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Textiles — Quantitative analysis of cashmere, wool, other specialty animal fibers and their blends —

Part 1: Light microscopy method

Textiles — Analyse quantitative du cachemire, de la laine, d'autres fibres animales spéciales et leurs mélanges —

Partie 1: Méthode de microscopie optique

Reference number
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Foreword

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The committee responsible for this document is ISO/TC 38, *Textiles*.

ISO 17751 consists of the following parts, under the general title *Textiles — Quantitative analysis of cashmere, wool, other speciality animal fibres and their blends*:

— *Part 1: Light microscopy method*

— *Part 2: Scanning electron microscopy method*

Introduction

Cashmere is a high-value specialty animal fibre, but cashmere and other animal wool fibres such as sheep's wool, yak, camel, etc. exhibit great similarities in their physical and chemical properties, so that their blends are difficult to distinguish from each other by both mechanical and chemical methods. In addition, these fibres show similar scale structures. It is very difficult to accurately determine the fibre content of such fibre blends by current testing means.

Research on the accurate identification of cashmere fibres has been a long undertaking. At present, the most widely used and reliable identification techniques include the light microscopy (LM) method and the scanning electron microscopy (SEM). The SEM method shows complementary characteristics to those of LM method.

— The advantage of the LM method is that the internal medullation and pigmentation of fibres can be observed; the disadvantage is that some subtle surface structures cannot be clearly displayed. A decolouring process needs to be carried out on dark samples for testing. An improper decolouring process can affect the judgment of the fibre analyst.

—The SEM method shows opposite characteristics to those of LM method so some types of fibres need to be identified by scanning electron microscope.

The LM and SEM methods need be used together to identify some difficult-to-identify samples in order to utilize the advantages of both methods.

It has been proven in practice that the accuracy of a fibre analysis is highly related to the ample experience, full understanding, and extreme familiarity of the fibre analyst to the surface morphology of various types of animal fibres so besides the textual descriptions, several micrographs of different types of animal fibres are given in Annex C.

Textiles — Quantitative analysis of cashmere, wool, other specialty animal fibers and their blends —

Part 1: Light microscopy method

1 Scope

This part of ISO 17751 specifies a method for the identification, qualitative, and quantitative analysis of cashmere, wool, other speciality animal fibres, and their blends using light microscopy (LM).

This part of ISO 17751 is applicable to loose fibres, intermediate-products, and final products of cashmere, wool, other speciality animal fibres, and their blends.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 139, *Textiles — Standard atmospheres for conditioning and testing*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
specialty animal fibre
any type of keratin fibre taken from animals (hairs) other than sheep

3.2
light microscope
optical instrument used to produce magnified images utilizing visible light source

Note 1 to entry: Types of microscopes suitable for fibre identification include projection microscopes and visual microscopic image analysers. Transmitted–light type microscopes with direct graduated scale equipped on optical lens are also applicable.

3.3
scale
cuticle covering the surface of animal fibres

3.4
scale frequency
number of *scales* (3.3) along the fibre axis per unit length

3.5
scale height
height of the cuticle at the *scale's* (3.3) distal edge

3.6
fibre surface morphology
sum of the physical properties/attributes characterizing the fibre surface

EXAMPLE The fibre surface morphology includes *scale frequency* (3.4), *scale height* (3.5), patterns of scale edge, scale surface smoothness, fibre evenness along its axis, transparency under *light microscope* (3.2), etc.

3.7
lot sample
portion representative of the same type and same lot of material drawn according to the requirements from which it is taken

3.8
laboratory sample
portion drawn from a *lot sample* (3.7) according to the requirements for preparing specimens

3.9
test specimen
portion taken from fibre snippets randomly cut from a *laboratory sample* (3.8) for measurement purposes

4 Principle

A longitudinal view image of fibre snippets representative of a test specimen is magnified to an appropriate scale/size under an optical microscope. All the fibre types found in the test specimen are identified by comparing them with known fibre surface morphologies for different types of animal fibres.

For each fibre type, the number and mean diameters of the fibre snippets are counted and measured. The mass fraction is calculated from the data for the number of fibre snippets counted, mean value and standard deviation of the snippet diameter, and the true density of each fibre type.

5 Apparatus, materials, and reagents

5.1 Apparatus

5.1.1 Projection microscope, comprised of a light source, a light condenser, a stage, an objective, an ocular, and a circular transparent viewing screen or non-transparent projection table with a graduated scale in millimetres. The objective and ocular shall be capable of providing at least a magnification of ×500 at the screen.

5.1.2 Visual microscopic image analyser, comprised of a microscope, a camera, a computer, a data acquisition card, exclusive analysing software, and a display. The objective and ocular of the microscope shall be capable of providing at least a magnification of ×500.

5.1.3 Transmitted-light type microscope, comprised of a light source, a light condenser, a stage, an objective, and an ocular with a graduated scale. The objective and ocular of this type of microscope shall be capable of providing a magnification of ×400 to ×500.

5.2 Materials

5.2.1 Microtome.

5.2.2 Scissors, tweezers, cleaning fabric, watch-glass, etc.

5.2.3 Slides and cover glasses.

5.2.4 Wedge scale, with divisions of ×500 magnification. A moveable linear rule-type scale finely graduated in millimetres may also be used.

5.3 Reagents

5.3.1 Liquid paraffin with a refractive index between 1,43 and 1,53.

6 Drawing of laboratory sample and conditioning

6.1 Drawing methods for lot samples and laboratory samples are given in Annex A.

6.2 The laboratory sample shall be conditioned for at least 4 h under the standard atmospheres stipulated in ISO 139.

7 Preparation of the test specimens

7.1 Number of test specimens

Prepare one or more slides so that at least 1 000 fibres shall be identified.

7.2 Preparation of the test specimens

7.2.1 Loose fibre

7.2.1.1 Place the laboratory sample flat on the test table, pick up approximately 500 mg of fibres randomly on not less than 20 spots with tweezers (5.2.2) from the top and bottom sides of the sample. Blend them homogeneously and divide them into three equal portions. Sort these drawn fibres into basically parallel fibre bundles.

7.2.1.2 Cut each fibre bundle in the middle with a microtome (5.2.1) to get approximately 0,6 mm long fibre snippets. Cut only once in each of the fibre bundles.

7.2.1.3 Place all the fibre snippets on the watch glass, drop an appropriate amount of liquid paraffin (5.3.1), stir with tweezers (5.2.2) to make the suspended snippet liquid distribute uniformly on the watch glass, then take an appropriate amount of this specimen blend and put it on the slide. Cover with a cover glass.

7.2.2 Sliver

7.2.2.1 Cut the laboratory sliver sample into three sections. Take out an appropriate amount of the fibre bundle in the longitudinal direction from each sliver section.

7.2.2.2 Cut in the middle of each fibre bundle to obtain approximately 0,6 mm long fibre snippets with a microtome (5.2.1). Cut only once in each fibre bundle.

7.2.2.3 Other operating procedures are the same as those stipulated in 7.2.1.3.

7.2.3 Yarn

7.2.3.1 Divide the laboratory sample into three equal portions.

7.2.3.2 Cut each portion in the middle with a microtome (5.2.1) to obtain approximately 0,6 mm long fibre snippets. Cut only once in each yarn portion.

7.2.3.3 Other operating procedures are the same as those stipulated in 7.2.1.3.

7.2.4 Woven fabrics

7.2.4.1 If the warp and weft yarn share the same composition, all the yarns unravelled from a square sample of a complete pattern may be cut to obtain an appropriate test specimen. For those fabric samples composed of different compositions of warp and weft yarns, unravel the warp and weft yarns and weigh them separately. (If the fabrics have a definite repetition in the pattern, unravel at least the integral multiple of a complete pattern.)

7.2.4.2 Cut from the parallel yarn portion in the middle with a microtome to obtain approximately 0,6 mm long fibre snippets. Cut only once in each yarn portion.

7.2.4.3 Other operating procedures are the same as those stipulated in 7.2.1.3.

7.2.5 Knitted fabrics

7.2.5.1 Unravel at least 25 yarn segments from the laboratory sample for woollen knitted fabrics. Unravel at least 50 yarn segments for worsted knitted fabrics. Cut each yarn portion in the middle to obtain approximately 0,6 mm long fibre snippets. Cut only once in each yarn portion.

7.2.5.2 Other operating procedures are the same as those stipulated in 7.2.1.3.

If, prior to analysis, Soxhlet extraction in light petroleum (boiling point 40 °C to 60 °C) is carried out to remove excess surface greases or oils, it shall be reported.

7.3 Decolouring of the laboratory sample

If a decolouring process is carried out on those dark laboratory samples for which it is difficult to see the fibre morphology, prepare the test specimens according to the requirements in 7.2. The decolouring process application shall be reported.

The recommended decolouring methods are given in Annex B.

NOTE The decolouring process can lead to different fibre diameters measured from the decoloured fibres than from those diameters measured from the original fibres taken from fabric or yarns prior to decolouring.

8 Test procedure

8.1 Settings of magnification with micrometer scale

Put the micrometer with a 0,01 mm scale on the stage. The 20 scales from the micrometer (0,20 mm) projected on the screen shall be precisely magnified to 100 mm which means the magnification is ×500.

8.2 Fibre identification and fibre diameter measurement

8.2.1 Projection microscope with a graduated scale in millimetres on the screen (5.1.1).

8.2.1.1 The slide should be scanned in a raster pattern. This ensures that all parts of the slide are covered and avoids the possibility of any fibre being measured twice.

8.2.1.2 Observe and measure the diameters of the various types of fibres in the view. Measure the diameters of at least 100 fibres for cashmere and wool and at least 150 fibres for other speciality animal fibres. At the same time, identify the fibre types according to various fibre morphologies (reference details are given in Annex C). Record the number of different types of fibres, and identify more than 1 000 fibre snippets from each test specimen.

If the number of fibres identified reaches 1 000 while the measurement is still being carried out in the middle of the slide, keep moving and counting until the end of the slide. For fibre types in which only a minor proportion is blended into and the number of fibres measured fail to meet the requirement of number for fibre diameter measurement, measure all fibres of the type found in the specimen slide.

8.2.1.3 For those fibres observed with diameters exceeding 30 μm for cashmere, 35 μm for yak wool, 40 μm for camel, and 30 μm for Angora rabbit hair, record them as cashmere coarse hair, yak hair, camel coarse hair, and coarse rabbit hair respectively. Measure their fibre diameters and record the number of such fibres. If any of the above mentioned fibres accounts for less than 0,3 % of the total amount counted in the specimen, the component can be neglected.

