

Color Structure in the Persian Painting

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Abstract

Written manuscripts and literary treatises are among the most important documents of knowledge on traditional color production techniques related to painting, and as they have survived thanks to desirable maintenance and preservation from the ancient times to the present time, they can be good sources for identifying and extracting traditional color production methods related to painting. Especially, the illustrated books simultaneously with their writing are an evidence of the contents presented in those manuscripts and treatises. Therefore, by an aim to identify and revive traditional color production techniques, the present descriptive-analytic research examines some of the available handwritten manuscripts and literary treatises. Then, with emphasis placed on the knowledge acquired and the modern facilities, some of the colors are made. The present study was performed by raising the major question that what ancient literary books are the sources of production colors used in Persian painting, and what were the nature of color production techniques and traditional color characteristics in the past. Thus, the study population includes Golestan Honar, Qanun al-Sovar, Majmoueh al-Sanaye' and 14 other treatises relevant to this issue, and the data collection was performed in a library- and experimental-based manner. The result of this study was the extraction, preparation and remaking of seven main mineral colors in Persian painting.

Keywords: ancient literary texts, traditional Persian painting, mineral paint

1. Introduction

The use of mineral and organic materials (plant and animal) to utilize their color has a long history in Iran. Communities living in Iran plateau, since the seventh millennium BC used chromogenic materials, and gradually over time, range of colors was expanded and utilized in various affairs. Evidence suggests that most of the colors used by the Iranians in the far past include cave murals, pottery motifs and then textiles painting. With the advancement of human society, in addition to fulfill everyday needs, create motifs and designs to decorate the surrounding life spaces gradually become pervasive; as far as the Sassanian prophet Mani used religious paintings mentioned in his book to promote his faith. The significant role of painting and color in Iran's post-Islamic times was the same as pre-Islamic times, so that Manichaean book decoration tradition and style was domineering many years in Iran. Because of oral teaching of traditional arts and the relevant professions such as painting, numerous literary books has been written in the royal workshops to teach painting techniques and how to make tools and equipment used in painting and calligraphy. The importance of color and its related technologies in Iran has been to the extent that Jean Chardin French scholar after visiting Iran in 1631 has said about the dyeing and color-causing material in Iran that: "Dyers would conceal the original version of their work. In Iran, white and dark oil was used under the cover of color and the found oil was used for producing the same version that we use". Given that since the late Safavids, the oil paint and then industrial paints entered Iran, most of the techniques relevant to traditional paint production was gradually forgotten and as the most of the knowledge of Iran painting scholars has been acquired by the literary books and previous teachers or articles published at the present, therefore, to obtain the information contained in handwritten manuscripts and literary books related to paint production techniques in the area of painting and recovery of such intangible heritage, we can discover the secrets of making these colors through an analysis of the relevant papers, studies and research papers from the past and also ask questions from the masters of this technique. Therefore, the history of painting in Iran is examined and then the colors and their position in Iran's painting are analyzed. Then, the handwritten sources and colors expressed in the literature are analyzed and finally the chemical structure of such colors and their production method are proposed. In this way, the books "Golestan Honar" and "Qanun al-Sovar" as two of

the most significant resources in terms of extent of the content regarding consumables in painting, also books and treatises such as Golzar Safa Sirafi, translated version of Resaleh Boughlamoun and Kashf al-Sanaye', etc., are utilized. As well, scientific books and publications that rely on knowing the pigments in Iranian painting are also utilized.

1.1 A Look at the History of Painting and the Book's Layout in Iran



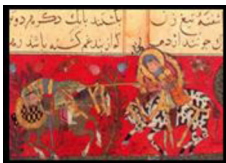

Book illustration and book decoration has long been highly regarded in Iran. In fact, the most valuable examples of Iran visual art can be found in handwritten manuscripts and scrapbooks that were usually published in royal workshops and under the patronage of the court. Iranian artists have always sought to illustrate an ideal and heavenly space. Even in facing surroundings, they have avoided mere imitation of nature and by using the purest and simplest lines and colors and utilizing micro-designs and symbolism have created visionary images. In the other words, "when speaking of learning and imitation of nature, it does not mean photographic imitation of nature; rather it is a nature that artist experiences and offers it in the form of art" (Coomaraswamy, 1994). Change in Iran's visual art has been started from prehistoric era and crystallized with the hybridization of the pictorial traditions of Western Asia in the form of Iranian pattern of the Persian Achaemenid. This pattern was hidden over a century under the influence of the Greeks, but it was re-emerged at the Sassanid era. In the remains and monuments of Sassanid and especially Manichaeism images, the application of motifs and colors used in the text is clearly observed. Despite these artists were inspired by the art of the West, always emphasized the model simplification and symbolism in their works. Also, regarding Manicheans' book decoration, it is said that "there is no written document about the Manichaean painting technique. Apparently, the surface on which the painting was already done was well beaten and become tightened and then their red border lines were filled with red ink or black color scheme and finally the pattern was filled by different colors. Some of the parts were covered with gold leaf. Primary colors with varying degrees include red, thick blue and green" (Dovialr, 2006). Continuity of artistic traditions of the Sassanid Persian and especially Manicheans in Iranian Painting is clearly obvious. Despite sanctions imposed on portrait art after Islam, Iranian taste not only did not stop, but also it attempted to manifest its capability in another form by decorating the lines of the Holy Qur'an. For this purpose, decorative motifs were made mostly with gold paint, which this method is called was Tazhib (gilding) that shown in Figure 1.



