Sea Snail Purple in Contemporary Japanese Embroidery

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Introduction

Purple dye

Sea snail purple, also known as Shellfish purple, Tyrian purple, Royal purple, Ancient purple or Murex purple, abbreviated to *purple* in this text, is a pigment obtained from the secretion of the hypobranchial glands of certain species marine mollusks (Fig. 1). The milky secretion from the glands includes a purple precursor which can be applied directly onto textiles (Fig. 2), where the final pigments are formed in the presence of oxygen and sunlight (Fig. 3). The main chemical constituent of the purple pigment was discovered by Paul Friedländer in 1909 to be 6,6′-dibromoindigo[1].

Purple dye in Central America

Purple has been used for dyeing of traditional textiles in Central and South America. It still continues to be used in Mexico, Costa Rica and El Salvador[2]. In April 2004, I stayed in the community of the Boruca in the south of Costa Rica. Borucan are known for

Figure 1. *Hypobranchial gland*

Figure 2. *Purple precursor*

Figure 3. *Color development to purple*

their traditional weaving, using cotton yarn dyed with purple. In Boruca, about 15 people, men and women, do purple dyeing work on the Pacific coast where only indigenous people have permission to collect the snails for the traditional dyeing.

Historically, El Salvador was the country that supplied purple yarn to Guatemala. The purple dye industry in El Salvador declined gradually from about 1930, and came to an end in around 1950[3]. At present, only two old men who live in Jicalapa village, called *Teñidor* or *Hilero*, still practice the traditional dyeing technique using fresh snails known as *Jute*. In September 2004 I visited the two remaining purple dyers and observed their dyeing work on the Pacific coast. The indigenous

[1] P. Friedlander, 'Uber den Farbstoff des antiken Purpus aus murex brandaris', *Ber. Dtsch. Chem. Ges.,* **42**, pp. 765-770 (1909).

[2] T. Terada, 'Shellfish purple; field trips to Costa Rica and El Salvador', *Kwassui Bulletin*, **50**, pp. 9-17 (2007).

[3] H. Kojima, 'Ultimos tenidores de purpura de caracol en El Salvador', *MUSEO DE TABACO Y SAL*, pp. 382-390 (2000).

dyers had one remarkable characteristic in their dyeing technique. They did not push or blow, they sucked the dye from the shellfish with their own mouths.
The scientific names of the shellfish which they usually used for dyeing, which they called 'Jute' , are two kinds of the Muricidae family, *Purpura (Patellipurpura) pansa* Gould, 1853 and *Purpura (Patellipurpura) columellaris* Lamarck, 1822. *Thais (Vasula) melons* (Duclos, 1832) were occasionally used to make up the unevenness of the dyed yarn. *Thais* cf. *haemastoma* (Linnaeus, 1767) and another three kinds of the Muricidae family were also observed.

Purple dye in Japan
In 1991, for the first time in Japan, purple pigment was detected in a few fragments of ancient silk which were found in three separate burial jars that had been buried at different times at the Yoshinogari site [4].

The Yoshinogari site is located alongside the Ariake Sea in Saga Prefecture, southwestern Japan. The site has received extraordinarily high acclaim from academia as the only site to show the establishment of the Japanese state during the Yayoi period (after third century B.C. to A.D. third century). In April 2001, the site was designated a national historical park. Compared to other national parks in Japan, this designation was made very soon after its discovery, due to its historical importance.

The oldest silk was attached to a shell bracelet made with *Tricornis latissimus* in the first century B.C. to A.D. first century. A second fragment was attached to a bronze dagger from the same period, and a third piece was attached to a Corn shell bracelet from the A.D. first century. The silk fabrics are likely to have been woven in Japan and those buried people are considered to be of high social position.

Background
I learned of the discovery of purple at the Yoshinogari site from my husband when he received an ancient shell bracelet from the office of the Yoshinogari site, in which the purple had been detected. My husband is an expert in restoring ancient shell bracelets, and he is also a shell collector, like my mother, who is a director of Okinawa Shell Museum (*Okinawa Kai-rui Hyouhon-kan* in Japanese, Nakamine Shell Collection). Since it was not known that purple had been produced in ancient Japan at that time, we found this discovery exciting.