8.2.1.4 If a measurement falls between two divisions, take the lower of the two values.

8.2.1.5 Calculate the mean fibre diameter and standard deviation for a given component according to Formulae (1) and (2), respectively.

$$\bar{d} = \frac{\sum(d \times F)}{\sum F} \qquad (1)$$

$$S = \sqrt{\frac{\sum F(d-\bar{d})^2}{\sum F}} \qquad (2)$$

where

$\bar{d}$ is the mean fibre diameter of the component, in micrometres (μm);

d is the group diameter, d = (recorded group value + 0,5) × 2, in micrometres (μm);

F is the number of fibres measured with the same diameter;

S is the standard deviation, in micrometres (μm).

8.2.2 Projection microscope used to measure the fibre diameter with a wedge scale or a transparent moveable linear-rule-type scale.

8.2.2.1 Measurement is made by moving the wedge scale (5.2.4) with its length at right angles to the fibre image until a division coincides with one edge of the focused fibre image. The width of the fibre image is read off on the other edge of the wedge scale. When measuring an image whose edges are not in focus together, adjust the focusing so that one edge is in focus when a fine line appears and the other edge shows a white line. Measure the width from the edge that is in focus to the inside of the white line.

8.2.2.2 If the width of a fibre image coincides with wedge scale division and lies exactly on a millimetre division of N, the width of the measured fibre image may be assigned to either data group N-1 or N+1 depending on actual conditions. If such cases reoccur, alternately assign them to data group N-1 and to data group N+1.

8.2.2.3 Other operating procedures are the same as those stipulated in 8.2.1.1 to 8.2.1.3.

8.2.2.4 The mean fibre diameter and standard deviation of a given component is calculated using Formulae (3) and (4), respectively.

$$\bar{d} = \frac{\sum(A \times F)}{\sum F} \quad (3)$$

$$S = \sqrt{\frac{\sum F(A - \bar{d})^2}{\sum F}} \quad (4)$$

where

$\bar{d}$ is the mean fibre diameter of the component, in micrometres (µm);

A is the median, in micrometres (µm);

F is the number of fibres measured;

S is the standard deviation, in micrometres (µm).

8.2.2.5 Fibre diameter measurement operation with rule-type scale and calculation are the same as stipulated in 8.2.1.

8.2.3 Visual microscopic image analyser (5.1.2).

8.2.3.1 Observe various type of fibres in the screen view. Measure the fibre diameter when edges of fibre in focus shows clear fine lines. Move the cursor to one side of the focused fibre, click on the left mouse button, then move the cursor to the other side of the focused fibre. Click on the left mouse button again, the fibre diameter value will be automatically recorded after measurement. Test result will be automatically calculated and recorded in the report sheet.

8.2.3.2 Other procedures are the same as those stipulated in 8.2.1.1 to 8.2.1.3.

8.2.4 Transmitted-light type microscope (5.1.3).

Proceed as described in 8.2.1, but with measuring using the graduated scale of the ocular.

9 Calculation of test result

9.1 Calculate the mass fraction of each component using Formula (5).

$$w_i = \frac{N_i\left(D_i^2 + S_i^2\right)\rho_i}{\sum\left[N_i\left(D_i^2 + S_i^2\right)\rho_i\right]} \times 100 \quad (5)$$

where

w_i is the mass fraction of the component, in %;

N_i is the number of fibres counted for the component;

S_i is the standard deviation of mean fibre diameter of the component, in micrometres (µm);

D_i is the mean fibre diameter of the component, in micrometres (µm);

ρ_i is the density of the component, in grams per millilitre (g/ml).

NOTE The density of various types of animal fibres is given in Annex D.

Take the mean value of calculations of the two tests as the test result. If the difference between two tests is larger than 3,0 %, the third specimen shall be tested. In such a case, the mean value of the three tests is taken as the test result (fibre content percentage of rabbit hair is the sum of percentages of both fine and coarse rabbit hairs).

Test result of fibre content is rounded to one decimal.

9.2 Calculate the mass fraction of a fibre component in woven fabric samples through Formula (6).

$$w_i = \frac{w_{iT} \times m_T + w_{iW} \times m_W}{m_T + m_W} \times 100 \quad (6)$$

where

w_i is the mass fraction of the component in the woven fabric sample, in %;

w_{iT} is the mass fraction of the component in the warp yarns of the woven fabric sample, in %;

m_T is the mass of the warp yarns in the woven fabric sample;

w_{iW} is the mass fraction of the component in the weft yarns of the woven fabric sample, in %;

m_W is the mass of the weft yarns in the woven fabric sample.

Annex A
(informative)

Drawing of the lot sample and the laboratory sample

A.1 Loose fibre

Fifty percent of the total number of packages should be sampled. Take out a bundle of fibres from at least three parts of each package. After blending them homogeneously, divide the sample into two equal portions, one portion randomly selected is retained and the other is rejected.

After mixing the retained portion to ensure it is homogenized, divide it again into two equal portions in the same way. Reject one portion (selected at random).

Continue the subdivision procedure until about 20 g of fibres remain; this is the lot sample.

Divide the 20 g fibre lot sample into two portions – use one portion as the laboratory sample and retain the other as a spare sample.

A.2 Sliver

Take one 30 cm long sliver from a ball top or a sliver can. Randomly, take four such slivers altogether. Strip each of the four slivers in its longitudinal direction to form another sliver, which is the laboratory sample. Retain the remaining portions as spare samples.

A.3 Yarn

Take twenty 20 cm long woollen yarn segments from each of five different cones or skeins to obtain 100 woollen yarn segments.

Take twenty 20 cm long worsted yarn segments from each of ten different cones or skeins to obtain 200 worsted yarn segments.

Cut the yarn bundle in the middle to get two portions — use one portion is used as the laboratory sample and retain the other as a spare sample.

A.4 Woven fabrics

Take three trapezoidal samples, each measuring 5 cm × 10 cm (warp × weft), from places which are 10 cm from the edges of the fabric. For each sample, mark its warp and weft directions respectively. (Cut at least the integral multiple of a complete pattern in the case of fabrics where there is a definite repetition of the pattern.) Cut along the weft direction from the middle of each fabric sample and divide it into two portions — use one as the laboratory sample and retain the other as a spare sample.

A.5 Knitted fabrics

Take three samples, each measuring 5 cm × 10 cm (transverse × longitudinal). Avoid rib sections such as cuff or bottom parts. Cut each sample from the middle along the longitudinal direction into two portions — use one as the laboratory sample and retain the other as a spare sample.

Annex B
(informative)

Decolouration

B.1 Method 1

B.1.1 Prepare a sodium hydrosulfite solution with a concentration of 50 g/l. The ratio of the specimen mass to the solution is 1:100.

B.1.2 Put the sample in the solution and heat it. Observe the decolouration after appropriate heating. The decolouring time and temperature are subject to the following conditions: the scales are clear so that they can be identified, and no damage is caused to the decoloured fibres.

B.1.3 Wash the sample completely, then put the treated sample in a well circulated place to allow it to dry naturally.

B.2 Method 2

B.2.1 Dissolve 0,20 g of citrate and 0,9 g of sodium hydrate in 15 ml of water. Dissolve completely.

B.2.2 Take a 0,5 g representative test sample (yarn shall be unravelled from woven fabric samples) and put it into the fully dissolved solution.

B.2.3 Oscillate for 30 min at a temperature of 70 °C ± 2 °C in a water-bath oscillator to ensure that all of the sample is thoroughly immersed.

B.2.4 Add 0,6 g of solid sodium hydrosulfite. Shake immediately after putting on the lid.

B.2.5 Oscillate another 10 min at a temperature of 70 °C ± 2 °C in a water-bath oscillator.

B.2.6 Take out the sample. After washing, drying, and conditioning, the sample may be used to carry out test.

Annex C
(informative)

Surface morphology of common animal fibres

C.1 Cashmere from China

C.1.1 Typical ring-shaped patterns

See Figures C.1 to C.7.

This cashmere has a high fibre diameter evenness in its axial direction. Scale patterns are regular, most are ring-shaped and a few irregular ring-shaped; few variations can be seen. The scale envelops the fibre shaft flatly and evenly; scales are thin with smooth surfaces and bright lustre. The distance between two adjacent scales is large.

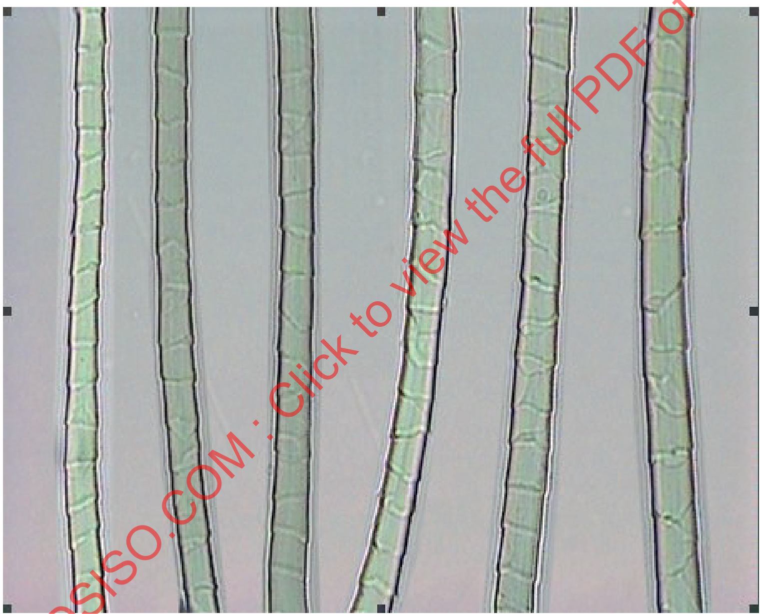

Figure C.1 — Scales tightly and orderly envelop fibre shaft with smooth edges showing regular ring-shaped patterns

