ISSN : 2249 - 8877 Volume 3 Issue 2

Trade Science Inc.

Research & Reviews On Polymer

Full Paper

RRPL, 3(2), 2012 [41-46]

Improvement of thermal aging of paper sheets by soluble collagen isolated from hide shavings

Samir Kamel[1]*, El-Shahat H.A.Nashy[2], Ahmed A.El-Gendy[1], Mohamed El-Sakhawy[1]

[1]Cellulose & Paper Department, National Research Center, Dokki, Giza 12622, (EGYPT)

[2]Department of Chemistry of Tanning Materials and Leather Technology, National Research Center, Dokki, Giza 12622, (EGYPT)

E-mail : samirki@yahoo.com

Received: 10th October, 2011 ; Accepted: 10th November, 2011

ABSTRACT

Commercial solid tannery by-product of white shavings of pickled hide was pretreated, to eliminate acid and salts, and hydrolyzed under alkaline medium with potassium carbonate at pH=10. The extracted gelatin (hydrolysable collagen) was used for surface treatment of paper sheets. The effect of gelatin concentrations (0.5-2.5 %) on mechanical properties of treated paper sheets was studied. A direct proportion was noticed between collagen concentration and improvements of paper properties. Paper sheets treated with 2.5 % collagen were subjected to thermal aging under different temperatures between 100-200°C for different intervals. Mechanical properties of aged paper sheets were investigated.

KEYWORDS

Hide shavings;
Thermal aging;
Gelatin;
Mechanical properties;
Paper strength.

INTRODUCTION

A paper sheet is formed from network structure between cellulose and non cellulose (hemicelluloses and lignin). These materials are held together with hydrogen bonds[1, 2]. The improvement of bonding between these constituents in paper sheet can be achieved by increasing the crossing between the cellulose fibers. To improve the wet strength of the paper sheets, a number of resins and polymeric materials have been used such as urea, phenol- and melamine-formaldehyde resins[3] in addition to polyacrylamide, polymethylmethacrylate[4, 5] vinyl acetate–vinyl chloride copolymer[6]. Moreover, some other polymers were used to increase the resistance of paper sheets toward water absorption such as perfluorated urethane mixture[7]. The feature of good strength additives must be: (a) soluble in water based system, (b) substantive to cellulose so that its retention is efficient, (c) compatible with cellulose, (d) film forming to offer adhesive resistance, (e) contain a functional group capable of ionic or covalent bonding with paper fiber.

On the other hand generation of solid and liquid wastes during manufacturing process is unavoidable in major industries. The tanning industry emanates huge composite tanning effluent and solid wastes, which discharged in the raw state, without any pretreatment. The entire leather operations such as trimming, shavings and cutting result with more than 50% of the raw hide being rejected as waste[8]. Leather processes can be broadly divided into five major steps including hide preservation, beam-house operations, tanning, wet-finishing and

the final dry finishing processes. Beam-house operations mainly include soaking, liming/de-hairing, de-liming/ bating and pickling steps. After de-liming and bating, the hides are pickled by treated in saline solution with acid. The thickness of hide naturally varies from one part of the animal's body to another. So that, the thickness is adjusted mechanically through shavings or splitting operations to attain the required/suitable thickness.

Gelatin does not occur free in nature, and can not be recovered from horns, hooves and other non-collagen containing parts of vertebrate animals, and there are no plant sources of gelatin[9]. Today, the principal sources of gelatin are cattle bones, cattle hides and porkskins. Various alkalis and acids were used for swelling of collagen and other proteins, but swelling due to acids will have adverse effect on fibers. It has been reported that, the swelling occurs quickly in case of alkalies. A great variety of alkalies are available based on the type of cations present[10]. Therefore, the pretreatment and hydrolyzed condition are produced several verities of gelatin. In general, the main source of gelatine is the hydrolysable collagen which obtained from solid tannery wastes.

In the present work gelatin is recovered from collagen fibres by alkaline hydrolysis based on white shavings of pickled hide after pre-treatment. The extracted gelatin (hydrolysable collagen) was used for surface treatment of paper sheets. The effect of gelatin concentrations on mechanical properties of aged paper sheets was investigated.

