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Studies on Structure and Color of the White *Antheraea pernyi*, Silkworm Cocoon[1]

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Abstract—Traditional *Antheraea pernyi* silkworm cocoon is tawny color. The white *Antheraea pernyi* silkworm cocoons studied here by IR and UV are new breeds of recent breeding. We discovered that the main body of the first grade structure of silk protein in the new white is as same as the one in the traditional tawny *Antheraea pernyi* silkworm cocoon, yet there are small quantities of cross-linked polymer of gentisic acid and silk protein in the white silkworm cocoons. In spite of the least surviving quantity of the polymer, the white silkworm cocoons are most white and its white color is similar to white *Bombyx mori* silkworm cocoon.

Keywords—*Antheraea pernyi* silkworm cocoon · *Bombyx mori* silkworm cocoon · Gentisic acid · Infra-red absorption spectrum (IR) · Ultra-violet absorption Spectrum (UV)

The traditional *Antheraea pernyi* silkworm is a wild type of which silkworm cocoon is tawny color. The production of the silkworm cocoon and its silk textile in China holds a safe lead in the world. The silkworm silk is quite welcomed by popular people, as well as the *Bombyx mori* silkworm silk. But there is still a thorny problem existing in its production, that is, the color of *Antheraea pernyi* silkworm cocoon is tawny instead of white, preventing further development in the *Antheraea pernyi* silk worm and its silk. We have studied the tawny chromogen, and the results indicated that tawny chromogen is due to a cross-linked polymer of gentisic acid and silk proteins, and also reported the possible mechanism of the chromogen formation (Tao *et al.*, 1993).

The white *Antheraea pernyi* silkworm cocoon studied by IR and UV, we report here, is new breed for the first time breeding succeed in the world in recent years. We discovered that the main body of the first grade structure of silk protein in the new white is as the same as the one in the traditional tawny *Antheraea pernyi* silkworm cocoon, yet there are small quantities of cross-linked polymer of gentisic acid and silk protein in the white silkworm cocoons. In spite of the least surviving quantity of the polymer, the white cocoons are most white and its white color is similar to white *Bombyx mori* silkworm cocoon.

Experimental

Specterometers and Samples - Infra-red spectrometr, NICOLET 20DXB FTIR. Ultra- Violet Spectrometer, SHIMADZU 240. White and tawny *Antheraea pernyi* silkworm cocoon, Dandong, China. White *Bombyx mori* silkworm cocoon, Henan, China.

IR Determination - Take 4 Kinds of White

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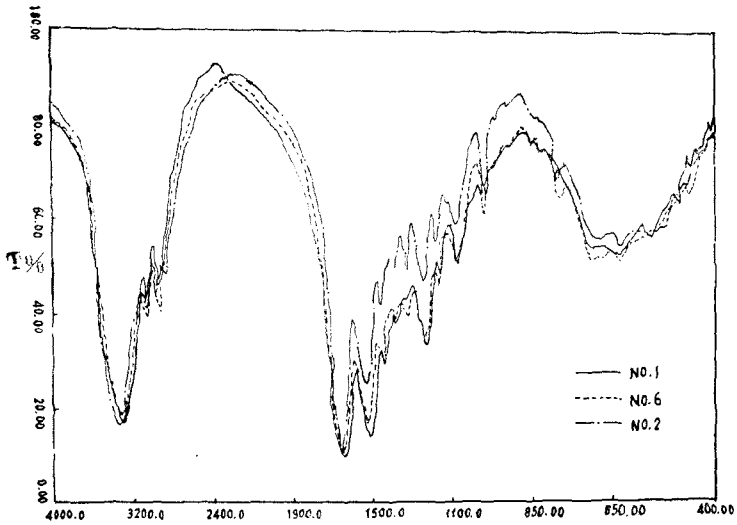

Fig. 1. IR Spectra of the various silkworm cocoons

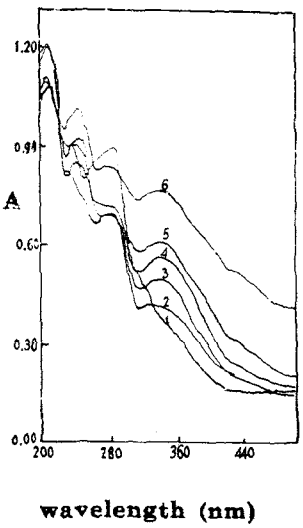

Fig. 2. UV Spectra of the various silkworm cocoons

Antheraea pernyi silkworm cocoon (No. 2, No. 3, No. 4, No. 5), white *Bombyx mori* silkworm cocoon (No. 1) and the traditional tawny *Antheraea pernyi* silkworm cocoon (No. 6), total 6 samples. Cut the silkworm cocoon shell with scissors into powder, use KBr pellet method to determine IR spectra of the samples separately. Fig. 1 shows the IR spectra of No. 1, No. 2, and No. 6 samples.

UV Determination - Peel the outer from an inner layer of the silkworm cocoon shells, then cut the middle part with scissors to be diameter 30 mm circular to determined flection UV adsorption spectra directly. Fig. 2 shows the UV spectra obtained.