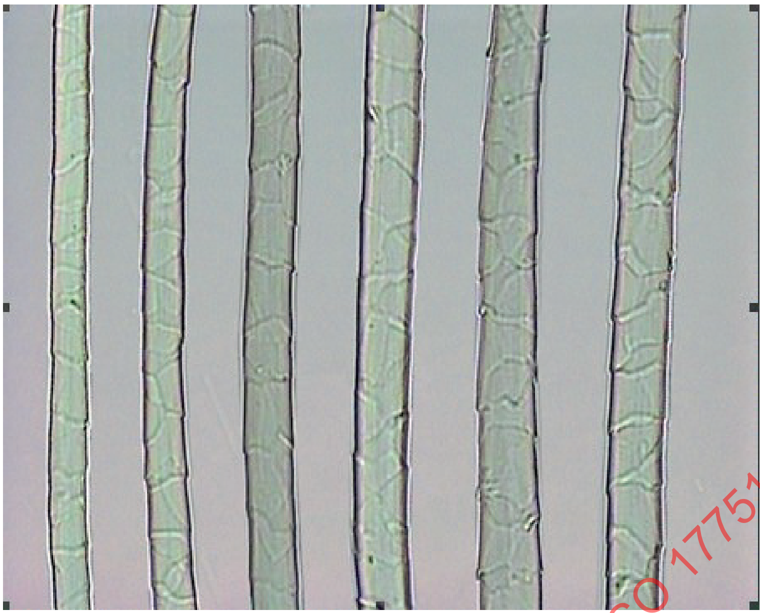

Figure C.2 — Thin scales showing slightly changed ring-shaped patterns

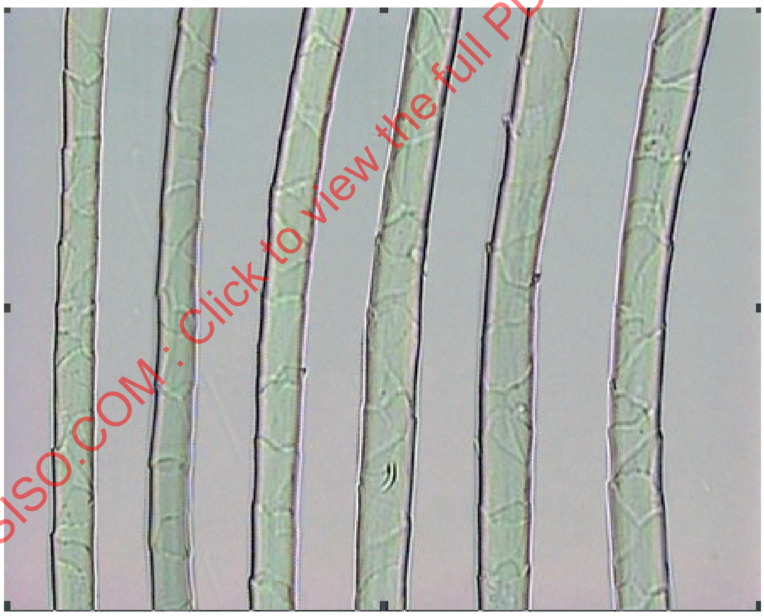

Figure C.3 — Thin scales, low scale frequencies, scale patterns are irregular

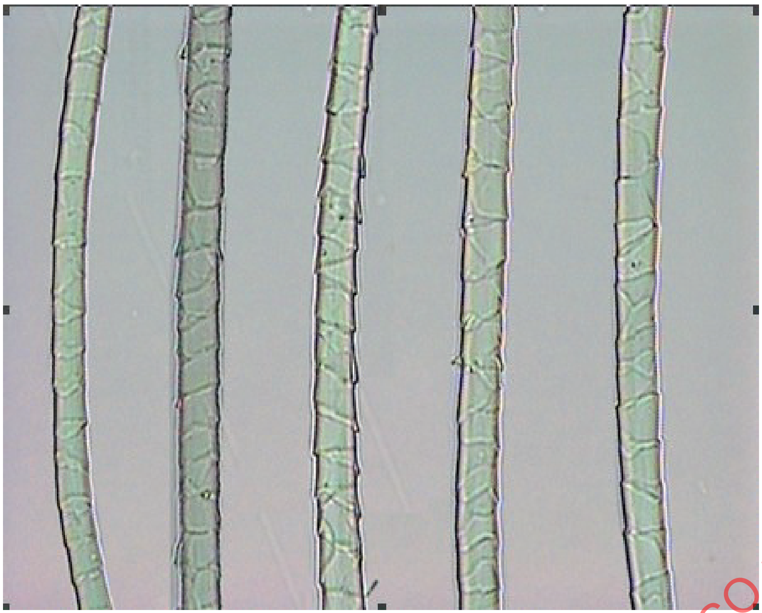

Figure C.4 — Slightly thicker scales with higher scale frequencies

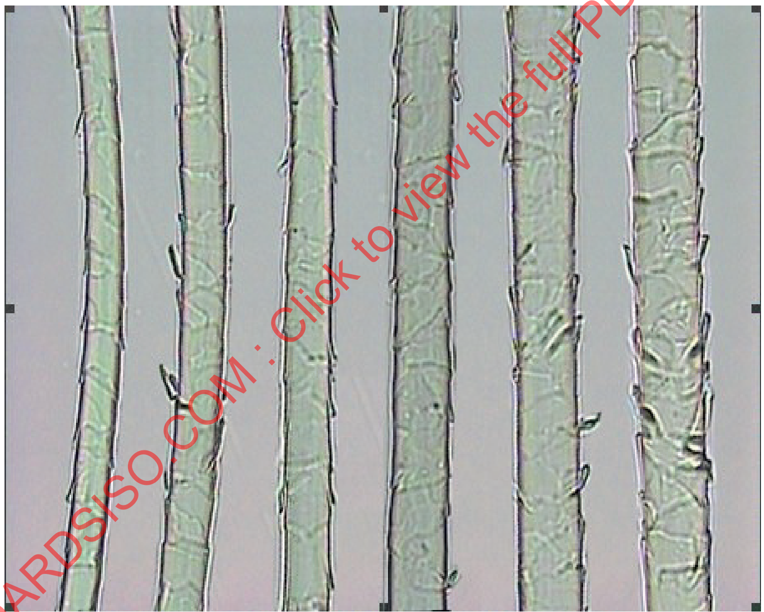

Figure C.5 — Slightly unclear scales with pricks on scale edges, scale edge lifting

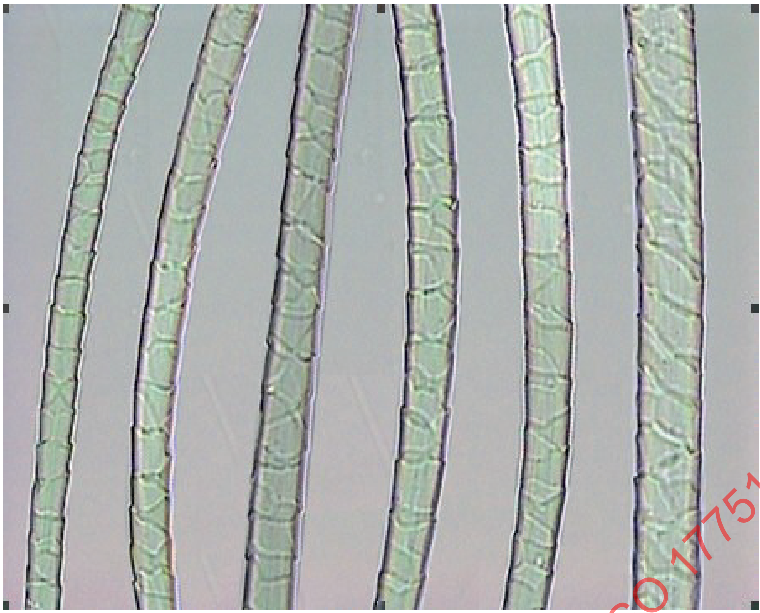

Figure C.6 — Higher scale frequencies and thicker scale heights

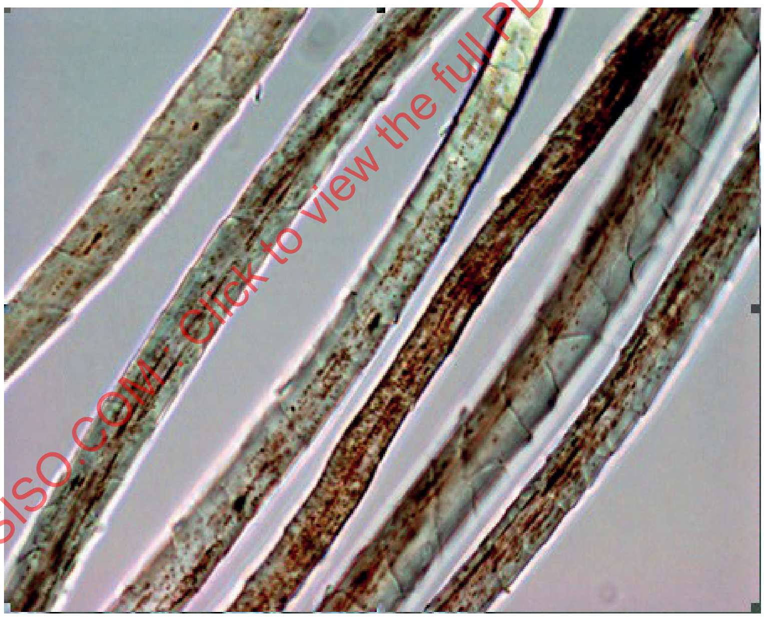

Figure C.7 — Fibre morphologies of brown cashmere

C.1.2 Irregular ring-shaped morphology

See Figures C.8 to C.10.

Irregular ring-shaped morphology of cashmere fibres: The scale morphology this type is slightly different from typical ring-shaped morphology. Some scale patterns are not regular, scale edges are not orderly, or scale edges are thicker with higher scale frequency; however, the scales envelop the fibre shaft flatly and orderly with smooth surfaces and high fibre evenness in the shaft's longitudinal direction.

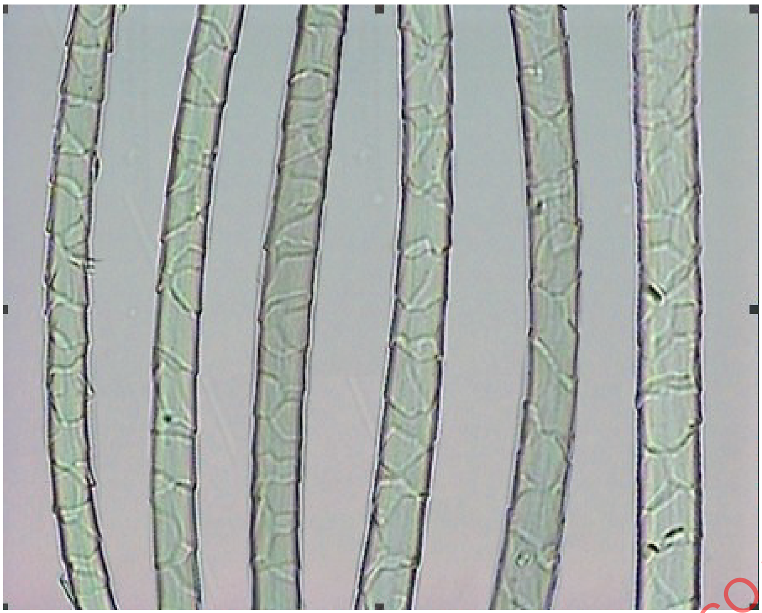

Figure C.8 — Larger changes in ring-shaped scale patterns with rougher scale edges

