



故宫博物院宫灯穗染料的科学研究 Scientific Research on Dye in Palace Museum

A Case in the Palace Museum : Palace Lantern Tassels



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博物馆纺织藏品的来源

Source of Textiles collection



Shoulder pad, ca. 1-3 century CE, Xinjiang Museum

- 考古出土

Excavated/ found from archaeological sites
badly preserved, fragments

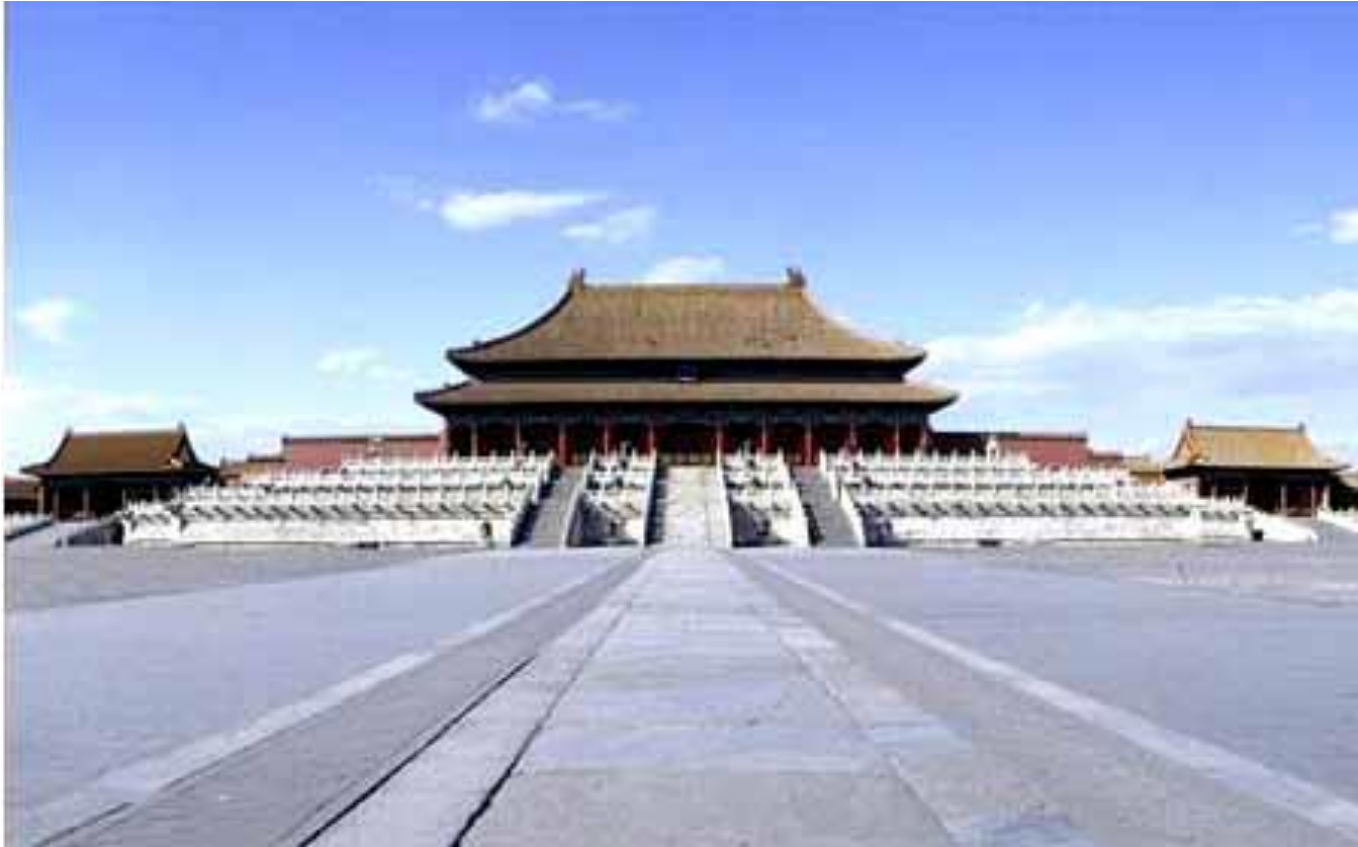
- 传世品

Fine arts: inheritance, imperial palace
well and fully preserved



Emperor's Dragon Robe, ca. 1736-1795. Palace Museum, Beijing

The Palace Museum, Beijing



故宫太和殿 Hall of Supreme Harmony

故宫的纺织品收藏

Textiles collection in Palace Museum

- 传世品为主

Mainly inherited from Qing court since 1925

- 明清藏品为主

Ming & Qing period 14 century-1925

- Fine arts and well preserved

保存较为完整

- 约有18万件

About 180,000 pieces



“Woman’s Robe with Dragonet Medallions” , Qing period, Palace Museum, Beijing

大量混合质地的文物

Combination of different materials





Phoenix crown,

Bamboo structure, Chinese lacquer coating, feather, pear, gemstone inlays, gold threads

点翠嵌宝石凤冠

此凤冠以髹漆细竹丝编制，通体饰翠鸟羽毛点翠的如意云片，18朵以珍珠、宝石所制的梅花环绕其间。冠前部饰有对称的翠蓝色飞凤一对。冠顶部等距排列金丝编制的金龙3条，其中左右两条口衔珠宝流苏。冠后部饰六扇珍珠、宝石制成的“博鬓”，呈扇形左右分开。冠口沿镶嵌红宝石组成的花朵一周。



Palace Lantern & tassels



染料的液相色谱分析

UPLC-Xevo G2-S QToF MS



Data acquisition : UPLC for separation
MS^E mode for MS acquisition



HPLC/UPLC 就好像让各种成分在跑道上奔跑，不同成分的物质运动速度不同就分开了







m/z (mass-to-charge ratio)