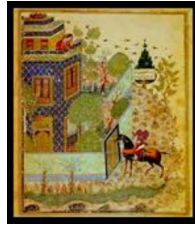
Figure 1. An example of Tazhib (gilding) of the fifth century; available in the Library of Astan Ghods Razavi of

From the late second century AD, paper manufacturing entered in most Islamic countries. As well, with the establishment of independent Iranian governments, paying attention to Iranian art and painting found a new life and then the art of book decoration was developed. To decorate porcelain, textiles, building walls and especially their books, influenced by Sasanian art, created a variety of works. It is possible to introduce the Seljuk period as the starting point of these arts (Table 1).

Table 1. Characteristics of Persian painting schools based on application of color (author)

School	Illustration Example	Painting Features
1 Pre-Islamic Period	 <p>Some pages of Manichean books found in Khocho (Kait, 2007, p. 156)</p>	<ul style="list-style-type: none"> • The illumination of a lustrous heaven with the use of bright and pure colors. • The use of Zebrbarg (course sheets) to induce light. • The use of allegorical and symbolic motifs. • The use of color in the background. • Linear rounding of forms and surfaces. • The use of pure colors in fine surfaces and motifs alongside large areas of broken color.
2 Baghdad Abbasi (3 & 4 AH)	 <p>“Two Dinars” Picture derived from Maqamat al-Hariri, Baghdad 1237 AD</p>	<ul style="list-style-type: none"> • Painting have been illustrated with the least amount of color. • Dress polishing is significant especially in terms of pleats of clothes. • Use of pomegranate motifs, angel wings and diverse ways of representations of animals borrowed from Sassanid art. • The presence of branches and leaves on the images to be seen as a sign of nature.
3 Saljoughi (5-7 AH)	 <p>A picture of “Varaqeh & Golshah”, the battle of Varaqeh with Edenic warrior, Library of Toupkai Museum in Istanbul (Pakbaz, 2005)</p>	<ul style="list-style-type: none"> • In many statutes, there is a halo around the head to separate body from background. These effects are inspired from the Manichaeen art. • Bright innovative colors and linear rounding (Mousavilor, 2013). • The heads are larger than the body and generally an armband is seen around the arms. Moon-faced people with oval eyes and lips bud could be seen. • In the paintings of this period, there could be seen simple compositions and the influences borrowed from Sassanid era (and pre-Islam) and Far East.
4 Ilkhani (7 AH)	 <p>The scene of moaning for the death of Alexander (Iskandar), the eighth century AD, Art, Ferry Gallery, Washington America</p>	<ul style="list-style-type: none"> • Creating a painting workshop and tradition of teamwork. • Combining Persian, Byzantine and Chinese elements. • Wide color range. • Use different color combinations. • Using a variety of shades of gray. • Lack of brightness and color purity.

5 Jalayiri (8 AH)



Homay & Homayoon, Khwaju Kermani,
Work of Janid, Shiraz School, 9th century
AH, Britannia Museum (Pakbaz, 2005).

- Removal of Chinese and Byzantine elements.
- Illustration of the world of poetry, fiction and utopia.
- Use a wide range of color.
- The use of pure and brilliant colors.
- Color rotation in the image color.
- Innovative and exquisite display of architecture in paintings.

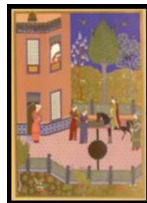
6 Shiraz 2 (9 AH)



Khavaran Nameh, Farhad Shirazi, Shiraz
School, 9 AH, Golestan Museum Palace,
Painting Masterpieces.

- Simple configuration.
- Symmetry.
- Wide color range.
- Color contrast of the image elements and its background.
- Use of bright and pure colors.
- More use of a family of warm colors.

7 Herat (9 AH)



Shanameh Baysonghori, Golestan i,
Golestan Museum Palace, Painting
Masterpieces

- Use of pure and bright colors along with complementary colors.
- Establishing peace and quiet throughout the picture.
- Less use of color combinations.
- Emphasis on dress colorful designs, tiles and carpets.
- Avoid symmetry.
- Greater use of warm colors family.

8 Tabriz Safavid
(10 AH)

Rustam says of the fate and death,
attributed to Abdulaziz, Tabriz School,
Tahmasp Shahnameh, and the Museum of
Contemporary Art (Karimov, 2006).

- Realism and historical representation through the colors diversity by making main colors close to the nature.
- Create imaginary and dream scenes with the use of bright colors, especially gold color.
- Variety of colors through the use of complementary and contrasting colors together.
- Viewing bump apex of Ghezelbash hat with red and white color combination.
- Representation of movement in statutes with the circular rotation of colors and their replacement in throughout the painting.
- Use of pure and brilliant colors, as well as the use of gold on a massive scale.

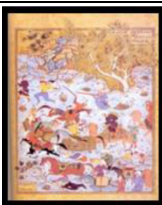


9	Mashhad & Bokhara (10 AH)		<ul style="list-style-type: none"> • Richness and purity of color. • The implementation of details and use of the simple forms. • Body of short stature. • The image of the face. • Diversity and contrasting colors to create fantastic scenes. 	
<p>Haft Orang, killing of Ayniah & Ryya (Pakbaz, 2005).</p>	10	Mashhad & Bokhara (10 AH)		<ul style="list-style-type: none"> • Simplicity of motifs and special fluidity in designing. • Limiting the variety of colors in the single sheet paintings. • Less color contrast throughout the image Less use of clear and bright colors. • Use a combination of colors and color impurity. • Introduction of pink and purple colors ranges into the area of painting as the result of communication with Europeans. • By removing the Ghezelbash Cap from images, the color turning is less seen. • promoting the murals and pictorial tiles that cause changes in the color and binders used. • Introduction of oil and other tools and equipment from Europe as well as manifestation of celebrities, issues and themes of European art in the art of that period. • loss of purity and brilliance in color with oil colors. • More darkening and opaqueness of colors using complementary colors and shades of gray. • Combination of Europe classic paintings and murals from Safavid period. • Copying the works of Renaissance masters. • Widespread use of red and brown color family. • The use of oil paint and canvas instead of paper. • Loss of purity and brilliance of the colors because PF the color combination. • Develop new style of Persian painting called “Modernization (Farangisazi)”.
<p>Shepherd with sheep and goats, Reza Abbasi, the National Library of Leningrad.</p>	11	Zand & Ghajar (11 & 12)		
<p>Fath Ali Shah, painter: Mehr Ali, Hermitage Museum.</p>				

