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Study on Exhaustion Behaviour of Red Chili on Cotton Fabric

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Abstract: Dying is a popular practice in textile industry which is prevalent at all parts of the world from the period of ancient civilization. Initially, natural dyes i.e. dye derived from natural resources like vegetables, flowers, minerals, plants etc. were used. Now-a-days, due to technological and scientific innovations synthetic dyes are processed at large scale in the laboratories as it is still one of the most profitable industry globally. However, the rapid utilization of chemicals in textile industry for production of synthetic dyes causes degradation of environment like soil pollution, water pollution etc. Hence, it is necessary to promote the utilization of natural dyes globally. In this paper, the exhaustion of dye extracted from red chillies, one of the most used vegetables same has been studied on cotton fabrics at different temperatures using UV-Visible light spectrophotometer. The colour strength of the fabric before and after application of soap therein are also studied experimentally.
Keywords: Natural dye, red chillies, cotton fabrics, exhaustion of dye, absorption.

I. INTRODUCTION

Dyeing has been practiced since ancient time across the globe in Europe, Greek, North Aerica, Egypt, India. Early time dyeing was done by the extraction of dyes from natural sources like minerals, animals, Plants. Today there are many methods of dyeing like Bale dyeing, Batik, Bean, Chain, Cross, Jig, Piece dyeing, with civilization taking place in different places of the world dyeing was also introduced as a means to identify gender , standard of people , else before dyeing all the clothes were of pale grey and white colour. Natural dye was the earliest form of dyeing, in modern time synthetic dyeing has been gaining grounds also.

Natural dyes composed of those dye stuff which are extracted through natural means and done without the use of chemical processing. These are free from any kind of chemical, are environmentally friendly and produce rare colour combination .In spite of the use of natural dye is very less compared to synthetic dye , like natural dye uses is just 1 % of the synthetic dye internationally .It is basically due to the certain restrictions and technical problems which limit its uses in the dyeing of textile. So dyeing of textile using natural dye needs to be explored more and used in a scientific manner to add value to the product , as natural dyes don't produce any kind of health issues compared to synthetic dye . A lot of research has been going on across the globe to make the use of natural dyeing in textile a success. The present investigation is aimed to determine the exhaustion profile of Kashmiri red chili & saffron natural dye on silk & cotton fabric at different temperature and different time scale.

II. LITERATURE REVIEW

Synthetic dyes largely used today become a growing concern for the sustainability of environment due to its adverse impact on soil and water that may lead to serious health issues like cancers. Variety of chemicals, acids, dyes and other toxic pollutants extracted from the textile mills of Pali district of Rajasthan in India become a serious concern for the environment scientists as these industrial effluents have been proved to be hazardous and carcinogenic. Natural dyes are dyes or colourants derive from natural elements like flowers, invertebrates, minerals without any chemical treatment. Most of them are extracted from vegetable sources like herbs, tree roots etc. However, they are not readily available and involve an extraction process. Flora driven dyes such as indigo, saffron, red chili, madder were important trade goods in the economics of Asia and Europe. Dyes extracted from insects like cochineal and kermes, came into existence and become popular in the 15th century followed by that in the 17th century, dyeing cloths in the wood was initiated in England readily available and involve an extraction process. Textile dyeing can be traced back to the period of Neolithic.

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Extraction of materials which were available locally was used in the dyeing of textiles , however extraction from natural elements was not available at the time. Crimson Kermes and Tyrian Purple was considered to be very high quality and expensive dyes color , The introduction of Synthetic dye in the mid - 19th century , resulted in the downfall of natural dyes in the market , with industrial revolution , the synthetic dye could be easily produced in huge amount and it was the beginning of the use of synthetic dye in textiles . However in the 21st century we are seeing a demand for natural dye as there are harmless and environmental friendly , where as synthetic dyes requires the excess burning of fossil fuels . Here we are going to study about the exhaustion behavior of red chili dye on cotton fabric

III. OBJECTIVE OF THE PAPER

1) To study the exhaustion behavior of red chili dye on cotton fabric.
2) To find out the optimum exhaustion time and temperature of red chili dye on cotton fabric.
3) To find out optimum dye saturation point of red chili dye on cotton fabric