Contents

1. Introduction of the palace lantern tassels

2. Dye identification of the tassels

3. Scientific research on dye

The Palace lanterns

Illumination & Decoration

日常照明用灯 节日喜庆的彩灯



High level requirement for place lanterns

- special supplies

Imperial workshops

内务府造办处 灯裁作

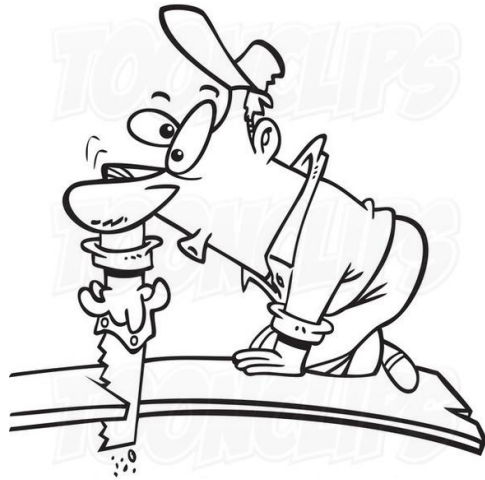
Special local offers

地方专门进行采购或接受纳贡



High level requirement for palace lanterns

- Skillful craftsmen,



- Precious material

Rare woods, gemstone, textile

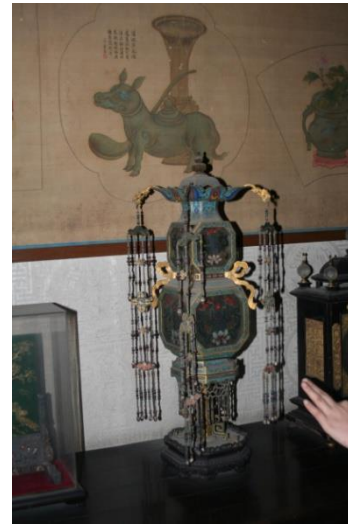


Classification of palace lanterns

- Geometric shapes 几何形状:
polyhedron (多边形), round, gourd
Circular (圆形)

- Holder Methods 悬挂和支撑方式:

Suspension, stand support, table lantern, mobile high lantern,



制作宫灯的主要材料 Materials for making

灯笼支架 **Lantern Structure:** wood / bamboo
with lacquer coating, caving, etc.



木材



竹子



天然大漆

透明材料Transparent cage:
羊皮Sheep horn,



玻璃glass (enamel),

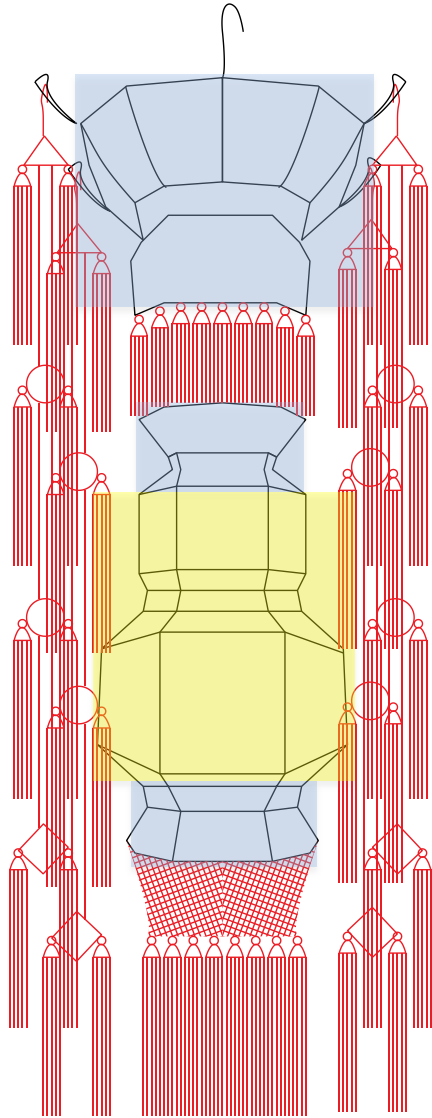


纸paper

- **Decoration:** Weights, inlays, caving, lacquer coating and painting
- Weights: textile, paper, beads, Bi shape, etc.



Structure of a palace lantern



Structural supporter 框架结构：
圆形、四角形、六角形、八角形等
木质、雕漆、珐琅、牛角等

Cage structure 主体部分：
圆形、方胜形、花篮形、葫芦形、鱼形等
玻璃、纱绢、牛角、牙雕等

Weights 灯穗部分：
悬挂吉祥杂宝、流苏璎珞等

What are the question faced

* Underestimation

Conservation problem——Textile parts

- Dirty
- Fragile
- Fading



Making Technique Research

- Dye: identification of dyestuff and its provenance, dying technique and chronology

- Weights:

Paper board with raised decoration

Beads-glass and gemstone

Enamels



- Date
- Provenance





故宫博物院
THE PALACE MUSEUM

Difficulty in date identification by typology



Difficulty in date identification by typology



Dyestuff before 19th century

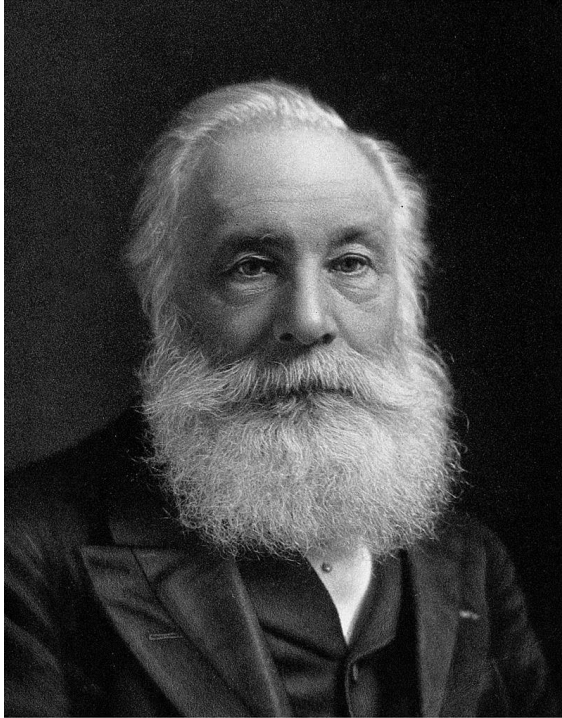
明清代最常用的染料（四本古代书籍中）：苏木、红花、黄檗、槐米、靛蓝、橡碗、五倍子、黄栌*。



Figure 1. 1 Photographic images of eight common dyes recorded in the dye recipes
From left to right, top to bottom: safflower, sapanwood, smoketree, pagoda bud, Amur cork tree, indigo, acorn cup and Chinese gallnut.

