High-energy discrete processing in technology of extraction of wool grease

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Keywords:

Wool
Grease
Lanolin

Article history:

Received 10.06.2014
Received in revised form 23.07.2014
Accepted 02.09.2014

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Abstract

Introduction. Existing ways of extraction of wool grease have the high cost price and are not harmless. For increase of efficiency of extraction of wool grease in work application high-discrete processing (HDP) wool-washing water is offered.

Materials and methods. Determination of conductivity, RedOx-potential, temperature, pH and the total number of lipid-water ions was carried out using a combined tester Combo HI 98129 («HANNA Instruments»). Concentration of free radicals was determined by titration method. Viscosity change of wash water under the influence of HDP was investigated by the method of measurement by an Ostwald. Influence of duration of the HDP to change the surface tension of the wash water was measured by counting drops.

Results and discussion. As a result of HDP, there is a change of physical and chemical properties of the wash water, namely: reduction of conductivity wool-washing water (from 2969 μS/cm to 2837 μS/cm) and the total ion content (1487 mg/l to 1298 mg/l), increased pH environment (8.35 to 9.40), temperature (from 18°C to 43°C) and RedOx-capacity (from 60 mV to 93 mV). This is because HDP helps create areas of high concentration of mechanical energy, which leads to a high impact strength and high pressure. Temperature rise in turn affects the hydrogen bonds, with the collapse cluster complexes of water and hydration shells around ions with the formation of free radicals, which means, that the presence of chemical reactions in the water. Reduced viscosity (with $1{,}034 \cdot 10^{-3} Ns/m^2$ to $0{,}903 \cdot 10^{-3} Ns/m^2$) and surface tension (from 39.86 cN/m to 37.56 cN/m) of wash water under the influence of the HDP is due to breaking of hydrogen bonds of water associates and the weakening of the forces of attraction between the molecules within the clusters and in the surface layer – structural changes of water. The most important chemical and structural changes occur in the washings at 180 with the processing time.

Conclusions. Under the influence of the HDP occur chemical and structural changes that contribute to the intensification of the process of extraction of wool grease.

Introduction

Fat contained in sheep's wool, due to specific properties, is an indispensable raw material for various industries such as food, medical, cosmetic, mechanical engineering, as well as in production of military-technical and military-space specialty [1, 2].

The composition of wool grease (lanolin) is very complex and till now has not been studied thoroughly. Mostly it is a mixture of esters of high alcohols (cholesterol isocholesterol etc.) with higher fatty acids (myristic, palmitic, cerotic et al.) and free high molecular alcohols [3].

The most valuable feature is its ability lanolin emulsified to 180-200% of its own weight of water up to 140% glycerol and 40% ethanol (70% concentration) to form an emulsion of «oil-water». Addition of a small amount of lanolin to fats and hydrocarbons sharply increase their miscibility with water and aqueous solutions, which resulted in its widespread use in the composition of the hydrophilic-lipophilic bases [4].

In the food industry the use of lanolin is allowed in all countries because of the lack of evidence on the safety of the substance. International designation of the food additive is E 913 [5-7].

In food production lanolin is used as glazes agent and flame damper [8]. Glaze with the addition of lanolin shine and pleasant appearance of products, and also plays a role in the formation of taste. Flame dampers prevent foaming and make uniform consistency of the product. Additive E 913 can be found in the composition of the glaze on the following foods: pastry flour products, candy, chocolate, jelly beans, nuts and chewing gum. Extend the application of lanolin as a component of the coating mixes for fruit. Such mixtures give the fruit trade appearance, allow longer keep them attractive to the consumer. Most often these procedures are subject to oranges, lemons, limes, apples, pineapples, peaches, pears, melons, plums [9].

Due to the vast scope of lanolin in wool fat demand is constantly increasing. However, now in Ukraine wool grease virtually all of which could produce a valuable product – lanolin, lost along with the washings. In addition, untreated wash water harms the environment and creates environmental problems. Therefore, the maximum recovery of wool grease from washing solutions is an important issue.

Literary review

To date, for the extraction of wool grease from waste solutions used physical and mechanical or chemical methods [10].

Among the physical and mechanical methods for recovering wool grease the most widely separator (processing of cleaning solutions in a centrifugal field) and flotation-separator (flotation cleaning solutions) methods [11]. The average number of trapped fat by using physical and mechanical methods of fat extraction is 60-65%. However, these methods have several disadvantages: sophisticated equipment, high consumption of water, detergent and energy, lower the quality of the fat-lanolin in this way, because of its pollution and exposure to use in the cleaning chemicals.