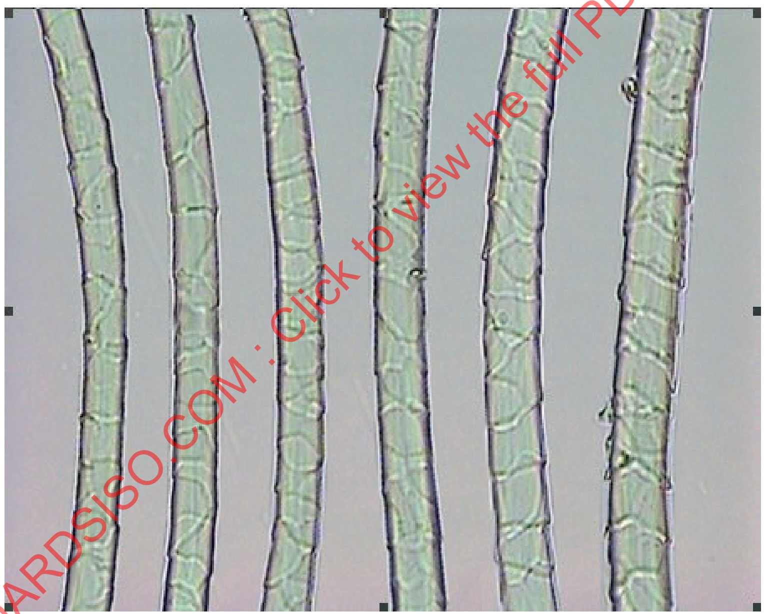

Figure C.9 — Thicker scale height and higher scale frequency with unsmooth scale edges

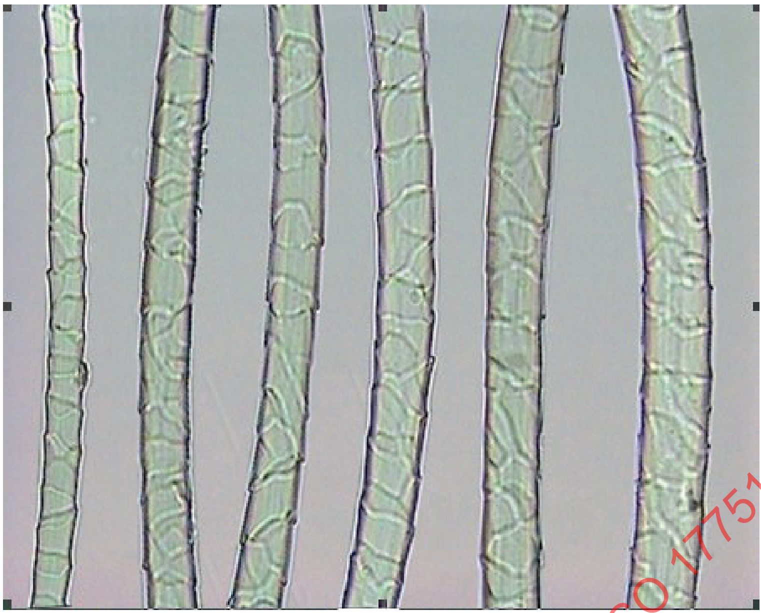

Figure C.10 — Thick scale height and high scale frequency with irregular scale patterns

C.1.3 Morphology of variation cashmere fibres

See Figures C.11 to C.15.

The term “morphology of variation cashmere fibres” refers to fibre morphologies which deviate from those of other fibres and which belong to either morphologies which are difficult to distinguish or easy to be identified as wools.

If cashmere fibres with such morphologies are encountered in the testing process, the following conditions should be taken into consideration.

a) When testing pure cashmere samples: Whether fibres with such morphologies are variation cashmere or wool, blends should be judged based on whether there are wools blended into the samples.

   1) If there is no wool artificially blended, fibres with variation morphology can be identified as variation cashmere.

   2) If wool is deliberately blended into the sample, fibres with variation morphology should be identified according to the corresponding characteristics of cashmere and wool, including scale structure (scale frequency, scale height, scale patterns), longitudinal fibre evenness, fibre lustre, etc., following the principle that if more features of the tested fibre conform to the characteristics of cashmere, the fibre is identified as cashmere. If more of the features of the tested fibre conform to the characteristics of wool, the fibre is then identified as wool. Variation fibres should be reported as “wool-like cashmere” in the test report.

b) When testing cashmere/wool blend samples: Pursuant to the above mentioned principle, if more features of the tested fibre conform to features of cashmere, then identify it as cashmere. Otherwise, identify it as wool.

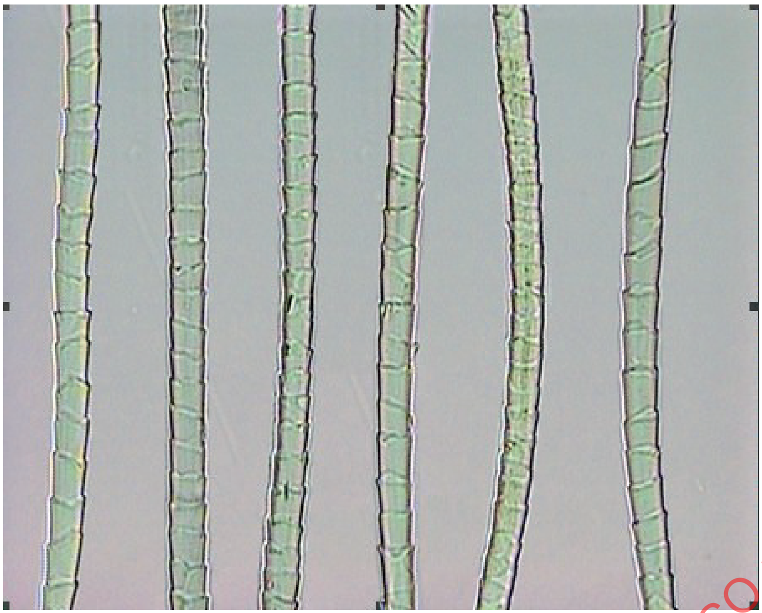

Figure C.11 — Corollaceous scale patterns with very high scale frequency exhibiting characteristics of fine sheep's wools

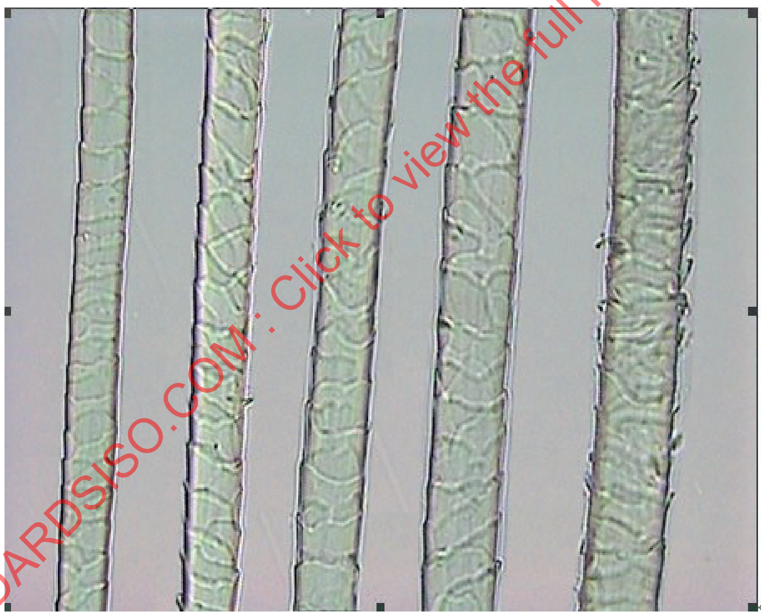

Figure C.12 — Scales are thin but scale frequency is high, scales of this type belongs to those transitional from undercoat cashmere to coarse hair which is called transitional type cashmere

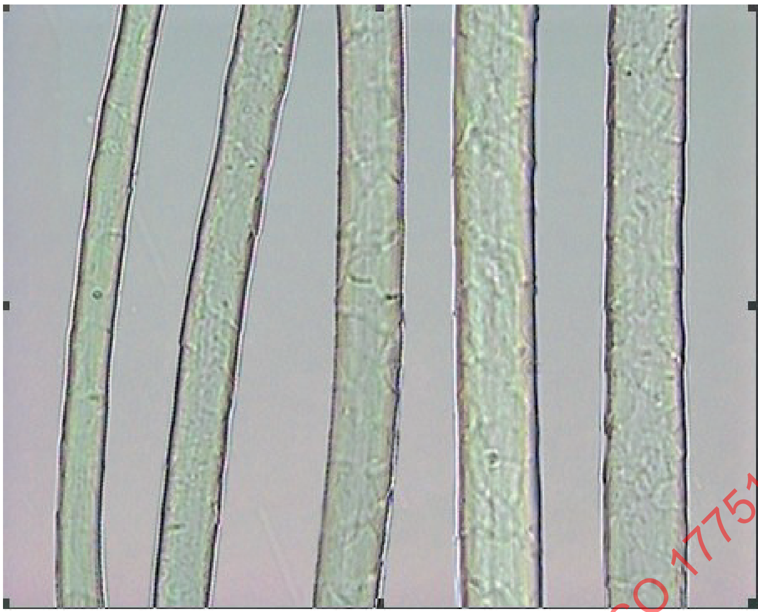

Figure C.13 — Scales shed from fibre shaft showing features of treated wool

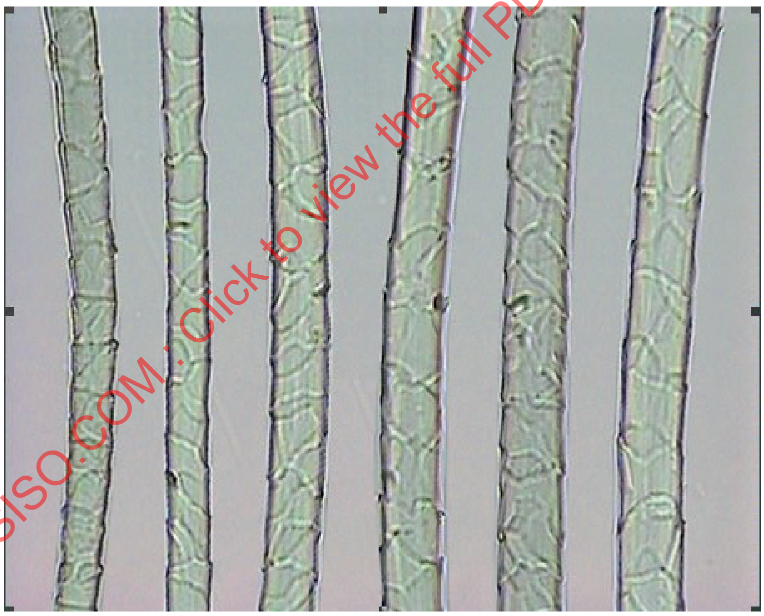

Figure C.14 — Scales are irregularly arranged, fibre surfaces are not smooth showing characteristics of Chinese native sheep's wool

