Rewritable Paper Sheets having Kapok Fibers containing Chromic Materials

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Abstract

The target of this present work is, using natural hollow fiber named Kapok fiber and functional materials, to obtain color changeable sheets which have potential to be used as rewritable and electronic paper in simple preparation and with low cost. We will introduce three types of kapok fibers containing chromic materials such as thermochromic, solvatochromic and piezochromic materials.

1. Introduction

Kapok fiber is a natural half-transparent tube whose inner and outer diameters are 18 and 20 μm, respectively. This fiber has high hollow rate of 80% and over, while that of a typical synthetic hollow fiber is at most 50%. Kapok fibers can contain functional materials due to their strong capillary force. We have succeeded in obtaining three types of functional kapok fibers containing chromic materials such as thermochromic, solvatochromic and piezochromic materials.

2. Kapok fibers containing thermochromic materials

2.1 Thermochromic material

The first example of chromic kapok fibers contains thermochromic materials. We utilized a thermo-sensitive ink as thermochromic material which shows blue at room temperature and pink at 40℃ and over [1]. The thermo-sensitive ink consists of leuco dye, developer and pigment. The lueco dye and the pigment show blue and pink, respectively, at room temperature. The total color of the ink is blue because blue from the lueco dye is much stronger than pink from the pigment. However, at high temperature, the leuco dye reacts with developer and then becomes transparent. As a result, the pink color from the pigment appears as shown in Figure 1.

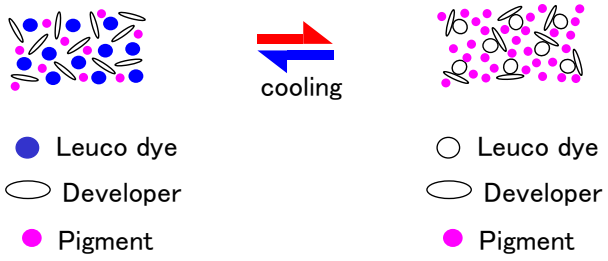

Figure 1. Thermosensitive ink which shows blue at room temperature and pink at 40℃ and over

2.2 Preparation and characterization

It is quite easy to prepare kapok fibers containing the thermo-sensitive ink [1]-[3]. All we have to do is to disperse and mix the thermo-sensitive ink particles and the kapok fibers in water as shown in Figure 2. The ink particles were automatically absorbed into kapok fibers due to the capillary force. The kapok fibers were dried to fix the ink particles onto their inner walls. We have confirmed that, using SEM, the thermochromic ink particles are fixed on the inner wall of the kapok fiber (see Figure 3).

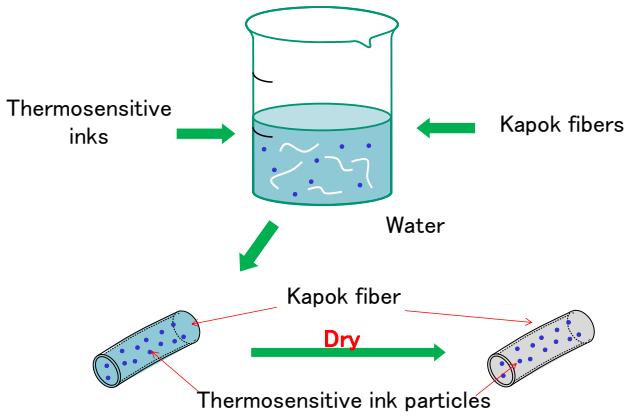

Figure 2. Schematic diagram for the preparation of kapok fibers containing thermosensitive ink particles

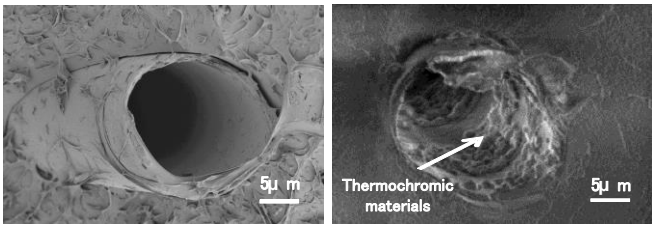

Figure 3. SEM micrographs in the absence (left) and presence (right) of thermosensitive ink particles

Even in the kapok fibers, the lueco dye exhibits blue at room temperature. However, the lueco dye loses its color when reacting with developer at high temperature. As a result, the fibers exhibit pink which originally comes from the pigment as shown in Figure 4.

