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The Study of Moisture Absorption and Release Properties of Tencel Fiber

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Keywords: tencel LF; tencel G100; tencel A100; moisture absorption; moisture release; moisture regain; regression curve

Abstract: Tencel fiber is an environmental friendly regenerated cellulose fiber generated using solvent spinning method, which has been widely used in recent years for its good wearability. The experiment of moisture absorption and release properties was carried out in standard atmospheric conditions for different kinds of tencel fiber in this research, and then moisture absorption, moisture release, moisture absorption rate and moisture release rate regression curves were established and compared with those of ordinary viscose fiber. The results showed that the moisture absorption and release properties of different tencel fiber were different for their different processing processes. The moisture absorption equilibrium regain of tencel LF is 8.89%, tencel A100 is 11.44%, and tencel G100 is 10.33%. The moisture absorption ability of tencel A100 is the best, tencel G100 is the second, and tencel LF is the third. The moisture release equilibrium regain of tencel LF is 10.66%, tencel A100 14.12%, and tencel G100 11.47%. Moisture absorption, moisture release, and their rate regression curves are all close to exponential curves.

Introduction

Tencel fiber is generated using solvent method, which is environmental friendly regenerated cellulose fiber and used widely. Common tencel fiber has three kinds: tencel LF; tencel G100, tencel A100. Tencel fiber mainly owes its use in a wide range to its strong moisture absorption and release ability. In order to grasp the moisture absorption and release law of different kinds of tencel fiber and to develop product, the moisture absorption and release properties of different tencel fiber were tested and analyzed in this study.

The design of research program

Experiment sample. In order to make test data comparable, the fiber selected was cotton type with a specifications of 38 mm×1.7 dtex, and the samples were tencel LF, tencel G100 and tencel A100.

Experiment instruments and conditions. Experiment instruments: YG747 ventilated eight basket constant temperature oven, electronic balance, YG501D moisture permeability test box, glass dryer, glass dish, seal weighing box.

Test index: moisture absorption curve, moisture release curve, balance moisture regain.

Test conditions: moisture absorption and release experiment was carried out and balance moisture regain was measured in the standard atmospheric conditions with temperature 20˚C±2˚C and relative humidity 65%±4%.

Experiment method. Moisture absorption experiment: fiber sample about 1g was put into YG747 ventilated eight basket constant temperature oven with temperature 105˚C and then put into glass dryer to undergo closed cooling process, which was weighed as the initial quality of samples. Then the samples was put on electronic balance and kept in fluffy state into moisture absorption process. The weight of sample was recorded one time every 5 min, until the fiber reached to moisture absorption balance in standard condition. The moisture regain of sample every 5 min was obtained through calculation and balance moisture regain in standard condition was also calculated.

Moisture release experiment: fiber sample about 1g was put into YG501D moisture permeability test box with temperature 20˚C and relative humidity 90% for 6h to make samples absorb moisture sufficiently. The weight of samples was weighted to be the initial quality in moisture release experiment and the quality change of samples was measured in the process of moisture release in standard condition, until the fiber reached to moisture release balance in standard condition. After balance, the samples were dried, closed cooled, weighted in dry state and balance moisture regain was calculated in standard condition.

Experiment results and analysis

Moisture Absorption Properties. The change of moisture regain of several tencel fiber with time was calculated and drawn based on the data of moisture absorption experiment, as shown in figure 1.