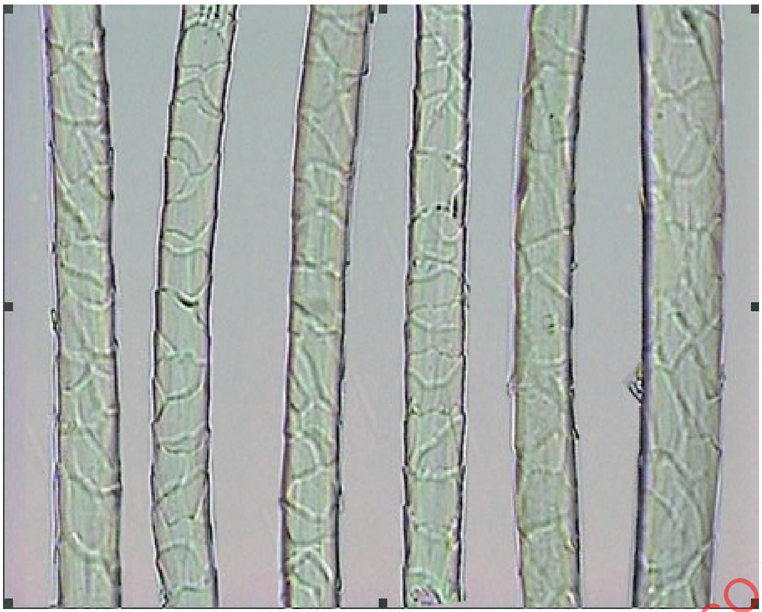

Figure C.15 — Irregular scale patterns and rough surfaces showing characteristics of Chinese native sheep's wool

C.2 Cashmere from Mongolia

See Figures C.16 to C.19.

Almost all cashmeres from Mongolia are coloured cashmeres with blurry scale patterns on the whole. Their fibre lustre is not as good as that of the Chinese cashmeres. Most scales show block-shaped patterns. There is almost no pigmentation, but severe damage to scales can be seen due to the progress in decolouration techniques in recent years. So if decoloured Mongolian cashmere is blended into Chinese cashmere, experienced testing operators can distinguish them. Mongolian cashmere is coarser and longer compared with Chinese cashmere so it is easy to be distinguished from each other by its corresponding fibre appearances.

No classification of cashmere fibre morphology types is made because scale morphologies are relatively consistent. Micrographs are shown in accordance with the fibre morphologies from good to bad.

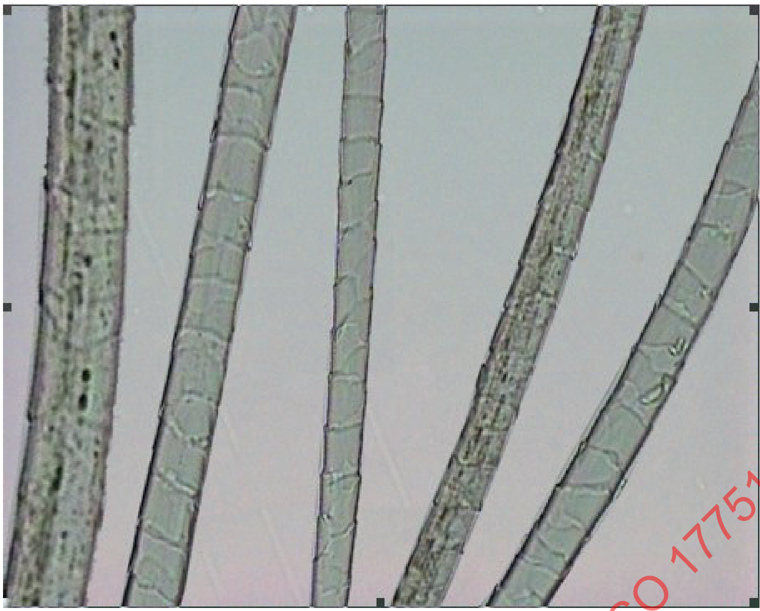

Figure C.16 — Regular ring-shaped scales with thin and smooth edges, scale frequency is low

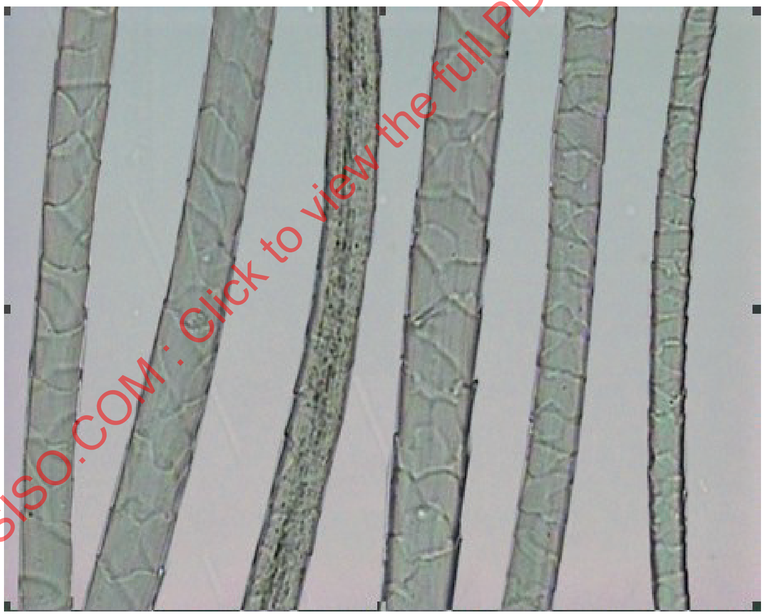

Figure C.17 — Scale edges are somewhat not smooth showing block-shaped scales on the whole

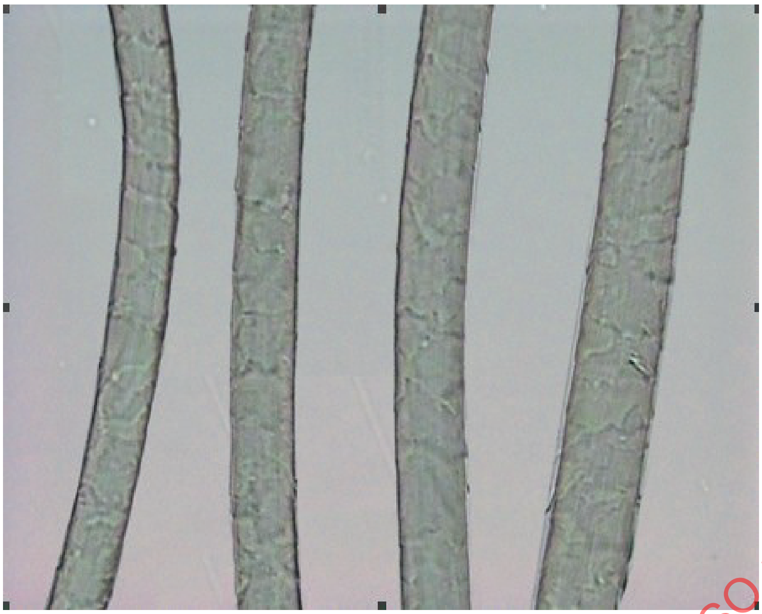

Figure C.18 — Scales are thin but scale frequency is high, scales of this type belongs to those transitional from undercoat cashmere to coarse hair which is called transitional type cashmere

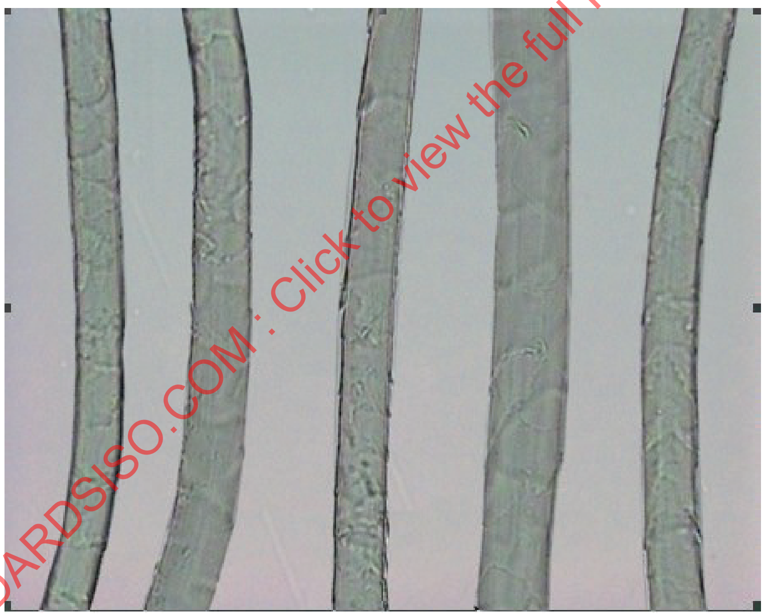

Figure C.19 — Blurry scales

C.3 Cashmere from Iran and Afghanistan

See Figures C.20 to C.23.

Cashmeres from Iran and Afghanistan are basically coloured cashmeres with more colour types. Cashmere produced in Iran and Afghanistan exhibits the same characteristics as Mongolian cashmere. Cashmeres from Iran and Afghanistan can be determined from the aspect of mean fibre diameter when an entire lot of material is tested. The mean fibre diameter of brown and grey cashmere produced in China is lower than those of white cashmere; it is <15 µm. The mean fibre diameter of cashmeres from Iran and Afghanistan is higher than 16 µm. However, if these cashmeres are blended into cashmere from China, it is not easy to distinguish them.

As for the cashmere from Mongolia, no further classification of fibre scale morphology types is made because the scale morphologies of this type are relatively. Micrographs are shown according to the fibre morphologies from good to bad.