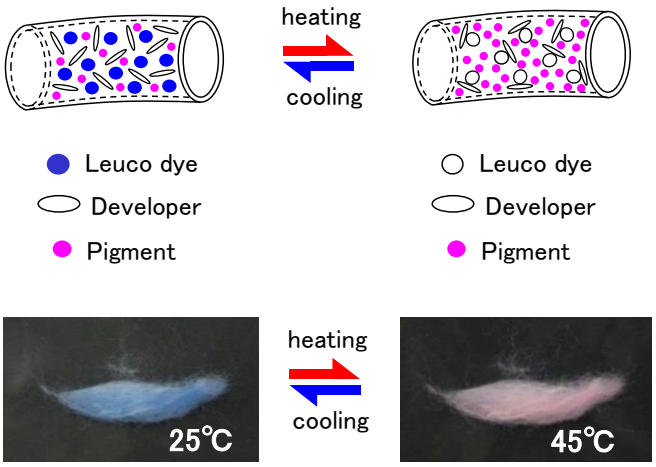

Figure 4. Reversible color change in kapok fibers

It is also very easy to prepare paper sheet having kapok fibers containing the thermo-sensitive ink [1] -[3]. All we have to do is to drop kapok fibers containing the thermosensitive ink particles on a wet paper sheet and then dry the sheet as shown in Figure 5.

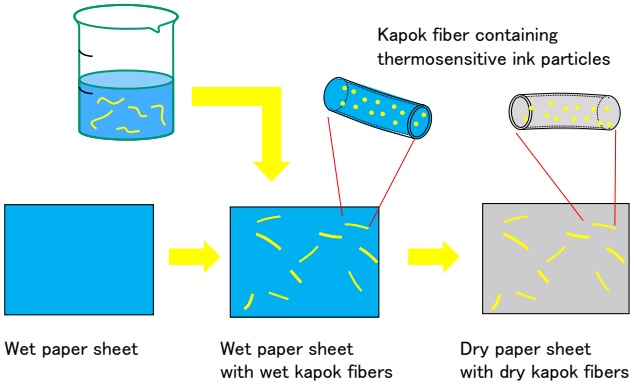

Figure 5. Preparation of paper sheet having kapok fibers containing thermosensitive ink particles

2.3 Potential application

A paper sheet having these kapok fibers changes its surface color from blue to pink by heating. And then, by cooling, the color is easily changed from pink to blue again as shown in Figure 6. Therefore, the paper sheet could be used as a rewritable medium and an electronic paper sheet.

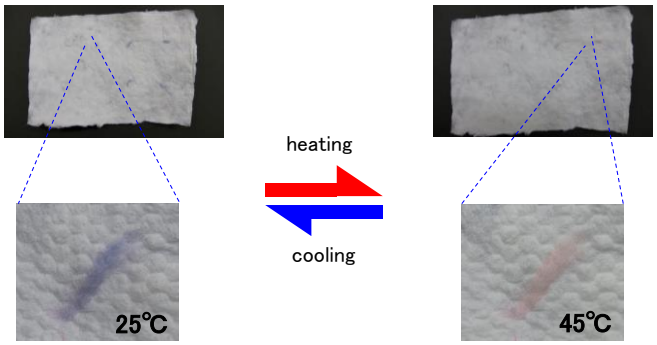

Figure 6. Potential application of paper sheet having kapok fibers containing thermosensitive ink particles

3. Kapok fibers containing solvatochromic materials

Let's move onto the next example of chromic kapok fibers. We utilized a cupper complex (see Figure 7) as a solvatochromic material which is transparent in water and yellow in ethanol as shown in Figure 8.

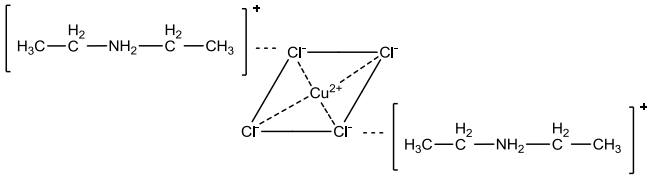

Figure 7. Cupper complex, Bis (diethyl ammonium) tetra copper chloride (Ⅱ), which is transparent in water and yellow in ethanol

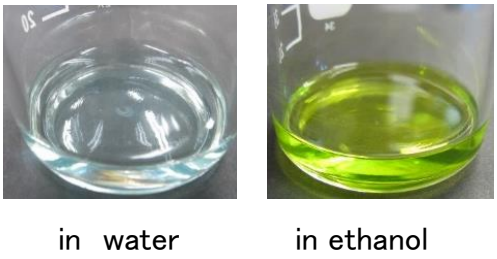

Figure 8. Solutions of Bis (diethyl ammonium) tetra copper chloride (Ⅱ), which is transparent in water and yellow in ethanol

We have observed a kapok fiber prepared with the cupper complex using EPMA. In this observation, in Figure 9, the red area corresponds to cupper and the green area does carbon. Therefore, it can be said that we have succeeded in making kapok fibers containing the cupper complex, in other words, one of solvatochromic materials.

