SAKARYA ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ DERGİSİ

Sakarya University Journal of Science
SAUJS

ISSN 1301-4048 | e-ISSN 2147-835X | Period Bimonthly | Founded: 1997 | Publisher Sakarya University | http://www.saujs.sakarya.edu.tr/

Title: The Turkish Art of Marbling (Ebru) on Textile Fabrics: Investigation of Thickening Agent, Mordant and Fixation Temperature

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Recieved: 2023-04-17 00:00:00

Accepted: 2023-06-08 00:00:00

Article Type: Research Article

Volume: 27
Issue: 5
Month: October
Year: 2023
Pages: 930-942

How to cite
Cigdem AKDUMAN, Habibe KAHVECIOGLU SARI; (2023), The Turkish Art of Marbling (Ebru) on Textile Fabrics: Investigation of Thickening Agent, Mordant and Fixation Temperature. Sakarya University Journal of Science, 27(5), 930-942, DOI: 10.16984/saufenbilder.1283596
Access link
https://dergipark.org.tr/tr/journal/1115/issue/80257/1283596

Sakarya University Journal of Science 27(5), 930-942, 2023

The Turkish Art of Marbling (Ebru) on Textile Fabrics: Investigation of Thickening Agent, Mordant and Fixation Temperature

Cigdem AKDUMAN *[1], Habibe KAHVECIOGLU SARI[1]

Abstract

Ebru is a mysterious art and briefly described as the art of paper decoration. Turkish “Ebru” or “Marbling Art” was included in the list of world cultural heritage by UNESCO in November 2014. Today, people use marbling mainly for fabrics and papers in many ways. From a technical viewpoint, the marbling process depends on the balance of relations between the chemical character and particle size of the color pigments and their relation between the viscosity and surface tension phenomena of the marbling bath upon the surface. This study investigates the surface tension, pH and conductivity of the sizing baths and acrylic dyes, compares carrageenan and sodium alginate as thickeners for the marbling bath. Then it also explores the effect of self-fixation, fixation temperature and alum application on the fastness properties and print durability results for cotton and polyester fabric. It was seen that pattern transferring ability of carrageenan bath was better than sodium alginate bath, marbling paints have some self-crosslinking ability, alum application do not have an influence on the print durability and fastness properties, whereas, only fixation temperature of 150^{o}C had a slight effect.

Keywords: Ebru, marbling, fixation temperature, marbling bath, print durability

1. INTRODUCTION

Ebru is briefly described as the art of paper decoration. In Ebru, a composition made with the help of paint, sprinkled with a brush on water concentrated with the help of tragacanth gum or another material [1, 2] is transferred to paper and many materials. The origin of the word Ebru comes from Persian AbRu (water face) and Ebr (cloud like) and carries the meaning of 'cloud' [1, 3-5]. Also recognized as paper marbling and is not known exactly where and when the art of marbling started. It is a mysterious art dating back to the 1100s [6]. Patterns resembling scalloped and tidal marbling were found on glass bottles dated 1365 BC in Egypt. However, there is some information that the modern marbling known today was made in Turkestan, Samarkand in the 13th century and is thought to have spread in the 14th century to Iran, India and Anatolia [5, 6]. It is accepted that the art of marbling came from the east to the west, just like paper, using the silk road and other trade routes [1].

Turkish “Ebru” or “Marbling Art” was included in the list of world cultural heritage by UNESCO in November 2014. By this progress, the art of marbling was declared and registered as a wealthiness that Turkish

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culture brought to the world cultural heritage [1]. It was used most often on the inner covers of fine books as a stylish transition between cover and content. Today, people use marbling mainly for fabrics and papers in many ways, including scarfs, ties, picture framing, wrapping paper, origami, lampshades and for decorating just about anything, tissues, boxes, woods, cans etc [3, 6].

From a technical viewpoint, the entire marbling process seems to depend on the balance of relations between the chemical character and particle size of the color pigments used and their relationship to the viscosity and surface tension phenomena of the viscous bath upon the surface [7]. In marbling, the pigment particles must be completely insoluble in water, otherwise the pigment dye or paint will mix with the aqueous solution of the bath, contaminate the bath, sink into the bath, and disappear from the surface.

A proper balance established between the viscosity of bath, hence its buoyancy power and the surface tension and the dispersion properties, results in the design of many of the beautiful patterns and color. Many thickening agents can be used to thicken water and create a gum bath (or a size) for marbling paints. Carrageenan, methyl cellulose, gum tragacanth, starch, sodium alginate and some other plant-based mucilage can be used as thickener to make size solution. Among them the most commonly used ones are, carrageenan and methyl cellulose [7, 8].

