Investigating the Effluent of Aluminum Acetate as a Pre-Mordant on Cotton Print Cloth

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Background. Aluminum mordants can be applied to textile fibers prior to natural dyeing to increase the affinity of dyes to fibers which improves color fastness properties (Haar, Schrader, & Gatewood, 2013). The residual metal ions from metal salt mordants may cause adverse impacts on the environment and public health if not properly treated (Chavan, 1995; İşmal, Yıldırım, & Özdoğan, 2014). When estimating the chemical load of simultaneous mordant and dyed fiber, aluminum effluent was below Austria's legal limit for textile effluent. Despite environmental concerns over mordant effluent, little information is available on actual amounts of mordant remaining in the effluent bath. Therefore, the objective of this study was to determine an effective method to measure metal ions remaining in an aqueous solution following the mordant process.

Methods and Analysis. Bleached and desized cotton print cloth samples (8 g) were scoured with liquid scour at 5.5% owf and sodium carbonate at 2% owf. Samples were mordanted with aluminum acetate at five concentrations (0.0, 2.5, 5.0, 7.5, and 10% owf). All solutions were aqueous reverse osmosis (RO) water 1:70 material to liquor ratio. The following liquor and substrate conditions were collected at three replications and used in the equations below.

Reverse Osmosis Water (RO): water used in mordant solution
Control Solution Liquor (CSL): mordant solution
Mordant Treatment Liquor (MTL): control solution after mordant treatment on substrate
Rinse Water (RWL): water following 60 sec continuous rotation of treated substrate
Untreated Substrate (US): cotton print cloth
Scoured Substrate (SS): scoured cotton print cloth
Mordant Treated Substrate (TS): scoured, mordant treated substrate

Inductively coupled plasma mass spectrometry (ICP-MS) technology was used to determine the amount of aluminum present in the mordant liquor and substrate samples. The Inductively coupled plasma (ICP) converted the atom of the mordants into ions and mass spectrometry (MS) separated the ions and detected only the Al ions. The equation used to determine the total aluminum present in aluminum acetate mordant available in the process was:

$$\text{Pre (Conc.)}_{Al} = \text{Post (Conc.)}_{Al} + \text{TS (Conc.)}_{Al} + \text{RW (Conc.)}_{Al} + EL$$

Where, Pre $(\text{Conc.})_{Al}$ = CSL concentrations of aluminum; Post $(\text{Conc.})_{Al}$ = MTL aluminum concentrations; EL = Loss of mordant to the environment or operational loss of aluminum acetate from the procedures. From the above equation, the actual loss of aluminum from mordanting processes is measured as:

$$\text{Actual Loss} = \text{Post (Conc.)}_{Al} + \text{RW (Conc.)}_{Al} + EL$$

Results and Discussion. The amount of aluminum absorbed by the cotton print cloth (TS), regardless of mordant concentration, was low (**2.31 -5.16%)** compared to the amount of aluminum (158.9 – 36.6 mg) in the control solution (CSL). The aluminum absorbency was most efficient at the lowest (2.5%) concentration at 5.16%. Most of the aluminum (**92.3-96.4%**) remained in the mordant treated liquor solution (MTL) across all concentrations.

Table 1

Amount of aluminum across mordanting conditions for cotton print cloth to determine actual loss of aluminum.

	Amount of mean Al (mg)						
(%) owf	US, SS, RO	CSL	MTL (%)	RWL	TS	EL	Actual Loss
2.5	US = 0.40	36.64	33.82 (**92.3**)	0.15	1.90 (**5.16**)	0.77	34.74
5.0	SS = 0.63	81.08	74.65 (**92.1**)	2.24	2.21 (**2.73**)	1.98	78.78
7.5	RO = 3.47	118.09	113.78 (**96.4**)	1.20	3.08 (**2.61**)	0.03	115.01
10.0	Total = **4.50**	158.90	145.88 (**91.8**)	1.58	3.67 (**2.31**)	7.77	155.23

Note. The sum amount of Al found in untreated, scoured fabrics (SS) and RO water were subtracted from the calculation of control (CSL), mordant treated solution liquor (MTL). The amount found in RO water was subtracted from the rinse solution (RWL).

The results of this study suggest that the aluminum acetate mordant treatment bath for cotton print cloth retains most of the metals while the fabric absorbs comparatively small amounts. If such effluent is released without filtering it may negatively impact certain environments. For example, the acidity of aluminum acetate could harm aquatic species requiring low pH for survival (Taghizadeh, Imanpoor, Hosseinzadeh & Azarin, 2013). There is also economic loss from wasted mordant. On the other hand, reuse of the mordant bath is supported which can reduce the overall amount of water usage and amount of mordant left in the final effluent. However, further research is required to measure aluminum in reuse conditions.

While the ICP-MS technology was efficient at determining aluminum, it was unable to measure acetate. In addition, such technology is expensive and may not be readily available for industry use. Thus, other technologies should be sought to measure both elements.

In conclusion, this study is one of the first to report actual amount of aluminum remaining in the mordant solution following treatment of cotton print cloth. It lays the foundation for future research on reuse of mordant solutions and examining chemical effluent of protein fiber mordant conditions.

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