Table 2. Different illustrated books at different painting schools (author)

	School	Illustrated Book
1	Pre-Islam	Arjang or Artang and Manichaeen works (Sasanian and later)
2	Baghdad Abbasi (3 & 4 AH)	al-Adwiyah al-Mofradah (on medical materials) ma'rifat al-hiyal al-hindasiyya (715 AH) fi ma'rifat al-hiyal al-hindasiyya (geometry & mathematics) al-Khavas al-Aqaqir Kelileh o Demneh (Note 2) Harīr's Maqāmāt (by Yahya ibn Vaseti Hamadani) (Note 3) Al-Bitara (Note 4)
3	Saljughi (5-7 AH)	Varaqah & Golshah Smak Ayar Al Aqani (on music, by Abolfaraj Isfahani) Mofid Al-khas (Zakariyā Rāzī) Khawass Al-Ashjar (Zakariyā Rāzī) Shahnameh Kama (Reserved in Kama Oriental Institute in Russia)
4	Ilkhani (7 AH)	Ibn Bakhtishu's Manafi' al-Hayawan (695 AH) (Note 5) he Jāmi al-tawārikh Rashidi by Khajeh Rashidodin Fazlolla, 714 AH Shahnameh Ferdowsi (so called Shahanameh Damut or Abu Saeidi), 731-737 AH
5	Shiraz (8 AH)	Mounes al-Ahrār Shahnameh Qavamoddin Hassan Vazir (741 AH)
6	Jalayiri (8 AH)	Divan Khwaju Kermani (by Jonid Baghdadi, 797 AH) Ajā'ib al-makhlūqāt (Zekaryaye Ghazvini, 741 AH) Kelileh o Demneh (Nasrollah Monshi, 76-775 AH) Divan Sultan Ahmad Jalayer (Note 6)
7	Shiraz 2 (9 AH)	Iskandar Sultan Miscellany (813 AH) Shahnameh Ibrahim Sultan (837 AH)
8	Heart (9 AH)	Shahnameh Ferdowsi (Baysonghori Shahnameh) (Son of Shah Rukh) Kalīleh o Demneh (Baysonghori Kalīleh o Demneh) Miraj Nameh (Mirāj Nāmeḥ) Hoday & Hodayoon Saadi Bustan and Golistan Khmaseh Nezami
9	Mashhad & Bokhara (9 & 10 AH)	Haft Orang by Jami (Mashhad) Tuhfat-ul-Abrar Nezami's Makhzan Al-Asrar Bustan Saadi (Bokhara) Scrapbook of Sultan Morad III (Bokhara) Manuscript paintings of Meht & Moshtari Book (Bokhara)

10	Tabriz Safavid (10 AH)	The Shahnama of Shah Tahmasp Khamseh Tahmaseb Divan Hafez Sam Mirza Divan Amir Alishir Navaei Silsilah-i zahab by Jami (977 AH) Ahsna al-Kibar (Note 7) (988 AH) Shahnameh Shah Ismail II (984 AH)
11	Isfahan (11 & 12 AH)	Bustan Saadi (1059 AH) Shanameh Shah Abbasi Shahnameh Shamlou The Windsor Castle Shahnameh Divan Hafez (Note 8) Divan Amir Alishir Navaei (Note 9) Masnavi Miscellany
12	Zand & Qajar (12 & 13AH)	Davari Shahnameh One Thousand and One Nights (Hezaro Yek Shab)

2. History of Color

Iranians have been well versed in the application of color and motif, and their talent and taste could be found in all ancient monuments and a great number of the historical works. So Naser Forouzan states that “although the influence of Asian and American civilization has played fundamental roles in Iranian’s learning, the climactic situation of this land has caused that knowledge of color by the fusion of Iranian talent and aptitude same as other sciences and profession pass down from generation to generation in the form of a traditional knowledge and orally and then preserved” (Farzan, 1998). In addition, “Will Durant History” (Note 10) has said that in Susa excavations, some murals have been discovered depicting archers dressed in bright and multi-color clothes. Also, the historical monuments of the city of Susa 4000 BC were found in a cemetery whose surroundings were adorned with the exceptionally beautiful tiles, and some geometric, animal and plant motifs in black and red were inscribed on it. The importance of color along with decoration of books and literature in the history of civilization has continued after Islam, same as the other periods. Industries related to the color in book decoration art and dyeing craft as a subtle art and technique has flourished and gradually reached perfection. As the literature indicates, paint production techniques not only were promoted in royal workshops, but also recorded and maintained in literary texts.

3. Types of Pigments

Pigment (Note 11) is a material that due to the selective absorption of light wavelength changes the color of light transmitted or reflected. However, industrially, it is the combination of solid materials that are linked by an interface. Solid materials are powders known as pigments and there should be a gravitational force between pigment particles and the solid that will be painted. This task must be performed by the materials known as interface or pigment. Interface is a thick and sticky liquid whose duty is to cover solid materials and enabling them to become widespread on the surfaces to be painted (Jokar, 2006). Pigments are generally divided into two categories: natural and synthetic. Natural pigments include:

- 1) Inorganic pigments.
- 2) Organic pigments.
- 3) Organic-metallic pigments.
- 4) Plant pigments.