In marbling process, the pigment particles must also be surrounded by a surfactant film such as oxgall. Surfactants leads to a reduction of the interfacial tension at liquid/liquid interfaces [9]. So that thanks to the surface tension-reducing effect of the surfactant, the pigment particles are supported and finely dispersed on the bath surface, creating a floating appearance. If the surfactant does not reduce the surface tension, the pigment particles will sink to the bottom of the bath due to their weight exceeding the buoyancy of the gum solution [7, 10].

As a surfactant, oxgall or other glycols, solutions of soaps, and some other organic substances may be used to disperse the color upon the surface of the bath, while other chemicals appear to react in the opposite manner to contract or coagulate the color into a condensed pattern. Natural oxgall, the oldest of these surfactants is obtained from animal bile. The bile of all animals contains certain organic acids containing nitrogen when these acids are chemically treated to remove sulfur and nitrogen compounds, it yields an acid known as glycocholic acid. This glycocolic, which is the main component of oxgall, is responsible for the spreading of the colors. Prior to marbling process an alum (aluminum potassium sulfate, $KAl(SO_4)_2$ is used in treating the fabric and paper. When the pigment, surrounded by a film of surfactant or oxgall, is transferred to the fabric or paper, a chemical reaction occurs between the alum and the glycocholic acid. This reaction results in the formation of insoluble aluminum glycocholate salt and binds the pigment permanently to the fibers [7, 10].

In traditional marbling art, natural dyes as earth (soil) dyes and plant extract dyes are used. Soil dyes are also called earth oxide dyes. They are obtained from soils of different colors according to the minerals in the soil [11]. The main pigmenting (coloring) agents in soils are organic matter, iron, and, to a lesser extent, manganese [12]. Herbal dyes or plant extract dyes, on the other hand, are made from the roots, stems or leaves of plants that give color [11]. The modern way is to use commercial ready-to-use acrylic-based paints. They are already premixed and diluted and sold in bottles or are in the form of powder pigments which needs preparation. Today mostly water based acrylic paints consist of pigment particles dispersed in an acrylic polymer emulsion are used. In any acrylic paint there are three main components- pigment, binder and vehicle [13-14]. Pigments are milled to tiny particles and do not dissolve in water but suspended in the paint. Pigments can be organic, inorganic, natural or synthetic. They have little or no affinity to the surface which they applied.

Acrylic paint formulation varies considerably depending on the additives, pigments, surfactants etc., that manufacturers choose to use [13]. The binder holds the pigment on the surface of the fabric or paper after the paint dried. Acrylic paints include acrylic polymer binder, which forms a film after the water evaporates. Vehicle or body carries the pigment and binder. Water is the carrier for the water-based acrylic and when combined with the binder it forms a polymer emulsion. Surfactant reduces the surface tension of the water in the acrylic emulsion thereby increasing the slickness and flow of the paint.

Although Ebru has been known for centuries, there are very few academic publications on its technical basis. Halfer's "The Progress of the Marbling Art" was the first book about technical scientific principles of marbling [10]. Then Kantrowitz and Spencer released a research bulletin named "The Process of Marbling Paper" in 1947 [7]. Some other books were mainly about patterns and methods for marbling designs. Recently, Benli et al. studied hibiscus and black carrots as alternative dyestuff sources instead of soil-based dyestuffs [4]. Begiç summarized the Marbling art, its importance as a cultural heritage and its needs [1]. Tozun an Uzunca examined and summarized the way of applying marbling to textiles, the dyestuffs, the types of fabrics, the areas of use in textiles, the color and composition characteristics, and the types of marbling on textile fabrics [5]. Xu et al., designed a real-time physical simulation for traditional marbling design, making it possible for users to create marbling patterns following the same procedure as real marbling [6].

And Karabacak investigated the effect of different types of fabric and dyes on the quality marbling of textile products. She chose cotton, rayon, polyester fabrics with mordant and without mordant. Traditional marbling dye, liquid fabric dyes and ready to use commercially available synthetic marbling dyes were also compared. She observed that alum treated fabrics are brighter and cleaner. According to her results, in terms of ease of application, appearance, and fastness properties, ready-to-use acrylic synthetic marbling dyes are the best and followed by liquid fabric dyes and soil marbling dyes [11].

This study includes two parts. Apart from the previous studies, in the first part, the surface tension, pH and conductivity of the sizing baths and acrylic dyes were measured. Then, the use of **c**arrageenan and sodium alginate as thickeners for the application bath and the fixation temperatures as post-treatment were compared. In the second part of the study, the effect of the mordant and self-crosslinking on the fastness properties were investigated.