Before investigating purple, I studied the development of functional polymer materials. I also researched the patterns of shells, the similarities among traditional textile patterns in the world, and the use of molluscs by people, which were linked to my pastimes of shell collecting, dyeing, weaving, and embroidery. Okinawa prefecture in southern Japan, where I was born, is known for its diverse species of molluscs, as well as traditional textiles.

Soon afterwards, I was asked by one of my friends, a conchologist connected to the Yoshinogari site, to reproduce the fabric dyed with purple. Some of my works are exhibited in the museum of the site. The process of reproducing purple aroused my strong interest in its history, chemistry, and application.

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[4] Saga Prefecture Board of Education, 'The Yoshinogari Site' ('Yoshinogari iseki' in Japanese), *Saga-ken Bunka-zai Chousa Houkoku-sho*, **113**, pp.98-465 (1992).

In 1994, I started my own full-scale studies on purple, receiving a grant for scientific research from the Japanese government. My years of this study have enabled me to identify the dyeing properties of purple using some Japanese species, and my research has also allowed me to develop optimal dyeing conditions [5].

I have visited about twenty-two countries to investigate purple. I also have been collecting data of sea snails, natural dyes, silk, shell bracelets, burial jars, and human bones in the fields of natural science, archeology and anthropology, as well as information from such as classical literature and folklore[6].

Techniques of Purple Dyeing

Dye sources

The majority of purple producing sea snails belong to the Muricidae family. I have so far confirmed approximately 2,000 species in the Muricidae family, of which about 600 species are found in East Asia. I checked whether or not purple could be obtained from the hypobranchial glands of the Muricidae family species by carrying out my own experiments, by asking specialists, and by studying references. I have confirmed that there are approximately 300 mollusk dye species in the world, of which about 200 species are presently found in East Asia.

I have been collecting pigment from the hypobranchial glands of shellfish and analyzing the types and composition ratios based on the relative comparison converted by the peak area ratio of high-performance liquid chromatography (HPLC) (Figure 4).

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[5] T. Terada, 'Study on the Colouring Mechanism of Shellfish Purple', *Research Project, Grant-in-Aid for Scientific Research (C), Ministry of Education, Cultures, Sports, Science and Technology, Japan,* ('Kai-murasaki no hasshoku-kikou ni kansuru kenkyu', *Heisei 6 nen-do - heisei 7 nen-do, Kagaku kenkyu-hi hojyo-kin, Ippan kenkyu C, Kenkyu seika houkoku-sho,* in Japanese), No. 6808006, pp. 1-33 (1997)

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[6] T. Terada, 'Practice of the dyeing with Shellfish Purple', ('kai-murasaki zome no zissen' in Japanese), *Katei-ka Kyoiku,* **72,** pp.88-92 (1998)

T. Terada, 'Dyeing with Shellfish Purple on Silk', ('Kaimurasaki ni yoru kenshi no senshoku' in Japanese), *Memoirs of Tamaki Women's Junior College,* **6**, pp.7-13 (1997)

T. Terada, 'Purple Dyeing with Shellfish in Ariake Bay', ('Ariake-kai no kaimurasaki-zome' in Japanese), *Senshoku-α,* **180**, pp.37-39 (1996)

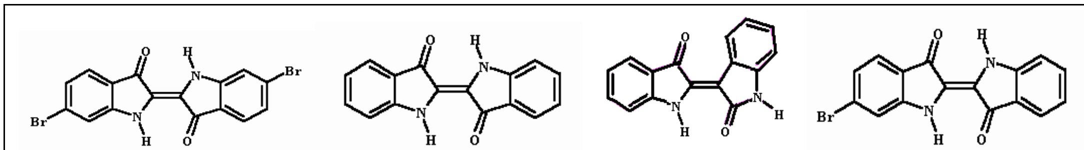
T. Terada, 'Notes of the Fieldwork on Shellfish Purple ', ('Kai-murasaki ni kan-suru field chousa' in Japanese), *Memoirs of the Tamaki Women's Junior College,* **7**, pp. 29-35 (2003)

T. Terada, 'Fieldwork on Shellfish Purple', ('Kai-murasaki ni kan-suru field chousa' in Japanese), *Kwassui Bulletin*, **48**, pp. 51-62 (2005)

