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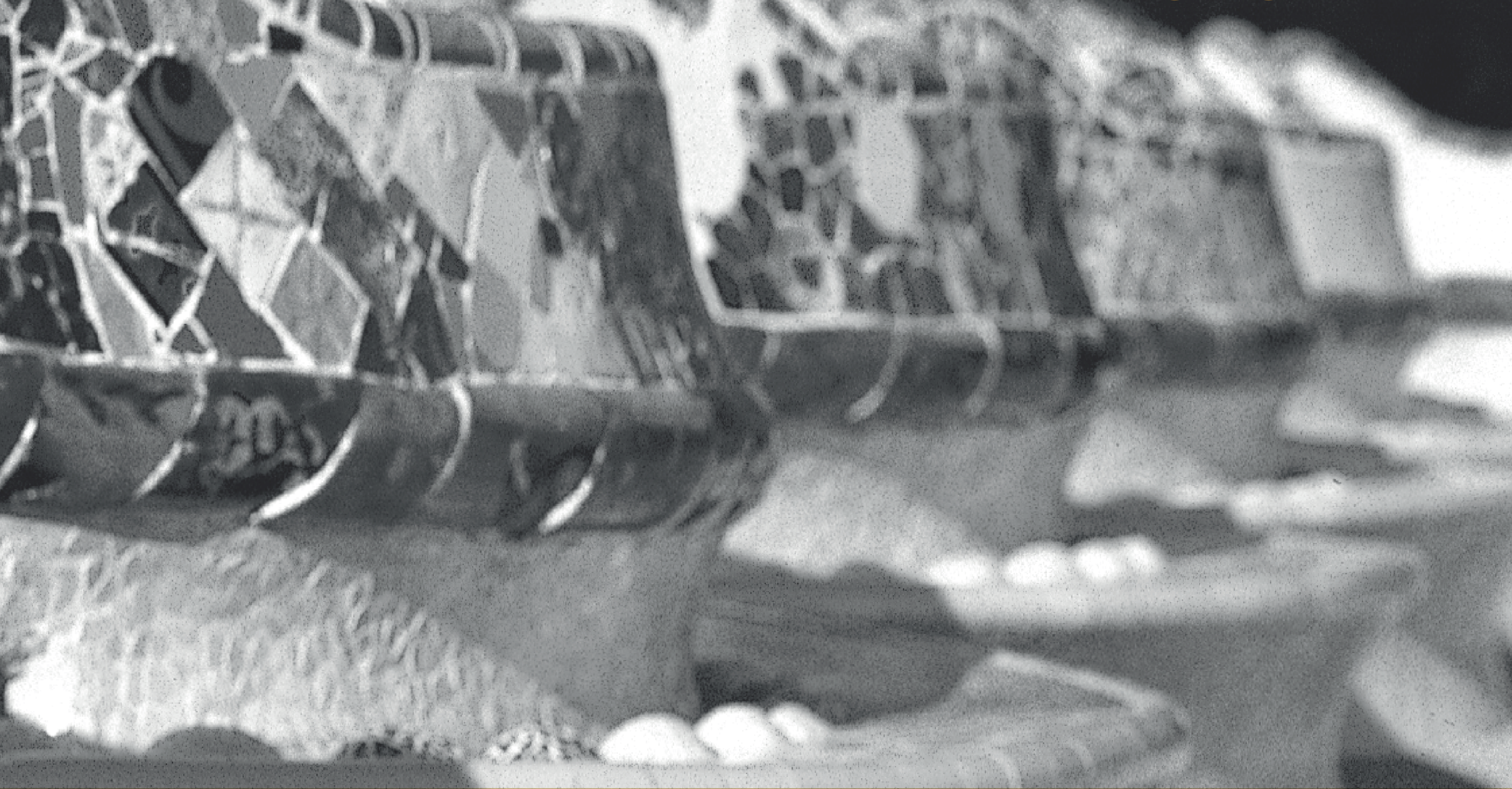

ERSCP 2019 BARCELONA

15-18 October 2019, Barcelona

19th European Roundtable on Sustainable Consumption and Production

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INSTITUTE FOR Sustainability Science AND TECHNOLOGY

