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MICROWAVE ASSISTED DYEING OF COTTON FABRIC WITH REACTIVE DYES

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ABSTRACT

Microwaves are a form of electromagnetic waves, like other radio waves. Microwave technology, which provides homogeneous and fast heating, attracts attention as an ecofriendly alternative new method in industrial processes. So, the use of microwave technology in many industries has become widespread recently.

In this study, conventional heating and microwave heating in the exhaust dyeing of bleached cotton fabric with reactive dyestuff were studied. The aim of this study is dyeing of cotton fabric with reactive dyestuff using microwave media to save time, energy and money. The conventional reactive dyeing process time is 90 minutes. The L level dyeing time in microwave media was completed in 10 minutes, and a deeper color was obtained. It has been observed that the cotton dyeing process time with microwave heating is significantly reduced compared to the traditional cotton dyeing process.

Keywords: Microwave, Reactive Dyestuff, Fastness.

Introduction

Microwaves are electromagnetic radiation with wavelengths of 1 mm to 1 m, corresponding to frequencies of 300 mm to 300 GHz. [1].

Since the heating of the sample in microwave heating is in the internal part, it is quite different compared to conventional heating methods. The properties of microwaves, such as absorption by substances containing water and the ability to pass through substances other than metals, provide fast and uniform heating in the interior with microwave energy, unlike conventional heating methods that start from the outer surface of heating [2]. Thermal stresses decrease due to the homogeneous spread of temperature in the treated sample [3].

A molecular movement begins with the rotation of dipolar particles or the migration of microwave ionic particles. Depending on the type of material, they can be absorbent, reflective or permeable [4]. Dipolar molecules gain a rotational moment in the electric field and move. With this movement, they generate heat by rubbing against each other, and materials that can absorb microwave energy well heat up quickly [5].

Heating with microwave technology in industrial processes is preferred because it reduces process time and energy costs. The field of use of microwave technology is expanding day by day and has become a more common method of processing various materials. Examples of the use of microwave energy are cooking [6], sterilization [7], pasteurization [8], sintering in ceramic production [9], germination enhancement [10] chemical synthesis [11].

Conventional dyeing of textile materials is an energy intense process. It requires a large

amount of energy, as well as time to perform the dyeing process. The use of microwave technology in pre-treatment, dyeing, finishing and drying processes requiring high energy applied to fabrics in the textile sector is obvious. Nowadays, textile process studies in microwave environment are quite new. It is more efficient in many ways than traditional methods [12].

Cotton is the main fiber in the textile industry [13]. Reactive dyestuffs of different structures are used in the dyeing of cotton fiber depending on the purpose of use, desired color and characteristics.

In this study conventional heating and microwave heating in the exhaust dyeing of bleached cotton fabric with reactive dyestuff were studied. The aim of this study is dyeing of cotton fabric with Reactive Red 141 using microwave media to save time, energy and money.

Materials and Methods

In experimental studies, 100% bleached cotton knitted fabric ready for dyeing was used. Na_2SO_4, Na_2CO_3 are used as auxiliary materials for dyeing, while cotton fabric is used for coloring (C.I. Reaktif Red 141) Iyazol Red HE7B. It used in the Kumtel brand KUM-1225 (1150 W) model with the trade name as a microwave oven. The reflectance values of all dyed fabrics were measured using a Gretag Macbeth Color Eye 7000 color spectrophotometer [14]. For fastness tests, ECE phosphate test detergent B, Sodium perborate tetra hydrate, friction fastness cotton test fabric, multifiber were used. Laborteks brand light cabinet and grey scale were used in the fastness tests evaluations.

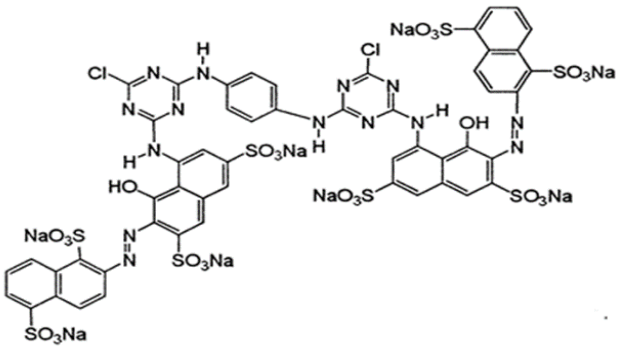

Fig. 1. Iyozol Red HE7B (C.I. Reaktive Red 141) [15].