Chemical methods include a washing treatment solution with different chemical reagents: acid chloride of lime, calcium chloride, bentonite (colloidal clays), organic solvents [12]. Completeness of extraction of fat using these methods, up to 90%, but the fat clogged by impurities, detergents, has high acidity. In addition, these methods are required equipment, resistant to chemicals [4].

As a result of these factors, the existing methods of extracting wool grease have a high cost and are environmentally unfriendly.

According to [13], the washings resulting from the washing of wool comprise suspended solids, such as sand, clay, wool fibers, dissolved mineral salts, mainly sodium chloride, potassium and magnesium. Organic components wash water – an alkaline agent (soap, soda, surfactants), fatty acid salts, wool grease (Table 1). It should be noted that the composition of the wash water varies depending on the type of processed wool and its mode of washing.

Table 1

The indicators of quality of wash water

Indicator	**Fine wool**	**Semifine wool**	**Coarse wool**
Concentration of suspended solids, g/l	15-25	15-17	40-70
Wool grease concentration, g/l	12-20	10-15	1-3
Solids, g/l	35-50	45	15-75
Ash content of dry residue, %	35	40	40
Transparency, cm	0	0	0
pH	10-11	9-10	8-10

Given the relatively high alkalinity and the presence of surfactants, wool grease is water stable emulsion state, so the conventional methods of extraction are inefficient and require intensification. According to the authors, the most promising in this respect are the physical methods of influence.

So, today is known to use a physical method of intensification of obtaining wool grease, which is purified by electro-dialysis suspended solids wool-washing of water by electro-coagulation, which enables up to 89% of wool grease, deodorize and return the purified water in the wash cycle of wool [14].

As an alternative method of extraction of the wool fat from wool-washing water foreign scientists proposed method which based on the action of the microwaves (8 min, 750 W, 2450 MHz), in combination with a co-solvent acetone-hexane (1: 1) [15].

Innovative direction in the extraction technology is the use of wool grease HDP. The essence of this method consists in the fact that the implementation in the bulk liquid in an open or closed vessel, specially shaped impulse electric discharge zone around its formation having extremely high hydraulic pressures which can perform useful mechanical work, and supported by a complex physical and chemical phenomena [16, 17].

In order to intensify the process of extraction of wool grease in the work carried out determination of physical and chemical properties of wool-washing water under the influence of the HDP.

Materials and methods

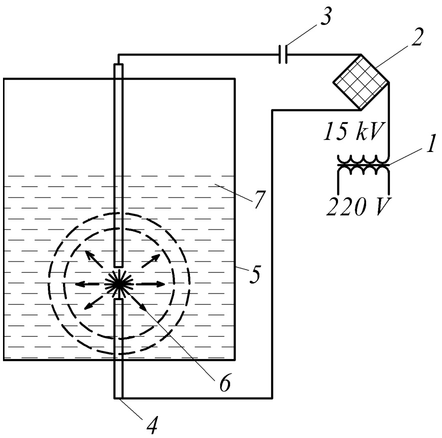
The study was the water after washing semifine Tsigal wool. Table 2 shows the characteristic parameters wash water, which further exposed to HDP.

Electrical discharge treatment was carried out in a laboratory setup (Fig. 1), which was developed by the Institute of Pulse Processes and Technologies NAS of Ukraine (Nikolayev), together with scientists from Kherson National Technical University.

Table 2

Quality indicators used wash water

Indicator	Value
Suspended solids, g/l	16.6
The particle size of contaminants, microns	100
Wool fat content, g/l	7-8
Surfactant content, mg/l	0.7
Total hardness, mEq/l	11.6
Transparency, cm	2
Turbidity, mg/l	132
pH	7.65



1 – boosting transformer;
2 – diode bridge;
3 – condenser;
4 – electrodes;
5 – the reactor vessel;
6 – zone of occurrence of the discharge;
7 – liquid.

Fig. 1. Schematic diagram of the laboratory setup

Equipment performances are presented in Table. 3.

Table 3

Equipment features

Name of the parameter	Value
Mains current	AC, single phase
Frequency, Hz	50±0.1
Supply voltage, V	220±22
Efficiency, at least	0.7
Operating voltage, kV	15
Pulse repetition frequency, Hz	1.5
Capacity of the capacitor bank, uF	0.5
Power consumption, W	400

Wool-washing water with varying exposure time from 30 s to 300 s exposed the electrical discharge.

Electrical conductivity, RedOx-potential, temperature, pH and the total number of ions is determined by the combined tester Combo HI 98129 («HANNA Instruments»). Accuracy of data values in the measured intervals are ± 0.5%.

Free radical concentration was determined by consumption of oxalic acid, which reacts only with radicals by permanganometric titration [18].

Viscosity change of wash water under the influence of HDP was investigated by the method of measurement by an Ostwald runtime fluid outflow via a glass capillary viscometer [19], and the surface tension (ST) – stalagmometric method [20] by counting drops.