The aim of the work is to investigate the effect of hydrolyzed white shavings on the mechanical properties of the paper sheets (Rakta paper sheets). Also the effect of ageing time and temperature on the mechanical properties of the paper sheets is studied.

MATERIALS AND METHODS

Materials

Commercial white shavings were collected from local Egyptian tanneries Cairo, Egypt.

Sodium chloride, sodium format and potassium carbonate were of A.R quality and used without further purification.

Rakta paper sheets were made from blended bleached rice straw pulp 60%, bleached bagasse pulp 20% and bleached wood pulp 20% beaten at 40 SR.

Methods

Hydrolysis of White Shavings

The shavings were first washed many times with water by shaking in a 300% float for about 30 minutes. The water was drained off, and then sodium chloride (10%) was added to float ratio and running for 15 minutes. Thereafter, the depickled shavings was washed by 1% sodium formate for further 10 min. after that, the leather pieces were washed with water for another 10 minutes.

The dried shavings are shaken in 200% float of potassium carbonate (pH=10) at 60°C until complete hydrolysis, then filtration of the hot hydrolyzed is done. After that, the hydrolyzed liquid is dried with freeze drier.

Bloom strength was determined with a TA.XT2 Texture Analyzer (Scarsdale NY). The dried gelatin give 12% weight/weight concentration are used for measurement.

Treatment of Paper Sheets

Paper sheets were dipped in the different concentration of hydrolyzed shaving solution for 30 sec. These After dipping, the paper sheets were pressed between two filter paper sheets to remove the excess polymer, and then dried on drum at 105ºC for 2 hr.

Thermal Treatments

Paper sheets from Rakta were placed in oven at 100, 120, 140, 160, 180 and 200°C for different intervals (1, 2,3,4,5, and 6hrs), then the sheets were cooled down to room temperature.

The strength property of paper sheets (breaking length and tear factor) were measured according to Tappi standard.

RESULTS AND DISCUSSION

The obtained gelatine from the hydrolysable collagen of white solid tannery wastes was used as a surface treatment of paper sheets. Gelatin (gel) strength is referred as Bloom. It is the force, expressed in grams, necessary to depress by 4 mm the surface of a gelatin gel with a standard plunger (AOAC). Bloom is linked

to mechanical elasticity of the gel and is used to classify gelatin types. It generally ranges from 50 to 300 Bloom and classified as following; Low Bloom: below 120-g, Medium Bloom: gel strength between 120 and 200-g, and High Bloom: gel strength above 200-g. The obtained gelatin has gel strength 125 –g.

Effect of hydrolyzed shaving solution concentration

TABLE 1 : Effect of hydrolyzed shaving solution concentrations on retention aid

Concentration %	0.5	1.0	1.5	2.0	2.5
Retained weight (gm/m^2)	0.39	0.79	1.20	1.61	2.11
Retention %	78.0	79.0	80.0	80.5	84.4

TABLE 1 shows a direct relation between hydrolyzed shaving solution concentrations and retention %. High retention % of about 80 was attained even with high gelatin concentrations which prove an excellent affinity of paper sheets to gelatin. Unfortunately, gelatin solubility limits the study to the maximum of 2.5 %.

Treatment of paper sheets by dipping in hydrolyzed shaving solution increases the mechanical properties of paper sheets and the higher the concentration, the higher the strength (Figure 1). This is due to the increase of the cross-linking and interfiber bonding between the fiber and polymer. Also the polymeric material contains functional groups capable of bonding by ionic or covalent bonds with the paper fiber surface. If the polymer content of the solution is increased by more than 1.5 % tear factor is level off. This can be attributed to the fact that the interfiber bonding has reached a maximum at a certain amount of retained hydrolyzed shaving solution, and this maximum result from a 1.5% hydrolyzed shaving solution. Using of 2.5% hydrolyzed shaving solution results in maximum breaking strength and due to difficulty of solubility at higher concentrations we used up to 2.5% hydrolyzed shaving solution.