Inorganic pigments have a high resistance and stability to light and chemicals and also take advantage a high covering power. However, organic pigments are produced and consumed in large quantities in the industry and its resistance to light, heat and chemicals is less than inorganic pigments. Some of the most recent pigments have organic metal structures. Most of organic pigments are organic chemicals which are deposited on an aluminum

hydroxide (Note 12) inorganic core. One of the most important organic pigments is phthalocyanine group that include spectrum of blue and green colors. In addition, the cochineal insect, or Indigo (Blue Nile) and petroleum dye products such as tar are a part of organic paint production group. In addition to organic pigments, plant dyes are abundant in nature. However, these plants are frequently used for dyeing fibers. Also, they are applied to paint the white paper surface, prior to calligraphy and painting, but due to transparency and lack of coverage are not used as dye in painting. Some of these colors include madder, reseda, indigo, sugar beet, onion skins, flower color, promenade peel, oak, walnut shell, Halileh, sumac, saffron, etc.

4. The Status of Color in Painting

Color and light in Iran painting has always been of great importance. According to Seyyed Hossein Nasr “space in Persian miniature is indeed manifestation of heavenly space and its shapes and colors are a display of shapes and colors of the aura of the world. The colors, especially the colors of gold, sapphire and turquoise have not originated only from the artist’s talent; rather they are the result of vision and intuition of an objective reality which belongs to the world of forms ... miniatures such as Persian rugs, and Iranian original garden are the examples of the reality beyond mundane environment and human daily life” (Nasr, 2010). Therefore, painters use the most qualified materials in producing their required colors; these colors ultimately represent purity and luminosity of handmade papers prepared by artists and also their juxtaposition that would provide audience with a pleasing and ideal space. According to Islamic art, this space is the symbol of Islamic art wisdom and a divine and sacred space, which painter intends to represent. This space is an example of world of forms and subtle bodies (Note 14) incorporated. Since the Iranian painting is based on a sense of signification and creation of a dream space and since the symbolic implications of colors in painting is obvious, therefore, artists have used the colors with high purity and luminance in order to depict the beauty of artistic work and incorporate a bright, illuminant and meaningful space throughout the painting. So, “colorful space of Iranian painting is filled with a pervasive light, and some heterogeneous, complementary, bright colors free of vignette. This space on the one hand is rooted in the Muslim artist’s worldview and on the other hand is completely satiated with the sources of Iran ancient wisdom and traditions of Iranian art. For this reason, inner observation of light and color has been able to lead to a visual display in the world of painting” (Hosseini-rad, 2008).

5. The Colors Used in the Painting

In addition to color composition, the masters of Persian painting take advantage of lots of skills and experiences in the provision of many different colors and binders. They are often have used binders and colors that are still in good condition over the centuries. Colors used in the painting can be classified into natural and synthetic pigments. Natural colors can originate from animal and mineral sources. Inorganic dyes such as oxide, sulfide, carbonate and sulfate, etc., are found in nature and their combination is also very simple; so that after mining, inorganic material will be dried in the sun and after removal of its impurities it could be seen in the form of dry powder and following paint preparation process it is applicable. The perfect type of colors often has very small gradation and all stages of the procurement must be conducted on them. But our knowledge of the nature of the colors used in Iran painting is rooted in words and texts that are left from that era. It is clear that the authors of these texts were well versed in this field or they had been aware of the color production processes and the relevant applications in the paintings through attending the workshops involved in painting and inscription. According to Professor Taherzadeh Behzad “in painting, only mineral (inorganic) colors were used in the painting, just because it was imperative that they were dark and opaque and only plant colors were transparent. This opaqueness was necessary because the successive layers of color were often imposed on the brightness of impressiveness of artistic work, and its combination with a transparent material would make an intermediate sub shadow and manifest itself instead of required pure tone. For example, plant color of yellow on blue would produce green. However, such combination would not come out by inorganic dark and opaque colors” (Taherzadeh Behzad, 2006). Also the book “Qanun al-Sovar” expresses the methods of making physical colors for painting. Given the literary texts, the symbolic meaning of color and light in painting, covering properties, color stability, purity and brightness of inorganic colors, it is obvious that the Iranian painters mainly would use inorganic paint for imagism in their paintings.

Table 3. Classification of different types of natural colors

	Classification	Colors
1	Inorganic Colors	<ul style="list-style-type: none"> • Blue: azurite, Prussian blue, ultramarine • White: zinc oxide, titanium dioxide, lead white, zinc white • Green: oxide of chromium (III), Viridian • Red: Lead Tetroxide, Vermillion, Minium • Yellow: Orpiment, calcium chromate
2	Organic Colors	Cochineal Indigo or color wheel blue Color producing or petroleum products such as tar dyes Types of soot
3	Plant Colors	Madder, reseda, Neil, grape leaves, beetroot, onion skin, mulberry leaves, pastel, flower color, leaf fig, pomegranate peel, oak, walnut shell, Halileh, sumac, saffron, Prangos Ferulaceae (Joshir, in Persian), etc.

6. Brief Look at the Literature Relevant to Paint Production Techniques

Given the literary texts and the time of creation of works of Persian painting, these texts can be considered to be the most valuable resource in terms of preserving the heritage of the Iranian painting. So extraction of information from these documents must be done with precision and delicacy to ensure the future use of these rich resources. Due to the fact that “collecting and publishing technical dissertation and treatises on art in Europe has a long history, in the eighteenth century treatises written by the artists of the Middle Ages were released, which some them include Moratory (Note 15) in 1739 , Lessing (Note 16) in 1774 and Risp (Note 17) in 1781. Paying attention to manuscripts and technical treatises was continued and the major published work of that period was “the treatises on painting techniques” by Merrifield in 1849 that is still re-published (Clarke et al., 2005, p. 2).