Therefore, each cotton and polyester fabrics were marbled with and without alum application and allowed to wait for a week to see whether they would self-crosslink or not. These self-crosslinked fabrics were compared with 10 min fixated fabrics at temperatures of 110, 130 and 150°C for both cotton and polyester fabric. All results were compared in terms of fastness properties such as rubbing, washing and print durability.

2. MATERIALS AND METHODS

2.1. Materials

In the first part of the study cotton-1 and polyester fabrics, in the second part of the study with same polyester fabric cotton-2 were used. In the second part, 50/1 Ne cotton-2 was used, and in the conclusion it was compared with the 40/1 Ne cotton-1 fabric used in the first part. It was examined whether the increase in the surface area due to the finer yarn count had an effect on the marbling results or not. Carrageenan, fabrics and natural soft spring water and alum (aluminium potassium sulfate dodecahydrate,

($KAl(SO_4)_2 \cdot 12H_2O$) were supplied locally. Fabric properties are given in Table 1. Sodium alginate was supplied from CHT Group, Turkey. Commercial acrylic paints were supplied from Pebeo.

Table1. Fabric properties

Fabric Type	cotton-1	polyester	cotton-2
Finishing process	Bleached	Bleached	Bleached
Yarn number	Warp:40/1 Ne Weft: 40/1 Ne	Warp:90/1 Denier Weft: 90/1 Denier	Warp:50/1 Ne Weft: 50/1 Ne
Density	Warp:31 Weft:27	Warp:46 Weft:35	Warp: Weft:
Weight (g/cm^2)	125	90	115

3. METHODS

3.1. Marbling Process and After Treatments

For marbling process, first, two separate marbling baths were prepared by mixing 7 g carrageenan and 20 g sodium alginate per liter with spring water and let swell for 4 hours. Using horse hair brushes, paints were dripped on the surface of marbling baths. For spreading out the paint drops, few seconds was waited. Once the surface was covered with paint, fabric was placed on the surface of the colored bath. After few seconds, fabric was removed and line dried.

In the first part of the study, after 24 hours, marbled cotton-1 and polyester fabric were cold washed to remove the thickening bath remains and line dried. Then, just referring ironing, they were fixated shortly, for 30 seconds at 110, 130 and 150ºC for cotton-1 and 100, 110 and 120°C for polyester fabric. Since polyester fabrics are more sensitive to ironing temperature, we used lower temperature for them.

In the second part of the study before the marbling process, one pair of each fabric was dipped into an alum bath for comparison. First, 15 g of alum was dissolved in warm water (40°C), then fabrics were dipped into this bath and waited at least 20 minutes. After squeezing, they were line dried. To achieve a flat and smooth surface they were all ironed.

After marbling cotton-2 and polyester fabric were line dried and waited for a week for self-crosslinking. To evaluate the increased fixation period a piece of cotton and polyester fabric fixated for 10 minutes at 110, 130 and 150 °C and compared with non-fixated marbled fabrics. In order to investigate whether elevated temperatures further improve the fastness properties of polyester fabric, in this part, temperatures of 110, 130 and 150 °C are also used for polyester fabrics.

3.2. Characterization and Fastness Tests

Viscosity of the polymer solutions was measured by using Brookfield DV-III Rheometer with the spindle type SC4-21 at 50 rpm. Surface tension measurements were carried out by a Kruss Easy Dyne Analyzer by Plate Method. Conductivity measurements were carried out using a J.P. Selecta Conductivity meter, CD-2004. All measurements were carried out at room temperature (22±2 °C), where the relative humidity was 22-40%.

Washing and rubbing fastness was carried out according to ISO 105-C06 A2S at 40oC and ISO 105-X12 as dry and wet rubbing, respectively. Print durability tests were done accordingly C15 (Marks and Spencer, Print Durability Test) at Durawash washing machine. Natural tap water was used at 50°C. 30g of automatic heavy-duty, low-lather, powder detergent containing optical brightening agent was added to the machine. Then, all specimens were tumble dried until the specimens were, dry. The degree of loss of print/marbling was assessed and each color was graded individually as no, negligible, slight, distinct, or complete.

4. RESULTS AND DISCUSSION

The conductivity, surface tension and pH measurement results for spring water, marbling baths and paints were given in Table 2. Since we used spring water, its conductivity is relatively high because it contains more or less ions. Sodium alginate has almost neutral pH and show very low conductivity value but slightly higher than carrageenan bath because of the carboxylic groups.

pH of 1.5% carrageenan solutions lays between 8.0 and 11.0 [15] and in this study it was measured 8.60 which is consistent with literature. All paints have very low conductivities because they just include acrylic binder polymer emulsion, pigment, water, and surfactant, do not include ions, so they do not have a remarkable conductivity value. Their pH values were between 7.43 and 8.46, possibly related to their formulations.