*ref. Jing Han. The historical and chemical investigation of dyes in high states Chinese costume and textiles of the Ming and Qing Dynasties(1368-1911)[D].University of Glasgow, 2016.

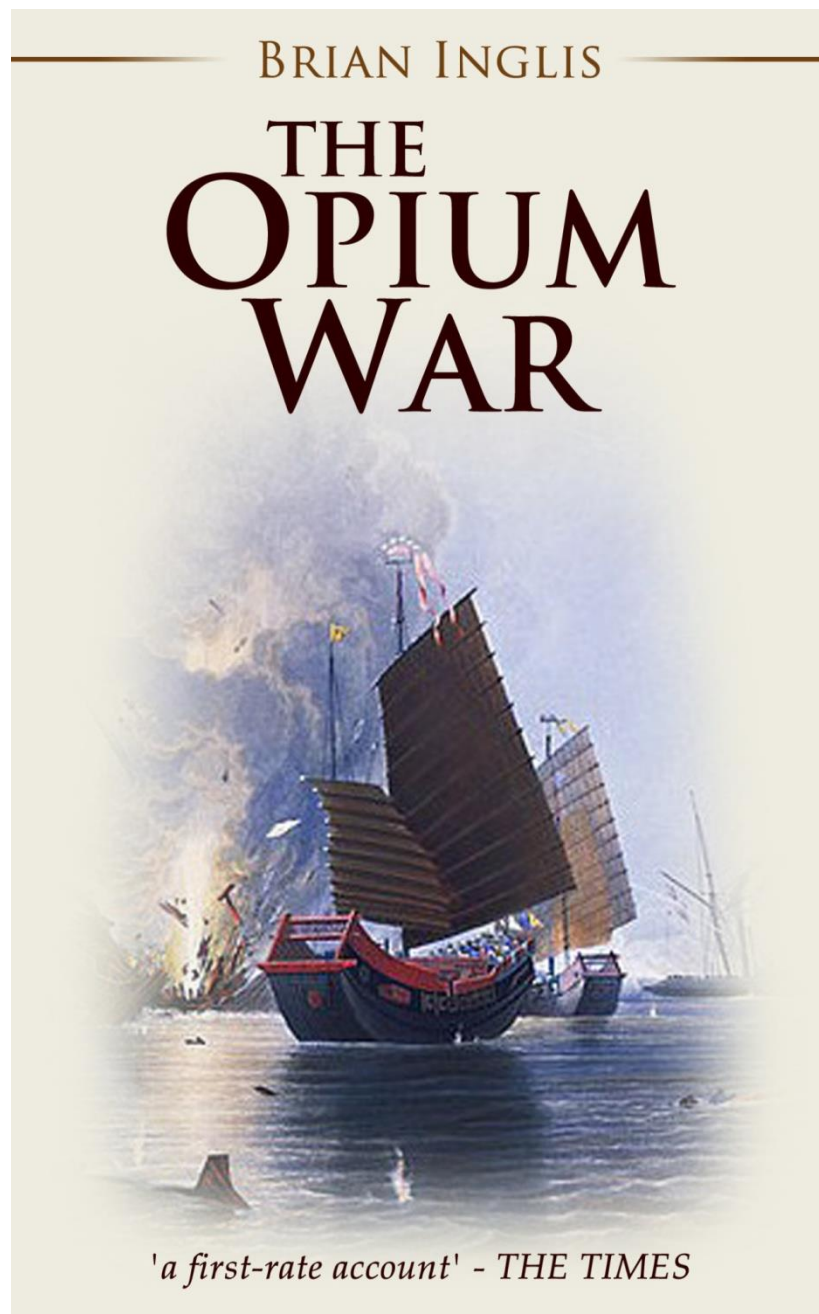
In 1856, 18-year-old **William Henry Perkin** was experimenting in his home laboratory, accidentally discovered the first aniline dye



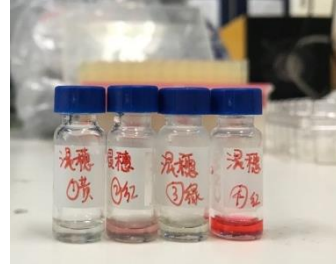
*Yours sincerely
W H Perkin*



- **After the two opium wars**(First 1839–1842; Second 1856–1860), the European synthetic dyes entered China quickly and almost took the place of traditional natural dyes.



Identification of Dye



Identification of Date for tassels (before/after **opium wars**)

Date assumption for other weights



文物介绍: Weight I

Structural supporter: Hardwood (Zitan)

Wood cage: with transparent glass boards

Shape: gourd

紫檀木嵌玻璃大吉葫芦式灯

文物编号	故00182545
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文物级别	资料藏品
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年代	清代
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类别	生活用具
----	------