Since the research on Iran artistic treatises has been conducted by Europeans and most attention attached on the book “Golestan Honar” and Qanun al-Sovar, these texts are among the first essays translated into English (Note 18). The most complete collection of manuscripts regarding book decoration, painting and calligraphy, as well as the tools and equipment required in this crafts has been collected by Professor Najib Maiel Heravi in a series entitled Book Decoration in Islamic civilization and also Mr. Hamid Ghelichkhani in a book entitled “The Treatises in Calligraphy and Art”. Except for specialized treatises on art techniques, some encyclopedia or collections that have survived from ancient industries, such as Kashf al-Sanaye’e (Ghelichkhani), Majmoue al-Sanaye’e, Persian Encyclopedia, also have addressed the above issue. Therefore, in order to identify relevant literature in Iranian paint production techniques in Iranian painting, a brief introduction of these treatises is discussed.

Table 4. A comparison of inorganic (mineral) colors with organic and plant colors (source: author)

Feature		Inorganic Colors	Organic Colors	Plant Colors
Radiance	1	Rank the second after organic colors	Maximum transparency and shine	Transparency due to sustainability lack, but with minimum brightness
Light Resistance	2	Maximum resistance to light	Ranks the second after organic colors	Minimum resistance to light
Color stability	3	Maximum Color Stability	Ranks the second after in organic colors	Minimum color stability
Covering	4	Covering up capability	Less covering in inorganic colors	No covering
Dissolution	5	Low solubility in organic solvents	High solubility in organic solvents	High solubility

Thermal Stability	6	Stability at high temperatures	Decomposable at high temperatures	Unstable
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Table 5. The colors embodied in literary essays (author)

	Book	Author	Year of Authorship	The colors embodied in treatise	Other Additives
1	Bayan al-sana'at (Note 19)	Habish ibn Muhammad Taflisi (Note 20)	6 th Century AH	Vermillion, patina, azure, orpiment, white lead, begooneh mardom , violet, roseate, soot	Starch sizing, rice sizing, gold pencil
2	Adab al-Mashgh	Rafighy Heravi (Note 21)	10 th Century AH	Black, vermilion, gold	Writing instruments, make ink and reed pen
3	Golestan-e-Honar (Note 22)	Qazi Ahmad Monshi Ghomi (Note 23)	1006 AH	Vermillion, patina, azure, gold and silver, azure, orpiment, gole hormoz, talc, white lead, red orpiment, white lead, lapis lazuli, roseate, black	Making brush painting, drawing table Make ink
4	Resalah Boughlamoun	Ibn Badis Sanhaji (Note 24)	887-924 AH	Vermillion, patina, azure, Orpiment	Color Liqah (flake of cotton), pencils, glue water, pencils
5	Golzar Safa (Note25)	Ghotboddin Mohammad Yazdi	994 AH	Vermillion, patina, gold, silver, lapis lazuli, orpiment, Gol <i>Hormuz</i> , talc, white lead	Fish sizing, starch and different sizing
6	Qanun al-Sovaf (Note 26)	Sadegh Baik	1001-1010 AH	Physical colors, vermilion, patina, gold and silver, minium, orpiment, ruby, isinglass colors, white lead	Oil painting, isinglass, varnish oil, making brush painting
7	Midad Al-Khutoot	Mir Ali Heravi (Note 27)	10 th century AH	Black, vermilion, patina, gold and silver	Making ink
8	Savad Al-Khotout	Rafighi Heravi	940 AH	Black, vermilion, patina, gold	Writing instruments and making ink
9	Heliya al-Kitab	Unknown	1005 AH	vermilion, patina, orpiment,	Make ink, dope sheet
10	Book binding & paper covering Resalaye Khat	Seyed Yousef Hossain	12nd Century AH	Dark, silver, gold	Binding instruments, drawing table, making the ink and Abri paper
11	Morakab (A Treatise on Inscription & Ink) (Sakhtane Morakkab	Hosseini Aghili Rostamdari (Note 28)	930-984 AH	Vermillion, patina, gold, silver, lapis lazuli, orpiment, Gol Hormuz, talc, Range Range Aroosak	Writing instruments and making ink, paper paint, pen cutting
12	Alavan Making of color ink	Unknown	11 th Century AH	Vermillion, patina, gold, silver, azure	Make ink, how to paint paper

	Ink & Paper				
13	Covering (Morakab & Jeldsazi) Treatise on gold and silver	Ali Hosseini	Qajar	Vermillion, patina, gold	Make ink, how to boil isinglass, and how to make paper
14	(Resaleh Hale Tala va Noqreh) Kashf	Unknown	11 th Century AH	Vermillion, patina, gold, silver, azure	
15	al-sanaye' (Note 29) Treatise on inscription, ink & paper	Ali Hosseini	1322 AH	White, black, yellow, red, green, eggplant, how to make vermilion, patina, orpiment, dissolve gold.	Boil & bind isinglass, how to build paper
16	(Resaleh Khat, Morakab & Paper)	Unknown	9 & 10 th AH	vermillion, patina, gold, silver, azure, orpiment, black	Making ink, paper paint, pen cutting, sizing
17	Majmoue al-Sanayie	Abbas Ali Navaei	1235 AH	Vermillion, patina, lapis lazuli, orpiment, turquoise, white lead, soot	Boil & bind isinglass

Table 6. The colors embodied in literary essays (author)