PROCEEDINGS

of the

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Circular Europe for Sustainability: Design, Production and Consumption

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Institute for Sustainability Science and Technology (ISST-UPC)
Universitat Politècnica de Catalunya – BarcelonaTech
C/ Jordi Girona, 1 – 3
08034 Barcelona
Spain

Phone: +34 934 05 43 91 - email: institut.sostenibilitat@upc.edu
http://is.upc.edu

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Editors' Preface

The European Roundtable for Sustainable Consumption and Production - ERSCP is one of Europe's most remarkable conferences in its field and has taken place periodically since 1994. ERSCPs favour discussions about the key issues in sustainable consumption and production, the exchange of thoughts, knowledge, experiences and SCP proposals and the creation of a European (also worldwide) community of research and practice in sustainable consumption and production. The main goal of the ERSCPs is to encourage discussion amongst stakeholders involved in sustainable consumption and production: businesses, public institutions, universities, institutes and research centres, NGOs, SMEs, professional associations, decision-makers, etc.

The 19th European Roundtable for Sustainable Consumption and Production Conference was held in Barcelona, from 15 to 18 October2019. It was organised by the Institute for Sustainability Science and Technology of the Universitat Politècnica de Catalunya - BarcelonaTech in cooperation with the ERSCP Society.

Participants from almost 40 different countries contributed their work to the conference. Different parallel events took place during the event, such as the 'Circular Design Conference'; the 'European Network for Research, Good practice and Innovation fur Sustainable Energy - ENERGISE'; a discussion session on Sustainable Consumption and Care held by the 'Sustainable Consumption Research and Action Initiative – SCORAI Europe' and a PhD day. The 19th ERSCP encouraged event sustainability among its participants and took action to organise a sustainable conference through diverse initiatives, such as proposing a voluntary CO^2 compensation programme, promoting a zero-waste conference event, and fostering specific sustainable consumption practices.

19th ERSCP conference proceedings are organised in a 'Book of abstract' and a 'Book of full papers'; the latter, consisting of two volumes. Respectively, 196 abstracts and 110 full papers are included. Each book and each volume has a separate ISBN number. The proceedings will be available for conference delegates and ERSCP members in digital format.

CONFERENCE TOPICS

- Circular design
- Circular Economy
- Circularity through public procurement
- Creative approaches in sustainable consumption & lifestyle
- Cross cutting design
- Cross Cutting Policy
- Cross cutting transdisciplinarity
- Cross-cutting innovation
- Design and consumption
- Designing consumption
- Disruptive high – tech solution to promote sustainability in industry and tertiary sector
- Education for sustainable transitions
- Food and waste
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Two experimental outcomes from solid waste of leather industry

Silvia Pérez-Bou[1], Amaia Zuazua-Ros[2], Marina Vidaurre[3], César Martín-Gómez[4]

[1]*Dept. of Theory, Projects and Urbanism, Universidad de Navarra, 31009 Pamplona, Spain, sperezb@unav.es* [2]*Dept. of Construction, Building Services and Structures, Universidad de Navarra, 31009 Pamplona, Spain, azuazua@unav.es* [3]*Dept. of Construction, Building Services and Structures, Universidad de Navarra, 31009 Pamplona, Spain, mvidaurre@unav.es* [4]*Dept. of Construction, Building Services and Structures, Universidad de Navarra, 31009 Pamplona, Spain, cmargom@unav.es*

Abstract

Leather industry is an example of circular economy, using meat industry wastes (hides and skins) as raw materials. However, it also produces a big amount of organic waste in the process of tanning. This paper presents an experimental study of several proposals to reuse the weekly tons of left-overs (both shavings and hair) issued by a tannery, as new resources, instead of taking them to an external composting plant or to the landfill. Three different types of solid wastes (chromium and vegetable tanned shavings, and discarded hair) have been characterized and analysed to obtain biomass and acoustic panels for building industry. The calorific values of the discarded hair and the shavings have been analysed both in wet and dried samples. After testing the samples according to the Spanish Norm UNE-EN 141918:2011, the results showed that the calorific value obtained from the dried hair is higher than the standard values considered for general biomass, forestry biomass or even wood pellet. Thus, bearing in mind that the plant already has installed a cogeneration system, the daily discarded hair obtained in this tannery, after the processing of drying, would cover completely the gas consumption coming from the boiler installed for the heating demand of the industrial plant, and part of the consumption from the gas engines. The wet hair gives no interesting results. The second approach to the waste has been to look for new products in building sector. After obtaining the granulometry of both chromium and chromium-free leather shavings, different tests were done with different additives: gypsum, glue, cement, cement plus latex, resin, cement plus sand and latex resin. The mechanic tests showed no interesting results in terms of resistance to flexion or compression in gypsum composites. However, the results in terms of acoustic absorption are good, giving similar data as agglomerate cork or some carpets. The outcomes of the experimental research have been promising, as they open several paths to get the maximum use of leather solid waste.

