ISSN 1392–1320 MATERIALS SCIENCE (MEDŽIAGOTYRA). Vol. 9, No. 3. 2003

Forming of Fire-resisting Properties of Leathers

M. Przybyłek*

Radom University of Technology, Chrobrego27, 26-600 Radom, Poland

Received 10 September 2002; accepted 06 April 2003

This work deals with the investigation of the thermal and flammability characteristics of tanned leather based products. The materials testing under extreme conditions has been defined. It has been shown that semi-finished tanned products are slow burning materials. Moreover the burning process was dependent on the tanning methods.
Keywords: leather materials, tanning methods, fire resistance.

INTRODUCTION

XXI-st century is called the Age of Materials. A deep knowledge of the correlation between the materials structure and properties, which can be intentionally made during the production, did the basis of a branch of knowledge which forms the basis of materials engineering. Four groups of functions describe the product quality, which can be called in an other way, the group of properties, which include: performances, aesthetics qualities, a comfort and safety during the use [1, 2]. The safety function is the main parameter, because it can make a decision about health hazards and the user's life.

The main properties which define the user product's safety are the following:

- inflammable products and their ability to resist flame and incandescence, the intensity of smoke and gases emitted during combustion as well as their toxicity.
- the release from the products of specific substances with significant harmful influence on the human body under the conditions of use.

The study of a given material (product) behaviour in contact with fire and as a probable fire carrier is very important for its selection, specific application and conditions of use.

Depending on the resistance to fire, textiles are divided in three groups [3]:

- inflammable,
- slow-burning,
- non-flammable.

The products are:

- inflammable, if they burn in contact with the flame and burn completely or to the moment of oxygen depletion,
- slow-burning, if they burn, but stop burning a short time after getting away from the source of fire,
- non-flammable, if they don't burn and retain their shape, when exposed to a hot environment or to 600ºC temperature surface.

Prof. Herzog from Austrian Institution of Fibrous [4], making research of burning textiles showed that the quantity and toxicity of gases releasing during burning are the main and fastest reasons of the people death. The most dangerous toxicity product of decomposition and burning textiles are CO, HCN, HCl, NO_x and CO_2 [5]. It's known, the source of fire and outside conditions don't influence not only on the burning materials, but also their chemical composition. The structure of product affect on simple access of the oxygen from air and the same time holds up (or delays) the burning process [6, 7]. The leather is used as a material against high temperature (thermal insulation). From the thermogravimetric tests of dressed leather there aren't any distinct lists of weight, beside the beginning of excrete the water vapour. Most of the soft leather is finishing now using polymers. At the contact with hot elements, they show low resistance.

It's known that Cr (III) changes to Cr (VI) during utilization and burning of leather products [8, 9, 10].

The work was carried out to investigate effect of chemical reagents as well as conditioning methods on the fire resistance of leather based products [11].

EXPERIMENTAL

Semi-finished tanned products have been chosen for this study. They have been treated by mineral tanning agents and also by using organic compounds (syntanins, resins). The samples which have been tanned by combined procedure (i.e mineral-organic) have been also tested.

Testing Methods

In this work we have estimated the flammability and over heating parameters, which are defined as:

- No-flammability – as a process which takes place when no sample will ignite by flame and the destroyed surface doesn't exceed 0.006 m^2.

Two methods have been used to describe the materials flammability:

- Flammability determination of flat textiles, applying the specific method of the Fire Protection Research Centre ("BOP" in Józefów/ Warsaw) [8]
- Flammability determination of samples which were tested in vertical position. In this method, time which is needed to ignite sample is estimated according to ISO 6940/7-1998 norm.

*Corresponding author. Tel.: + 48-48-3617514; fax: + 48-48-3617598.
E-mail address: *jadwiga25@poczta.onet.pl* (M. Przybylek)

We define the burning (X) as a time needed to overheat the sample by using a glow electric spiral under a fixed temperature and pressure and sample thickness (PN-76/01141):

$$X = t / d,$$

where t is the average time which is needed to overheat the sample and d is the average sample thickness.

The samples have been previously conditioned during 24 h at a relative humidity of 65 ±5 % and a temperature of 20 ±2 ºC.

RESULTS AND DISCUSSIONS

The results which deal with the flat textiles flammability are presented in Table 1.

The data presented in Table 1 describe the process of burning. The samples which were treated by vegetable tanning agents burnt within 13 – 18 s and samples which were treated by chromium tanning agents after 20 s.