Figure C.20 — Regular ring-shaped scales with smooth and thin edges, scale frequency is low

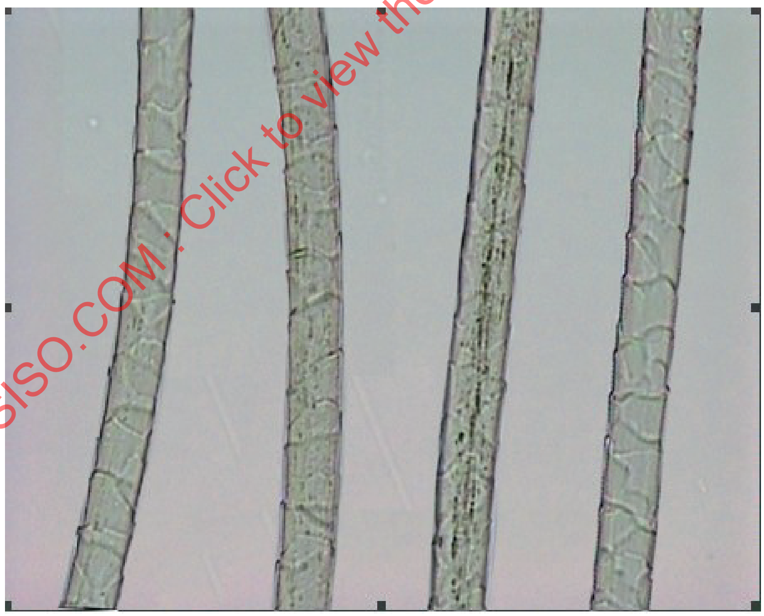

Figure C.21 — Scale heights are slightly large

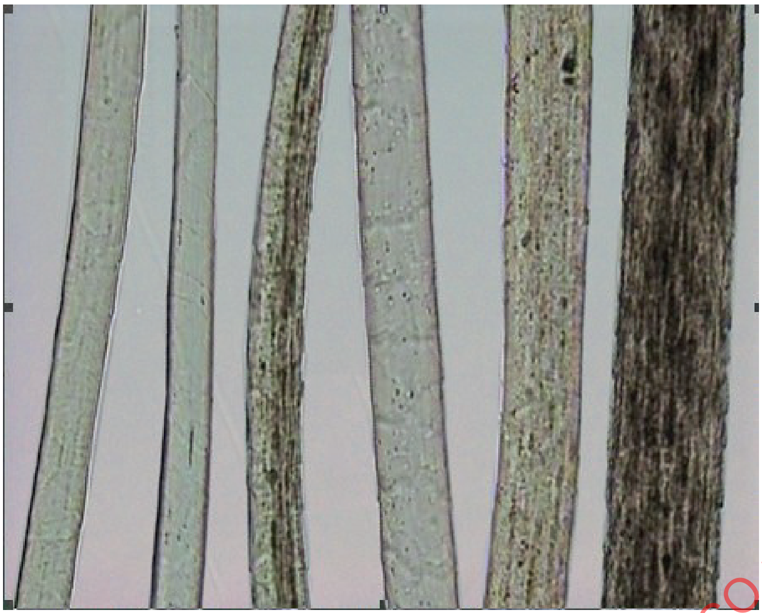

Figure C.22 — Scales are blurry and unclear

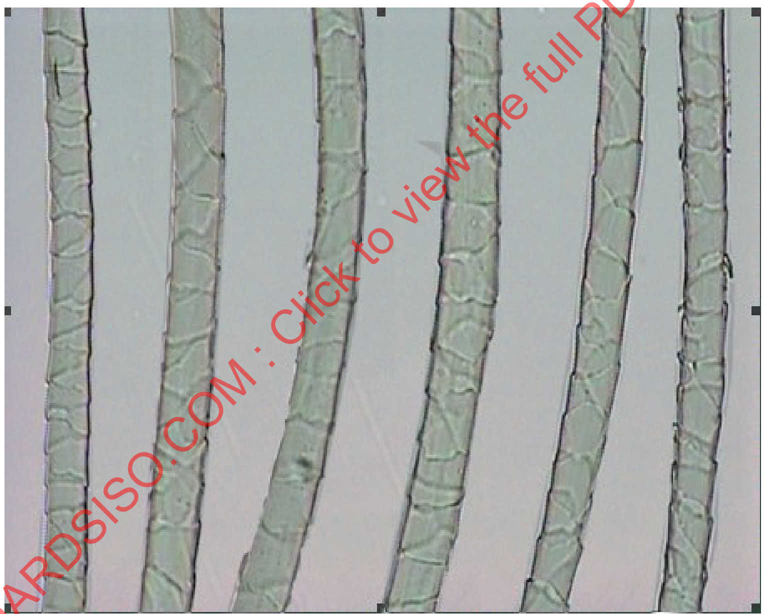

Figure C.23 — Scales are thick, scale frequency is high

C.4 Sheep's wool and modified sheep's wool

C.4.1 Chinese native fine sheep's wool

China is rich in resources of native fine sheep's wool. Very fine wool can be found under the layer of coarse wool in some local breeds such as those in Hebei, Gansu, Tibet, and Kazakh. These fine wools can be separated out after more than 10 times of dehairing as there are larger differences in the fibre diameters between coarse and fine wool in these heterogeneous wools than in homogeneous wools.

Four groups are classified according to fibre scale morphology from good to bad.

Group I: See Figures C.24 to C.27. Fibre morphologies of native fine sheep's wool in Group I are basically the same as those of cashmere, that is fibres show high diameter evenness in the axial direction with regular ring-shaped scales, scales envelop the fibre shaft regularly, but fibre lustre is a little worse, and the scale height is higher than that of cashmere. The diameter of wools with such scale morphologies is basically below 15 µm; this accounts for 5 % to 10 % of the whole lot when testing using the light microscope method.

Figure C.24 — Regular ring-shaped scales encircle fibre shaft flatly and evenly

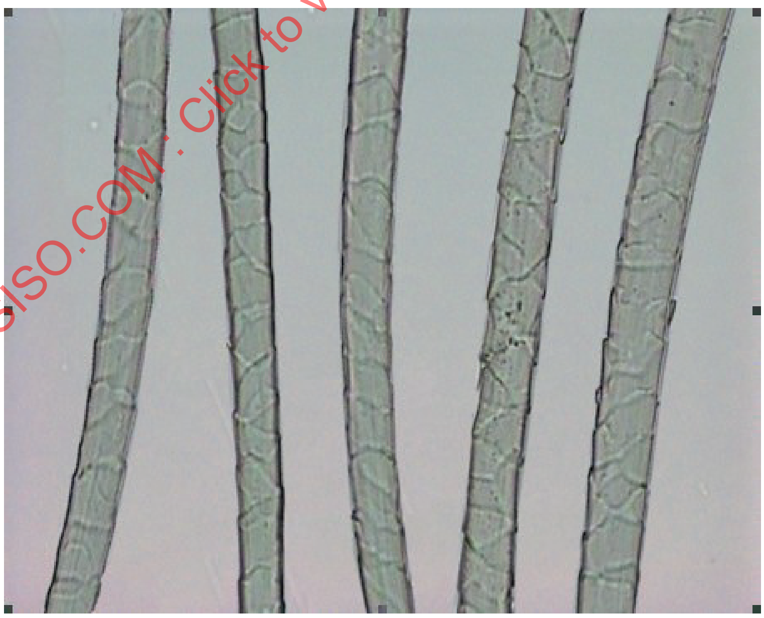

Figure C.25 — Comparatively thicker scale edges

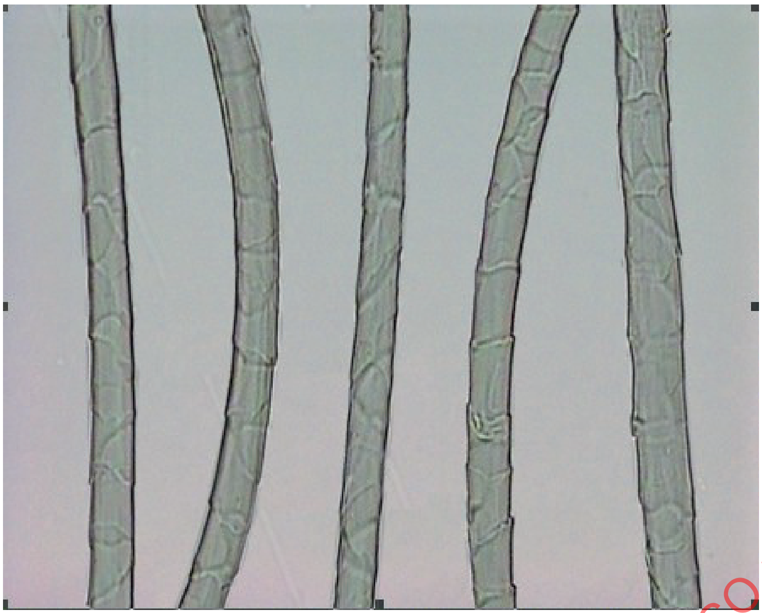

Figure C.26 — Irregular scale intervals

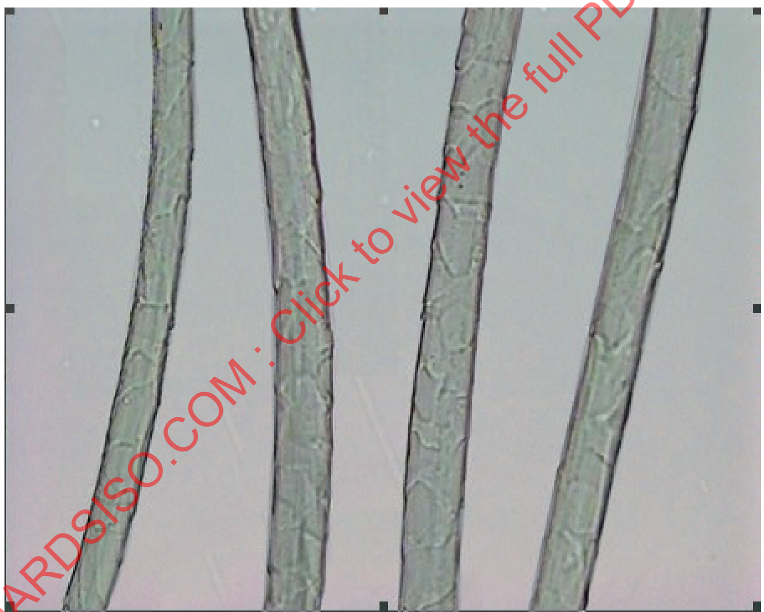

Figure C.27 — Blurry and unclear scales

Group II: See Figures C.28 to C.29. Scales display irregular ring-shaped patterns. The fibre diameter is comparatively even in its axial direction, Wool fibres of this group show worse lustre, rougher scale surfaces, thicker scale heights, higher scale frequency, and larger warping angles compared to those of cashmere. Misidentification can be made by those fibre analysts who lack experience dealing with scale morphologies of Chinese native sheep's wool.