Keywords: Waste Leather**,** Cogeneration, Acoustic absorption, Circular Economy

1. Introduction

Leather industry is an important player in the global economy with an estimated trade value of approximately US$100 billion per year (UNIDO, 2010). Moreover, it is an example of the industrial symbiosis of circular economy (Park et al., 2010), as more than 99% of the world leather production comes from the processing of raw hides and skins from

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animals raised mainly for milk and/or meat production (Brugnoli, 2012). Although the consume of red meat in developed countries is decreasing, for developing countries is increasing. Predictions indicate that the supply of leather raw material will continue to follow in growth with population (FAO, 2016;

Pringle et al., 2016; UNIDO, 2010). The average production in 2012-2014 reached more than 7 million tonnes of raw hides and skins, being more than 6.5 million bovine and nearly 0.5 sheep. In number of pieces, we had for the same period, an average of 364 millions of bovine hides, 550 millions of lambskins and 486 millions of goat and kidskins per year. Only in Spain, the average production from 1999 to 2014 has been 2.5 million pieces per year of bovine hides and skins, with a slight decreasing the last years (FAO, 2016).

Leather industry generates a significant quantity of solid wastes: 0,7 kg/kg of hides or skins processed, according to different authors (Kluska et al., 2018, Pringle et al., 2016; Sekaran et al., 2007; World Bank, 1999), or a wider range depending on the processes or raw materials: 0,45-0,73 kg/kg, World Bank (2007). Currently, a great amount of these by-products is sent to landfill generating serious environmental damages. There is an increasing concern about how to diminish the undesirable effects of this industry. Some recovery or disposal options existing are: extraction of organic material for fertilization or pharmaceutical industry, thermal incineration (incineration, gasification and pyrolysis), vermin composting, regenerated leather, etc., (Pringle et al., 2016; Sekaran et al., 2007; Yilmaz, 2007).

This experimental project has been the response to a tannery located in Spain, highly committed to circular economy and environmental aspects. In that factory, they receive the raw material (hides and skins) and do the main operations: pre-tanning, tanning (both chromium and chromium-free), dyeing, and finishing. We have used three kinds of solid waste generated during the pre-tanning and tanning processes: discarded hair, chrome shavings trimmings and buffing dust from fleshing. The daily amount of wet discarded bullock-hair in that tannery is about 10 tonnes, while the amount of dried wet-blue trimmings is 2 tonnes.

We have conducted two experimental researches. On the one hand, the study about the use of buffing and hair waste as fuel source for heat production and, on the other the potential of the shavings and buffing dust as construction material for the design of acoustic panels.

2. Methods

As explained before, the experimental experience is divided in two different topics. On the one hand, the study about the use of buffing and hair waste as fuel source for heat production and on the other the potential of the shavings and buffing dust as construction material for the design of acoustic panels.

Waste of the leather industry as biomass:

At a first stage, the calorific value of the waste is measured and analysed. The waste material studied are both, the buffing dust and the discarded bullock hair. For the test, the standard UNE-EN 14918:2011 "Solid biofuels - Determination of calorific value" was used as a reference.

Regarding the discarded hair, the raw waste material is wet with high humidity since it is the output of the first cleaning and pre-tanning step of the process. Thus, in order to evaluate the possibility of using this material without any pre-combustion drying process, the potential of the wet waste as fuel source is also considered. In this case, the characteristics of the raw material under study led to the adaptation of the standard to the requirements of the material.