原状陈列	长春宫
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文物介绍 Weight II

紫檀木嵌玻璃大吉葫芦式灯

文物编号 故00182548

文物级别 资料藏品

年 代 清代

类 别 生活用具

原状陈列 长春宫



文物介绍（三） Weight III

彩漆嵌玻璃四方委角挂灯

文物编号 故00182617

文物级别 资料藏品

年代 清代

类别 生活用具

原状陈列 长春宫





→ No colorant

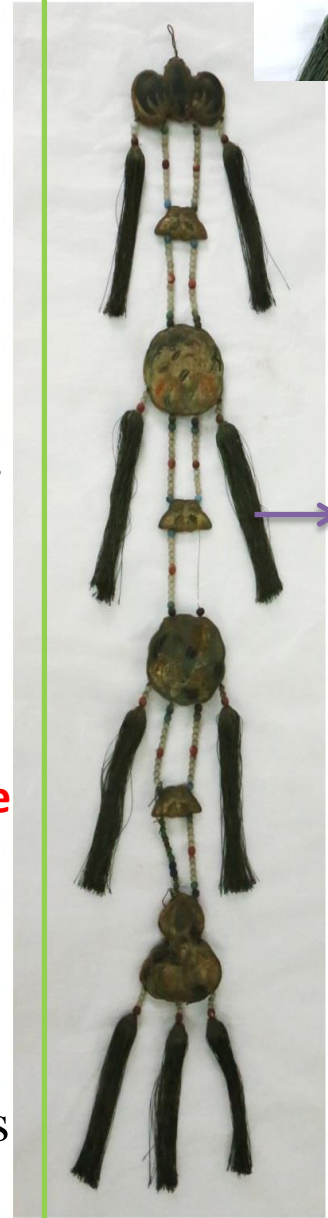
酸性红87
溴代苯酸盐类

→ Industrial
Bromo-benzoates
Acid red 87

→ 槐米
Pagoda bud

**Mixture of Chinese
and industrial
dyestuff**

→ 酸性红151
磺酸盐类
Industrial Sulfonates
Acid red 151



→ 黄檗和靛蓝
Amur cork tree
and Indigo

**Chinese local
dyestuff**



→ 金胺O
苯胺盐类
Industrial
Aniline salts
Auramine O

**European
Industrial
dyestuff**

Analysis results of the palace lantern tassels



槐米的介绍 (Introduction of pagoda bud)

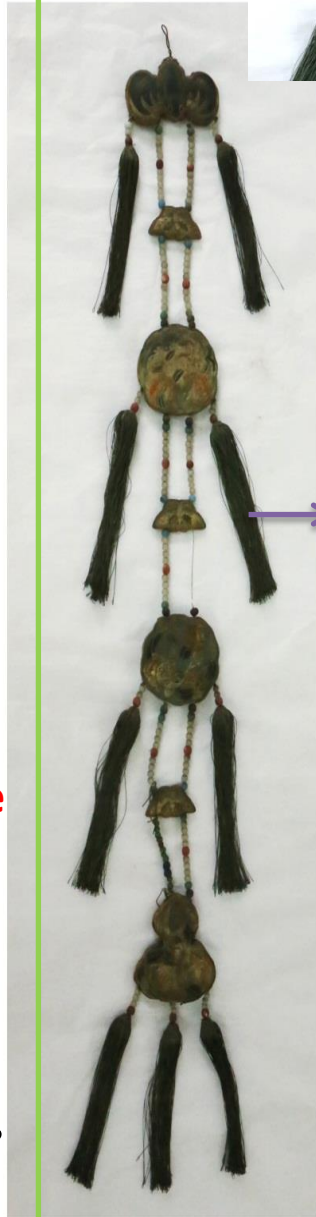
槐米通常指国槐花的干燥的花蕾，学名*Sophora japonica* Linn.，在中国的栽植历史悠久，古代人认为槐树有灵气，在商周时期就有“北社为槐”的说法，认为槐树掌管着北方的土地神。槐米作为黄色植物染料应用十分广泛，李时珍在《本草纲目》中记载：“其花未开时，状如米粒，炒过煎水染黄甚鲜。”古代人们摘取新鲜的槐花蕾，利用高温将其炒干或烘干，使其中的糖苷酶失去活性，避免芦丁被糖苷酶水解，再通过煎煮等方式对纺织品进行染色。



槐米中的色素成分是黄酮类化合物，其主要成分是芦丁（又名芸香苷），还有少量的槲皮素、山奈酚等化合物及其衍生物。槐米是一种媒染型染料，可以用于染黄和绿色，在刘基的《多能鄙事》中有相关记载，槐米用于直接染色时织物颜色偏淡，若使用明矾（ $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ ）媒染则可以得到亮黄色，若使用绿矾（ $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ ）媒染可以得到油绿色。



→ No colorant
 酸性红87
 溴代苯酸盐类
 Industrial
 Bromo-benzoates
 Acid red 87
 → 槐米
 Pagoda bud
**Mixture of Chinese
 and industrial
 dyestuff**
 酸性红151
 磺酸盐类
 Industrial Sulfonates
 Acid red 151



→ 黄檗和靛蓝
 Amur cork tree
 and Indigo
**Chinese local
 dyestuff**



→ 金胺O
 苯胺盐类
 Industrial
 Aniline salts
 Auramine O
**European
 Industrial
 dyestuff**

Analysis results of the palace lantern tassels



黄檗的介绍 (Introduction of amur cork tree)

berberine

黄檗又名黄柏，学名*Phellodendron amurense Rupr.*，黄檗用于染色的部位是其芯材，经过煎煮之后可以直接染黄色。南北朝时期的鲍照有诗曰“锉檗染黄丝”，也表明当时黄檗染黄的普遍性。黄檗的主要染色成分是原小檗碱类化合物，包括小檗碱、巴马汀、药根碱、黄柏碱等。小檗碱类物质具有杀虫防霉的功效，因此黄檗也用于染制经书和账簿等。

黄檗
amur cork tree



黄檗的树皮
bark of amur cork tree



通常古人用黄檗染色时，取其第二层树皮，以高温热水煮的方式对织物进行染色，可以得到略带绿色感觉的沉稳黄色*

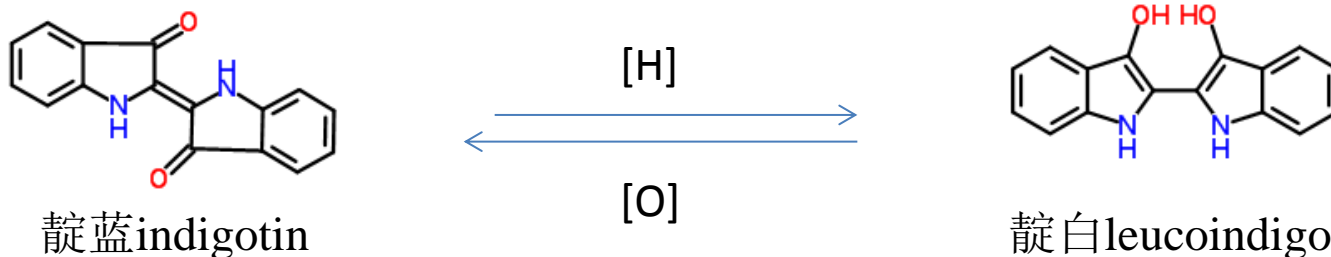
*Y Sasaki, K Sasaki. Analysis of Protoberberines in historical textiles: determining the provenance of east Asian textiles by analysis of Phellodendron[J]. e-Preservation Science, 2013, 10, 83-89.