The surface tension of water changes from about 72 mN/m to about 57 mN/m [16], and the spring water used in this study was 60.2 mN/m. Carrageenan bath has higher surface tension of 54.2 than sodium alginate bath of 49.0 mN/m. As the density of the liquid increases, the surface tension increases, because surface tension is a reflection of cohesive forces in a liquid [17].

When the surface tension of the liquid decreases, its wetting ability increases. Since acrylic paints have lower surface tensions and lower densities than marbling baths, they have tendency to spread out on the surface of the bath. Because of the immiscible fluids; paints and baths, paints are separated out on the bath and do not mix with each other due to their different interfacial tensions. Interfacial tension is defined as the work which must be expended to increase the size of the interface between two adjacent phases which do not mix completely with one another.

So, the reason for immiscibility is the large difference in cohesion forces between the molecules in the two liquids. If the interfacial tension strength between liquids is lower, they mix easily and emulsify at the interface, otherwise we see a sharp interface between them. Therefore, we would expect paints to spread out more on the alginate baths. Patterning would be more difficult to control, as there is less difference in surface tension between alginate bath and paints. Viscosity measurement of carrageenan bath and sodium alginate baths were 16 and 40 centiPoise (cP).

Table 2. The conductivity, surface tension and pH measurement results

	Conductivity (µS/cm)	Surface Tension (mN/m)	pH	Viscosity (cP)
Spring water	57.2	60.2	7.32	-
Carrageenan bath	5.86	54.2	8.60	16
Sodium alginate bath	11.78	49.0	7.61	40
Yellow	4.80	36.3	7.56	-
White	5.30	34.2	7.50	-
Brown	5.48	37.7	7.50	-
Black	6.11	38.0	7.43	-
Red	4.49	36.9	7.70	-
Green	3.60	37.5	8.19	-
Pink	5.47	35.7	7.65	-
Cyan	3.68	38.0	8.46	-
Blue	4.83	36.4	7.77	-

Color fastness to rubbing and washing results for the first part of the study is given in Table 3. Fastness to rubbing is given as dry and wet rub, fastness to washing is given as change in color and staining to cotton and lyocell. Multifiber fabric consist of six yarn type, since we observed some staining on cotton and lyocell, thus we only give staining onto cotton and lyocell. The effect of thickening agent for marbling bath and fixation temperature were compared. As mentioned, short fixation of 30 seconds was conducted to simulate the ironing effect. According to the results, for cotton fabric carrageenan bath resulted better rubbing fastness for cotton than sodium alginate bath. For polyester fabric it is not significant as cotton fabric. Wet rubbing fastness are better than cotton, because in wet rubbing fastness, there is also removal of the fibers from the printed surface of the fabric, however in case of synthetic filament polyester yarns, it is not possible to remove fibers from the structure.

Table 3. Color Fastness to Rubbing and Washing Results of Cotton-1 and Polyester in Part I

Fabric	Medium (Thickening agent)	Fixation Temp. ºC	Fastness to Rubbing ISO 105-X12 Dry	Fastness to Rubbing ISO 105-X12 Wet	Fastness to Washing ISO 105-C06/A2S Change in Color	Staining Cotton	Staining Lyocell
Cotton-1	Carrageenan	110	4	2-3	4-5	4-5	4-5
		130	4	2-3	4-5	4-5	4-5
		150	4	2-3	4-5	4-5	4-5
	Sodium Alginate	110	2	1-2	4-5	4-5	4-5
		130	2	1-2	4-5	4-5	4-5
		150	2	1-2	4-5	4-5	4-5
Polyester	Carrageenan	100	2	3	4-5	4-5	4-5
		110	1-2	3	4-5	4-5	4-5
		120	1-2	3	4-5	4-5	4-5
	Sodium Alginate	100	2	3-4	4-5	4-5	4-5
		110	2	3-4	4-5	4-5	4-5
		120	2	3-4	4-5	4-5	4-5