Table 1. Flammability of flat textiles samples

Parameters	Tanned leather based samples								
	Vegetable			Chrome-vegetable			Chrome		
Time needed to keep the sample in contact with the flame (s)	60	120	180	60	120	180	60	120	180
Time of sample's ignition (s)	13	15	18	–	68	60	20	20	20
Burning of samples without flame (after turning off the flame (min)	0	0	0	>10	>10	>10	>10	>10	>10
Destroyed surface (%)	1.5	3.5	4.0	1.0	7.1	15.5	1.3	11.6	15.0
Observations	[3]Sampes are glowing in flame			[1'2'3] The smoke is emitted			There is a little smoke, the sample is burning and de-forming after 60 s.		

For samples which were tanned by vegetable agents burning without flame has not been noticed. Others samples were burnt without flame more within more than 10 min.

Surface of flame destructed materials has been analyzed at the end of the testing. As shown in Figure 1, the destruction of all samples was the same after 60 s – 1.3 %. The less destruction was achieved after 120 s for samples which were tanned by using vegetable – 3.5 %. The destruction (4.0%) has been made after 180 s for samples which have been tanned by using vegetable agents, and about 15.0 % for samples tanned simultaneously with chrome and vegetable.

The results of investigations of flammability for samples which were in vertical position are presented in Tables 2 and 3.

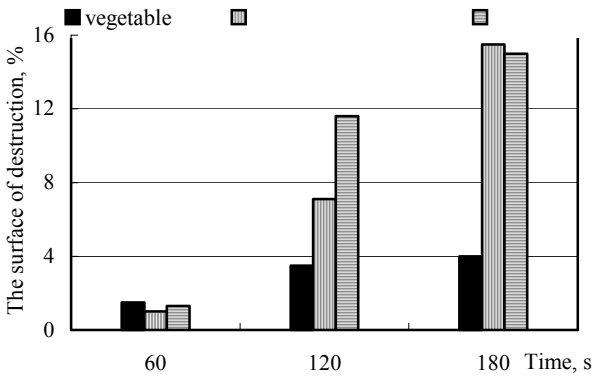

Fig. 1. The destroyed surface of leather samples which have been tanned vs time

Table 2. Flammability of leather tanned samples

Tanning methods	Number of samples	Time needed to maintain the sample in contact with the flame (s)	Burning time after the sample is away from the flame (s)	Results
Vegetable	1	60	-	0
	2	65	3	0
	3	70	7	x
	4	65	2	0
	5	70	4	0
	6	75	10	x
	7	70	6	x
	8	65	-	0
	9	70	5	x
	10	65	-	0
Chrome-vegetable	1	23	14	x
	2	21	10	x
	3	19	7	x
	4	17	-	0
	5	19	3	0
	6	21	6	x
	7	19	4	0
	8	21	7	x
	9	19	5	x
	10	17	-	0
Chrome	1	15	6	x
	2	13	-	0
	3	15	3	0
	4	17	12	x
	5	15	7	x
	6	13	1	0
	7	15	8	x
	8	13	5	x
	9	11	-	0
	10	13	6	x

Fig. 2 illustrates the time of ignition of the tested samples. The best results are for the samples which have been tanned in vegetable way.

Average values of flame resistance to burning of leather samples for different tanning methods are presented in Table 4.

Table 3. Flammability resistance of the tested samples

Tanning methods	Time needed to maintain the sample in contact with the flame (s)	Amount of burned samples	Amount of unburned samples	Average sample's ignition time of (s)
Vegetable	75	1	0	71
	70	3	1	
	65	0	4	
	60	0	1	
Chrome-vegetable	23	1	0	19
	21	3	0	
	19	2	2	
	17	0	2	
Chrome	17	1	0	14
	15	3	1	
	13	2	2	
	21	0	1	

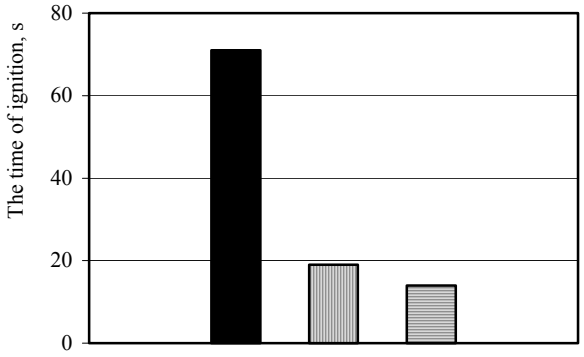

Fig. 2. The ignition time of tanned leather samples (marked as in Fig. 1)