Aging of Paper Sheets

Ageing of untreated and treated paper sheets at different temperatures (100-200°C) for different times namely (1, 2, 3, 4, 5 and 6 hrs) caused deterioration in the mechanical properties (Figures 2-5).

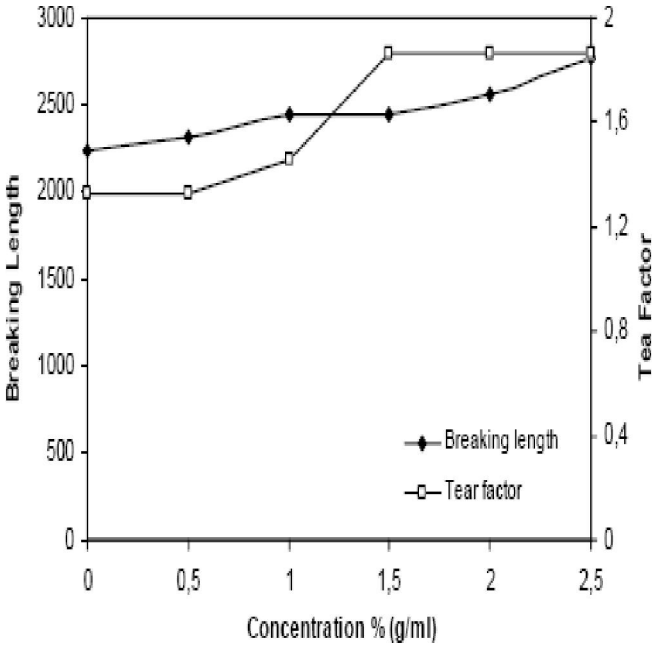

Figure 1 : Effect of hydrolyzed shaving solution concentration on th mechanical proerties of paper sheets

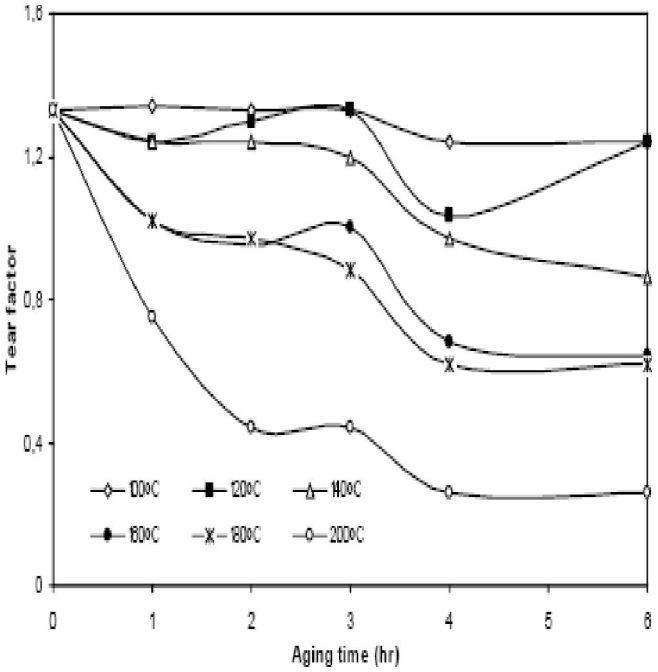

Figure 2 : Effect of aging on tear factor of untreated paper sheets

This is due to the increased degradation of the cellulosic fibers and oxidative formation of C=O double bonds, which are the reason for the yellowing of the treated sheets[11]. Loss in the mechanical properties was increased with increasing ageing time and temperature.