IV. THEORETICAL CONSIDERATION

The exhaustion of dye by the cotton was measured using a UV-Visible light spectrophotometer at the wavelength of maximum absorption i.e. at λmax. The percentage of dye-bath exhaustion i.e. E was measured using Eq. 1 where A_0 and A denote the absorbance of dye solution at λmax before and after the process of absorption of dye by the cotton fabric respectively.
The colour strength of the dyed fabrics (K/S) was also measured before and after soaping using Eq. 2 where R is the reflectance of the dye.
The fixation of the dye absorbed used to calculate using Eq. 2 and 3 and finally the total fixation of the dye applied was measured using Eq 2, 3 and 4.
The samples were tested according to ISO standard methods.

1) $E\% = (1 - A/A_0) \times 100$
2) $K/S = (1 - R)^2 / 2R$
3) $F\% = (K/S\ 1)/(K/S\ 2) \times 100$
4) $T = E \times (K/S\ 1)/(K/S\ 2)$

The simplest physically plausible isotherm is based on three assumptions:

- **Adsorption cannot proceed beyond monolayer coverage**
- **All sites are equivalent and the surface is uniform**
- **There are no interactions between absorbed molecules, so the ability of a molecule to absorb at a given site is independent of the occupation of neighboring sites[21].**

and Langmuir adsorption isotherms.
[C]f = KP X [C]s The Langmuir isotherm is well suited to describe dye adsorption by certain textile fibers.
Considered in terms of dyeing, the basic postulate is that adsorption of dyes take place on specific sites in the fiber and that when a dye molecule occupies a site, that site is saturated and incapable of further adsorption[22].
The Langmuir model is valid for monolayer sorption on to a surface with a finite number of identical sites. This theory is based on the assumption homogeneous surface[23].
On the basis of those assumptions, equations can be written as:
Cf,a = K/ Cs, m / (1 + K/ Cs,m)Where ,
Cf,a = concentration of absorbed dye molecules on the fibre.
Cs,m = concentration of mobile dye molecules in the bath.
K/ = adsorption constant.

The Nernst isotherm is considered as a limit case of Freundlich
In case of Freundlich model, the dye is considered as being contained in an interval phrase of volume V in the fiber.

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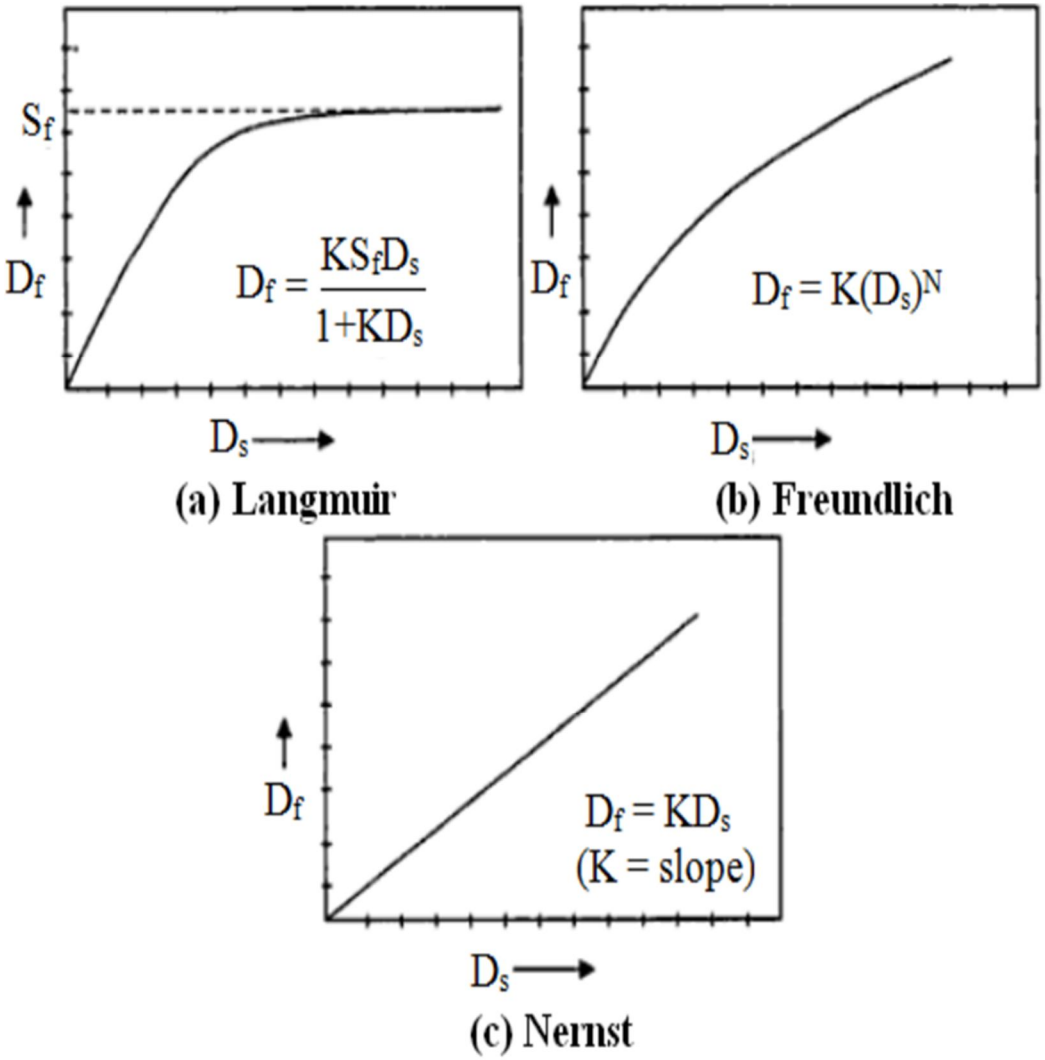

