Paper B15

Study on biodegradation of several chrome-free goat garment leathers

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ABSTRACT

The biodegradability of chrome tanned leather, vegetable tanned leather, organic phosphonium tanned leather, organic phosphonium-zirconium combination tanned leather and organic phosphonium-aluminum combination tanned leather was studied by outdoor soil burial method. When these leathers were buried in outdoor in summer for 150 days, their biodegradation rate reached to 6.87%,27.50%,19.92%,34.83% and 80.88%, respectively. The DSC analysis showed that the glass transition temperature (Tg) of leathers with good biodegradability were lower than that with bad biodegradability. The results of SEM observation showed that the surface of leathers obviously became rough after biodegradation. The biodegradability of organic phosphonium-zirconium combination tanned leather and organic phosphonium-aluminum combination tanned leather were much better than that of organic phosphonium tanned leather, which illuminated that zirconium and aluminum were benefit for the growth of microorganisms and as well as strengthened the biodegradability of leathers. The vegetable tanning agent was natural product, so the biodegradability of vegetable tanned leather was good. The biodegradability of chrome tanned leather was the worst as chrome was poisonous to microorganisms. The study provided theoretical support for the production of environmentally friendly leather and the alleviation of environmental stress.

Introduction

It was reported in the seventeenth congress of the communist party, that the sustainable development strategy should be better implemented; the development quality and efficiency also should be improved to archive rapid development and found the firm basis for socialism with Chinese characteristics. Therefore, it is necessary to implement the green strategies for the sustainable economic development in China. The content of the strategy include developing recycling economy to improve the use efficiency of resource; developing clean production to reduce the pollution cost in production; developing green consumption to reduce ecological destruction; developing new energy to thoroughly transform the production methods and leap to the eco-industrial civilization, forming friendly environment between

people and nature. So it is necessary to study the biodegradability of finished leather to give the guidance for the sustainable and healthy development of leather industry and reduce ecological destruction to the environment during the consumption process. In the study, the biodegradability of chrome tanned leather, vegetable tanned leather, organic phosphonium tanned leather, organic phosphonium-zirconium combination tanned leather and organic phosphonium-aluminum combination tanned leather was studied by outdoor soil burial method.

1 Experimental

1.1 Materials and equipments

chrome tanned leather, vegetable tanned leather, organic phosphonium tanned leather, organic phosphonium-zirconium combination tanned leather and organic phosphonium-aluminum combination tanned leather were self-prepared; NETZSCH STA 409 PC / PG thermal gravity analyzer was produced by NETZSCH Instrument company in Germany; KYKY1000B scanning electron microscope(SEM) was made by instrument factory of Chinese Science academy.

1.2 Process of biodegradation

In biodegradation process the survival organisms trigger and catalyze the structure transformation of organic pollutants. While the microbial degradation is the heterotrophic microorganisms decompose organic compounds which are as carbon and energy sources, as a result, the microbial biomass increases and the chemical structure of the parent compound changes. The biodegradability is defined as the degree that microorganisms make certain substances change its original physical and chemical structure.

In theory, all organic substances can be degraded by microbe, but in fact the process is very complicated. According to the degradation degree of organic substances, they can be divided into easily biodegradable, biodegradable and difficultly biodegradable.

Organic substances in soil took on different degradation degree. The easily degradable components include saccharides with simple structure, starch, cellulose and hemi-cellulose, protein and polypeptide. In degradation process these substances were firstly decomposed. With the decrease of easily degradable substances, cellulose wrapped by lignin began to be degraded. The biodegradation is a slow decomposition process.

Experimental procedure: The samples of tanned leather with uniform size were buried under the soil 10cm. After certain days, the weight loss of the buried samples was measured, and the samples were scanned by SEM to characterize the sample surface.

1.3 Characterization

Synthetical thermal analysis: The carrier gas was nitrogen and its flow was 20mL/min. The temperature was controlled by program and the heating rate was 10K/min.

SEM observation: The leather samples were dried at 105°C for 5h, and then were plated by gold and observed by SEM.