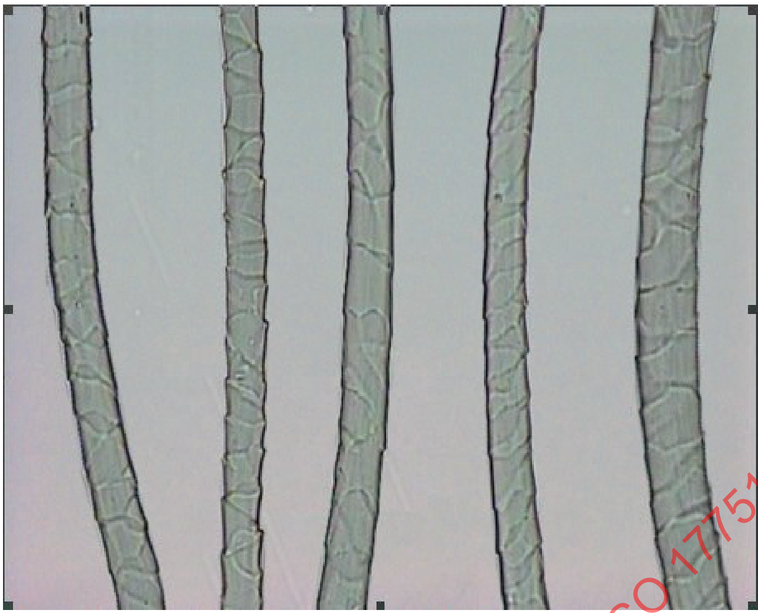

Figure C.28 — Irregular annular scales with large warping angles

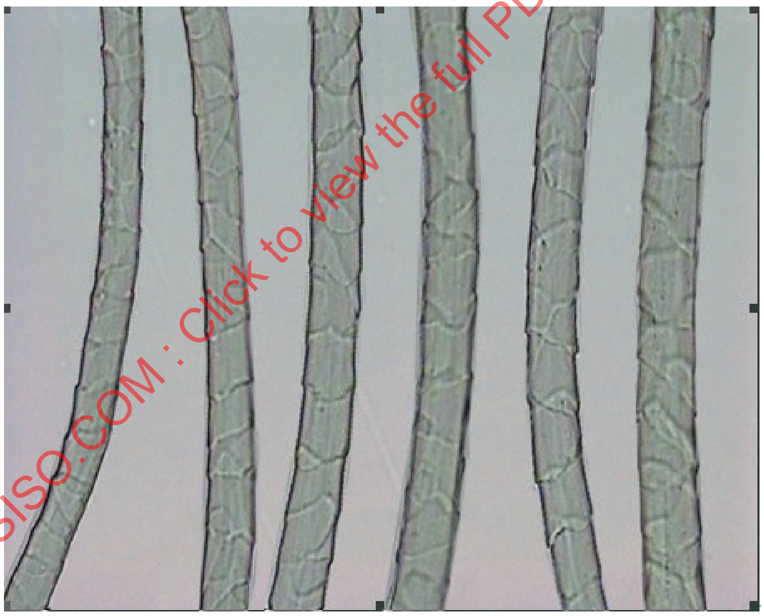

Figure C.29 — Irregular annular and thick scales showing high scale frequency

Group III: See Figures C.30 to C.31. Fibres show higher diameter evenness in their axial direction than Australian wool with the same fibre diameters. Fibres show worse lustre and larger warping angles. Fibres show lower scale heights and higher scale frequency than fibres in Group II. The misidentification rate of fibres in this group is fairly low.

Figure C.30 — Irregular annular scales with thicker scale edges and high scale frequency

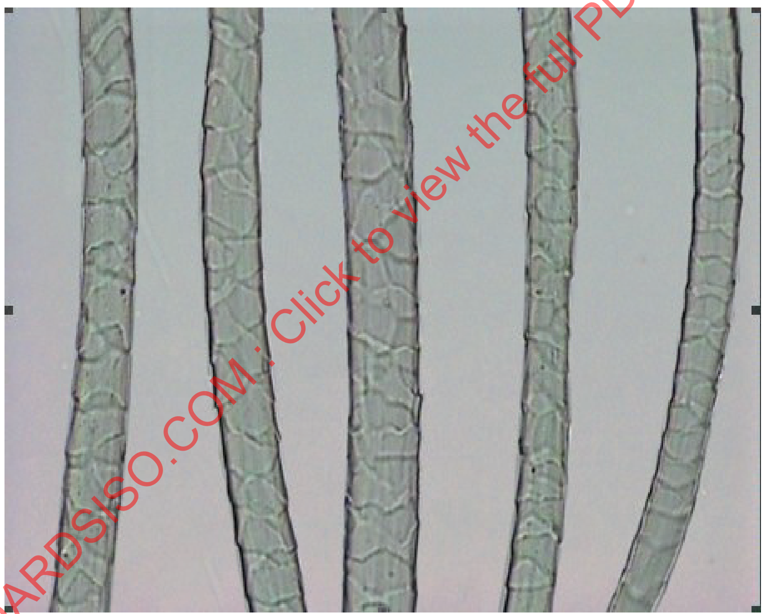

Figure C.31 — Irregular scale on unsmooth fibre surfaces

Group IV: See Figures C.32 to C.34. The fibre diameter of this group is basically larger than 20 µm. Fibres show higher evenness in the axial direction than Australian wool with the same diameter. Scales show large variation on the tile or ramous-shaped patterns with thicker scales. Fibre surfaces are rough with bad lustre. Striations and furrows are obvious and some scales shed from the fibre shaft.

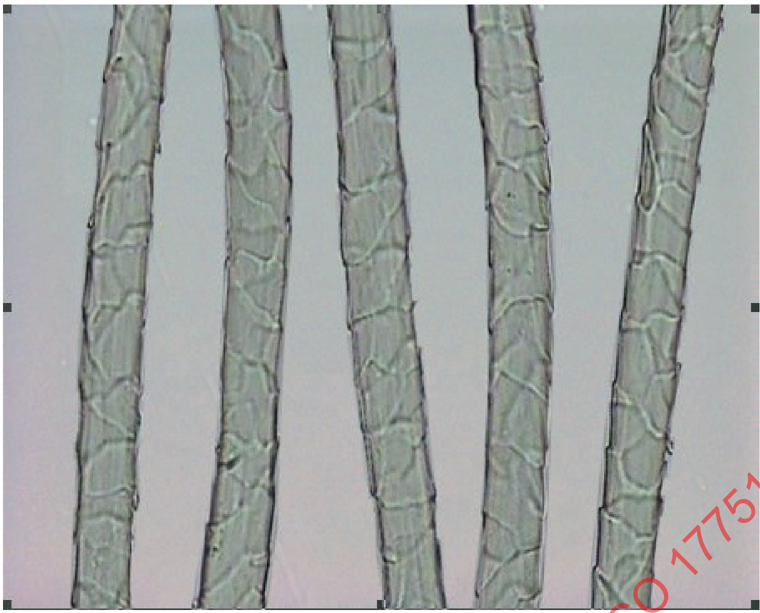

Figure C.32 — Scales are thick and fibre surfaces are rough

Figure C.33 — Irregular scales on rough fibre surface with furrows shown on fibre shaft

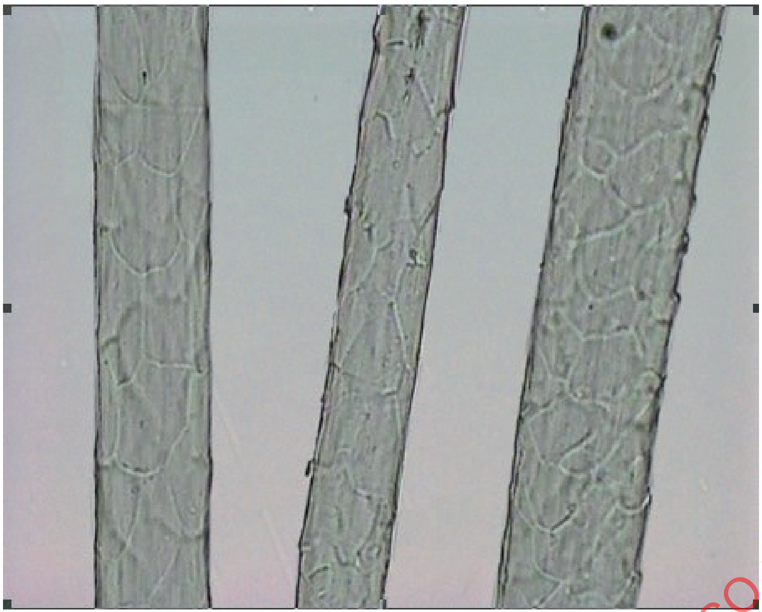

Figure C.34 — Scales with tile or ramous-shaped patterns

C.4.2 Black sheep's wool

Black sheep is one type of Chinese native sheep. Black sheep produce brown wool. Fibre morphology of brown wool is basically the same as that described in C.4.1, but it is very hard to observe the rough conditions of its fibre scales due to the heavy pigmentation when blended with brown cashmere (see Figures C.35 to C.36).

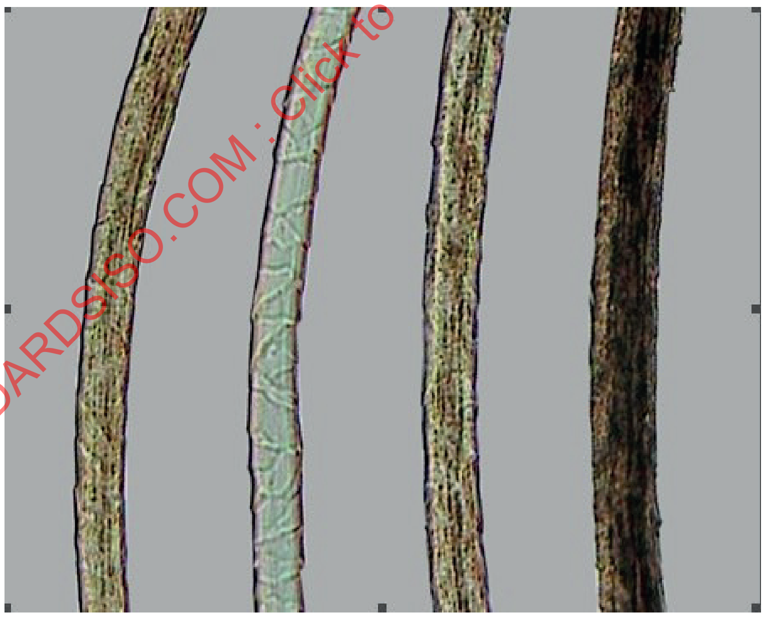

Figure C.35 — Irregular scales with thicker scale edges

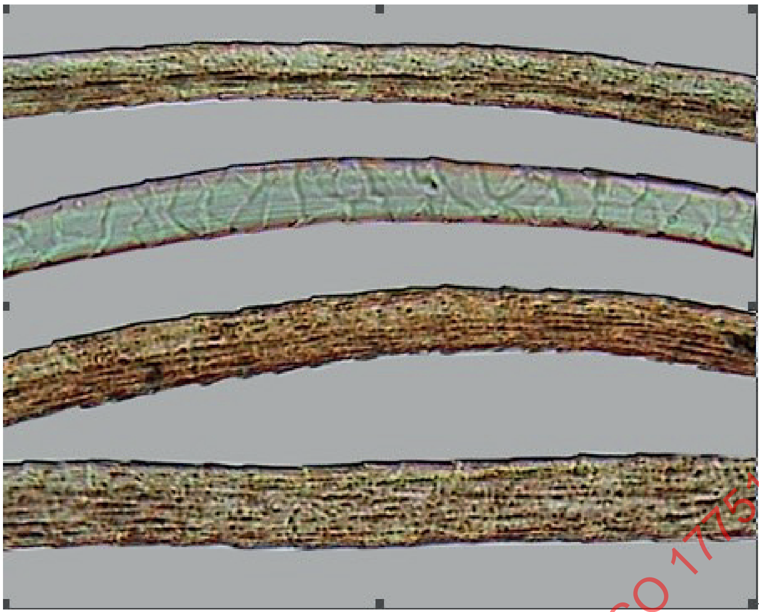

Figure C.36 — Irregular scales with larger warping angles

C.4.3 Australian Merino wool

Both scale frequency and scale height are high. These are the distinguishing features of Australian Merino wool (see Figures C.37 to C.39).

