IOSR Journal of Polymer and Textile Engineering (IOSR-JPTE)
e-ISSN: 2348-019X, p-ISSN: 2348-0181, Volume 1, Issue 4 (Sep-Oct. 2014), PP 10-13
www.iosrjournals.org

Effects of temperature on the dye uptake of leather with anionic dyes

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Abstract: *The leather used was obtained from cow hides; goat and sheep skins. The dyeing of the leather was carried out with the use of anionic dyes: direct dyes (Solophenyl black) and acid dyes (Erionyl red, Ingrain black and Amido black). It was found that dyeing the leather with Ingrain back which is a metal complex dye had the highest dye levelling and quick rate of exhaustion, as compared to the other anionic dyes, owing to presence of metal ions which attach themselves readily to specific sites on the leather substrate, forming a strong ionic bond. It was also discovered that at certain temperature above 60°C that the leather tends to shrink and becomes strong and rigid after drying.*

I. Introduction

Leather is a difficult substrate to dye; it has structural differences as well as other imperfections. To achieve the target of a level and uniform dyeing the leather dyer (Booth, 1988) needs to be experienced and to have a thorough understanding of the dyeing properties of the dyes and auxiliaries used. Uniformly tanned leather and a suitable selection of dyes are essential for an even shade (Heidemann, 1993). It has been shown that to combine dyes of different structures, for example, the usual acid with direct dyes or 1:2-metal complex dyes, can lead to problems in achieving levelness and shade consistency (Covington, et al., 2005).

However, the appropriate auxiliaries can minimize the differences in dyeing behaviour between the dyes and the leather (Baker and Luijten, 1988). The major reason for the different dyeing behaviour of dyes in leather is their varying affinity for the leather substrate and the variations between the dyes themselves (Gordon, 1983). The behaviour of leather dyes is primarily determined by the charge of both the dye and the leather to be dyed. Differences in exhaustion rate or bath exhaustion and in build-up of the dye on specific leathers are the chief problems (Greenhalgh, et al., 1985). The affinity of a dye to leather depends mutually on the structure and state of both the dye and the substrate (leather). For the leather, it depends on the type of tannage, the presence of chemical active substances in the float, surface active agents (Gregory, et al., 2005; Li, et al., 2006) on the fibre surface, salt content of the float etc. For the dye, it depends on the structure of the dyestuff or mixtures thereof, their sensitivity to any of the dyeing conditions such as temperature, acidity, salt concentration (ionic strength) and so on. The reaction of the dye with the leather is a chemical reaction and is ruled by the laws of chemical reactivity (Lan, et al., 2000; Ramasami, 2001). This reaction is a heterogeneous one between a soluble compound and an insoluble substrate. The desired result is a surface fibre reaction that is uniform in colour regardless of whether the colour is deeply tinted or very faint. And this is necessary in spite of the fact that the substrate is quite often very uneven in structure (Covington, et al., 2005).

Acid dyes are applied below the isoelectric point of the leather in the acidic pH region. For chrome leather the isoelectric point is close to pH 7 and for retanned leather it is around pH of 4 (Sivabalan and Jayanthi, 2009). This means that for fixation of the dye, the dye bath has to be acidified at the end of dyeing for retanned leather to a pH between 3 and 4. For pure chrome leather, which really doesn't exist anymore, the acidification does not need to be as strong (Sivabalan and Jayanthi, 1985). The affinity based on the charge interactions is usually very strong for low molecular weight dyes. These dyes can be stripped easily from the leather with alkaline floats or liquids. As the molecular weight increases forces other than charge comes into play. Higher molecular dyes may often dye superficially (Borasky, 1987).

II. Materials

The materials used are: Solophenyl black (Direct dye), Erionyl red (Acid dye), Ingrain black (Acid dye), Amido black (Acid dye), NaCl (salt) and chrome tanned leather.

III. Methods

The skin was soaked in clean water for 5 hours to wash the blood and other dirt. The skin was removed from the water, drained and weighed. One gram each of the chrome tanned leather samples were cut out and used for the experiment. The dye bath was prepared as follows: leather sample = 1gm, percentage shade = 3%, liquor ratio = 50 : 1. The dye bath was prepared separately for the 2-type of dyes (direct and acid dyes) used.

The volume of the dye used can be calculated using: V = WxP/C where; W=1, P=3, C=1. Therefore; Dye solution used = 3ml. Similarly, the volume of NaCl (salt) used can be calculated using: V = WxP/C where, V=volume, W=weight (1gm), P=percentage shade (3%), C=concentration (1). Thus; Salt solution used = 3ml. This is the volume of dye and salt used, when 1gram of the dye and 1gm of salt were dissolved in 100cm3 of warm distilled water respectively. The leather samples were dyed at different temperatures.

IV. Results

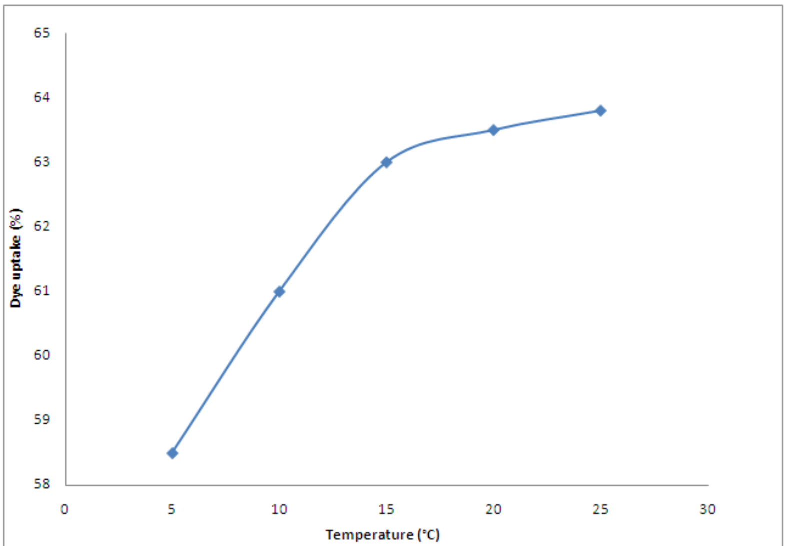

Fig. 1: Tanned leather dyeing with Igrain black (metal complex dye) at different temperature