By comparing the tear factor of untreated and

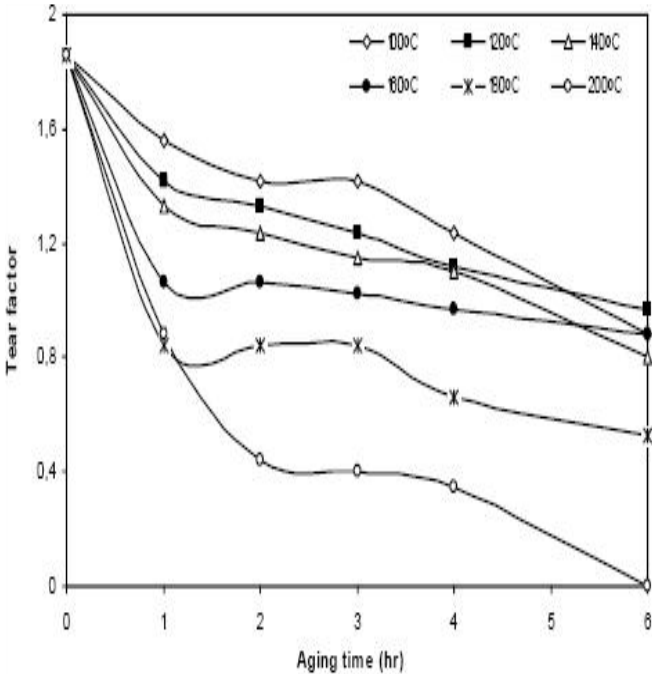

Figure 3 : Effect of aging on tear factor of treated paper sheets (2.5% HC)

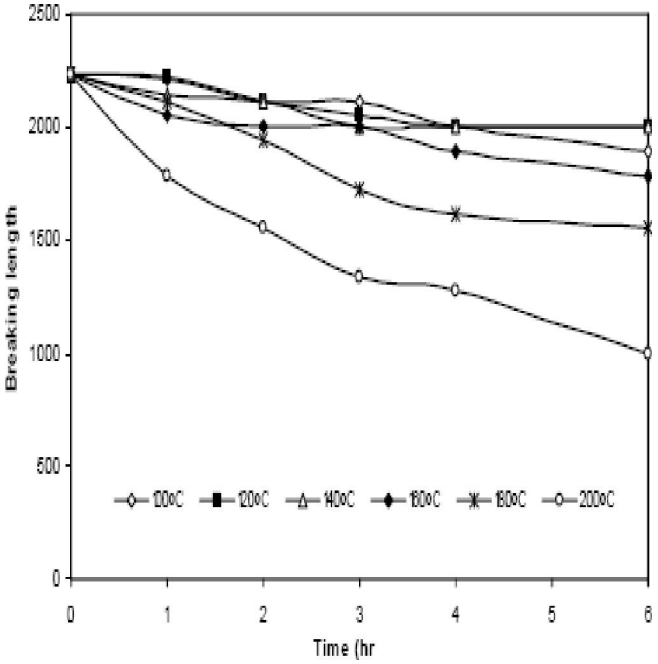

Figure 4 : Effect of aging on breaking length of untreated paper sheets

treated paper sheets at the same temperature for the same aging time, Figures 2&3, it was found that the gained improvement in tear factor of paper sheets by gelatin treatment was lost upon heating especially at higher temperature and at longer heating time. While by comparing the breaking length of untreated and treated

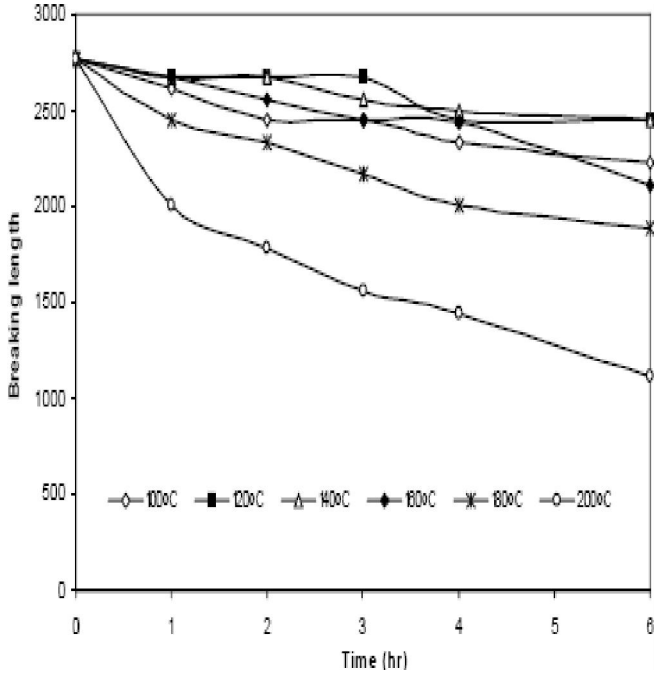

Figure 5 : Effect of aging on breaking length of treated paper sheets

paper sheets at the same temperature for the same aging time, Figures 4&5, it was found that the acquired improvement in breaking length was noticed even after aging.