Figure C.37 — Fine type

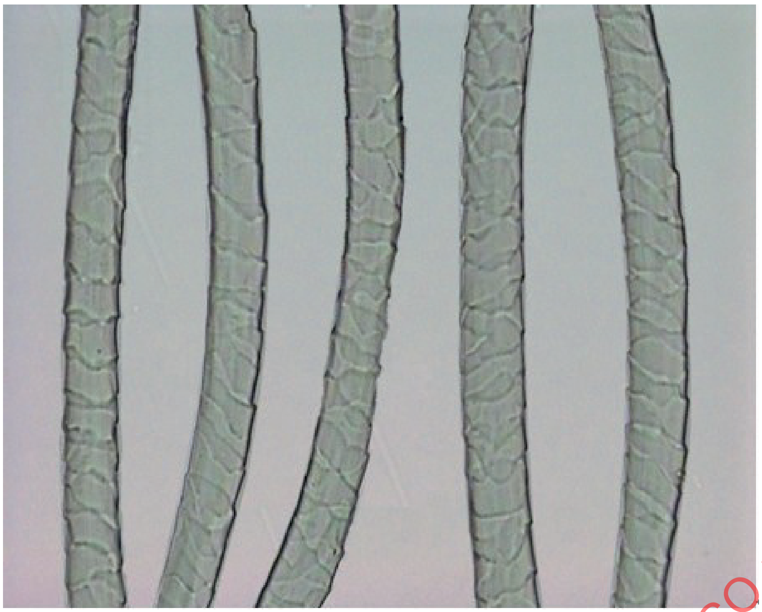

Figure C.38 — Medium type

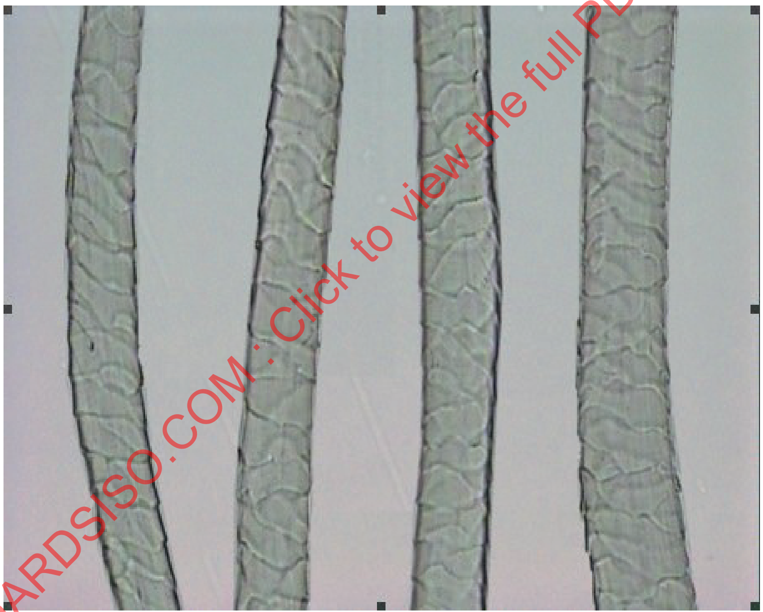

Figure C.39 — Coarse type

C.4.4 Modified wools

Modified wools which are commonly used include shrink-resistant wool, mercerized wool, and stretched wool as shown in Figures C.40 to C.42.

Shrink-proof treatment includes additive (polymer) treatment and oxidative treatment; the most commonly used is the latter method. The figures show typical patterns of shrink-resistant wool and mercerized wool. These two types of wool coexist in mass treated wool, but the amount varies on different occasions.

The scale surface changes during the stretching process. The fibre surface becomes smoother decreasing the diffuse reflection while enforcing the reflection to the same direction, thus the fibre lustre is better. At the same time, stretched wool can show a similar lustre effect to that of silk due to changes in the cross-section. This is very important to determining whether stretched wools are blended into cashmere or not. Stretched wool also shows characteristics such as unevenness in the fibre's axial direction, larger scale interval, and partially shed scales, etc.

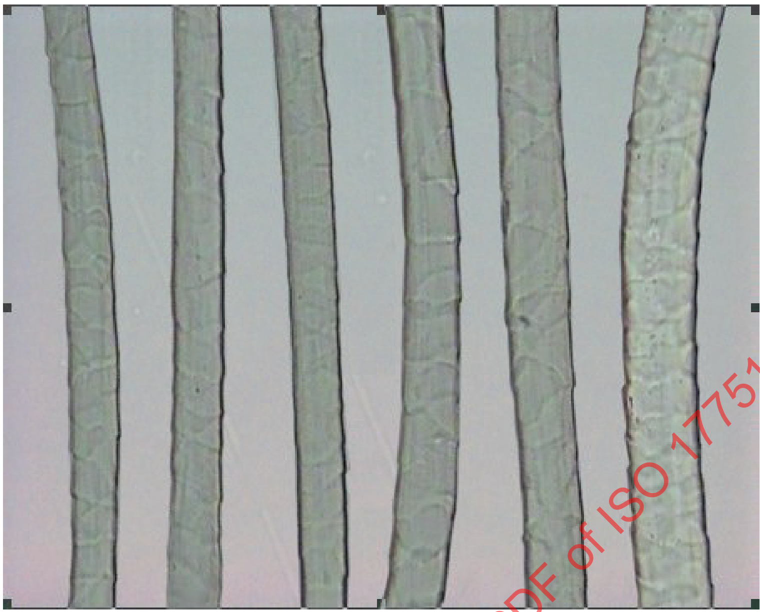

Figure C.40 — Shrink-resistant wool

Figure C.41 — Mercerized wool

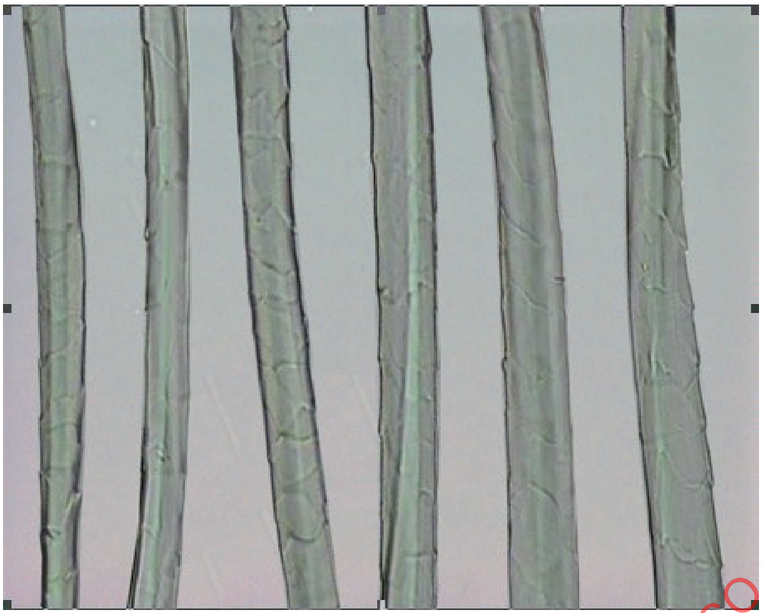

Figure C.42 — Stretched wool

C.5 Other speciality animal fibres

C.5.1 Camel hair and decoloured camel wool

See Figures C.43 to C.47.

When observing in the light microscope: Finer camel fibre has less pigmentation so scales are easy to see clearly; these show slantwise strip patterns with a few parts of the fibres showing ring-shaped patterns which are similar to those of cashmere. Coarser fibres show blurry and disorder scale patterns. Some camel fibres show similar scales as Chinese native sheep's wool, but the scales have lower scale heights and higher fibre evenness in the axial direction than those in sheep's wool.

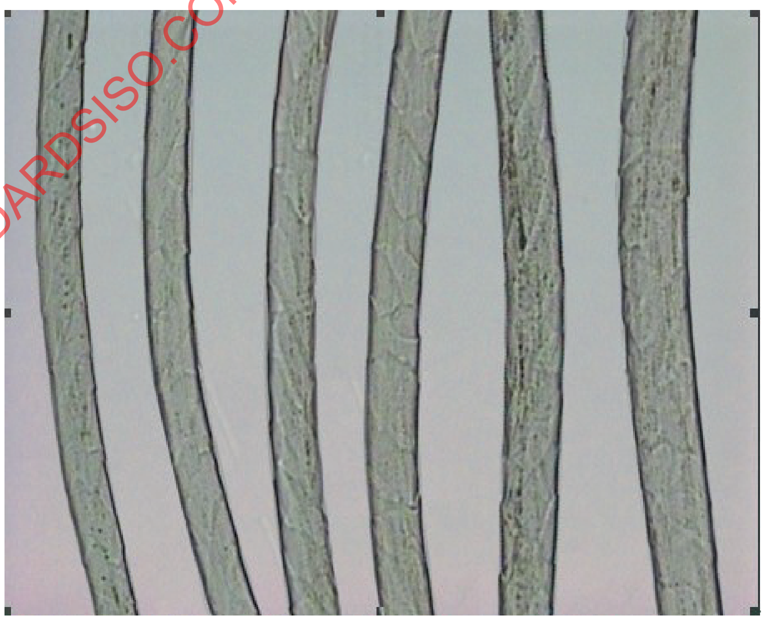

Figure C.43 — Camel hair