In [C]f = In KF + Xx In [C]s

Where,[C]f represents the dye concentration in the fiber at equilibrium in mole per kg dry fiber, [C]s represents the dye concentration in solution at equilibrium in mole per liter ; KF is a sub unitary power.

The Freundlich model assumes a heterogeneous multilayer adsorption surface with sites that have different energies of adsorption which are not equally available.

Nernst isotherm equation is a mathematical representation of the distribution law, which states that a dissolved substance, irrespective of its total amount, distributes itself between two layers or phases in a constant concentration ratio, at constant temperature, the ration equals to the constant in the above equation is referred to as the distribution or partition ration.

V. MATERIAL AND METHODS

1) *Fabric:* Bleached cotton fabric will use for the experiment, specifications of which are given below.
2) *GSM:* 120
3) *Chemicals Used:* Laboratory grade glacial acetic acid was purchased from Merck Company. The same has been used without any further purification.
4) *Dye Used:* A good grade red chili(chilli paste after treatment)in powder form will obtained from India. The same has been use without any further purification.
5) *Machine:* Water dyeing bath was used for the dyeing of cotton fabric with red chili natural dye. UV spectrophotometer (x-rite) was finally used to deter

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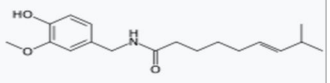
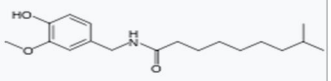
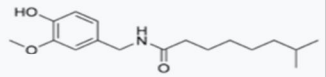
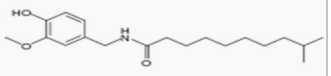
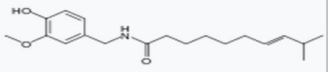
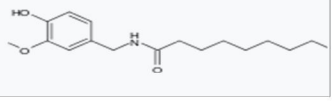
VI. RED CHILI CHEMISTRY

The most commonly occurring capsaicinoids are capsaicin (69%), dihydrocapsaicin (22%), nordihydrocapsaicin (7%), homocapsaicin (1%), and homodihydrocapsaicin (1%) Besides the five natural capsaicinoids (table below), one synthetic member of the capsaicinoid family exists: vanillylamide of n-nonanoic acid (VNA, also PAVA) used as a reference substance for determining the relative pungency of capsaicinoids.