Scanning Electron Microscopy

The SEM is suitable for pulp fiber and paper studies. This microscope offers high quality imaging with high resolution[12].

Composite materials containing cellulose have been of interest due to their environmentally friendly origin and high specific strength. The percolation threshold in composites is related to the homogeneousness of the mixing of individual components of the composites, hence, the surface morphological properties of untreated and treated paper sheets by dipping in 2.5% hydrolyzed shaving solution were investigated by SEM. The SEM photographs of the composites support the homogeneity of the composites and uniformity of film surface which produced. A comparison of the original paper matrix with that of coated paper sheet shows that this polymer appear to form largely on the paper fibers and that the open structure of the paper matrix has been retained (Figure 6). This provides a large available surface area of the polymer for chemical and physical interactions.

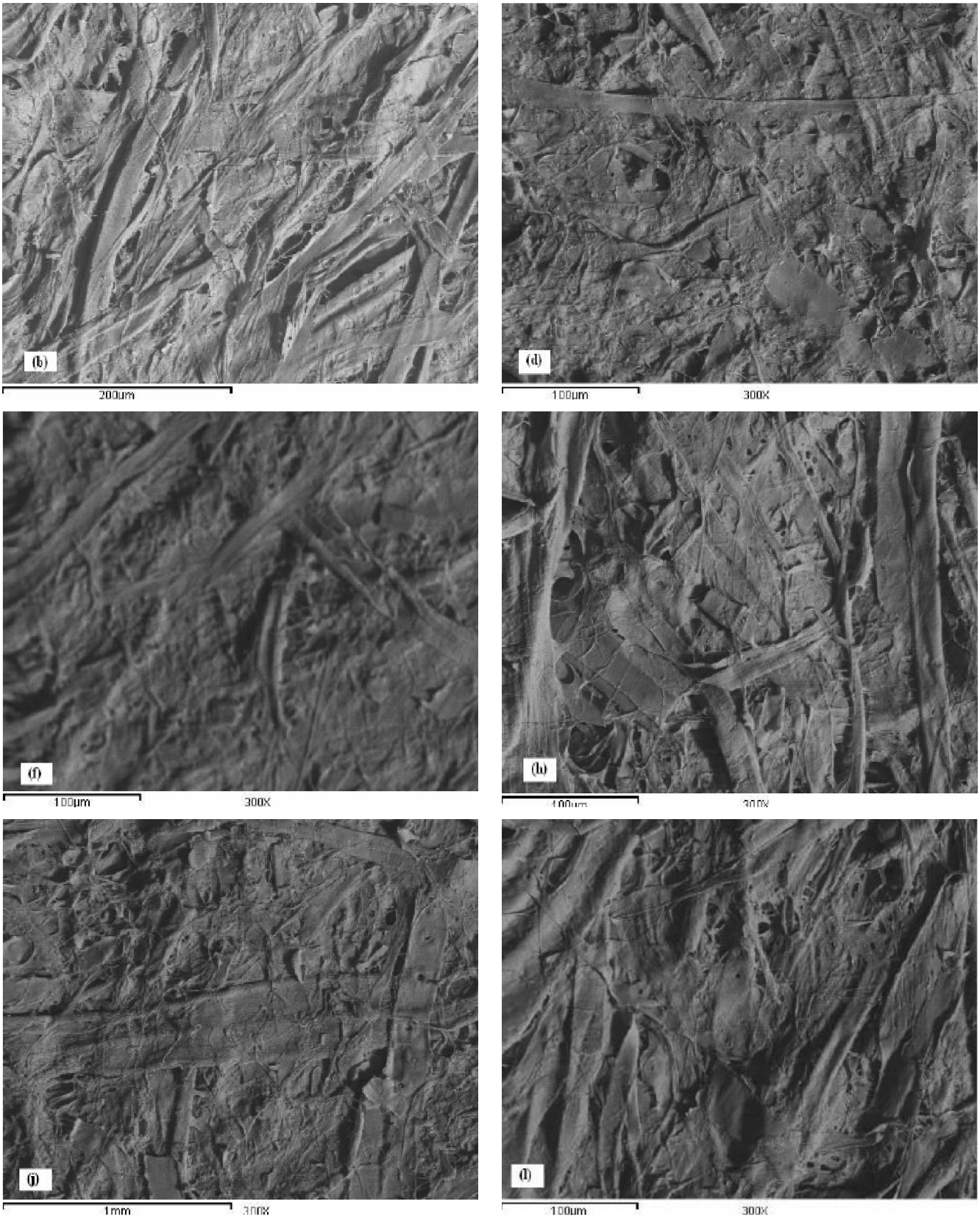

Figure 6 : SEM photographs of untreated and treated paper sheets by dipping in 2.5% HC; (b) untreated, (f) untreated and aged at 140°C for 6hrs, (d) un-aged treated, (h) treated and aged at 140°C for 6hrs, (l) treated and aged at 180°C for 6hrs, (j) untreated and aged at 180°C/6hr.

CONCLUSION

Commercial solid tannery by-product of white shavings of pickled hide could be usefully used for surface treatment of paper sheets. A direct proportion was noticed between collagen concentration and improvements of paper properties. The gained improvement in tear factor of paper sheets by gelatin treatment was lost upon heating especially at higher temperature, while the acquired improvement in breaking length was retained even after aging. The SEM photographs of the composites support the homogeneity of the composites and uniformity of film surface which produced.