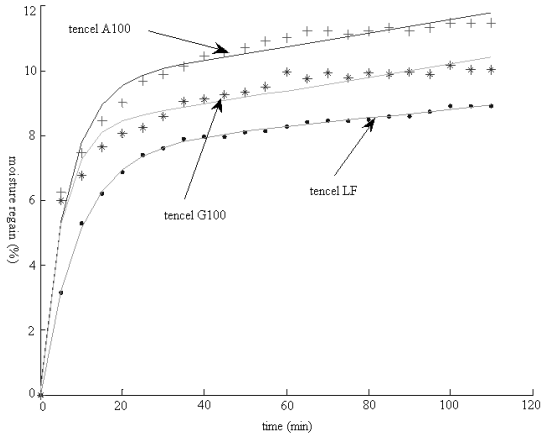

Figure 1 The change of moisture absorption of several tencel fiber

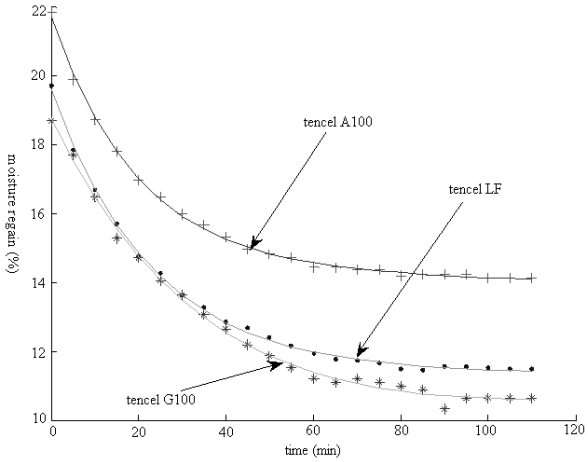

Figure 2 The change of moisture release of several tencel fiber

It can be seen from figure 1 that the change trend of moisture absorption of three kinds of tencel fiber is consistent, and present the characteristics that the change varies quickly in initial stage, changes slowly in later stage, and tends to be stable at last. In the first 5min, moisture regain changes quickly, especially for tencel A100 and tencel G100, the changes of the two are consistent basically, and when moisture regain rises to about 6%, the moisture absorption properties are both better than that of tencel LF. In 5min~30min, moisture regain changes slowly. In 30~60min, moisture regain changes more slowly. When time is about 100min, the moisture regain of three kinds of tencel fiber tends to be stable, reaching moisture absorption balance. The balance moisture regain of tencel LF is 8.89%, tencel A100 is 11.44%, tencel G100 is 10.33%, which shows that the moisture absorption properties of three kinds of tencel fiber are different, and tencel A100 is the best, tencel G100 the second, and tencel LF the third.

Moisture Release Properties. The change of moisture regain of several tencel fiber was calculated and drawn based on the data of moisture release experiment, as shown in figure 2.

It can be seen from figure 2 that he change trend of moisture release of three kinds of tencel fiber is also consistent. The specimens were conditioned at a temperature of 20˚C and humility of 90％ for 6 hours, and the initial moisture regain is different, thereinto, tencel LF is 19.72%, tencel A100 21.86%, and tencel G100 18.68%. In the first 30min, moisture regain changes quickly; in 30min~60min, moisture regain changes slowly; in 60min~100min, moisture regain changes more slowly. After 100min, the moisture regain tends to be stable, reaching moisture release balance. At this time, the moisture regain of three kinds of tencel fiber are different, and tencel LF is 11.47%, tencel A100 14.12%, tencel G100 0.66%, which is consistent with that of moisture absorption experiment. The decline curves of moisture regain of three tencel fibers are parallel basically, which explained that moisture release properties are close.

Comparing the difference between the moisture absorption and moisture release balance moisture regain of tencel fiber, it was found that tencel LF is 2.58%, tencel A100 3.72%, and tencel G100 0.33%, which explained that the tencel fiber has moisture absorption hysteretic nature. Among three fibers, tencel A100 has higher moisture release balance moisture regain because its moisture absorption properties are the best, and the space between of fiber macromolecular is increased after water molecules enter into fiber amorphous area and water molecules are prevented leaving because more polar groups on macromolecular attract water molecules when tencel fiber releases moisture.

Fitting Equations. In order to master the law of moisture absorption and release of several tencel fiber better, MATLAB software was used to fit the regression equations between moisture absorption and release regain and time, which is expressed as

$$Y = ae^{bx} + ce^{dx}$$

The regression equations of moisture absorption

- Tencel LF

$$Y = 7.538e^{0.001543x} - 7.551e^{-0.1094x}$$

The confidence intervals of each coefficient: a (7.426, 7.65), b (0.001354, 0.001732), c (-7.713, -7.389), d (-0.1147, -0.1042).