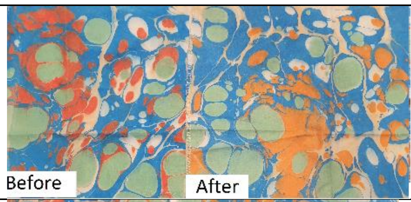
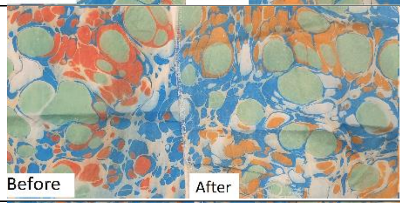
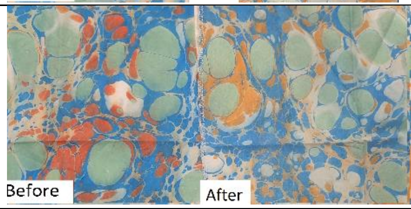
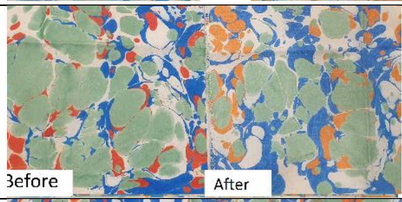
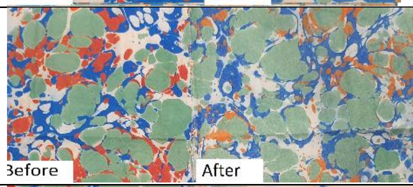
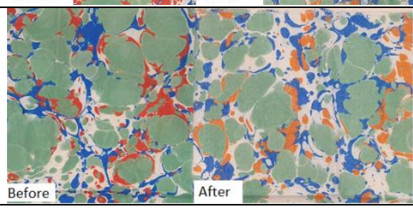
When washing fastness were compared, both cotton and polyester fabrics show good results for both carrageenan and sodium alginate baths. It was also seen that fixation temperature has not an effect on the washing and rubbing results. In washing fastness, each color should be assessed for change in color. But only in red color there was a significant color change therefore we just assessed general color change of all marbling and assessed as 4-5.

Print durability results for the Part I are given in Table 4 and Table 5 for cotton-1 and polyester, respectively. Marbling designs on the surface of the bath depend on the how much and where drops are dripped. So, it is not possible to achieve exactly same design for each sample. For instance, when dropped paints are more or less than the other one, the color depth could be slightly different. It was seen that green paint spread out more than blue and red paints, because of higher surface tension of 37.5 mN/m than blue and red paints.

It was more significant for sodium alginate bath. Since sodium alginate bath’s surface tension was lower than carrageenan bath, spreading of the green color was larger in sodium alginate bath. It pushed red and blue paint and green color became dominant. For all specimens, blue and green paint preserved their color tone however red color lost its tone and turned to orange, most probably because of the pigment dye it consists of. Therefore, apart from other colors, red color change was evaluated with grey scale and scored 1 to 5, and together with the color change, print loss was commented in the same column.

According to the Table 4, for cotton-1 carrageenan bath resulted in better print durability than sodium alginate bath, while increase of the fixation temperature had no significant effect. While better durability was expected with increasing fixation temperature, worse results were also seen in some cases. Just for 150°C, slight improvements were achieved. Since all samples were individually marbled, generally clearer patterns were obtained for the first marbling samples, the later ones slightly blurred because of the contamination of the sizing bath. And these blurred marblings showed worse print durability than clearer ones.

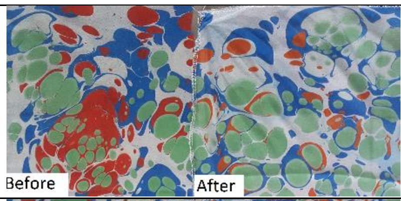
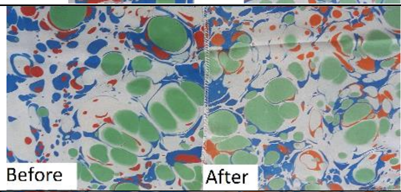
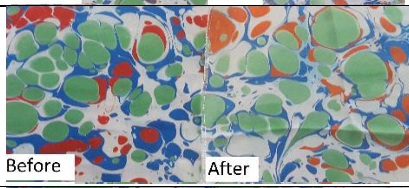
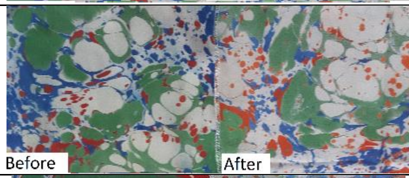
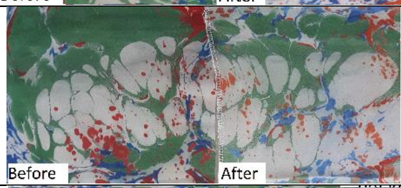
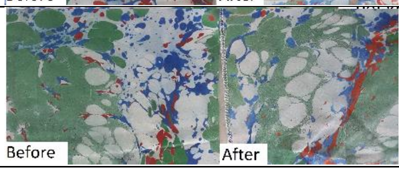
Table 4. Print durability results of cotton-1 in Part I