	Title	Binders
1	Bayan al-sana'at	Starch sizing, starch, rice sizing, Arabic glue, egg yolk
2	Adab al-Mashgh	Glue
3	Golestan-e-Honar	Glue, black isinglass, Arabic glue, egg yolk
4	Treatise Boughlamoun	Starch, glue, Arabic glue water, egg yolk, isinglass
5	Golzar Safa	Fish isinglass, starch, zinnia, glue
6	Qanun al-Sovar	Oil painting, isinglass, varnish oil
7	Midad Al-Khutoot	Glue, isinglass, Arabic glue, Sarcocolla glue
8	Majmoue al-Sanayie	How to boil isinglass, isinglass binder, Arabic glue
9	Heliya al-Kitab	Glue-Arabic Glue
10	Book binding & paper covering	Glue
11	Kashf al-sanaye'	Glue, isinglass, Arabic glue, egg yolk, varnish Oil, Sarcocolla glue
12	Making of color ink	Glue, black, isinglass, Arabic glue, Sarcocolla glue
13	Resalah jeld Sazi (Paper covering treatise)	Isinglass, glue

7. Binders Used in the Color Production in the Literature

Every painting is composed of three main components including pigments, background and binder. Binder attaches pigment to the ground. A review of the literary texts studied shows that they have not equally addressed the issue of color, and they cover a different number of binders and colors, and even some treatises have only described producing ink for calligraphy. However, because of binders' importance in supplying and lasting of colors, so in addition to the recipes for preparing paint colors, different combinations of binders have been addressed as well.

8. Summing Up

- What comes from the analysis of the literature is that Iranian artists mostly used the colors that had high covering and corporeality. In addition, purity and brightness of their colors are other characteristics desired. This feature can be seen more in inorganic (mineral) colors.
- Among the natural colors, mineral colors have greater stability against light, time, and other natural factors than the organic and plant dyes. This is another reason why inorganic pigments are preferred over other pigments by painters.
- In each of these texts alone the numerous mineral colors were used to apply to use in the paintings of that period. However, the colors that were commonly expressed in the literature, and had the maximum application among Persian are as follows: 1-Azure, 2-Vermilion red, 3-orpiment yellow, 4-green patina, 5-gold color 6-white lead (ceruse) and 7-Balck.
- The main source of these colors was minerals and mostly in natural way from the nature, with the exception of green patina and they were turned into the colors applicable in the painting by the artists who had expertise in the techniques of paint production.
- Since there is the probability of error in writing, and artists of different ages have utilized a variety of methods to make these colors, so after studying and analyzing these methods, a method that includes all the necessary things to make the color was extracted among them.
- Azure as a blue ore is used a gem in jewelry due to its hardness and special blue color. In addition to jewelry, it is used in other products such as sculpture, chess beads and more importantly in the paint industry, especially painting, murals, tile, glazed ceramic and fiber dyeing. Because of its thick blue color and also its potential to be powdered and engraved, this precious stone has received attention since thousands of years ago in the universe and its extraction has longevity of more than 2500 years. The main mines of this stone reside in the mountains of Kashan, Natanz, Ghamsar, and also Badakhshan in Afghanistan. Azure color is resistant to alkali, yet weak acids can affect it and turn it into a colorless and gray in color and form. This pigment is highly resistant against sunlight and it will not be susceptible to any change of color.
- To make the azure color, first the azure stone is thoroughly rinsed and finely grinded, in a way that it turns very soft and round, and again it is rinsed to be clean more. Then, Arabic gum is added to be formed as dough. After gum adjustment, water is added to it drop by drop until the desired concentration is attained and it is ready to use. If excessive water is poured, the stone loses its physical property and becomes a mental color.
- Vermilion (Note 30) or Cinnabar, with the chemical formula HgS is a mineral. It could be found in the form of crystalline in nature, yet it is produced in an industrial way. Vermilion vapors in flame, and it is insoluble in nitric acid and sulfuric acid. Originally it is black, while after heating, it will change into a red sustainable type. The use of this color has a very long history and there Cinnabar mines in the most regions of world, in a way that "Cinnabar was widely used in the Roman murals especially in Pompeii. That is why it is also known as Pompeii red color. This color has a special clarity and brightness. Also, the Chinese people were aware of the advantages of this color in the paintings, and since the second millennium BC used it in the paintings and as red ink" (Aqajani Esfahani, 2007, p. 24).
- In addition to the murals of Pompeii, Vermilion was used in Persian monuments such as Parthian and Sassanid murals, and also Arjang Book. According to some sayings, Vermilion also is produced artificially. In the fourth century AD, synthesized vermilion was produced. Physical and chemical properties of natural and synthetic vermilion are very similar to each other. This is a stable pigment but in the face of the sun will be dark. This color change occurs earlier in synthetic pigments and it is just because of the physical changes and the formation of semi-stable mercuric sulfide.
- To make red vermilion, cinnabar ore is first pulverized and then it is rinsed with a weak acid. After the initial rinse with weak acid, the resulting powder will be washed with water two or three times to completely remove

the mud and impurities. Finally, wait until the color powder is precipitated and water over it is poured away. After drying pigments, the Arabic gum is added to it little by little until it is ready to use. However, in some of the texts, the way to make the synthetic pigment is expressed: heating an equal amount of mixture of mercury and sulfur, along with bran and goat hair. When ore is used this method of making color becomes cheaper, while there is possibility of toxicity of mercury and sulfur. In this way, the pigment is mixed after drying with Arabic gum.