SSE: 0.08813, RMSE: 0.06811

R-square: 0.999, Adjusted R-square: 0.999.

- Tencel A100

$$Y = 9.584e^{0.001864x} - 9.328e^{-0.1539x}$$

The confidence intervals of each coefficient: a (9.143, 10.03), b (0.001253, 0.002475), c (-10.11, -8.542), d (-0.1835, -0.1243).

SSE: 2.168, RMSE: 0.3378

R-square: 0.9849, Adjusted R-square: 0.9825.

- Tencel G100

$$Y = 8.243e^{0.002122x} - 8.084e^{-0.1943x}$$

The confidence intervals of each coefficient: a (7.836, 8.649), b (0.001457, 0.002787), c (-8.89, -7.278), d (-0.240, -0.1482).

SSE: 2.295, RMSE: 0.3475

R-square: 0.9785, Adjusted R-square: 0.9751.

The Regression Equations of Moisture Release.

- Tencel LF

$$Y = 8.22e^{-0.04284x} + 11.36$$

The confidence intervals of each coefficient: a (8.085, 8.355), b (-0.0445, -0.04118), c (11.29, 11.43).

SSE: 0.1371, RMSE: 0.08278

R-square: 0.9988, Adjusted R-square: 0.9987.

- Tencel A100

$$Y = 7.276e^{-0.05045x} + 14.43e^{-0.0002405x}$$

The confidence intervals of each coefficient: a (6.87, 7.682), b (-0.05534, -0.04556), c (14, 14.86), d (-0.0005528, 7.178e-005).

SSE: 0.1411, RMSE: 0.08617

R-square: 0.9985, Adjusted R-square: 0.9983.

- Tencel G100

$$Y = 10.04e^{-0.02731x} + 8.697e^{0.001383x}$$

The confidence intervals of each coefficient: a (7.963, 12.12), b (-0.03409, -0.02052), c (6.515, 10.88), d (-0.0006058, 0.003371).

SSE: 0.4238, RMSE: 0.1494

R-square: 0.9967, Adjusted R-square: 0.9962.

Moisture absorption and release rate

The Equations and Curves of Moisture Absorption and Rrelease Rate. The equations of change of moisture absorption and release rate were obtained through derivation to the moisture absorption and release equations of tencel fiber.

The equations of moisture absorption rate

Tencel LF: $Y = 0.01163e^{0.001543x} + 0.826e^{-0.1094x}$

Tencel A100: $Y = 0.01786e^{0.001864x} + 1.4356e^{-0.1539x}$

Tencel G100: $Y = 0.01749e^{0.002122x} + 1.5707e^{-0.1943x}$

The curves of moisture absorption rate were obtained by using MATLAB7.0 software based on the equations of moisture absorption rate, which is shown in figure 3.