靛蓝的介绍 (Introduction of indigo)

靛蓝类染料在世界各地都有广泛的应用，中国古代常用的靛蓝类植物包括马蓝、蓼蓝、菘蓝、木蓝等。它们虽然属于不同的科目，但其中均富含靛苷（吲哚酚和葡萄糖的缩合物），可以用于制靛蓝。



靛蓝是一种典型的还原型染料。由于靛蓝类染料不溶于水，因此在染色之前需要在碱性条件下将其还原为易溶于水的隐色体靛白，等靛白上染到织物上之后，经过风干氧化，使染料再次变为靛蓝，获得最终的蓝色织物。



套染：靛蓝的配伍性能很强，经常会和其他植物染料一起套染得到其他的颜色。在《天工开物》中有很多关于套染法的记载，如提到豆绿色，是使用黄檗与靛蓝共同染制，“黄蘗水染，靛水盖。今用小叶菟蓝煎水盖者，名草豆绿，色甚鲜。”与我们实验所得结论相符。



→ No colorant

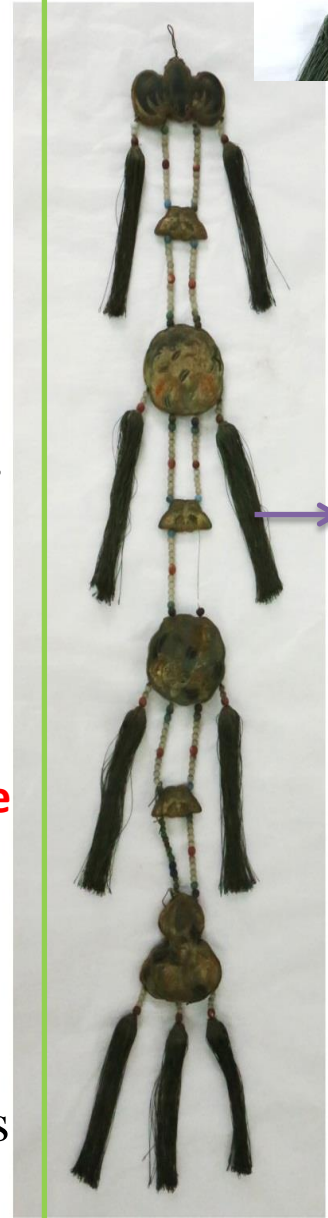
酸性红87
溴代苯酸盐类

→ Industrial
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→ 槐米
Pagoda bud

**Mixture of Chinese
and industrial
dyestuff**

→ 酸性红151
磺酸盐类
Industrial Sulfonates
Acid red 151



→ 黄檗和靛蓝
Amur cork tree
and Indigo

**Chinese local
dyestuff**



→ 金胺O
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Industrial
Aniline salts
Auramine O

**European
Industrial
dyestuff**

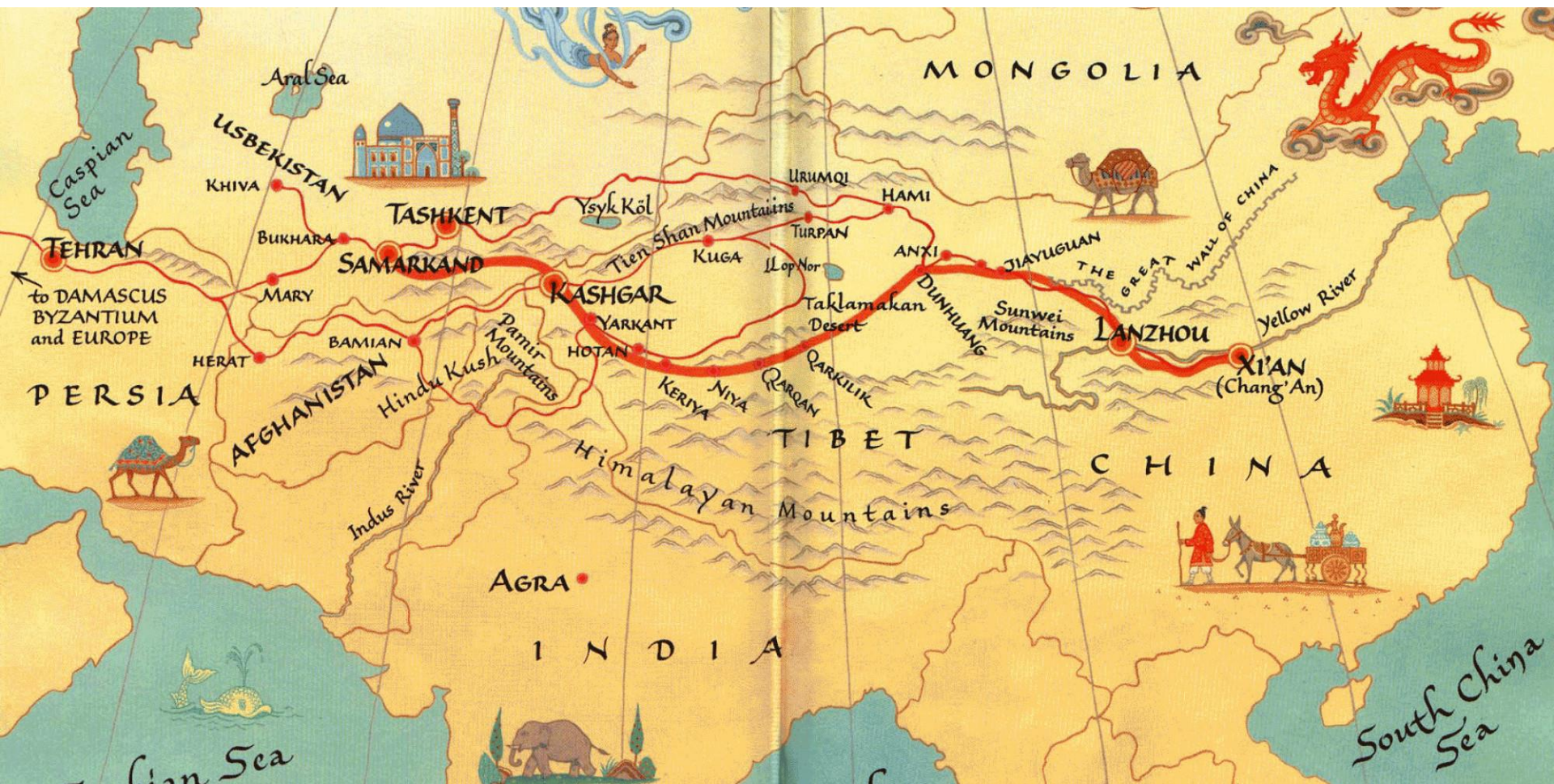
Analysis results of the palace lantern tassels