The standard defines the tests to measure the Lower Calorific Value (LCV), which corresponds to the heat of the combustion that does not consider the energy of water condensation, and the Higher Calorific Value (HCV), which considers the energy from the condensation of water vapor.

In this context, the waste material samples tested are the wet hair (Base Wet Hair, BWH), the dry hair (Base Dry Hair, BDH, this sample follows the drying process defined in the standard) and a wet white shaving sample (Base Wet White, BWW), which follows the standardized drying process.

Once the results are obtained, a comparison of the outputs of the lower calorific values with other biomass materials is made to evaluate its potential. Besides, a brief study and analysis of energy savings to assess the possibility of replacing the use of natural gas for the heating plant with the waste material from the factory itself.

Waste as new material for the construction industry

First of all, we reviewed the existing literature on the research about recovery of leather by-products to use in the building industry. We have not found specialised centres, but some approaches in preliminary phases using these materials as additives in cements, and their performance in mechanic and thermic terms.

We begin mixing trimmings with gypsum in different proportions, to study the new panels' mechanic properties.

Then, we proposed the use of these discarded materials as acoustic panels, due to the lightness of the buffing dust and the huge amount of waste material generated by the industrial plant. Regarding this application, the method followed is divided in two steps.

First, a review of binders used in ceiling panels is carried out in order to select several components to develop the experimental samples. At the same time, the granulometry of the waste material is analysed in order to evaluate the size and amount of material per sample. After numerous combinations, finally ten samples of possible panel compositions are chosen to be tested. The binders used in these samples are cement, latex resin, gypsum and wood glue. Regarding the size of the shavings, the samples are divided in two groups, those under 4 mm diameter and those over 8 mm.

Second, an acoustic study is made following the standard UNE EN ISO 10534-2 "Acoustics - Determination of sound absorption coefficient and impedance in impedances tubes". Thereby, a comparative study between the different options of samples finally chosen is made.

3. Results and Discussion

Biomass potential

We have obtained Higher Calorific Value (HCV) and Lower Calorific Value (LCV) in MJ/KG of the respective samples: discarded hair (both wet and dry) and wet-white bullock shavings.

Table 1. *Results of the determination of the calorific value in MJ/kg.*

Sample	HCV	LCV
Dry hair (BDH)	20.3	19.1
Wet hair (BWH)	5.7	3.7
Shavings (BWW)	21.4	20.0

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As we can extract from these results, the use of wet hair directly from the process of leather tanning to obtain biomass is to be dismissed, because of its low calorific value, being HCV 5.7 MJ/Kg and LCV 3.7 MJ/Kg insignificant compared to dry hair and shavings. So, in order to use discarded hair as biomass, we need to take a drying process.

Nonetheless, the results of both dry hair (BDH) and wet-white bullock shavings (BWW) are surprisingly promising if we compare them with the Low Calorific Value of the materials currently used for biomass in cogeneration, as we can see in the next figure. They are significantly higher than the standard values like general biomass, forest industry biomass or even wood pellet.

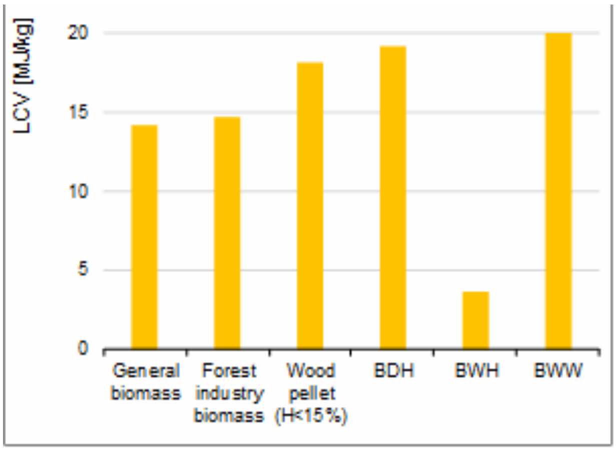

Figure 1. *LCV of the samples analysed in comparison with other common products used for biomass.*

The industrial plant we have worked with has already installed a cogeneration system. We have compared the current production in MWh with the potential production of waste material analysed, in order to determine the savings' possibilities.