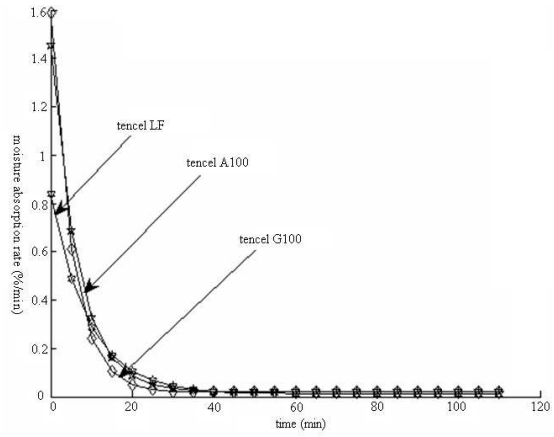

Figure 3 The curves of moisture absorption rate of several tencel fiber

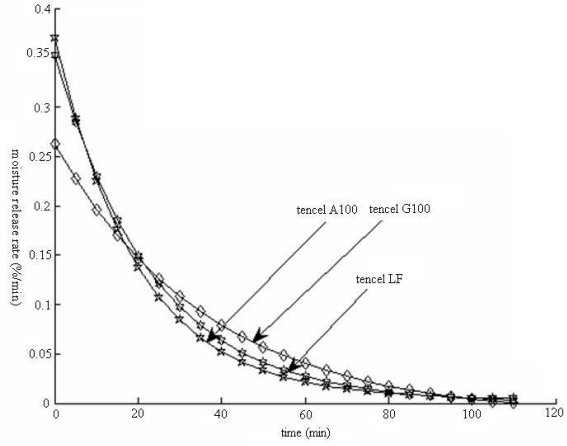

Figure 4 The curves of moisture release rate of several tencel fiber

The equations of moisture release rate

Tencel LF: $Y = \left| -0.35214e^{-0.04284x} \right|$

Tencel A100: $Y = \left| -0.3671e^{-0.05045x} - 0.00347e^{-0.0002405x} \right|$

Tencel G100: $Y = \left| -0.2742e^{-0.02731x} + 0.01203e^{0.001383x} \right|$

The curves of moisture release rate were obtained by using MATLAB7.0 software based on the equations of moisture release rate, which is shown in figure 4.

The Analysis of Moisture Absorption and Release Rate. It can be seen from figure 3 that in the early stage of moisture absorption, the moisture absorption rate of tencel G100 is the biggest, tencel A100 the second, and tencel LF smaller. With the change of time, moisture absorption rate reduces quickly, especially for tencel G100. After 10 min, moisture absorption rate is reduced to almost 0.2% / min. After 20 min, moisture absorption rate is close to zero, and moisture absorption reaches to balance basically. The change of moisture absorption rate of tencel LF is gentler, and the moisture absorption rate of tencel G100 and tencel LF is close to zero and reaches to moisture absorption balance after 40 min .

It can be seen from figure 4 that in the early stage of moisture release, the moisture release rate of tencel A100 is the biggest, tencel LF slightly small, and tencel G100 relatively small. With the change of time, moisture release rate all reduces obviously, of which moisture release rate of tencel A100 and tencel LF reduces more quickly, the rate reducing about by half within 20min, in 20 min ~60min, moisture release rate reducing slowly, in 60min ~100min, moisture release rate changing very slowly, and after 100min, moisture release rate tending to zero, and reaching to moisture release balance

gradually. Moisture release rate of tencel G100 changes more slowly. In the first 30min, it changes quickly; in later stage, the change reduces gradually; after 100min, moisture release rate also tends to zero, and reaches to moisture release balance.

Conclusions

- Moisture absorption and release properties are different because of the difference process of different tencel fiber. The regression curves of the change of moisture absorption and release and its change rate are all close to index curves.
- The regain of moisture absorption balance of three kinds of tencel fiber: tencel LF is 8.89%; tencel A100 is 11.44%; tencel G100 is 10.33%. The moisture absorption properties of tencel A100 is the best, tencel G100 the second, and tencel LF the third. The moisture absorption rate in initial stage is the best, and with the change of time, the rate reduce quickly, especially for tencel G100. After 10 min, moisture absorption rate is reduced to almost 0.2% / min. After 20 min, moisture absorption rate is close to zero, and moisture absorption reaches to balance basically. The change of moisture absorption rate of tencel LF is gentler, and after 40 min, the moisture absorption rate of tencel G100 and tencel LF is close to zero and reaches to moisture absorption balance.
- The regain of moisture release balance of three kinds of tencel fiber: tencel LF is 10.66%; tencel A100 is 14.12%; tencel G100 is 11.47%. The moisture release change trends consistently and moisture release abilities are close. In initial stage, moisture release rate is different: tencel A100 is the biggest; tencel LF is the second; and tencel G100 is the smallest. With the change of time, moisture release rate reduces obviously, and the rate of tencel A100 and tencel LF reduces quickly, and that of tencel G100 reduces gently. After 100min, the moisture release rate of the three tencel fiber also tends to zero, and reaches to moisture release balance.

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