Molluscs species	Locality	Dibromoindigo	Indigo	Indirubin	Monobromoindigo	Unknown
Thais clavigera	Oura, Saga	88.1	8.9	1.8	1.2	0.0
Thais clavigera	Hunatsu, Nagasaki	76.5	22.2	0.1	1.0	0.2
Thais clavigera	Mie, Nagasaki	93.4	5.0	0.2	1.3	0.0
Thais clavigera	Konoura, Nagasaki	96.2	1.9	0.2	0.4	1.4
Thais clavigera	Kurosaki, Nagasaki	98.1	0.7	0.4	0.8	0.0
Thais clavigera	Kaminoshima, Nagasaki	98.4	0.7	0.0	0.9	0.0
Thais clavigera	Akatsuchi, Nadasaki	96.5	0.7	0.4	1.7	0.7
Chicoreus brunneus	Gesashi, Okinawa	97.3	1.1	0.3	0.8	0.5
Cronia margariticola	Kushi, Okinawa	33.2	29.0	17.2	4.7	15.9
Drupa albolabris	Gesashi, Okinawa	89.4	9.9	0.4	0.4	0.0
Drupa ricina hadari	Kushi, Okinawa	49.9	30.9	5.3	13.9	0.0
Morula anaxeres	Kushi, Okinawa	41.1	37.7	13.9	0.0	7.3
Morula granulata	Gesashi, Okinawa	29.2	44.0	26.8	0.0	0.0
Morula granulata	Kushi, Okinawa	59.3	29.6	6.6	3.1	1.4
Morula marginalba	Gesashi, Okinawa	61.3	34.9	3.3	0.5	0.0
Morula marginalba	Kushi, Okinawa	77.0	16.9	3.9	1.1	1.1
Rapana venosa	Oura, Saga	100.0	0.0	0.0	0.0	0.0
Thais bronni	Oura, Saga	71.8	22.2	3.6	2.4	0.0
Thais distinguenda	Kushi, Okinawa	98.5	1.5	0.0	0.0	0.0
Thais hippocastanum	Gesashi, Okinawa	82.8	15.3	0.7	1.3	0.0
Thais hippocastanum	Kushi, Okinawa	77.2	16.1	5.5	0.0	1.3
Thais intermedia	Gesashi, Okinawa	97.3	0.5	0.2	1.5	0.6
Thais tuberosa	Gesashi, Okinawa	86.0	13.1	0.0	8.9	0.0

Figure 4. *Composition ratio of the pigment derived from hypobranchial glands of Japanese mollusks.*

For example, 6,6'-dibromoindigo, indigo, indirubin, and 6-monobromoindigo (Fig. 5) were identified from the pigment obtained from *Thais clavigera* (Kuster, 1860). The content of indigo was greater in *T. clavigera* that inhabit Hunats, Oura and Mie at the Ariake Sea (inland sea) than in those that inhabit Konoura, Kurosaki, Kaminoshima and Akatsuchi at the East China Sea (open sea). This suggests that the environment which the shellfish inhabit affects the type and quantity of pigment produced.



6, 6'-Dibromoindigo **Indigo** **Indirubin** **6-Monobromoindigo**

Figure 5. *Chemical structure of the pigments.*

Direct dyeing

The thick and viscous paste yielded from the hypobranchial gland which includes the pigment precursor, can be applied directly onto textiles by the techniques of painting, printing or stencil.

First, the gland secretions from fresh sea snails of the Muricidae family are collected in a container. The liquid (saliva) excreted by the snail during this process was collected in another container. The liquid effectively developed the colors of precursors. The gland secretions were strained into a stainless steel or glass (inorganic) pot with a wire-mesh strainer.

For immersion dyeing, the amount of dye liquid used was sufficient to just cover the fibers, skeins of yarn or fabrics being dyed. All processes were conducted in the shade. The items to be dyed are then deposited in the dye bath and left there for at least 30 minutes. Then, exposed to the air and the sun, the purple color develops. Last, soaping and rinsing were carried out as usual.

Direct dyed with purple precursor from *Rapana venosa* on natural fibers, such as cotton, wool, and silk gave a reddish-purple color. On the other hand, precursor dyed chemical fibers, namely, rayon, acetate, nylon, polyester, acrylic, and vinylon took on a purple colour. Precursors from one Rapana venosa were sufficient to dye approximately 100 square centimeters of fabric, and one Thais clavigera was sufficient to dye approximately 4 square centimeters.

There were two advantages of this method. First, there was no use of chemicals, and second, the pigment could be used to dye almost all kinds of organic fibers. The two disadvantages are that the dyeing is somewhat uneven, and a slight odor remains.

