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Recovery of chromium from chrome shaving dust

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Abstract:

Leather industry one of the polluting industries because of the generation of the large amount liquid and solid waste. Chrome shaving dust is one of the hazardous pollutant come out of tannery process. Treatment of chrome shaving dust is not cost effective and economic burden to the tannery. In our study we use acid and alkali to extract, chromium from chrome shaving dust. Recovery of chromium ranging from 7.87 to 70.09%. Chromium concentration was measured using Atomic Absorption Spectrophotometer. The objective of this study is to treat and the recovery of chromium from chrome shaving dust.

Key words: Chrome shaving dust, recovery, hazardous.

1. INTRODUCTION:

Tannery is one of the oldest industries of the world. Now a day the demand of leather and leather goods in the global market is about 120 million US dollars [1]. In the past few decades,

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tannery industries play an important role in the economy of Bangladesh. At present, 113 tanneries in Bangladesh among them 60 percent is located in Hazaribagh [2]. Tannery industry has been associated with high pollution due to the bad smell, organic solid waste and toxic water caused during the traditional process of manufacturing [3]. Several studies suggest that nearly 200 kg of leather is manufactured from 1 ton of raw hides and skins [4, 5]. A report from FAO revealed that approximately 8.5 million tons of solid waste are generated during the production if 11 million raw hides and skins [6]. At present 6.5 million tons of raw hides and skins are processed worldwide [7]. Solid waste consists of 56-60% fleshing, 35-40% chrome shaving, chrome split or buffing dust, 5-7% skin trimmings and 2-5% hair [7]. Depending on process chrome shaving contain 2.5- 5% chromium [8]. Chrome shaving dust mainly contains trivalent chromium which is less toxic compared to hexavalent form. Every year 4 to 6 thousand tons of basic chromium is used in the tanning process and discharge 20-40% of it as a waste [8]. From this 50 to 60 % of chrome tanning waste water and 40 to 50 % of its in chrome shaving dust generated during mechanical operation [9]. The three major ways of solid waste management are landfill, incineration and pyrolysis. Landfill can cause leaching out of chromium, which creates an environmental threat for a long period of time [10]. Several research works have indicated that chrome shaving dust may be thermally treated to produce and ash containing approximately 50% chrome oxide. Recently, some work has been done on incineration, effect of the double pyrolysis safe disposal and recovery of chromium from solid waste [11, 12]. A process for incineration and chromium recovery was developed by Jones in 1975, while Shen extracted trivalent chromium from mineral acids [9]. Macchi carried out a bench study on the recovery of chromium from tannery sludge [13]. The cost of landfilling is much higher than incineration [14]. However, the thermal incineration of solid waste is harmful to the environment. During thermal incineration, the

trivalent chromium from solid waste can form hexavalent chromium [15, 16]. The aim of this study was to prevent the environment from leaching of chromium and better management of chrome shaving dust.

2. MATERIAL AND METHOD:

Sample collection:

The study materials, chrome shaving dust were collected from local tanneries in Hazaribagh area. Hazaribagh is located between 23043.85'N to $23^0$44.05'N latitude and $90^0$21.85'E to $90^0$22.15' E longitude.

Apparatus and chemicals:

In this experiment Sulfuric acid, nitric acid, hydrochloric acid, sodium hydroxide, calcium oxide, magnesium oxide and proteolytic enzyme. All chemicals used in this experiment are industrial grade. We measure chromium concentration by Atomic Absorption Spectrophotometer (AA-7000 Atomic Absorption Spectrophotometer, shimadzu).

Extraction method:

Acid extraction:

In this work we extract chromium from chrome shaving samples using acid and alkali chrome shaving samples were placed in an Erlenmeyer flask with various concentration of sulfuric acid, nitric acid, hydrochloric acid in 1:5 weight ratio (shaving dust and acid solution). These mixtures were then shaken for 24 hours on reciprocating shaker. After shaking mixture were filtered with Wittman filter paper.

Then solid chrome shaving dust were dried and grinded. 0.5 gm of every of them were taken in XP1500 plus vessels and then 10ml of concentrated nitric acid which is followed by 2ml of conc. hydrochloric acid and allow the samples to predigest by standing open for a minimum of 15 minutes in MARS. All of the

samples were hold in the XP1500 Plus and in the MARS machine at 1600 watt with 100% efficiency and ramp time was 15 minutes at a pressure of 800psi and the temperature was selected at about 200°C. After ramp time samples were hold for 15 minutes without stirring. After receiving the samples were kept at room temperature until analysis, then concentration of chromium in solid was determined by Atomic Absorption Spectrophotometer.