- Vermilion stone is soft and easy to pulverize, yet because of the dearth and preciousness of pure rock, nowadays the vermilion powder as a chemical product with almost the same quality of natural stone is used.
- Malachite is one of the oldest green pigments known. For the production of this pigment, the mineral is highly pulverized and then sifted. This stone comes in the form of a powder with a beautiful color that much of ancient artists used it.
- This pigment is predisposed to water, while its combination with oils is not desirable. Due to the high hardness at the stage of stone pulverization, low strength against light and also high sensitivity to acid, this pigment was replaced with a synthetic chemical compound, which the book “Golestan Honar” refers to a combination of synthetically-produced copper and green patina.
- To make a patina of copper, copper plates are placed in vinegar for a month in a damp place. After removing the patina plates, its upper part is separated and pulverized, and water is poured on it by the ratio of one to ten. Then it is placed a day in a dark place away from dust.
- After a day, the water over it is poured out, and it is filtered and Arabic gum is added by the ratio of three to two. It is better to added saffron extract for color stability.
- Orpiment pigment is two types including yellow and red. Orpiment yellow pigment is widely used in the East, but today because of its toxicity is less of interest. Orpiment has more arsenic and less sulfide and red orpiment has more sulfides. Pure orpiment has a lemon light color with high clarity and brightness (Pakzad, 2014). This natural sulfide is stable in the air and light, dilute acid and alkali have no impact on it and they only dissolves in strong acids.
- To build yellow color from orpiment mineral, orpiment should be pulverized well in water, and then dry it out slowly and add Arabic gum to it. For color dilution and a good level of concentration, water is added to it.
- White lead with the chemical formula $(\text{pbco}_3)_2\text{pb}(\text{oh})_2$, is one of the most important pigments that occurs mainly as the result of the lead compounds artificially and has alkali carbonate compounds of lead and lead hydroxide which usually contains 70% lead and 3% lead hydrate.
- Lead carbonate exists in the nature as a natural mineral substance called cirosit, but it never is considered as white pigment. In Iran white lead is known as “Sheikh White Lead”, “which the name is probably attributable to ‘Sheikh Bahaei’ who produced this material in an Iranian way and presented to Iranian paintings” (Karimi, 2007).
- In the literature, for making white color it is said that white lead is dissolved in water and filtered, then it is discarded and mixed with Arabic gum.
- Currently, the compounds of zinc oxide, lead hydroxide and titanium derivatives and sometimes a combination of zinc oxide and titanium are used to produce white color. It should be noted that Sheikh Lead Water that is mentioned in the literature is the same as lead hydroxide.
- To produce black color used in the painting, carbon soot and bone along with gum is used. But today, the bulk of the black pigment used in the new color industry is composed of soot, which is relatively pure or mixed with other inorganic materials such as animal-based soot. Other black pigments that are mainly consumed include graphite and iron black oxides.
- Nowadays, for the manufacture of gold required, the procedure is same as the past, so that thin sheets of gold are put into the porcelain bowl. Then the sheets are well pulverized with honey to be quite soft. If pulverization is done more than enough, intermolecular bond property is destroyed and the material will be so called hollow. Then, warm water is slowly poured on gold lightly agitate until honey is dissolved in hot water. After the settlement of gold dust, the water will be removed slowly. This will be done two or three times to clean gold and then isinglass is poured on it and mixed, and the final product when use is mixed with the required amount of water.

- Since each of these inorganic pigments must be combined with special binders or glue to be usable, the most applicable binders in painting colors are gums which are two types including natural and synthetic. Some of the natural gums include gum of an almond tree (Arabic Gum), oak, gum tragacanth and balm.
- Arabic gum comes from an almond called acacia. This tree grows mostly in the areas of the Zagros. Arabic gum solution should not be heated directly, because it loses its adhesion properties and is decomposed.
- Adhesives used in paint are divided into two categories: natural and synthetic. Natural adhesives are divided into two categories of plant and animal adhesives; animal adhesives (such as isinglass) are made by boiling bone, hair, wool and skin of the four-legged animals.
- In the manufacture of paints, resins and other oily binders can be used for the preparation of oily color materials such as oil paint, and even acrylic paints.

9. Color Analysis of Some Pictures (Paintings) Image Attributed to Herat and Tabriz Schools

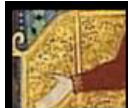
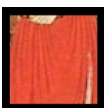
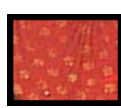
Malachite Green	Gold	Minium	Vermillion	Azure	Water Lead
					



Figure 2. Manzar learns chess in the presence of Anoushiravan, Baisonghori Shahnameh, Heart 1) azure, 2) water lead, 3) red vermilion, 4) minium, 5) gold color, 6) malachite Green

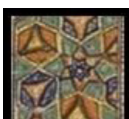

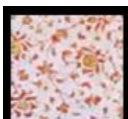
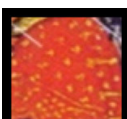

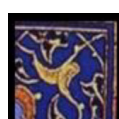
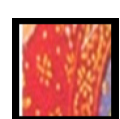
Green Patina	Malachite Green	Water Lead	Minium	Light Azure	Dark Azure	Vermilion
						

Figure 3. 1) Dark vermilion, 2) azure lightened with water lead, 3) minium, 4) dark azure, 5) light colors from the combination of mental colors with water lead, 6) Malacheate green, 7) green patina

10. Conclusion

The only way to learn about the techniques and methods of artistic production in Iran royal workshops is to refer to the handwritten manuscripts and the literary texts composed in those ages. Most of the manuscripts and the literary texts related to color making techniques in Iranian painting have been collected in Safavid Royal workshops and later. On the other hand, these techniques same as other art-crafts have been transmitted orally and from a generation to generation. So, the present study investigated seventeen books and treatises that have

analyzed different ways of making color. What can be inferred from the analysis of this bulk of literature is that Iranian paintings mainly used colors with high covering and corporeality. Also, purity and brightness were other desired characteristics. The other properties of these paints include environment compatibility, durability and their sustainability versus natural factors. These pigments were obtained directly from the lap of nature, and become the colors useable in painting by artists who were skilled in color making techniques. The property of compounding of these colors with other inorganic and mineral pigments to create new colors and their potential to be combined with gums and resins are other features of these pigments. So when combined with Arabic gum and a small amount of water, the mentioned colors find the property of physical colors such as gouache and acrylic, and by adding water to physical color they convert into a mental color and water color. In addition, if they mix with oily resins such as sesame oil or linseed oil, oil painting is obtained. As it is impossible to do a color analysis of illustrated manuscripts, to learn their similarities is only achieved with a comparison of the colors in the paintings of the books with the mineral colors made, since there are no industrial colors equivalent to mineral colors, and it is not possible to obtain a color similar to the original version by combining some industrial colors and also the point that this type of combination can reduce clarity and brightness, so recognition of traditional mineral color reproduction methods is a way to improve and enhance the quality of Iranian painting.