Table 4. Leather resistance to burning

Samples of leather which have been tanned	Average sample thickness, *d* (mm)	Average time of burning, *t* (s)	X (s/mm)	Average (s/mm)
Vegetable	1.16	6.67	5.75	5.11
	1.15	5.33	4.63	
	1.08	5.33	4.94	
Chrome-vegetable	2.26	30.00	13.27	13.42
	2.28	31.00	13.59	
	2.14	28.67	13.39	
Chrome	1.76	3.67	2.08	2.37
	1.69	3.33	1.97	
	2.06	6.33	3.07	

As shown in Figure 3, the samples which were tanned by using simultaneously chrome and vegetable agents, gave the best resistance to burning. The obtained result was 13.42. The samples which were tanned using chrome agents had the worst result (2.37).

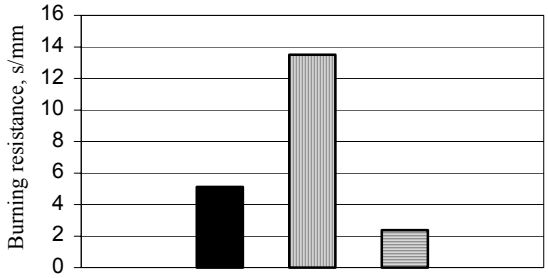

Fig. 3. Burning resistance of tanned leather samples (marked as in Fig. 1)

CONCLUSIONS

On the basis of the obtained results one may conclude:

Semi- finished tanned products can be described as slow – burning materials, however the burning character was dependent on the tanning methods.

The samples which have been tanned using vegetable agents, were flame resistant, but the samples showed very small resistance in contact with glowing metal.

The samples which have been tanned by using chromium agents had low resitance to flame and glowing metal.

The samples which have been tanned by using vegetable and chromium agents have shown the greatest resistance to burning.

REFERENCES

1. **Brzeziński, S.** Safe Consumption of Textiles. *The 3rd International Conference ANALITIKA in Łódź*. Poland, November 2000: pp. 1 – 14.
2. **Krauze, S., Muskalska, J.** Analysis of Textiles Concerning Harmful Substances, which are Emitted during Termal Decomposition. *The 3rd International Conference EKOTEXTIL* Poland, May, 1997: pp. 1 – 9.
3. **Żylińsk, T.** Textile Metrology. WNT Warsaw, 1973: 400 p.
4. **Herzog, W.** Burning as Advantageous Form of Recycling *International Symposium Intercarpet in Baden,* Austia,1993: pp. 12 – 16.
5. **Gaugihofer, J.** Thermal Resistance Estimation of Tanned Leather with Chrome. Bibliography Report CTE-Lyon 20 1995: pp. 21 – 27.
6. **Brzeziński, Z., Kilińska, D., Zatorski, W.** Procedures of Reduction of Inflammability of Plastics *Plastics Review* 10 2001: pp. 65 – 69.
7. **Brzeziński, Z., Kilińska, D., Zatorski, W.** Inflammability of Polymers *Plastics Review* 8 2001: pp. 65 – 69.
8. **Zhang, X., Jiang, X., Liu, M.** Determination of Trace Chromium VI Ion in Chrome Tanning Agents by Flow Injection Analysis *Journal of the Society of Leather Technologists and Chemists* 88 (6) 2000: pp. 255 – 257.
9. **Ferreira, M. J., Almeida, M. F., Pinto, T.** Influence of Temperature and Holding Time on Hexavalent Chromium Formation during Leather Combustion *Journal of the American Leather Chemists Association 3* 1999: pp. 135 – 138.
10. **Krzywicka, A., Boros, L., Graczyk, B., Glanc, Z.** The Technology of Tanning Stable to Heat Leather which are Used to Producing Cloths and Gloves *Leather Industry Institute* 19 1975: pp. 67 – 72.
11. **Pawłowa, M., Przybyłek, M., Kinach, A., Rokicki, J.** Investigation of Resistance to Flame, Tanning Semi Finished Products. International Conference: "Design, Materials, Leather Technology, Clothing and Shoes", Radom – Poland, 2001: pp. 143 – 148.