2 Results and Discussion

2.1 Biodegradability of finished leather

Biodegradability of chrome tanned leather, vegetable tanned leather, organic phosphonium tanned leather, organic phosphonium-zirconium combination tanned leather and organic phosphonium-aluminum combination tanned leather was shown in Table 1.

Table 1 The effect of time on biodegradability of leather

Time(d)	The rate of biodegradation(%)				
	chrome tanned leather	vegetable tanned leather	organic phosphonium tanned leather	organic phosphonium-zirconium combination tanned leather	organic phosphonium-aluminum combination tanned leather
3	1.66	5.91	2.61	5.53	4.42
7	2.01	6.97	2.65	5.63	6.50
14	3.30	8.69	4.17	9.37	9.13
21	5.30	12.78	6.99	15.84	15.47
30	5.65	16.34	10.05	16.33	19.63
45	5.78	19.14	12.01	22.19	20.53
72	5.95	25.89	15.58	28.90	32.02
135	6.15	26.67	19.56	33.60	60.79
150	6.87	27.50	19.92	34.83	80.88

As shown in Table 1, along with increase of the time, the biodegradation rate of these leathers increased. 150d later, the biodegradation rate of chrome tanned leather, vegetable tanned leather, organic phosphonium tanned leather, organic phosphonium-zirconium combination tanned leather and organic phosphonium-aluminum combination tanned leather respectively reached to 6.87%, 27.50%, 19.92%, 34.83% and 80.88%. Compared with other leathers, the degradation rate of chrome tanned leather was the minimum, the reason was the trivalent chromium made microorganisms poisoned and hindered its normal growth. The vegetable tanning agent was natural product, so the biodegradability of vegetable tanned leather was better than that of chrome tanned leather. The biodegradability of organic phosphonium-zirconium combination tanned leather and organic phosphonium-aluminum combination tanned leather were much better than that of organic phosphonium tanned leather,

which illuminated that zirconium and aluminum were benefit for the growth of microorganisms and as well as they could strengthen the biodegradation of leathers. It can give guidance for the sustainable development of leather industry to know about the biodegradability of chrome tanned leather, vegetable tanned leather, organic phosphonium tanned leather, organic phosphonium-zirconium combination tanned leather and organic phosphonium-aluminum combination tanned leather.

2.2 Analysis of DSC

Because the degradability of organic phosphonium-aluminum combination tanned leather was the best, its DSC spectrum before and after biodegradation was characterized. The results were shown in Figure 1 and Figure 2.

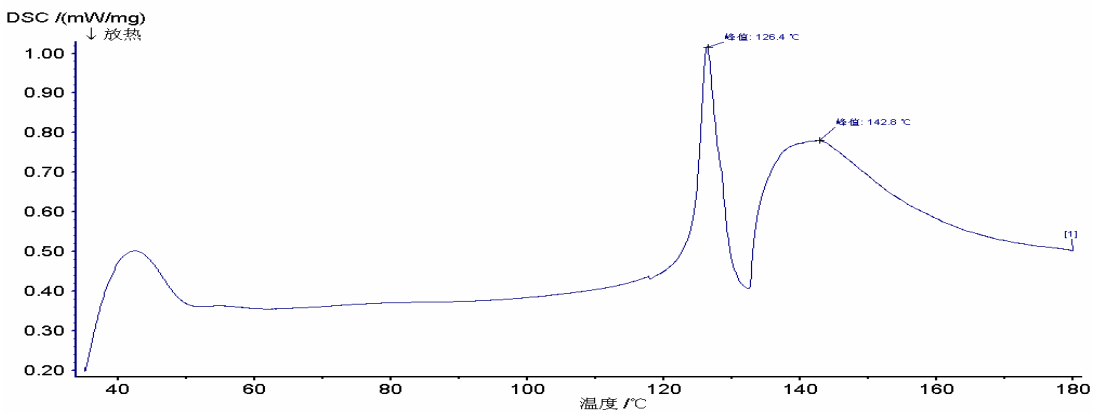


Fig.1 The DSC spectrum before biodegradation of organic phosphonium-aluminum combination tanned leather