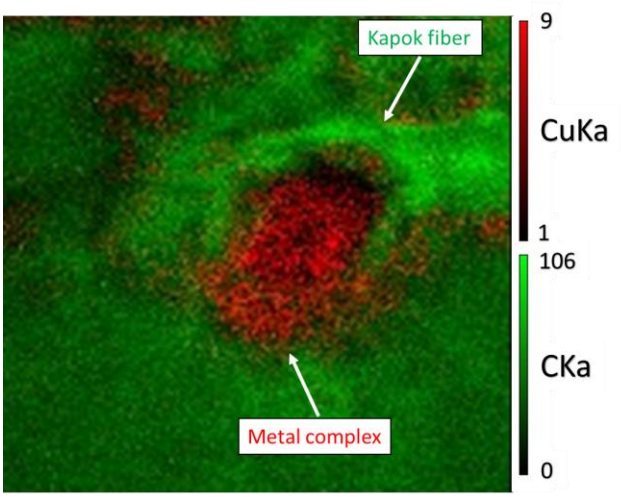

Figure 9. EPMA image of a kapok fiber prepared with the cupper complex, Bis (diethyl ammonium) tetra copper chloride (Ⅱ)

We note that the cupper complex shows not only solvatochromism but also thermochromism as shown in Figure 10. Therefore, we think that, utilizing the duality, the paper sheet having kapok fibers containing the cupper complex has a potential to be used as a new type of security paper.

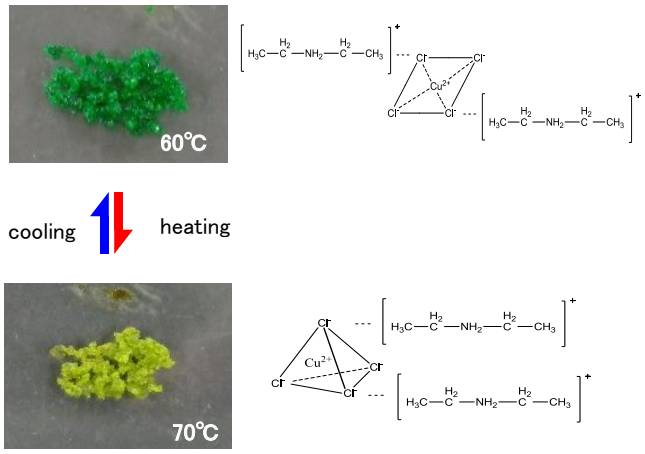

Figure 10. Thermochromism of the cupper complex, Bis (diethyl ammonium) tetra copper chloride (Ⅱ)

4. Kapok fibers containing piezochromic materials

This is the last example of chromic kapok fibers. We utilized Bianthrone (see Figure 11) as a piezochromic material which shows yellow and green in the absence and presence of pressure, respectively.

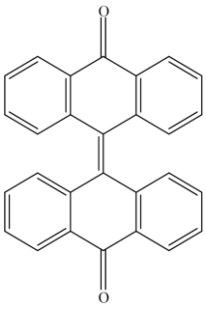

Figure 11. Chemical structure of Bianthrone which shows yellow and green in the absence and presence of pressure

We have observed reversible color change of a paper sheet having kapok fibers containing piezochromic materials in the absence and presence of pressure, although the color change looks relatively small as shown in Figure 12. One of interesting applications of the paper sheet might be for use in a pressure sensor.

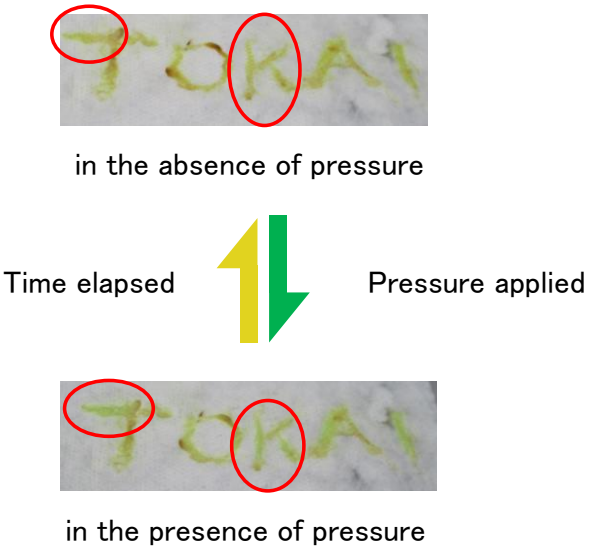

Figure 12. Reversible color change of a paper sheet having kapok fibers containing piezochromic materials in the absence and presence of pressure

5. Conclusions

We have succeeded in obtaining kapok fibers containing chromic materials and their paper sheets. Paper sheets with kapok fibers containing chromic materials have potential applications including security and rewritable paper since they are easy to prepare.

References

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Author Biography

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