Capsaicinoid name	Abbrev.	Typical relative amount	Scoville heat units	Chemical structure
Capsaicin	C	69%	16,000,000	
Dihydrocapsaicin	DHC	22%	15,000,000	
Nordihydrocapsaicin	NDHC	7%	9,100,000	
Homodihydrocapsaicin	HDHC	1%	8,600,000	
Homocapsaicin	HC	1%	8,600,000	
Nonivamide	PAVA		9,200,000	

A. *Plan of Work*

1) *Procurement of sample : we will take red chili from plant* genus *Capsicum.*
2) *Preparation of samples:*

- Dyeing with varying time & temperature
- Dyeing with varying concentration of dye solution

- Comparative study of K/S values of all set of samples.
- K/S values of samples dyed for 40 minutes with varying temperature
- Dye saturation concentration of red chili on cotton at fix temperature for 40 minutes
- Study the nature of the dye by buffer test, we get that the PH of the dye is 6.09

VII. EXPERIMENTAL METHOD

1) In this experiment, bleached cotton fabric will dye with red chili natural dye to determine the most optimum dyeing conditions (Time, Temperature and Concentration of dye). In order to do that, first cotton fabric will dye at 40^0C, 50^0C, 60^0C, 70^0C, 80^0C and 90^0C with a varying time that is 10 min, 20 min, 30 min, 40 min, 50 min, 60 min, 70 min and 80 min at each temperature.
2) The samples were then taken to spectrophotometer to check the surface colour strength (K/S).With the values obtained, most optimum time and temperature profile for dyeing of cotton with Red chili was determined. Using that optimum value, dyeing process was further continued with varying dye concentrations ranging from 5% own to 27.5% own with an interval of 2.5%.Now surface colour strength of the new samples were measured.

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Dyeing with various time and temperature

First of all, the stock solution (1%) of red chili natural dye was prepared. For this, 1 gram of dye powder was pasted with T.R. Oli and then 100 ml of distilled water was added. The solution was stirred for 10 minutes.

A. Recipe and Conditions

Shade percentage – 10
Acetic acid - 3% on the weight of material.
Dyeing temperature-40^{o}C
Dyeing time – 10 min, 20 min, 30 min, 40 min, 50 min, 60 min, 70 min, 80min.
pH – 4
MLR – 1:100

B. Dyeing with Varying Concentration of Dye Solution

Using the optimum time temperature profile for dyeing of cotton with red chili natural dye, dye bath was prepared. Cotton had been dyed with 5% shade, to27.5% shade at certain time and temperatures.

For this process, the stock solution (1%) of Indian Madder natural dye was prepared. For this, 1gram of dye powder was pasted with T.R. Oli and then 100 ml of distilled water was added. The solution was stirred for 10 minutes.

C. Recipe and Conditions

Shade percentage – 5% to 27.5%
Acetic acid - 3% on the weight of material.
Dyeing temperature-40^{o}C
Dyeing time – 40 min
pH – 4
MLR – 1:100

VIII. DYE EXHAUSTION & FIXATION

1) The dye uptake by the cotton was determined using a UV visible light spectrophotometer and the dye-bath absorbance was measured at the wavelength of maximum dye absorption (λmax). The percentage of dye-bath exhaustion (E) was calculated using Eq. (1) where A0 and A are the absorbance of the dye solution at the maximum wavelength before and after the process, respectively.
2) The use of reflectance values (R) to determine the concentration of dye in the fabric is well established and the relationship between R and K/S is shown in Eq. (2) The colour strength of the dyed fabrics was expressed as K/S values obtained for the unsoaped and soaped fabrics. The fixation of adsorbed dye (F) was calculated using Eq. (3) and the total fixation of the original applied dye (T) was calculated using Eq. (4) .(3) and (4) where the subscripts 1 and 2 indicate values obtained before and after soaping respectively.
3) Fastness The dyed samples were tested according to ISO standard methods

IX. EXPERIMENT DETAILS & RESULTS

1) K/S value of dyed cotton samples at 40^{o}C with variable time scale.
2) Surface colour strength measurement of samples: The samples so prepared were taken to reflectance spectrophotometer for surface colour strength measurement.
3) It is seen that surface colour strength increases with an increase in time from 10 min to 40 min. After 40 minute, the surface colour strength slightly decreases and remains unchanged with respect of time.