Comparison of conventional dyeing method and microwave dyeing method

Firstly, a 4% solution of Iyazole Red HE7B dyestuff was prepared. As components of the dyeing bath, the flotte ratio of 1/100 (fabric/dyeing liquor ratio), dye concentration of 1.50%, 20 g/L. Na_2SO_4, 5 g/L. Na_2CO_3 were used. Conventional dyeing process was started at 30oC, the dye bath gradual at 1oC/min. the bath was heated to 60^{o}C and the dyeing process was carried out at this temperature for 60 minutes. The conventional dyeing process diagram was shown Figure 2.

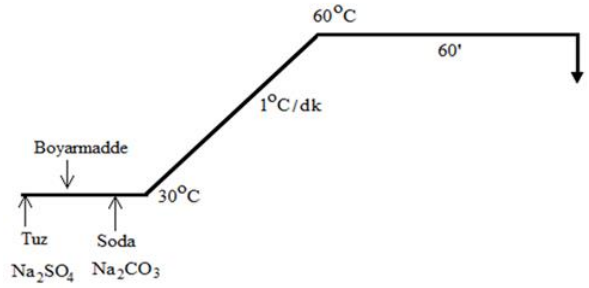

Fig. 2. Conventional Reactive Dyeing Process Diagram

In order to compare the dyestuff fixing and fastness properties of the microwave dyeing method according to the conventional reactive dyeing method, dyeing process with the same content and 1.50% dyestuff concentration was performed in the microwave environment. The dyeing process was performed in the microwave for 10 minutes at the L level, 8 minutes at the ML level, and 6 minutes at the M level. As the microwave power increases, it was predicted that the dyeing process would be completed in a shorter time, so the dyeing time was reduced when the power was increased. After, all dyed fabrics were washed according to reactive wash processes and dried. The reflectance values of the dyed fabrics were measured using a Gretag Macbeth Color Eye 7000 A spectrophotometer.

Fastness Properties

For all dyed fabrics, washing fastness was made according to ISO 105 C06 A2S method, dry and wet rubbing fastness were made according to ISO 105-X12 method. Fastness evaluations were made according to ISO 105 A02 and ISO 105 A03 method with grey scale.

Results

Photos of all fabrics dyed in conventional and microwave environment are shown in Table 2. The all dyed fabrics were dyed properly. The highest color depth was reached at the end of 10 minutes of dyeing at the L level in a microwave environment. Fabrics dyed at the 8-minutes ML level and at the 6-minutes M level had a slightly light color depth according to the traditional method. These experiments have been repeated three times and similar results have been achieved. It was observed that the best color efficiency was achieved after 10 minutes of dyeing in a microwave environment.

Table 1. The dyed fabrics according to conventional dyeing and microwave media

Conventional Dyeing 60ºC 60 min.	**Microwave L Level 10 min.**	**Microwave ML Level 8 min.**	**Microwave M Level 6 min.**
			

The color depth, washing fastness and rubbing fastness values of the fabrics dyed in traditional and microwave environment were shown in Table 3. The color depths of the fabrics dyed in conventional reactive dyeing and microwave environment were measured on a spectrophotometer, K/S values were determined. In the conventional method, the dyeing process is completed in a total of 90 minutes, while in the microwave method, the dyeing process is completed in 10 minutes. Although the dyeing time is very short in the microwave environment, very close K/S color values are reached according to the conventional method. Karadag et al. found that the dyeing time of organic cotton fiber with natural dyestuffs according to the conventional method takes sixty minutes in total, while the microwave dyeing method completes the dyeing process in 10 minutes and reaches higher K/S values compared to the traditional method, and the washing fastness values increase by 0.5 points [16]. In this study, similar results were observed in the washing fastness test results applied according to ISO 105 C06 A2S method to fabrics dyed by conventional and microwave methods. It has been found that the washing fastness nylon staining values of fabrics dyed according to the microwave method are 0.5 points better. Similar results were observed in the dry rubbing fastness test results applied according to ISO 105-X12 method to fabrics dyed by conventional and microwave methods. It has been found that rubbing fastness value of fabrics dyed according to the microwave method is 0.5 points better. It has been observed that the microwave dyeing method has a positive effect on fastness. Molla and etc. has reached similar results [17].