Cotton-1						
Marbling Bath (Thickening agent)	Fixation Temp°C	Print Durability				
		Blue	Red Color Change/ Print Loss	Green	Before	After
Carrageenan	110	Slight	3/ Negligible	Negligible		
	130	Slight	2-3/Slight	Negligible		
	150	Slight	3/Slight	Slight		
Sodium Alginate	110	Slight	2-3/Slight	Slight		
	130	Slight	3/Slight	Slight		
	150	Distinct	2-3/Distinct	Distinct		

When cotton-1 and polyester marbling was compared, it was seen that acrylic paints showed better patterns and print durability on polyester fabric especially in carrageenan bath. It might be related to the better adhesion forces between polyester and binder than cotton and binder, due to binder formulation. Because some copolymers that binders contain for "internal" crosslinking can be useful for prints on hydrophobic materials [18] and here marbling gave better results for polyester than cotton fabric. Another possible explanation is that polyester fabric has thinner yarns than cotton-1 fabrics, and due to texturized yarn structure, it has rougher surface than cotton. Thus, absorbed patterns are clearer and might be better hold onto the polyester fabric.

According to the Table 5, carrageenan bath pattern transferring ability was better than sodium alginate bath, and again this was resulted in better durability. According to the viscosity measurement sodium alginate bath has slightly higher viscosity and this may alter the absorption of the patterns which may also result the poorer durability.

Table 5. Print durability results of polyester in Part I

Polyester						
Marbling Bath (Thickening agent)	Fixation Temp°C	Print Durability				
		Blue	Red Color Change/ Print Loss	Green	Before	After
Carrageenan	100	Negligible	3/ Negligible	Negligible		
	110	Negligible	3/ Negligible	Negligible		
	130	Negligible	3-4/ Negligible	Negligible		
Sodium Alginate	100	Slight	3/Slight	Distinct		
	110	Slight	3-4/ Slight	Slight		
	130	Slight	3-4/ Slight	Distinct		

In the second part of the study, we would like to see whether these commercial ready to use acrylic marbling paints have self-crosslinking ability and, do alum application influences the print durability. In Table 6. rubbing fastness and washing fastness of both cotton-2 and polyester fabrics are given together. It is seen that for cotton samples, there is slight tendency of better rubbing and washing fastness with the increasing of fixation temperature to the 150°C. For polyester fabric, it is not significant, even without heat fixation both alum treated and not treated polyester fabric show good dry rubbing results than almost all other heat fixated polyester fabrics and heat fixation does not cause any notable difference. When we compare the washing test results, again there is no significant tendency of decreasing or increasing, just for 150°C of heat fixation slightly increased the staining results.

Table 6. Color fastness to rubbing and washing results of cotton-2 and polyester in Part II

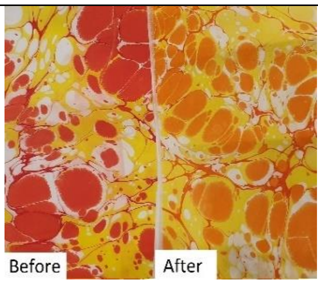
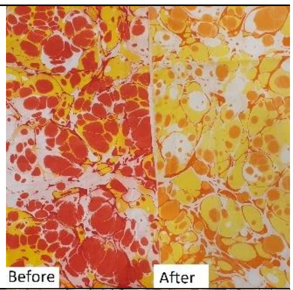
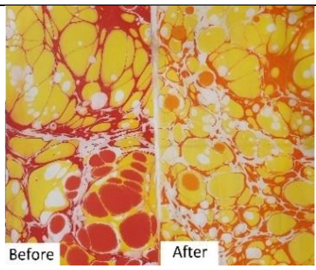
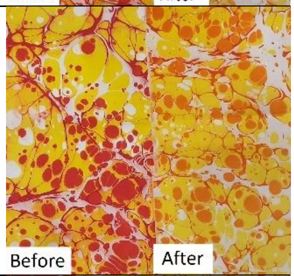
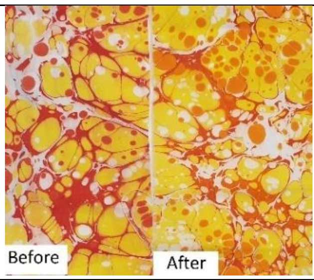
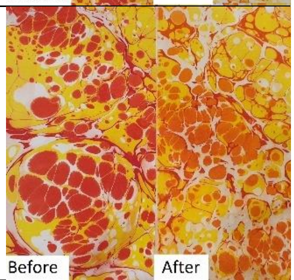
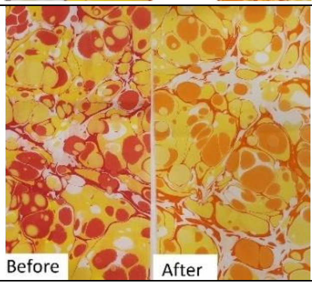
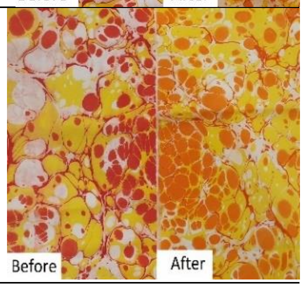
Process Conditions	Fixation Temperature ºC	Fastness to Rubbing ISO 105-X12		Fastness to Washing ISO 105-C06/A2S			
				Change in color		Staining	
		Dry	Wet	Red	Yellow	Cotton	Lyocell
Cotton-2							
Without Mordant	None	4-5	2-3	3	4-5	4	3-4
	110	4	2-3	3-4	4-5	4	4
	130	4-5	3	3	4-5	3-4	4
	150	4-5	3-4	3	4-5	4	4
With Mordant	None	4	2-3	3-4	4-5	3-4	3-4
	110	4	3	3	4-5	4	4
	130	3-4	3	3-4	4-5	4	4
	150	4	3	3	4-5	4	4
Polyester							
Without Mordant	None	4	2-3	3-4	4-5	3-4	3-4
	110	3-4	3	3-4	4-5	3-4	3-4
	130	4	3	3-4	4-5	3-4	4
	150	3-4	2-3	3-4	4-5	4-5	4-5
With Mordant	None	4	2-3	3-4	4-5	3-4	3-4
	110	3-4	2-3	3-4	4-5	4	3-4
	130	3-4	2-3	3-4	4-5	4	4
	150	3-4	3	3-4	4-5	4-5	4-5