As we have said before, the daily amount of waste in an ordinary working day in this tannery is 10 Tn hair and 2 Tn wet-white shavings.

Taking as a reference the consumption of the installed gas boilers and gas engines, the annual thermal energy generated is 21,285 MWh, being 4,100 MWh from the gas boiler and 17,185 MWh from the gas engines.

As a preliminary assessment, the results obtained from the calorific value test are used to calculate the potential of using these wastes as biomass. Hence, after applying a performance coefficient and calculating the monthly production of the factory, it can be considered that the thermal energy obtained from the BDH is 9,788 MWh and from the BWW is 2,050 MWh.

Table 2. *Annual thermal energy production in MWh.*

Current production		Waste material studied	
Gas boiler	Gas engines	BDH	BWW
4,099.8	17,184.8	9,788.8	2,050.0

Considering both BDH and BWW together, the waste would represent 56% of the real heat production.

The thermal production from BHD would completely replace the heat produced by the natural gas boilers. However, is not enough to totally replace the production from the gas engines.

As a result of this experimental research, we propose to substitute the gas boiler by discarded dry hair used as biomass.

It is not finished the evaluation of the possible savings using shavings as biomass and the in-depth analysis of the combustion gasses (in order to measure the sulphur amount).

Building panels

The second approach to the waste has been to look for new materials in building sector, first in different blends and, finally, as acoustic panels.

After obtaining the granulometry of both chromium and chromium-free leather shavings, we did several tests with different additives: gypsum, glue, cement, cement plus latex, resin, cement plus sand and latex resin. The mechanic tests show no interesting results in terms of resistance to flexion or compression in gypsum composites. Those are not included in this paper.

Another experimental approach has been to blend trimmings with bioplastics, using corn starch, Kraft paper pulp and two plastic polymers (LDPE and EVA 20%). In the latter case, the polymer and shavings mixture was crushed by mechanical grinding under cryogenic conditions to produce films of different compositions (10% or 50% shavings).

In the mixture of trimmings with these thermoplastics (LDPE and EVA) to produce the corresponding composite material, grinding produces a homogeneous material of good appearance and with acceptable mechanical properties at a qualitative level up to 10% LDPE and 50% EVA.
The mixture with Kraft paper pulp gives a mouldable product with similar texture and characteristics to the ones used in packaging. We need further investigation to study the sustainability and recyclability conditions of this product.

The mixture with corn starch is not satisfactory, as it gives an extremely soft and mechanically weak product

The mixture of trimmings with PLA in order to create a filament to 3D printing requires specific equipment not available in our laboratory. In consequence, the results of the samples are not profitable.

Table 3. *Composition of the different samples tested as acoustic panels*

Sample number	Binder	Ø shaving (mm)	Binder	Water	Shaving (WB o WW)
1.	Cement	<4	33,3%	33,3%	33,3% (WW)
2.	Cement	>8	33,3%	33,3%	33,3% (WW)
3.	Cement + latex	<4	30,0%	40,0%	30,0% (WW)
4.	Cement + latex	>8	30,0%	40,0%	30,0% (WW)
5.	Gypsum	<4	30,0%	50,0%	20,0% (WW)
6.	Gypsum	>8	30,0%	50,0%	20,0% (WW)
7.	Latex	<4	16,7%	33,3%	50,0% (WW)
8.	Latex	>8	16,7%	33,3%	50,0% (WW)
9.	Glue	varied	2,0%	49,0%	49,0% (WB)
10.	Glue	>4	2,0%	49,0%	49,0% (WB)

We had ten different samples, according to shavings' size, the proportion of binder, water and shavings (both wet blue and wet white, chromium and chromium-free respectively). Next images show the samples, following what is stipulated by the standard UNE EN ISO 10534-2.

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Figure 2. *Samples for the tests of acoustic performance according to the standard UNE EN ISO 10534-2.*

We sent the samples to Tecnalia, a company specialised in building technologies, in order to do the acoustic tests and the results are shown in Table 4.