Table 2. K/S and Fastnesses Values

	K/S	Washing Fastness ISO 105 C06 A2S							Dry Fastness ISO 105-X12	
		Color Chang	Multifber Stainig Wool	Acry.	PES	Nylon	CO	Acet.	Dry	Wet
Conventional Dyeing 60ºC 60 min.	8.43	4/5	5	5	5	4	4	5	4	3/4
Microwave L Level 10 min.	8.96	4/5	5	5	5	4/5	4	5	4/5	4
Microwave ML Level 8 min.	8.11	4/5	5	5	5	4/5	4	5	4/5	4
Microwave M Level 6 min.	6.32	4/5	5	5	5	4/5	4	5	4/5	4

Conclusion

It has been observed that all fabrics dyed in microwave environment are dyed homogenously and uniformly. It has been observed that the color depth of fabrics increases as the dyeing time increases. While the conventional reactive dyeing process is completed in 90 minutes, it has been observed that the dyeing process is completed in 10 minutes even at the lowest energy level in the microwave environment. Along with the reduction of dyeing process times, there will also be a decrease in energy costs. It is foreseen that the use of microwave dyeing as an alternative green

process will become widespread in the textile sector.

References

1. Yıldız, K., Alp, A. (1999). Using Of Microwave İn Metallurgical Processes, Metalurji Tmmob, 24 (125), 1300-4824.
2. Jennie Rebecca Lill, (2009). Microwave Assisted Proteomics, England, The Royal Society of Chemistry.
3. Kutbay, I., Kuşkonmaz, N. (2004). Mikrodalga ısıtmanın seramik üretiminde kullanımı, Metalurji Dergisi, sa.137, ss.52-56
4. Sutton,W.H. (1989). Microwave Processing Of Ceramic Materials, Ceramic Bulletin, 68 (2), 1100-1118.
5. Thostenson E. T., Chou T. W. (1999). Microwave processing: Fundamentals and applications, Composites A., 30, 9, 10055-1071.
6. Konak Ü. İ., Certel M., Helhel S. (2009). Gıda Sanayisinde mikrodalga uygulamaları, Gıda Teknolojileri Elektronik Dergisi, 4(3): 20-31.
7. Turgut T. (2016). The effect of microwave heating on the some quality properties and shelf life of yoghurt. Kafkas Üniversitesi Veteriner Fakültesi Dergisi, 22 (6): 809-814. https://doi.org/10.9775/kvfd.2016.14875.
8. Deghan A., Jamalian J., Farahnaky A., Mesbahi G., Moosavi-Nasab M. (2012). The effect of microwave pasteurization on some physical and chemical characteristics of milk. International Journal of food Engineering 8(1): 1-12. https://doi.org/10.1515/1556-3758.2423.
9. Agrawal D. (2006). Microwave sintering of Ceramics, Composites and Metallic Materials and Melting of glasses., Transactions of the İndian Ceramic Society, 65 (3), 129-144. https://doi.org/1080/0371750X.2006.11012292.
10. Eroğlu A., Selcuk Cirig N. (2019). Mikrodalga Enerjisinin Buğdayda Çimlenme, Erken Fide Büyümesi ve Mitotik Bölünme Üzerine Etkisi, Doğu Fen Bilimleri Dergisi / Journal of Natural&Applied Sciences of East, 2 (2): 61-68.
11. Keglevich G., (2022). The Application of Microwaves in the Esterification of P-Acids, Current Microwave Chemistry, 9, 62-64. https://doi.org/10.2174/2213335610666230105162405.
12. Kale M. J., Bhat N., (2011) Effect of microwave pretreatment on the dyeing behaviour of polyester fabric, Coloration Technology, Volume127, Issue6, pp. 365-371, https://doi.org/10.1111/j.1478-4408.2011.00332.x
13. Cevheri C.İ, Şahin M., "Dünya'da Ve Türkiye'de Pamuk Üretiminin Tekstil Sektörü Açısından Önemi", Harran Üniversitesi Mühendislik Dergisi, 5(2): 71-81, (2020). Erişim linki (To link to this article): http://dergipark.gov.tr/humder/archive
14. Alsan H. G. (2019). Reaktif Boyarmaddelerle Mikrodalga Ortamında Boyanma Kinetiğinin İncelenmesi, (Yüksek Lisans) Kimya, Sakarya Üniversitesi, Sakarya, Türkiye.
15. Montano, J.,G.,Torrades, F., Leonidas, A., Estrada, P., Ollder, I., Malato, S., Maldonado, M., I., Peral, J., Degradation Pathways Of The Commerical Reactive Azo Dye Procion Red H-E7b Under Solar - Assisted Photo – Fenton Reaction, Environmental Science Technology, 42(17), 6663-6670, 2008.
16. Büyükakıncı Y. B., Karadag R., Guzel, E.T., (2021). Organic cotton fabric dyed with dyer's oak and barberry dye by microwave irradiation and conventional methods, Industria Textila, Vol No, 72, 30-38, DOI: 10.35530/IT.072.01.1755
17. Mollaa M, Haggag K., Mahmoued A.M., (2014) Dyeing of cotton fabrics using reactive dyes