Scientific research on dye

- Provenance research
- Dying technique
- Fading



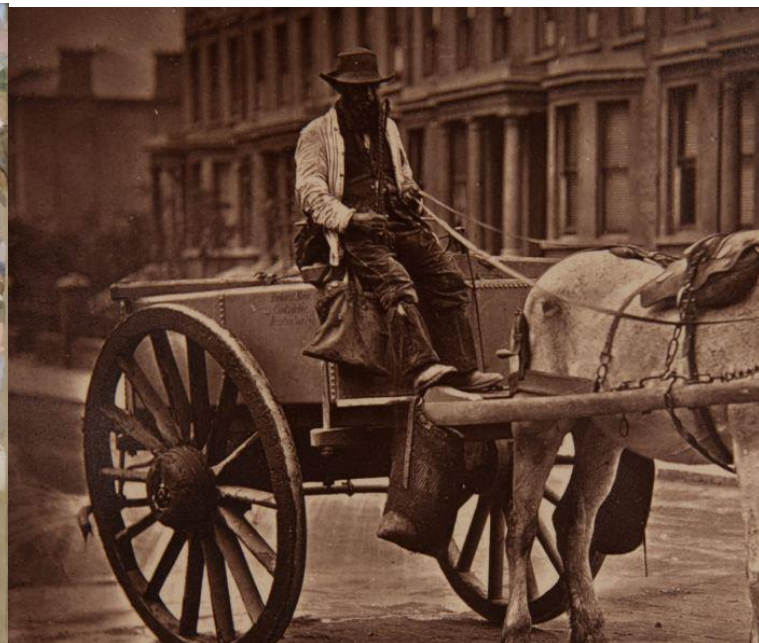
Provenance research



Land carrying



Land carrying





故宫博物院
THE PALACE MUSEUM

Xi'an, a historical capital city of China



Provenance research

石榴 西安市花

Pomegranate flower, city flower of Xi'an



西安的石榴是从伊朗沿丝绸之路传到长安的

Pomegranate is native to a region from Iran to northern India, It has spread along the route of the Silk Road to Xi'an in 7-8 century.

Provenance research

茜草 Madder

茜草，学名*Rubia cordifolia L.*，又称茅蒐、茹蘆，在西周初期的文学名著中就有对茜草的描写，是古代使用最早的红色植物染料。在康熙五十六年本《诸罗县志》有对茜草染色的记载，“茜草染絳之草，……，土番多用此以染兽毛，兼以染藤”。茜草的染色部位主要在根部，富含茜素、茜紫素等羟基蒽醌类染料。茜素在茜草根部分以配糖体形式存在，在古代通过发酵水解的方式斩断茜素与配糖体之间的糖苷键得到染料。



茜草种类较多，我国应用最广的是东洋茜，所染颜色偏橙色。茜通常使用金属媒染法进行染色以获得更好的色牢度，使用不同的媒染剂所得到的颜色也不同。

茜草属染料分类*

Dyestuffs	Botanical name	Origin	Composition					
			al.	pu.	xa.pu	mun	ps.pu	rub
Madder	Rubia tinctorum L.	Europe, middle and east India	+	+	(+)	+	+	(+)
Wild madder	Rubia peregrina L.	Mediterranean countries	-	+	-	-	+	+
Munjeet	Rubia cordifolia L.	India	+ (trace)	+	+	+	+	-
Japanese madder	Rubia akane Nakai	Japan	-	+	-	-	+	-
Chay root	Oldenlandia umbellata L.	India, Burma, Abyssinia, Ceylon	+	-	-	-	-	-
Relbunium	Relbunium hypocarpium (L.) Hemsl.	South and middle America	-	+	+	+	+	-
Lady's bedstraw	Galium verum L.	Europe, North Asia	-	+	+	+	+	-

al=alizarin, pu=purpurin, xa.pu=xanthopurpurin, mun=munjistin, ps.pu=pseudopurpurin, rub=rubiadin;
Highlight areas are the key identification markers.

大航海时代

Age of Sail



HK Maritime Museum





《坤輿萬國全圖》

彩繪《坤輿萬國全圖》屏風

原圖由利馬竇在1602年繪製；屏風約在17世紀於日本複製

書法及彩色手繪紙屏風

譚廣濂先生借出 香港海事博物館

Kunyu Wanguo Quantu

('Map of the Ten Thousand Countries of the Earth')

17th Japanese copy of an original map by Matteo Ricci, 1602

Hand calligraphy and coloured paper screen

On loan from K.L.Tam Collection, HK Maritime Museum





宫保鸡丁

Famous Chinese chili food



辣椒传入中国之前

Before Chili entered China



花椒
Chinese local pepper



美洲胭脂虫

American cochineal



Identification of a pink organic pigment



Pink ground: Lead white with a red dye

Calligraphy: Gugao *Tieluo*

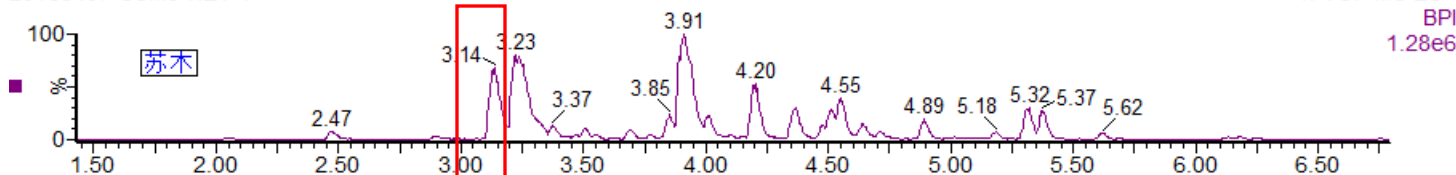
Writer: Gu Gao, Qing dynasty

Location: The Building of Auspicious Clouds (*Ji Yun lou*)