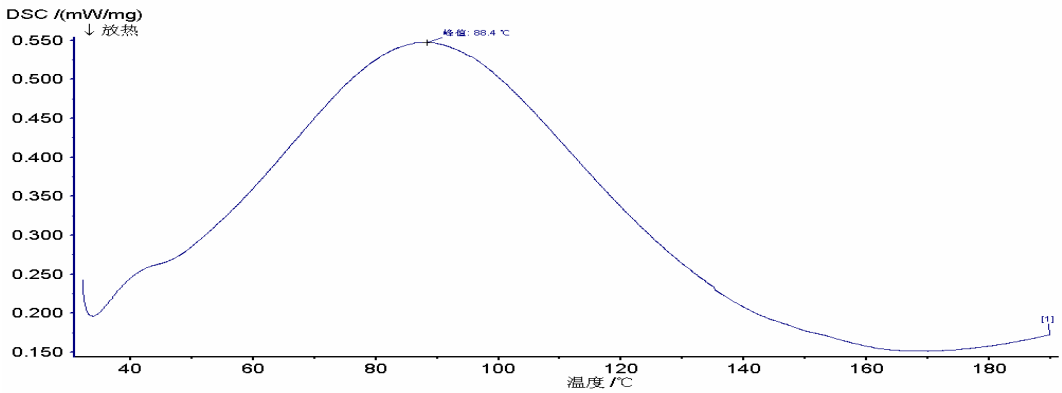


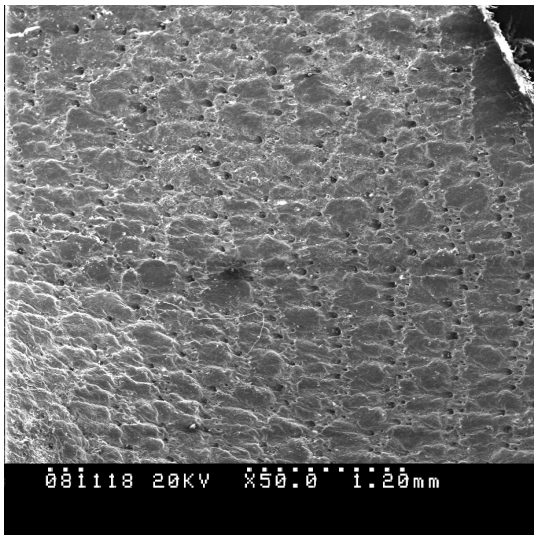
Fig.2 The DSC spectrum after biodegradability of organic phosphonium-aluminum combination tanned leather

The shrinkage temperature (Ts) reflects the critical condition of phase transformation from triple-helical collagen fiber structure to amorphous crimp state. For leather, the Ts usually is used to characterize the thermal stability of finished leather. The tanning process is the combination between tannins and collagen fibers in skin; consequently the thermal

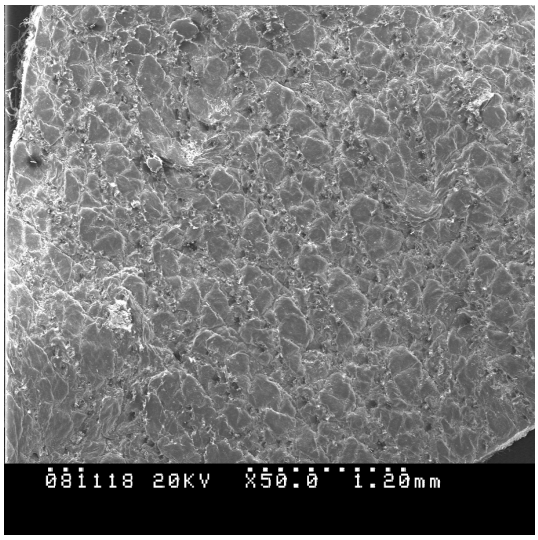
stability of leather is improved to meet the application requirements. As the DSC can sensitively track and capture the phase transformation of substances under heating condition, the DSC can be used to measure the thermal denaturalization properties of collagen fibers. It can be seen from Figure 1 and Figure 2 that after biodegradation of organic phosphonium-aluminum combination tanned leather, the thermal denaturation temperature of collagen fibers reduced from 126.4°C to 88.4°C. This was because the structure of collagen fibers was destructed by microbial degradation; as a result, the thermal stability was reduced.