Alkaline extraction:

Alkaline extraction was carried out by using magnesium oxide, calcium oxide and sodium oxide. 50gm of shaving dust were taken into a 2litter beaker. 4gm of alkali were taken into another beaker, add 1litter of deionized water and mixed well. Those alkaline solutions were then mixed with 2litter beaker containing 50gm chrome shaving dust. These mixtures were then shaken for 48 hours on reciprocating shaker. 40ml of different acid (sulfuric acid, nitric acid, hydrochloric acid) were added. Some of the samples were then filtered with Wittman filter paper after that chromium concentration was determined by AAS process which was indicated above.

For other remaining samples 0.25gm of proteolytic enzyme were added and then shaken for 30 minutes in reciprocating shaker. Then filtered with Wittman filter paper after that chromium concentration was determined by AAS process.

This two process was carried out to determine chromium extraction process from shaving dust were enhanced or not by the addition of proteolytic enzyme.

3. RESULT AND DISCUSSION:

Acid extraction of chromium from chrome shaving dust:

Table 1: Extraction of chromium from chrome shaving dust by using different acid.

Concentration of acid (M)	Initial concentration of Cr in chrome shaving dust (mg/kg)	H_2SO_4		HNO_3		HCl	
		Final conc. (mg/kg)	% recovery	Final conc. (mg/kg)	% recovery	Final conc. (mg/kg)	% recovery
1		20	7.87	29	11.4	25	9.84
2		31	12.21	47	18.50	51	20.1
3		63	24.80	81	31.89	77	30.32
4	254	87	34.25	101	39.76	89	35.04
5		121	47.64	157	61.81	149	58.66
6		141	55.51	178	70.09	171	67.32

Acid react with collagen thus weaken collagen and chromium bond. As a result chromium come out in the solution. From the above table it was found that increasing the concentration of acid, hydrolysis of collagen and chromium bond are enhanced. On the other hand HNO_3 is the better oxidizing agent and have better ability to broken down the bond between collagen and chromium. From the table it was found that at every concentration of acids recovery of chromium was maximum for HNO_3 than other acid.

Acid hydrolysis of chrome shaving dust is less popular than alkaline hydrolysis. Although HNO_3 shows better recovery of chromium than other acids. Acid and chromium salt both used in tannery industry during tanning process. So the recovered chromium could be used in tanning industry.

Alkali extraction of chromium from chrome shaving dust:

Table 2: Extraction of chromium from chrome shaving dust by using different alkali in presence of different acid without proteolytic enzyme

Alkali	Initial Con. (mg/Kg)	H_2SO_4		HNO_3		HCl	
		Final Con. (mg/Kg)	% recovery	Final Con. (mg/Kg)	% recovery	Final Con. (mg/Kg)	% recovery
MgO		104	40.94	111	43.71	107	42.13
CaO	254	97	38.19	101	39.76	91	35.83
NaOH		91	35.83	111	43.71	107	42.13

Alkaline hydrolysis is widely used method for chromium recovery and isolation from protein like chrome shaving dust. Some processes have been developed with proteolytic enzyme to remove and recovery of chromium from chrome shaving dust.

From above table 2 it was found that all alkali have nearly same ability to recover chromium from chrome shaving dust. But all other alkali MgO with HNO_3 have maximum recovery result (43.71%). Recover ability of alkali in presence of different acid without proteolytic enzyme was ranging from 35.83 to 43.71%.

Table 3: Extraction of chromium from chrome shaving dust by using different alkali in presence of different acid with proteolytic enzyme.

Alkali	Initial Con. (mg/Kg)	H_2SO_4		HNO_3		HCl	
		Final Con. (mg/Kg)	% recovery	Final Con. (mg/Kg)	% recovery	Final Con. (mg/Kg)	% recovery
MgO	254	124	48.81	141	55.51	137	53.93
CaO		111	43.7	127	50	123	48.43
NaOH		109	42.91	131	48.43	118	46.46

From the table 3 it was clear that MgO gives the better recovery ability than other alkali and in presence of HNO_3 its recover ability was maximum. Recover ability of alkali in presence of different acid with proteolytic enzyme was ranging from 42.91 to 55.51%. From table 2 and 3 it was clear that alkaline hydrolysis in presence of proteolytic enzyme have better ability extraction of chromium from chrome shaving dust.

CONCLUSION:

A large portion of chromium used in tanning process is lost as chrome shaving dust. This untreated chrome shaving dust is an environmental pollutant. In this study we treat chrome shaving dust with acid and base in presence of enzyme or without enzyme to remove chromium in an environmental friendly way. After treatment this treated chromium containing effluent can be used in tanning process.

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