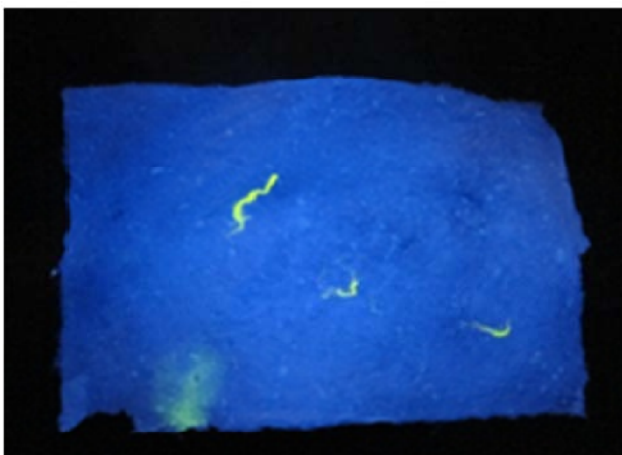


(a) Appearance under visible light.



(b) Appearance under visible and UV light.

Figure 9 Fluorescence of the paper sheets including fluorescent Kapok fibers.



(b) Appearance under visible and UV light.

Figure 8 Fluorescence of the paper sheets including fluorescent Kapok fibers containing Solid fluorescence particles.

Table 1 L*a*b* of the paper sheets including Kapok fibers containing Solid fluorescence particles.

	L*	a*	b*
Luminescent part	79.42	-24.25	51.49
Unluminescent part	43.68	-1.67	-52.93
Color difference	112.65		

Table 2 L*a*b* of the paper sheets including Kapok fibers with Fluorescein sodium.

	L*	a*	b*
Luminescent part	69.60	-26.65	3.74
Unluminescent part	39.31	-1.15	-51.17
Color difference	67.69		

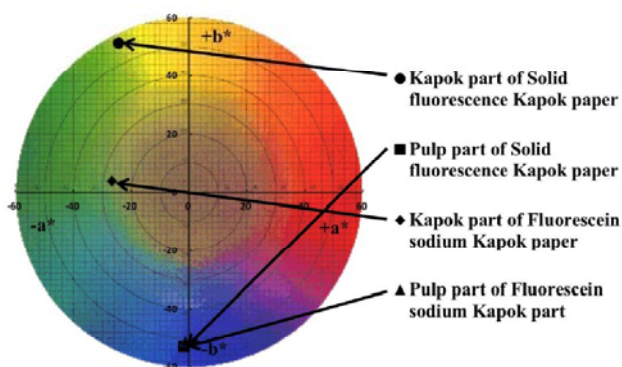


Figure 10 Color measurements of Kapok fibers containing Solid fluorescence particles or with Fluorescein sodium by spectrodensitometer.



Figure 11 SEM image of paper sheet made from only Kapok fibers.

6. Conclusion

We have succeeded to make Kapok fibers containing solid fluorescence particles. We have also succeeded to make paper sheets containing Kapok fibers above. We found that the paper sheets exhibits strong luminescent and high solvent resistance. The Kapok fibers including solid fluorescence particles have a beneficial effect on anti-counterfeit technologies. In addition, we have succeeded to make paper sheets made from only Kapok fibers, which can be used for the application such as the heat insulation and filters.

Reference

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Author Biography

Motochika Yukawa was born in 1990. He received his B.E. degree in 2013 from Tokai University. He is expected to receive his M.E. degree from the graduate school of Tokai University in 2015. He is now engaged in a study of novel paper sheets containing Kapok fibers.

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