Time (min)	10	20	30	40	50	60	70	80	
K/S Value	3.51	3.74	4.28	4.84	4.35	4.2	4.21	4.23	

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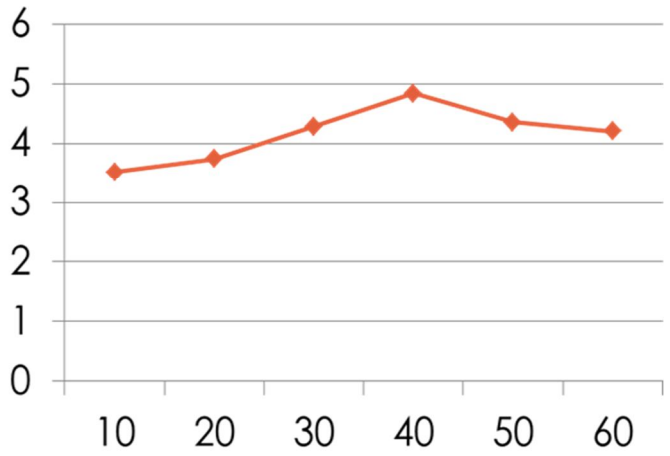
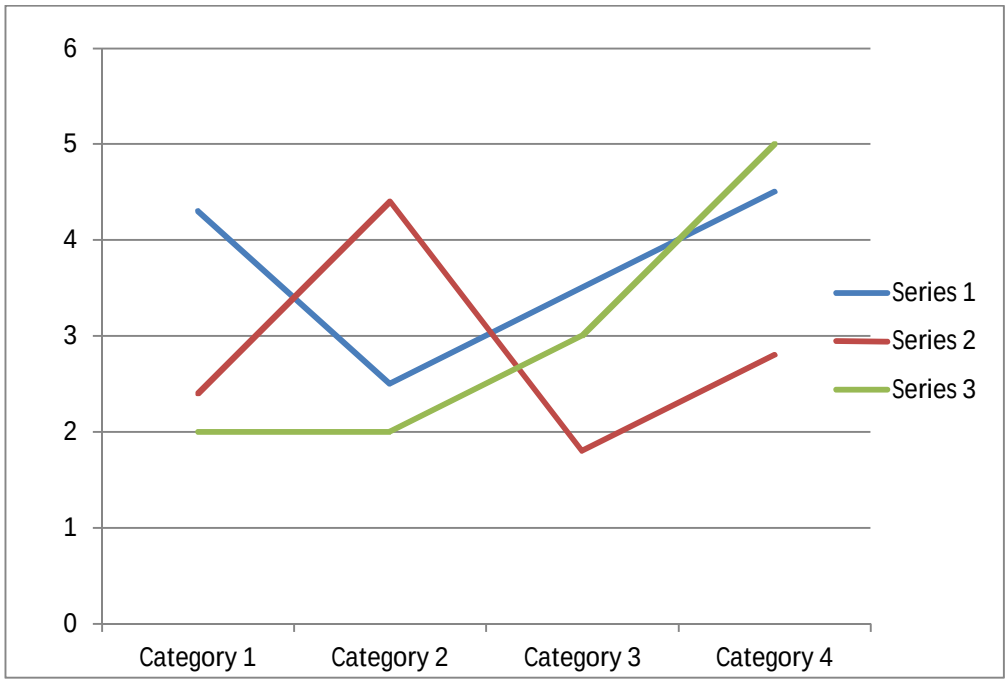
fig:1



▶ **K/S value of cotton dyed with Indian red chili with variations in dyeing time.**

The above table and figure shows that when cotton fabric is dyed with Indian red chili natural dye,an increase in surface colour strength is observed till 40 min. The same is noticed to decrease when the dyeing process is carried out for 50 to 80 minute.



Time(min)	10	20	30	40	50	60	70	80
K/S value	3.74	4.01	4.24	4.42	4.15	4.10	3.95	3.99