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Notes

Note 1. Kalileh o Demneh: illustrated in 3rd century BCE/translated by Nasrollah Monshi from SansAkrit into Arabic, and Abdullah Ibn al-Muqaffa translated it into Persian.

Note 2. Maqamat Al-Hariri, illustrated in 1237 AD, written by Yahya ibn Vaseti Hamadni.

Note 3. Albaitareh: Tavoosi (2011, p. 7), illustrated in 605 AH in the area of veterinary.

Note 4. Manafi' al-Hayawan by IbnIbn Bakhtishu in 695 AH; this book describes animal features and natural manifestations.

Note 5. School of Jalayeri or TABRIZ-baghdad; it has been called so due to the present of state at two capitals.

Note 6. Divan (collected poems) by Sultan Ahmad Jalayiri: eight of three hundred graphic pictures illustrated in the Divan are by the author-marginal schemes of statutes, landscape and angels wrapped in a cloud.

Note 7. Ahsan al-Kebar (988 AH): Ahasn al-Kebar fi Mar'rifat al Aemah al-Athar, composed by In Arabshah Mohammad Abi Zaid al-Alavi Varamini, a Shia scholar in 827 AH. This work is the first Persian book on the life of Shia Imams.

Note 8. Divan Hafez: inscribed by hieroglyphics of Shah Qasim since 1026 AH to 1038 AH, and illustrated by Reza Abbasi.

Note 9. Divan Amir Ali Shir Navaei: written by Fakhr al-Din Shahabi Heravi on the Dolat Abadi Paper in 1014 AH. The name of the illustrator is unknown.

Note 10. Will Durant.

Note 11. Orpiment is a powdered substance or liquid that whenever mixed by a Mahmel or liquid such as egg yolks, etc., makes a paint material. Mahemel is a colorless and relatively inert that suspends pigment and causing mixture adhesion to the surface (Pakbaz, 2010).

Note 12. Aluminum hydroxidase.

Note 13. Pathalocyanine.

Note 14. The subtle body is a limbo barrier that acts as an intermediate between earthly body and heavenly world.

Note 15. Muratori.

Note 16. Lessing.

Note 17. Raspe.

Note 18. In 1947, the first translated version of Golestan Honar (1947) was done by Zakhoder in Russian language and the first translated version of the book was also done by Minorsky in 1959.

Note 19. Treatise Bayan al-Sana'at by Hubaysh bin Ibrahim bin Muhammd Tiflisi is composed of twenty chapters including alchemy, jewelry, color, equipment and weapons, various figures, property of animals and plants, application of water and fire.

Note 20. Abu Al-Fazl Hubaysh Ibn Ibrahim ibn Muhammd Tiflisi, Georgian scholar, physician and author from the sixth century AH.

Note 21. Majnun Rafiqi Heravi, or Molana Majnun (died 951 AH), the son of Kamal al-ddin Mahmoud Rafiqi so called Majnun, and known as Left-Writer Majnun is one of the innovative poets and calligraphers of Heart in the era of Sultan Hussain Bayghra, at the end of ninth century and the first half of the tenth century.

Note 22. Golestan Honar, by Qazi Ahmad Monshi Qomi on the biography of calligraphers and painters. This work was written in the Safavid period in 1006 AH.

Note 23. Qazi Hussain Ahmed bin Sharafuddin Hussein Hussein so called Ahmad Monsh Ghomi (circa 925-circa 985) is from historians and writers of solar tenth century (the era of Shah Tahmasp I & Shah Abbas I of the Safavid). His most famous book is Khulasat Al Tavarikh on the the history of the Safavid period of time Sheikh Safi al-Din Ardabili (first half of the 8th century AH) to the early years of the reign of Shah Abbas I (late 10th century AH).

Note 24. Bin Badis. Abdolhamid Mohammad al-Mostafa bin Makki bin Badis Sahnaji (1889-1940), Algerian peacemaker and thinker. He was born in Constantinople as one of the main cultural centers of old Algeria. His family was descended from Mo'ez bin Badis as the founder first Sahnaji state, one of the old influential and distinguished ancestors of east Algeria.

Note 25. Ibn Manzoumeh was written in 994 AD by the Qutb al-Din Muhammad Yazdi.

Note 26. Book of "Qanun al-Sovar" is a valuable treatise on painters' etiquette and decorum, oil working and painting tools and equipment dating back to Safavid era.

Note 27. Mir Ali Sadat Heravi (died in 1544 BC) so called Mir Ali Heravi and Mirjan and nicknamed Katib Soltani is one of the great figures of calligraphy and hieroglyphists of 10th century AH.

Note 28. Molas Hossien Aqili Rostamdari, one of the authors in 10th century AD.

Note 29. Kashf al-Sanaye', a unique handwritten manuscript written in hieroglyphic way by Ali Hosseini in 13rd Century AH, and it is preserved in Tehran University Document Center by the No/2261.

Note 30. Vermillion is a body of Red hexagonal crystals. It is produced by conducting Sulfide Hydrogen Gas H₂S into mercury saline solution. The mineral similar to it include Ralgar, prostate, cup rite, Tarantula, hematite and so on.

Note 31. Orpiment is so dangerous and toxic, to prevent explosion and toxic gases, it should be pulverized gently in water.

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