Print durability results of cotton-2 and polyester fabrics for the second part of the study are given in Table 7 and Table 8. Images before and after print durability test are also inserted to the tables. Both tables include three fixation temperature as 110, 130 and 150°C for 10 min, longer than which has been carried out in the Part I and “none” for without fixation for both cotton-2 and polyester fabric. As we observed in Part I, red color loses its red tone after all condition. Therefore, its color change was evaluated with grey scale and scored 1 to 5, but together with the color change, print loss was commented in the same column as we have done in Part I. From the Table 7, for cotton-2, in contrary to alum treatment, fixation temperature has some effect on the print durability results.

It was also seen that, marbled samples that were not heat fixated, showed fair durability if they were let to stay few days without washing. Acrylic paints that are also used in painting art, attach to the surface of the canvas permanently with self-fixation. Also, it is known that for some heat sensitive fabrics, low heat fixation binders could be used in textile printing applications. Herewith it is supposed that ready to use marbling paints include a low fixation binder and if waited enough without washing, self-crosslinking occurs and strong bonds are formed, fair to good print durability results can be achieved.

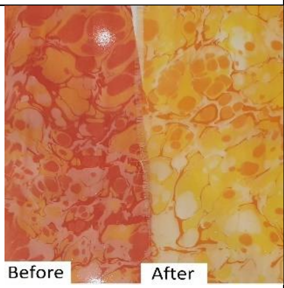
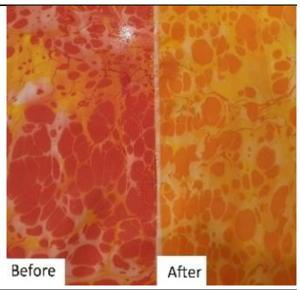
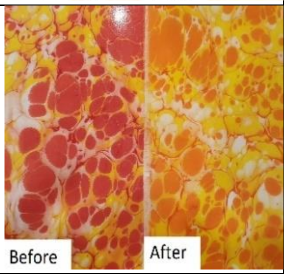
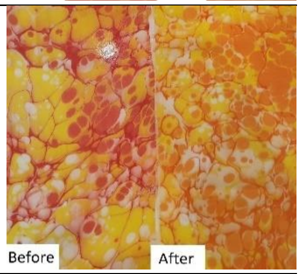
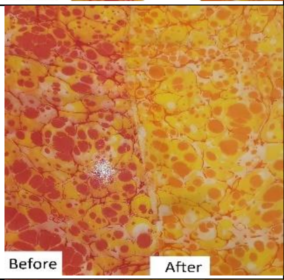
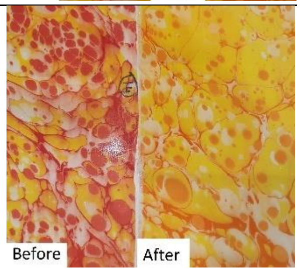
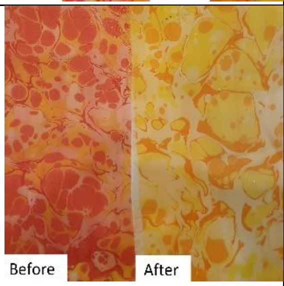
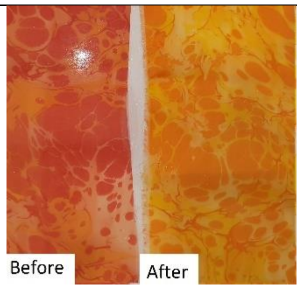
In case of mordant application, no significant difference could be seen in durability results between alum treated and not treated marblings. Because these ready to use paints include their own binder system and surfactant. As mentioned in the introduction part, in traditional marbling, natural earth dyes and some natural root and herbal dyes were used and in order to spread these pigment dyes, natural ox-gall was employed. These dyes did not include a binder system which can bind the pigment to the paper or fabric. For this reason, alum treatment was necessary to provide durable patterns to water. During the chemical reaction between the alum and the glycocholic acid, insoluble aluminum glycocholate salt is formed which binds the pigment to the paper or fabric. However, today's easy marbling paints already contain binders and surfactants. Thus, alum treatment is not necessary for the bonding, as we have shown in our print durability results as well as the rubbing and the washing fastness results.