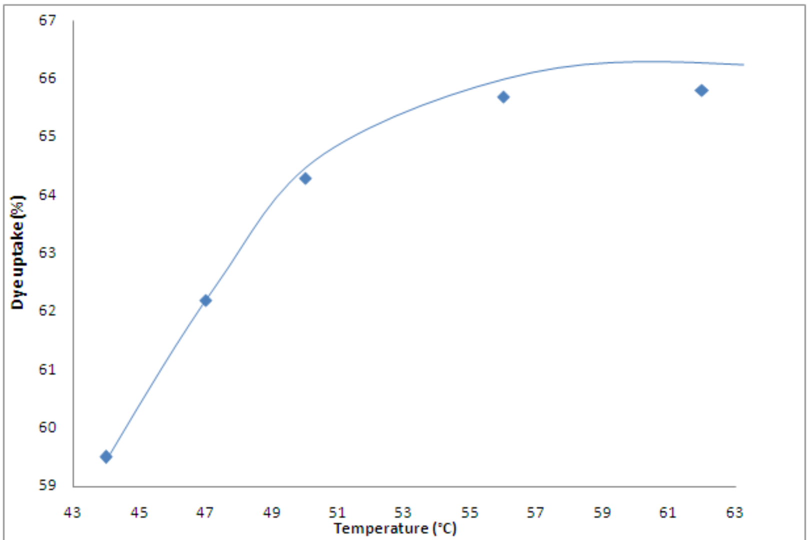

Fig. 2: Tanned leather Dyeing with C.I. Acid Black 1 at different temperture

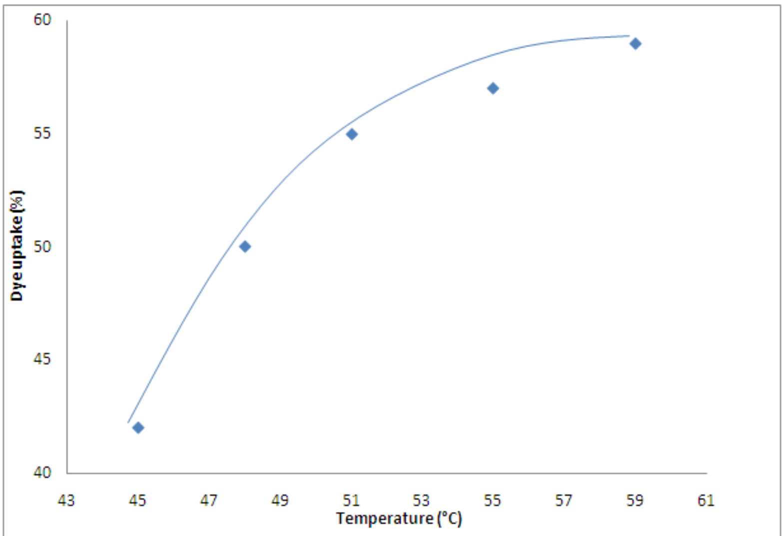

Fig. 3: Tanned leather dyeing with solophenyl black (Direct Dye) at Diffrent temperature

V. Discussion Of Results

The dye mechanisms are influenced by temperature. At high temperature, there is greater solubility, better de-aggregation and faster rate of reaction. Thus, Figures 1, 2 and 3 shows that as temperature of dyeing increases, the percentage dye uptake also increases. This effect is dependent on the dyestuff architecture such as the chromophore, premetallised and the solubilising groups. The pH affects the dissociation of the charged groups on the dye and on the leather (Lan, et al., 2000). The anionic dye in acid pH tends to "switch off its charge. If in the presence of a cationic group in the process of being "switched on" it tends to form a salt-link. In the case of direct (anionic) dyes, the molecules are so large that salt-linkage is relatively unimportant, fixation taking place between pH 4-7 (Lan, et al., 2000). Generally the larger the molecule, the poorer the penetration into the leather cross-section, however, increasing the number of sulphonic groups increases the anionic character of the dye can improve the penetration for anionic leathers. On the other hand this will reduce the depth of the dyeing, i.e. less intense, and can decrease the wet fastness if the dye is not subsequently fixed with cationic agents. Very small dye molecules, such as Acid Black 1 are able to penetrate the leather cross-section more easily but afterwards are notoriously difficult to fix successfully.

VI. Conclusion

The metal complex dye (Ingrain Black) had the best dye uptake as compared to other anionic dyes used. This is due to the presence of metal ions in its chemical structure that readily forms strong ionic bond with the leather material and a minimum damage to the physical characteristics of the leather substrate as desired in its end us. It was observed that increase in temperature increases the rate of dye uptake of the leather. It was also discovered that at certain temperature, the leather tends to shrink and becomes strong and rigid. New improved application techniques are being reinforced by new dyestuff ranges and automated process controls to meet the fast growing of modern developments in the automobile industry, clothing and textile industries, civil engineering (geotextiles), aero space and interior decorations.

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