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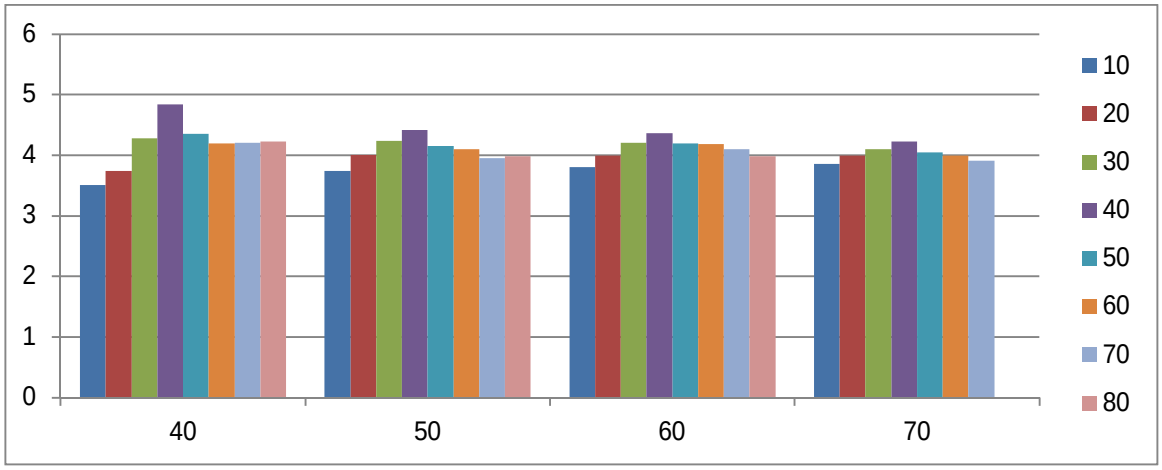
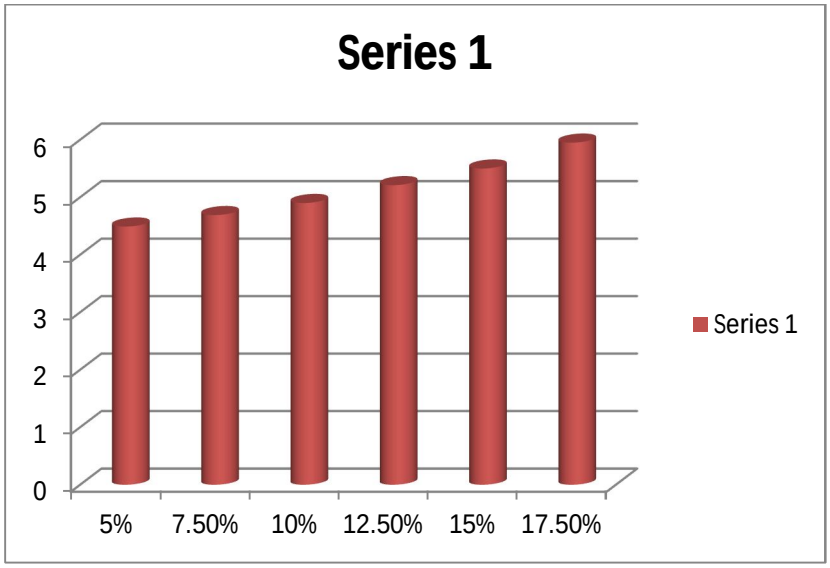
Min temp	10	20	30	40	50	60	70	80
40	3.51	3.74	4.28	4.84	4.35	4.2	4.21	4.23
50	3.74	4.01	4.24	4.42	4.15	4.10	3.95	3.99
60	3.81	4.00	4.21	4.37	4.20	4.19	4.10	3.99
70	3.86	4.00	4.10	4.23	4.05	4.00	3.91	3.93



Dye saturation concentration of Indian red chili on cotton at 40oC for 40 min:
Concentration of Dye 5% 7.5% 10% 12.5% 15% 17.5% 20% 22.5% 25% 27.5%
K/S value 4.49 4.69 4.90 5.21 5.50 5.95 6.33 6.32 6.30 6.33
Study of varying concentration of dye at a specific time and temperature had been done. The surface colour strength of the samples are shown in the above table and fig .

It is seen that, with an increase in concentration of dye, the surface colour strength increases up to 20%. No significant change in the value is observed thereafter. As, the values seem to have got the saturation at that point.



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X. CONCLUSION

From the above data which are found from the experiment, it can be concluded that

1) Maximum exhaustion is found in the sample which was dyed at 40^0C for a time period of 40 minutes. No significant change above the said time and temperature is recorded. So, for dyeing of cotton fabric with Indian red chili natural dye, it is advisable to keep the exhaustion temperature 40C and exhaustion time 40 minute. So, less amount of energy is needed and the process is time saving also.