Results and Discussion

As it can be seen from Fig. 1, IR absorption spectra of the white (No. 2) and the tawny *Antheraea pernyi* cocoon (No. 6) are very similar. Even though IR spectra of the *Bombyx mori* (No. 1) and *Antheraea pernyi* silkworm cocoon are also similar, the *Bombyx mori*silkworm cocoon is not appearing 960 cm^{-1} absorption band. According to a reference (Tao and Ying, 1991), the 960 cm^{-1} band is characteristic for the $(ALa)_n$ structure, indicating that there is not such kind of structure in the *Bombyx mori* silkworm cocoon.

According to assignments for characteristic groups of protein (Japan Biochemistry Society, 1979), we analysed the spectra as foellowings: ~3300 cm^{-1} absorption band is amide A (N-H stretching vibration): ~2950 cm^{-1} band is C-H stretching vebration; 1650-1660 cm^{-1} band is amide I (C=0 stretching vibration); 1530 cm^{-1} band is amide II (C-N stretching vibration and N-H in-plance deformation vibration), ~1450 cm^{-1} is CH_2 and CH_3 deformation vibration; ~1350 cm^{-1} band is CH_3 deformation vibration; 1235-1240 cm^{-1} band is amide III (C-N stretching vibration and N-H in-plance deformation vibration); ~1050 cm^{-1} band is C-O stretching vibration; 630-700 cm^{-1} bands are amide IV amide V. The results are listed in Table 1.

The IR spectra analysis showed that the main body of the first grade structure of silk protein in the new white and the tawny *Antheraea Pernyi* silkworm cocoon are the

Table 1. Assignments of IR adsorption bands in the various silkworm cocoons

Assignments bands(cm^{-1}) Samples	Amide A υN-H (υO-H)	υC-H	Amide I υC=O	Amide II υC-N δN-H	δCH_2 δCH_3	Amide III υC-N δN-H	υC-O	(Ala)n	Amide IV & V δN-H	
White *Bombyx mori* silkworm cocoon No. 1	3300	2950	1660	1530	1450	1240	1050		630	
Tawny *Antheraea pernyi* silkworm cocoon No. 6	3300	2950	1650	1530	1450	1235	1050	960	620	670
White *Antheraea pernyi* silkworm cocoon No. 2	3300	2950	1650	1530	1450	1235	1050	960	620	670
" No. 3	3300	2950	1650	1530	1450	1235	1050	960	620	670
" No. 4	3300	2950	1650	1530	1450	1235	1050	960	620	670
" No. 5	3300	2950	1650	1530	1450	1235	1050	960	620	670

same. In orter to determine the first grade structure of the silk proteins, we also determined their amino acid compositions, and they were also similar (it is not enunciated here).

As to the details of the UV spectra in Fig. 2, all the samples have two absorption peaks at 220 nm and 280 nm. These are due to the UV active ones of the 18 kinds of amino acids in the silk protein, i.e. Tyr, Trp and Phe (Tao *et al.*, 1992). The 3 kinds of amino acids contents in the *Antheraea pernyi* and *Bombyx mori* silkworm cocoons are similar, this is Why, there is no big difference between these two peaks among all the samples. Therefore, the two absorption peaks are exist in these silk proteins. In addition, all the *Antheaea pernyi* silkworm cocoons have two absorption peaks at 250 nm and 350 nm. However, *Bombyx mori* cocoon has no this two beaks. The two peaks are characteristic for the cross-linked polymer of gentisic acid and silk protein, which is tawny chromogen substance (Tao *et al.*, 1988). In order to compare the content of the cross-linked polymer in the various *Antheraea pernyi* silkworm cocoons, their absorbances at 350 nm are determined and listed in Table 2, as it can be seen from this intensity of the corss-linked polymer and degree of white color. The

Table 2. UV absorbances of the various silkworm cocoons at 350 nm

samples No.	1	2	3	4	5	6
absorbances (A)	0.36	0.42	0.50	0.56	0.60	0.77
A-A′	0.00	0.06	0.14	0.20	0.24	0.41

A: absorbance of the *Antheraea pernyi* silkworm cocoon

A′: absorbance of the *Bombyx mori* silkworm cocoon

degree of white of white *Antheraea pernyi* silkworm cocoon No. 2 is quite near to the white *Bombyx mori* silkworm cocoon.

Degree of white color of those white *Antheraea pernyi* silkworm cocoons (No. 3, No. 4, No. 5), following their absorbance increasing, the degree of white reducing.

As mentioned above, once again it shows that a point of view of tawny chromogen in the *Antheraea pernyi* silkworm cocoon we reported before is a right conclusion.

Conclusions

1. The main body of the first grade structure of silk protein in the new white and traditional tawny *Antheraea pernyi* silkworm cocoon is the

same.

2. There is a little cross-linked polymer of gentisic acid and silk protein in the white silkworm cocoon. The surviving quantity of the polymer in No. 2 white silkworm cocoon is the least, its degree of white color is the best, its degree of white color has no big difference from the one white *Bombyx mori* cocoon comparing by eye measurement, and the degree of white color of the No. 2 and the white *Bombyx mori* silkworm cocoon is very near too.

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