REFERENCES

[1] S.Kamel, M.El-Sakhawy, A.M.A.Nada; Thermochimica.Acta., **421**, 81 **(2004)**.

[2] G.G.Allan, J.R.Fox, G.D.Crosky, K.V.Sarkman; In: Proceedings of the Transaction of the Symposium on Fiber Water Interaction in Paper-making, Oxford, 1977, Fundamental Research Committee, **(1978)**.

[3] L.Gardlund, L.Wagberg, R.Gernandt; Colloids and Surfaces A-Physicochemical and Engineering Aspects, **218(1-3)**, 137 **(2003)**.

[4] A.M.A.Nada, M.H.Abo-Shosha, N.A.Ibraheim; Polymer-Plastics Technology and Engineering, **35(3)**, 365 **(1996)**.

[5] A.M.A.Nada, H.El-Saied; Polymer-Plastics Technology and Engineering, **8**, 787 **(1989)**.

[6] A.M.A.Nada, M.H.Ayoub; Elastomers and Plastics, **29(4)**, 111 **(1997)**.

[7] M.H.Aboshosha, N.A.Ibrahim, A.M.A.Nada; Science International Journal (Lahore), **8(3)**, 251 **(1996)**.

[8] K.Ravichandran, N.Natchimuthu; "Natural Rubber-Leather Composites" Polimeros Ciencia e Tecnologia **15(2)**, 102 **(2005)**.

[9] F.C.Luisa, J.M.Andrew, C.Y.Winnie, M.T.Maryann, M.B.Eleanor, N.M.William; "Process Simulation and Cost Estimation of Treatment of Chromium - Containing Leather Wastes", **93**, 299 **(1998)**.

[10] P.Thanikaivelan, R.A.O.Raghava, U.N.Balachandran, T.Ramasami; "Approach Towards Zero Discharge Tanning, Exploration of NaOH Based Opening Up Method, **96**, 222 **(2001)**.

[11] A.M.A.Nada, S.Kamel, M.El-Sakhawy; RESTAURATOR, **21**, 238 **(2000)**.

[12] T.Helle, P.O.Johnsen; J.Pulp Pap.Sci., **20(7)**, 189 **(1994)**.