2) Though above study was carried out using 10% dye concentration, it is found that the surface colour strength increases when the dye concentration is increased up to 20%. So, for darker shade, higher amount of dye can be used.

3) Maximum exhaustion at equilibrium decreases with an increase in temperature. That is why, it is better to keep the exhaustion temperature at 40^0C

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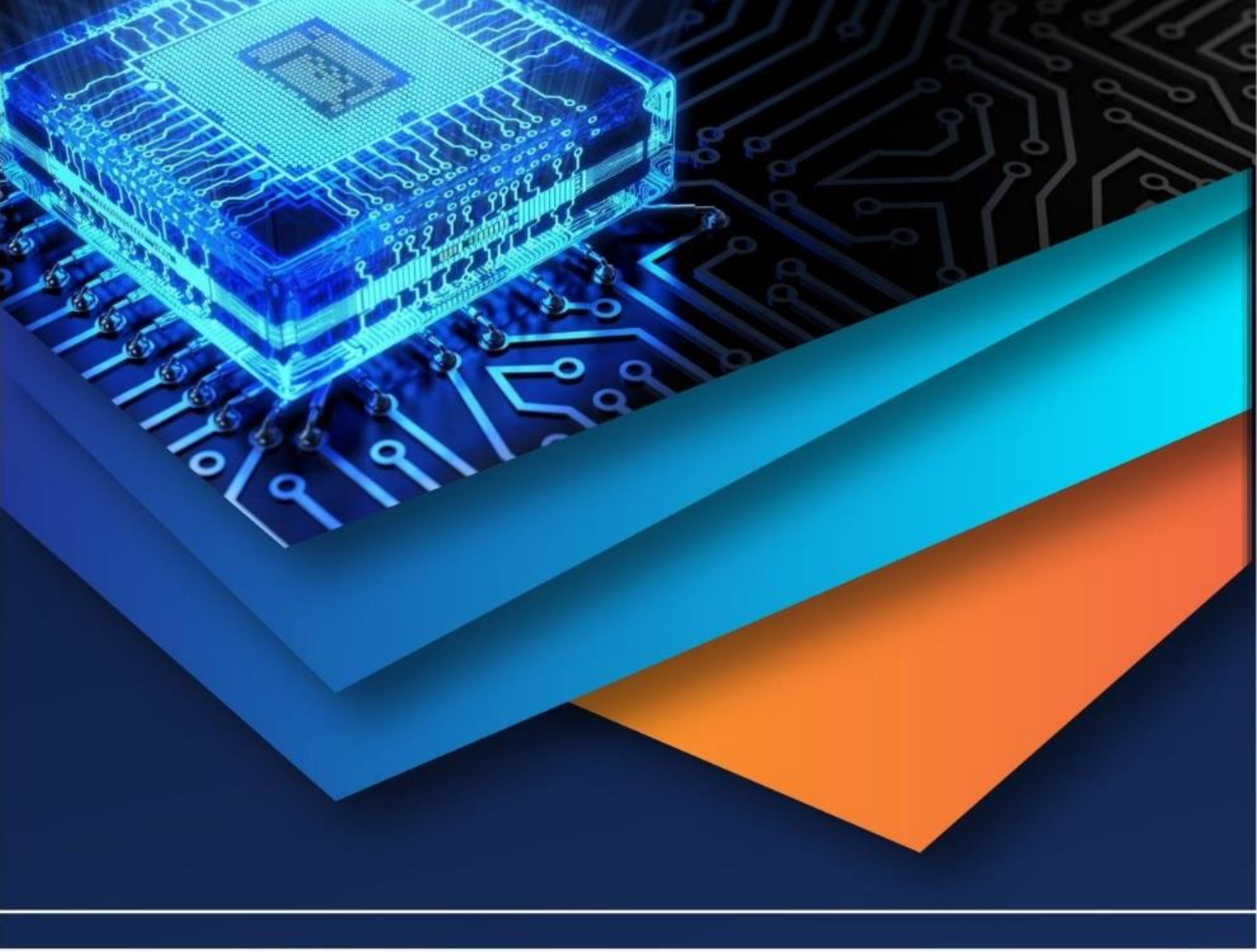

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