2.3 SEM Observation

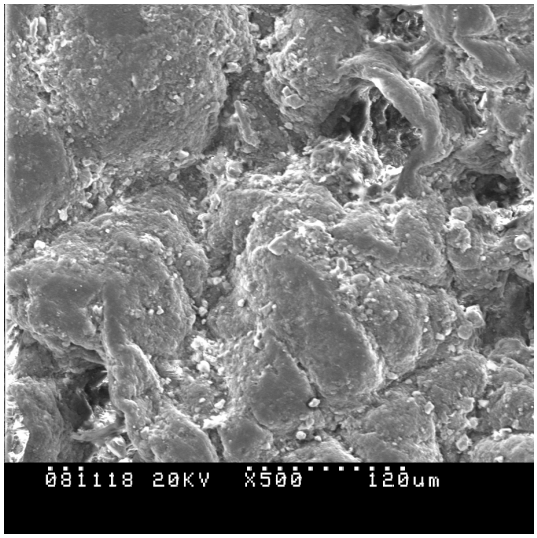
The degradability of organic phosphonium tanned leather and organic phosphonium-aluminum combination tanned leather was observed by SEM. The results were shown in Figure 3 and Figure 4.



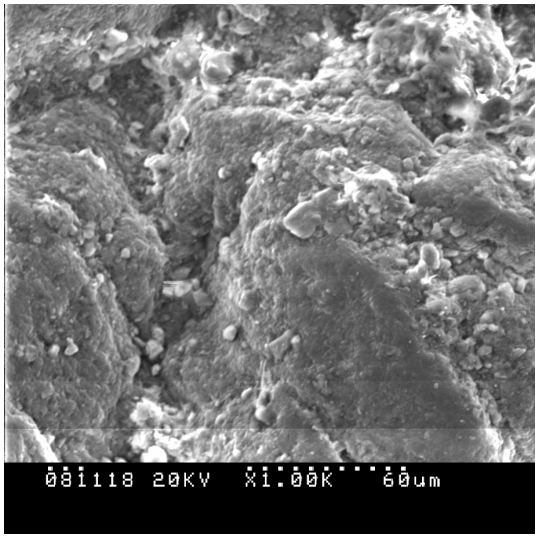
a. undegraded leather(magnification 50)



b. degraded for 150d(magnification 50)

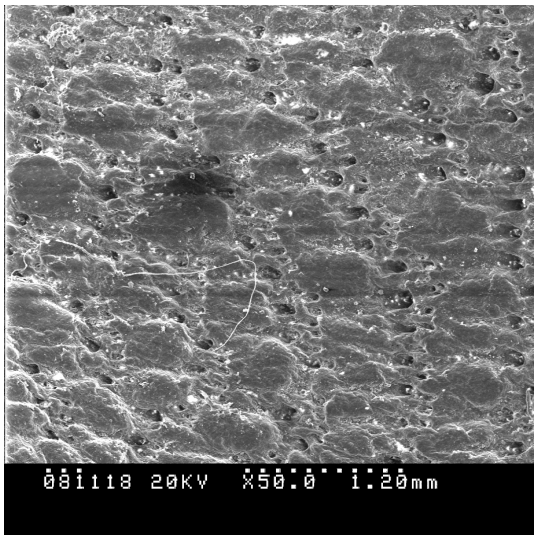


c. degraded for 150d(magnification 500)

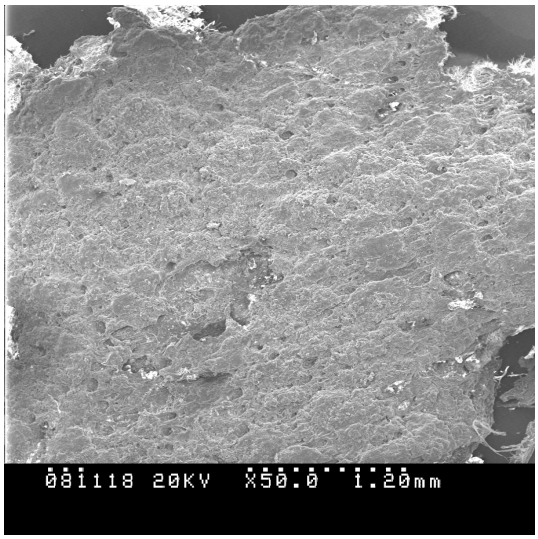


d. degraded for 150d(magnification 1000)