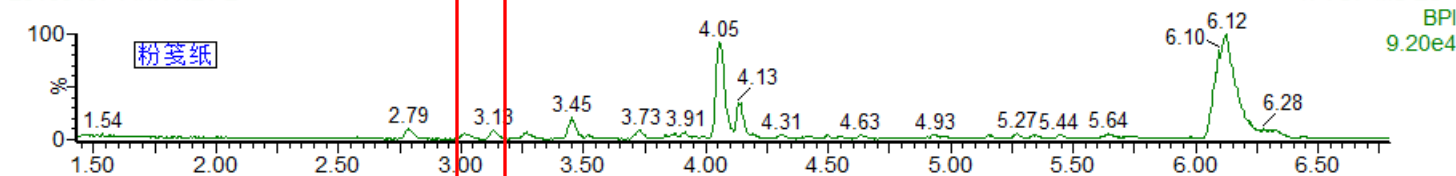
Dying technique

UPLC-QTOF Result in ESI⁻ mode

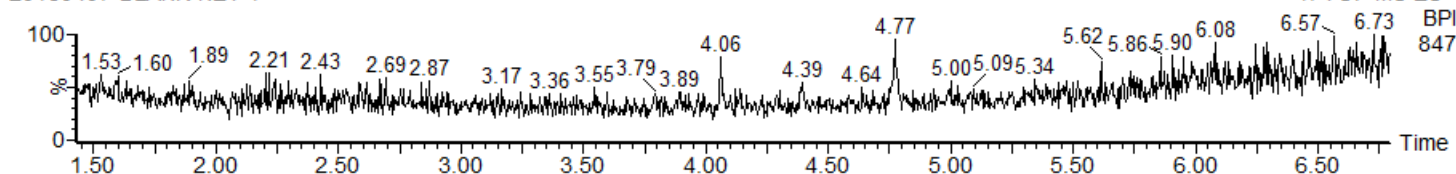
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20160407-PINK-NET-2

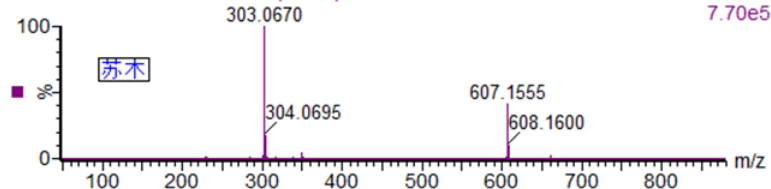


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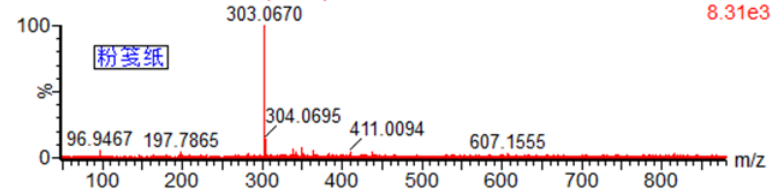


Mass Result

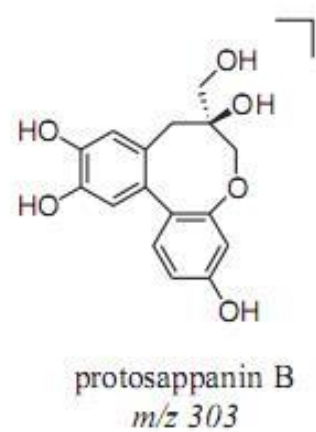
20160407-SUMU-NET-4 812 (3.146)



20160407-PINK-NET-2 808 (3.131)

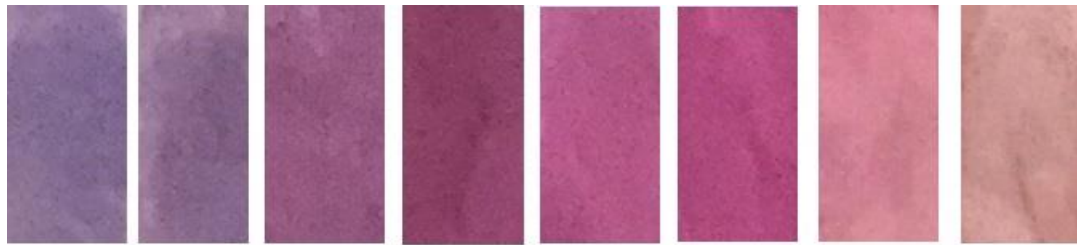
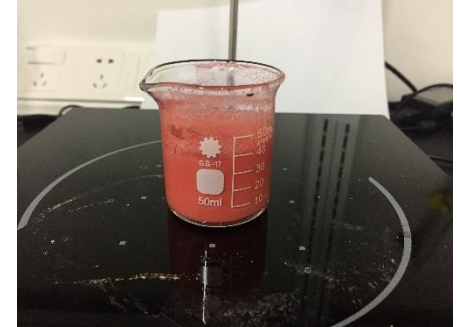
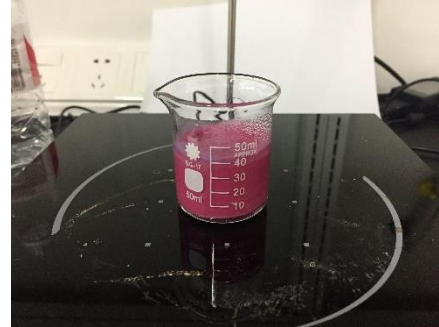
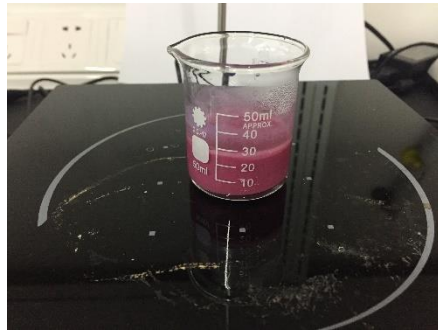
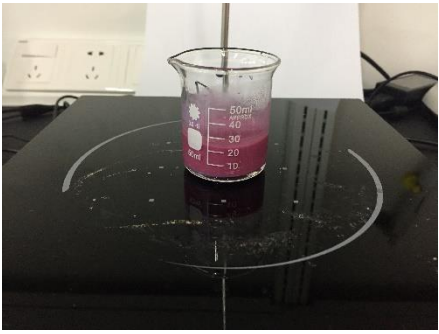
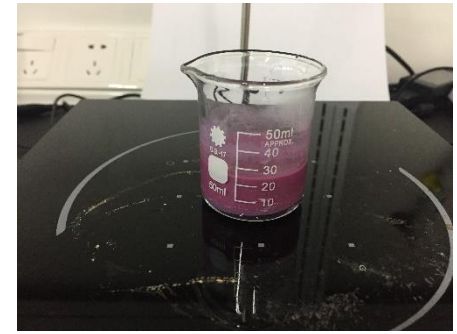
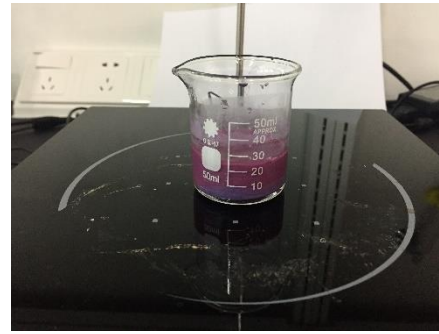
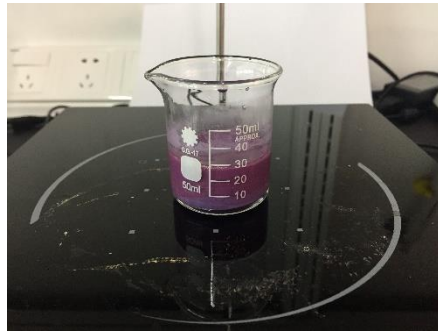
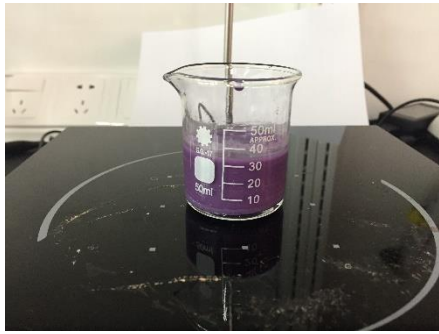