by microwave irradiation technique, Indian Journal of Fibre & Textile Research, Vol. 39, December, pp. 406-410.

MİKRODALĞALI SOBADA REAKTİV RƏNGLƏYİCİLƏRL VASİTƏSİ İLƏ PAMBIQ PARÇALARIN BOYANMASI

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XÜLASƏ

Mikrodalğalar digər radio dalğaları kimi elektromaqnit dalğalarının bir formasıdır. Homojen və sürətli isitmə təmin edən mikrodalğalı texnologiya sənaye proseslərində ekoloji cəhətdən təmiz alternativ yeni üsul kimi diqqəti cəlb edir. Belə ki, son zamanlar bir çox sənaye sahələrində mikrodalğalı texnologiyanın istifadəsi geniş yayılıb.

Bu işdə ağardılmış pambıq parçanın reaktiv boya ilə işlənmiş boyanmasında şərti isitmə və mikrodalğalı sobada isitmə tədqiq edilmişdir. Bu tədqiqatın məqsədi vaxta, enerjiyə və pula qənaət etmək üçün mikrodalğalı mühitdən istifadə edərək pambıq parçanın reaktiv boya ilə rənglənməsidir. Ənənəvi reaktiv boyama prosesinin müddəti 90 dəqiqədir. Mikrodalğalı mühitdə L səviyyəli boyama müddəti 10 dəqiqə ərzində tamamlandı və daha dərin rəng əldə edildi. Mikrodalğalı sobada qızdırılan pambıq boyama prosesinin ənənəvi pambıq rəngləmə prosesi ilə müqayisədə xeyli azaldığı müşahidə edilmişdir.

Açar sözlər: Mikrodalğa,reaktiv boyaq maddə, sürətlilik

КРАСЕНИЕ ХЛОПКОВОЙ ТКАНИ РЕАКТИВНЫМИ КРАСИТЕЛЯМИ В СВЧ-ВОЛНЕ

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АБСТРАКТ

Микроволны — это форма электромагнитных волн, как и другие радиоволны. Микроволновая технология, обеспечивающая равномерный и быстрый нагрев, привлекает внимание как новый экологически чистый альтернативный метод в промышленных процессах. Так, в последнее время широкое распространение получило применение микроволновой техники во многих отраслях промышленности.

В данном исследовании изучались традиционный нагрев и микроволновый нагрев при вытяжном крашении отбеленной хлопчатобумажной ткани реактивными красителями. Целью данного исследования является крашение хлопчатобумажной ткани реактивными красителями с использованием микроволновых сред для экономии времени, энергии и денег. Обычное время процесса реактивного крашения составляет 90 минут. Время

окрашивания уровня L в микроволновой среде завершилось за 10 минут, и был получен более глубокий цвет. Было замечено, что время процесса крашения хлопка с помощью микроволнового нагрева значительно сокращается по сравнению с традиционным процессом крашения хлопка.

Ключевые слова: микроволна, реактивный краситель, стойкость.