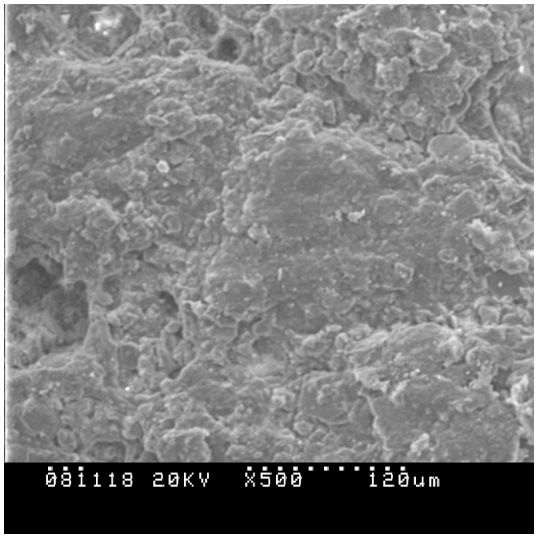
Figure 3 SEM images of organic phosphonium tanned leather



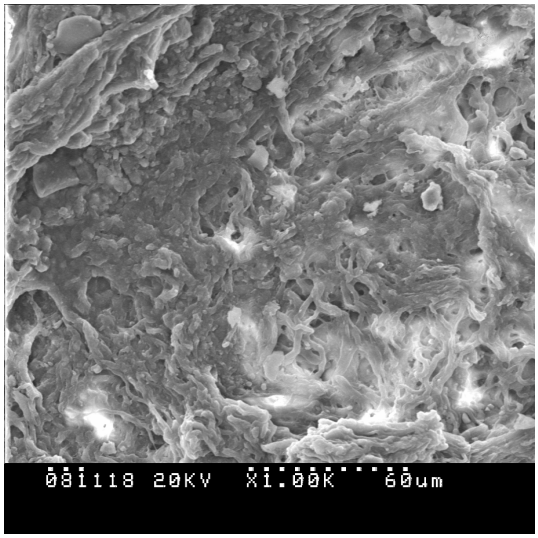
a. undegraded leather(magnification 50)



b. degraded for 150d(magnification 50)



c. degraded for 150d(magnification 500)



d. degraded for 150d(magnification 1000)

Figure 4 SEM images of organic phosphonium-aluminum combination tanned leather

As described in Figure 3 and 4, 150d later, microbe destructed the natural grain of the leather to make the grain more uneven. From the SEM images of organic phosphonium tanned leather and organic phosphonium-aluminum combination tanned leather degraded for 150d, it was obvious that the biodegradability of organic phosphonium-aluminum combination tanned leather were much better than that organic phosphonium tanned leather.

3 Results

3.1 150d later, the biodegradation rate of chrome tanned leather, vegetable tanned leather, organic phosphonium tanned leather, organic phosphonium-zirconium combination tanned leather and organic phosphonium-aluminum combination tanned leather respectively reached to 6.87%, 27.50%, 19.92%, 34.83% and 80.88%.

3.2 After biodegradation of organic phosphonium-aluminum combination tanned leather, the thermal denaturation temperature of collagen fibers reduced from 126.4°C to 88.4°C. This was because the structure of collagen fibers was destructed by microbial degradation; as a result, the thermal stability was reduced.

3.3 From the SEM images of organic phosphonium tanned leather and organic phosphonium-aluminum combination tanned leather degraded for 150d, it was obvious that the biodegradability of organic phosphonium-aluminum combination tanned leather were much better than that organic phosphonium tanned leather.

Acknowledgements

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