Table 7. Print durability results of cotton-2 in Part II

Cotton-2						
Print Durability						
Fixation Temp°C	Yellow	Red Color Change/ Print Loss	Without Potassium alum	Yellow	Red Color Change/ Print Loss	With Potassium alum
None	Negligible	3/ Negligible		Negligible	3/ Negligible	
110	Negligible	3-4/ Negligible		Negligible	3-4/ Negligible	
130	Negligible	3-4/ Negligible		Negligible	3-4/ Negligible	
150	Negligible	4/ Negligible		Negligible	4/ Negligible	

All similar results were seen in Table 8 for polyester marblings. Very slight improvement was only observed for the fixation at 150°C. Again, alum treatment had no effect and not necessary. When we compare Part I and Part II, cotton fabrics had different yarn counts and cotton-1 yarns were thicker than cotton-2. Like chiffon polyester marbling, due to the increased surface area of finer yarns, pigments and binders were better adhered to the fabric surface and resulted in good marbling and durability.

Table 8. Print durability results of polyester in Part II

Polyester						
			Print Durability			
Fixation Temp. °C	Yellow	Red Color Change/ Print Loss	Without Potassium alum	Yellow	Red Color Change/ Print Loss	With Potassium alum
None	Negligible	2-3/ Slight		Negligible	3/ Slight	
110	Negligible	3-4/ Negligible		Negligible	3-4/ Negligible	
130	Negligible	3-4/ Negligible		Negligible	3-4/ Negligible	
150	Negligible	3-4/ Negligible		Negligible	3-4/ Negligible	

5. CONCLUSION

The entire marbling process depends on the balance of relations between the chemical character and particle size of the color pigments and their relationship to the viscosity and surface tension phenomena of the viscous bath upon the surface. Although Ebru Art/marbling has been known for centuries, today easy marbling paints are quite different than traditional marbling dyes. Because of the immiscible fluids with different surface tensions; marbling paints are separated out on the baths and do not mix with each other. In this study, it was seen that, carrageenan bath has higher surface tension of 54.2 than sodium alginate bath of 49.0 mN/m. Therefore, paints were spread out more upon the surface of alginate bath than carrageenan bath which was not ideal to control the patterns. On the other hand, day after washing good washing fastness were obtained. However especially for cotton-1 wet rubbing fastness resulted 2-3 for carrageenan bath and 1-2 for sodium alginate bath. It was also seen that pattern transferring ability of carrageenan bath was better than sodium alginate bath. In case of short fixations, only for 150°C, slight improvements were achieved. In the second part of the study, it was shown that easy marbling paints have self-crosslinking ability and, alum application do not influence the print durability. Because these easy, ready to use marbling dyes include a binder system possibly with a low temperature fixating agent. When they are let to dry for few days without washing, they show good print durability results. Only slight improvements were observed for the fixation temperature of 150°C while alum treatment seemed unnecessary. Different fabric finishes and fabric construction would be the subjects of further studies about marbling onto textile fabrics.

Funding
The authors have not received any financial support for the research, authorship, or publication of this study.

Authors' Contribution
The authors contributed equally to the study.

The Declaration of Conflict of Interest/ Common Interest
No conflict of interest or common interest has been declared by the authors.

The Declaration of Ethics Committee Approval
This study does not require ethics committee permission or any special permission.

The Declaration of Research and Publication Ethics
The authors of the paper declare that they comply with the scientific, ethical and quotation rules of SAUJS in all processes of the paper and that they do not make any falsification on the data collected. In addition, they declare that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than Sakarya University Journal of Science.

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