Vat Dyeing

The hypobranchial gland secretions and the saliva are combined, mixed thoroughly, strained through a fine mesh into a shallow jar and gently stirred in full sunlight to develop the colour. When the water evaporated, the residue was removed from the jar, and ground into powder.

The purity of purple (6,6'-dibromoindigo) from the dried residue of hypobranchial glands is about 3%. It is equivalent to the concentration of indigo in fermenting previously dried indigo leaves (*sukumo* in Japanese). For just like sukumo, dried purple which was equivalent to approximately 30% of the weight of the fiber to be dyed, was required.

Vat dyeing with purple involves the use of sodium hydroxide (NaOH; 15g/L), and sodium hydrosulfite ($Na_2S_2O_4$; 30g/L). Ideal vatting temperature is 80℃, while 60℃ is the preferred dyeing temperature. It is necessary to shield all of the dyeing, oxidizing, and the coloring processes from the light. It is reported that the reduction form of dibromoindigo affected the light, de-bromination occurs [7]. After dyeing, finishing (for example, an acid bath treatment) is followed by soaping and rinsing.

Using the chemical vat dye method, the shade obtained varied according to the fiber used. The advantages of this method are that it is possible to preserve purple in powdered form, the dye is uniform and even; and there is the potential to develop a wide range of colors from reddish-purple to bluish-green merely by adjusting the dyeing conditions. Disadvantages of this method are the need for chemicals and accurate temperature and pH control.

Japanese Embroidery Works

On the textile works, Japanese embroidery is the work that I like most. I teach traditional Japanese embroidery techniques in school classes and at public seminars and also demonstrated these works in exhibitions, both within and outside Japan (Figs. 6 and 7).

My recent commissions include a reconstruction of the 15th century of Okinawan *Noro* (lady priest) costume from the office of the Okinawa Prefectural Museum and Art Museum (Fig. 8), and a chasuble for the Archbishop of Nagasaki using purple threads (Fig.9).

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[7] Y. Hiyoshi and Y. Fujise, 'Tyrian Purple: As a Learning Tool for Natural Product Chemistry', ('Kagaku kyouzai to shiteno kai-murasaki' in Japanese), *Kagaku to Kyoiku,* **40,** pp. 390-393 (1992)


***Figure 6a (left)**. 'Peony and Phoenix', 40 x 50cm, University Museum of Iowa State University, U.S.A. (2002).*
***Figure 6b (right).** Detail of 'Peony and Phoenix', University Museum of Iowa State University, U.S.A. (2002).*


***Figure 7a (left).** 'Cherry Blossoms', 50 x 120cm, Kimono Museum, Tokyo, Japan (2005).*
***Figure 7b (right).** Detail of 'Cherry Blossoms', 50 x 120cm, Kimono Museum, Tokyo, Japan (2005).*


***Figure 8a (left).** Reconstruction of the 15th century of Okinawan 'Noro' costume,*
Okinawa Prefectural Museum &Art Museum, Japan (2007).
***Figure 8b (right).** Detail of the embroidery (Photos from Chikako Ueki, Okinawa).*

Figure 9a (left). *Archbishop of Nagasaki wearing chasuble by Takako Terada (2005).*
Figure 9b (center). *Chasuble for the archbishop of Nagasaki, Japan. Takako Terada.*
Figure 9c (right). *Detail of the chasuble embroidery. Takako Terada.*

SUMMARY

I found that traditional purple dyeing was indeed performed by indigenous people on the Pacific coast in Costa Rica and El Salvador, and observed six kinds of snails of the Muricidae family on the Pacific coast.

Years of study have enabled me to partially identify the dyeing properties of purple using Japanese species, as well as the optimal dyeing conditions. The number of species in the Muricidae family and the number of species that produce purple are still under investigation.

Purple excavated from the Yoshinogari site is the only archeological evidence in Japan. Since there is little available historic data on the use of purple in ancient Japan, I am still looking for an effective investigational approach. It is likely that there are many unexplored sites and remains in Japan and East Asia still awaiting scientific research.

I have lectured on purple in school classes and at public seminars and also introduced traditional Japanese textiles and embroidery. I have also demonstrated these works in exhibitions, both within and outside Japan, and plan to continue these activities to share the technique, information, and passion.

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