Speculated Structure

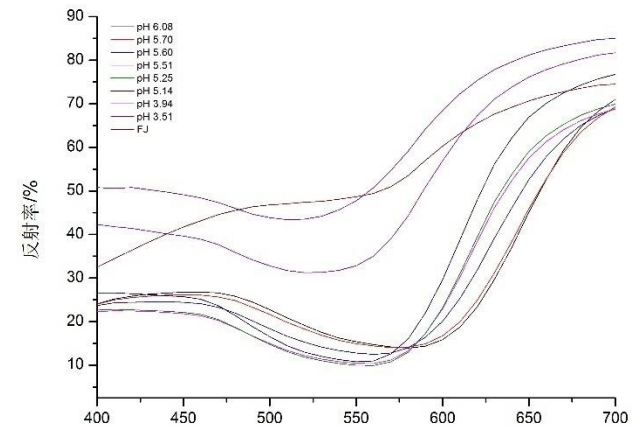


Effective component protosappanin B extracted from fenjian conforms to that from reference **sappanwood**
Natural dyestuff sappanwood is detected in the fenjian paper of Gugao *Tieluo*

Dyeing Process



pH 6.08 pH 5.70 pH 5.60 pH 5.51 pH 5.25 pH 5.14 pH 3.94 pH 3.51



The most possible simulated sample

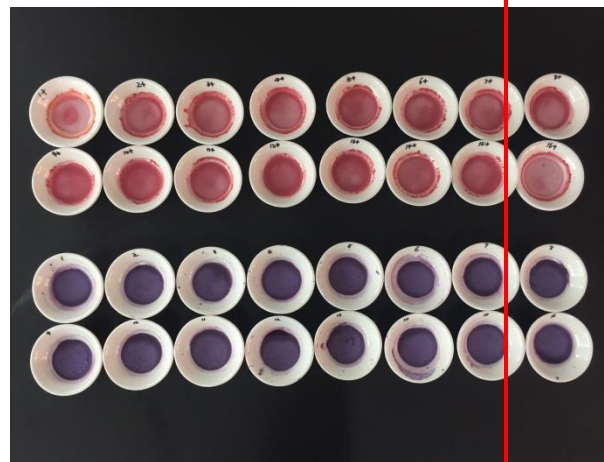
Dyeing technique



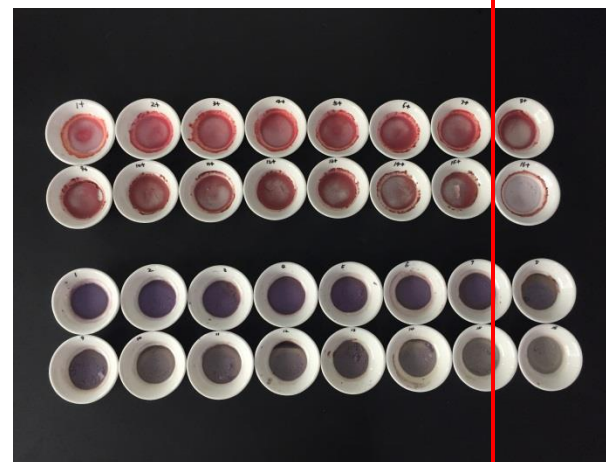
Fading

Fading experiment

- Selected 16 different time
- Sample1,1+: 0.5 h
- Sample2,2+: 1 h
- Sample3,3+: 5 h
- Sample4,4+: 10 h
- Sample5,5+: 15 h
- Sample6,6+: 1 day
- Sample7,7+: 1.5 days
- Sample8,8+: 2 days
- Sample9,9+: 3 days
- Sample10,10+: 3.5 days
- Sample11,11+: 4 days
- Sample12,12+: 4.5 days
- Sample13,13+: 5 days
- Sample14,14+: 1 week
- Sample15,15+: 2 weeks
- Sample16,16+: 3 weeks



before



after

Relevant study is underway to reveal the mechanism of the fading

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Thanks!

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