Table 4. *Mean values of Acoustic Absorption Coefficient of the ten samples*

	Mean values of Acoustic Absorption Coefficient incidence rate normal, α									
f(Hz)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
50	0,03	0,01	0	0,02	0,01	0	0,02	0,02	0,05	0,01
63	0,04	0,01	0,01	0,03	0,01	0,01	0	0	0,03	0,01
80	0,05	0,02	0,03	0,04	0,02	0,02	0,01	0	0,05	0,02
100	0,06	0,05	0,05	0,05	0,03	0,03	0,02	0,02	0,06	0,04
125	0,07	0,06	0,07	0,07	0,04	0,04	0,03	0,02	0,08	0,05
160	0,1	0,08	0,11	0,1	0,07	0,05	0,04	0,04	0,11	0,08
200	0,19	0,14	0,14	0,12	0,1	0,08	0,05	0,05	0,13	0,13
250	0,28	0,23	0,2	0,17	0,15	0,13	0,09	0,08	0,14	0,19
315	0,25	0,35	0,24	0,21	0,23	0,2	0,13	0,09	0,18	0,3
400	0,26	0,44	0,27	0,24	0,32	0,32	0,2	0,12	0,2	0,41
500	0,29	0,48	0,29	0,33	0,43	0,47	0,31	0,16	0,22	0,48

630	0,33	0,46	0,32	0,33	0,51	0,56	0,42	0,22	0,24	0,48
800	0,42	0,47	0,4	0,41	0,53	0,58	0,5	0,31	0,28	0,47
1000	0,5	0,52	0,5	0,54	0,53	0,6	0,5	0,43	0,34	0,51
1250	0,55	0,53	0,66	0,68	0,53	0,64	0,48	0,55	0,42	0,57
1600	0,49	0,48	0,62	0,63	0,53	0,61	0,49	0,69	0,4	0,54
2000	0,47	0,46	0,54	0,57	0,48	0,54	0,46	0,72	0,4	0,5
2500	0,46	0,46	0,47	0,52	0,45	0,47	0,42	0,63	0,41	0,46
3150	0,51	0,5	0,45	0,51	0,44	0,43	0,39	0,51	0,39	0,45
4000	0,56	0,54	0,48	0,54	0,46	0,44	0,38	0,43	0,4	0,48
5000	0,62	0,57	0,51	0,62	0,5	0,51	0,41	0,4	0,42	0,51
6300	0,66	0,64	0,57	0,73	0,57	0,65	0,56	0,5	0,5	0,58

Table 5. *Mean values of Acoustic Absorption Coefficient. Agglomerated cork tiles and carpet over solid wall*

f(Hz)	**Agglomerated cork**	**Carpet**
125	0,05	0,09
250	0,10	0,08
500	0,20	0,21
1000	0,55	0,27
2000	0,60	0,27
4000	0,55	0,37

The results in terms of acoustic absorption are good, giving similar data as agglomerate cork and some carpets. We consider them as adequate for a possible use in improving acoustic conditions in rooms. In this initial phase of experimental character, we have emphasised the number and variety of samples rather than going through an in-depth research in one of them.

A further research has to be conducted in order to obtain a better product in terms of compactness or with better surface finishing that improves the obtained values.

4. Conclusions

Nowadays many researchers are experimenting trying to find new uses for waste from raw materials during their whole life cycle and they are obtaining very interesting and needed outcomes. A huge amount of organic waste is produced during the process of tanning that could be used instead of being sent to the landfill.

Two approaches were analysed, and both showed interesting results to be further evaluated in the coming future. One is the use of the leather waste as fuel and the other is its potential, once agglomerated, as acoustic panel for architectural purposes.

Waste of the leather industry as biomass:

There is a high potential of energy savings using the dry hair and shavings as fuel but no interesting results were found for wet hair. The energy from burning the waste materials would be enough to replace the gas of the boilers. Nevertheless, more tests are needed to evaluate the emission of pollutant gases.

Sound absorption panels for the construction industry:

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The hair and the shavings were mixed with several binders (cement, latex, gypsum and glue) and ten of the samples were tested obtaining their sound absorption coefficient following the standard UNE EN ISO 10534-2. Preliminary results show absorption coefficients close to those of cork panels or carpets, but further research is needed to test panels of bigger dimensions.

As it has been demonstrated, there are several promising approaches to the use of tanneries' waste materials, but more research should be done so as to close life cycle loop.

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