Results and discussion

To determine the effect of HDP on the physical and chemical properties of wool-washing water in the measured indicators such as specific conductivity (σ), RedOx-potential, temperature (T), pH and the total number of ions (ΣI) are done. The results are shown in Table 4.

Table 4

Research of influence HDP on indicators of washing waters

τ, *s*	**σ**, *µS /cm*	**RedOx-potential**, *mV*	**T**, *°C*	**pH**	**ΣI**, *mg/l*
0	2969	60	18	8.35	1487
30	2917	64	25	8.80	1414
60	2875	67	28	8.88	1348
90	2867	68	31	9.07	1340
120	2861	71	35	9.13	1333
150	2861	85	43	9.32	1324
180	2849	86	43	9.37	1310
240	2841	89	43	9.36	1304
300	2837	93	43	9.40	1298

Analysis of the results showed that with increasing duration of HDP decrease the conductivity of wool-washing of water and the ions, increasing the pH of the medium, temperature and RedOx-building. This is because HDP helps create areas of high concentration of mechanical energy, which leads to a high impact strength and high pressure. Temperature rise in turn affects the hydrogen bonds, with the collapse cluster complexes of water and hydration shells around ions with the formation of free radicals, which means that the presence of chemical reactions in the water.

But the information on chemical reactions in the washings after washing of wool fiber is absent. Therefore, it was determined by the quantity of waste in the washings of free radicals in the HDP. The results are shown in Fig. 2.

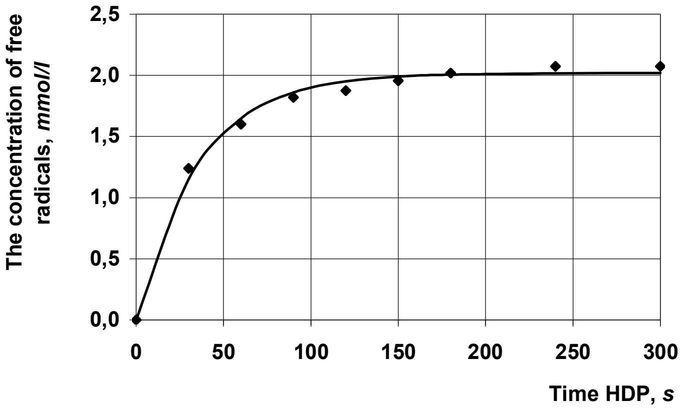


Fig. 2. The dependence of the concentration of free radicals on the duration of the HDP

According to data presented in Fig. 2, the concentration of free radicals increases with the duration of the HDP. Moreover, within the first 30 s of processing, a sharp increase in free radical concentration to 1.63 mmol/l. With further increasing treatment time up to 180 s free radical concentration increases uniformly (2.02 mmol/l), and more 180 s – does not lead to a significant increase in their concentration (2.75 mmol/l).

According to [16, 17, 21] cavitations lead not only to chemical, but also for structural changes in the water. In the works Vitenko T.N. [17, 22] shows that the restructuring of water is characterized by a change in viscosity and surface tension. Therefore, in the study, we investigated the effect of the duration of HDP on the viscosity and ST wash water. The data obtained are presented in Fig. 3 and 4.

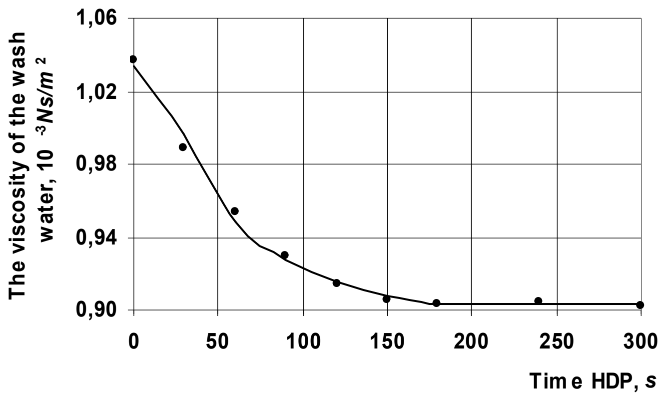


Fig. 3. The effect of the duration of HDP on the viscosity of the wash water

Analysis of the results presented in Fig. 3 shows that an increase in the HDP, there is a decrease in viscosity wash water. Thus, during processing, the water for 60 s there is a considerable decrease of the viscosity from $1.2 \cdot 10^{-3}$ *Ns/m*^{2} to $0.86 \cdot 10^{-3}$ *Ns/m*^{2} and with duration of greater than 180 s comes to equilibrium water system under study. This, in our opinion, can be explained by the fact that under the influence of cavitations is the process of restructuring the water.

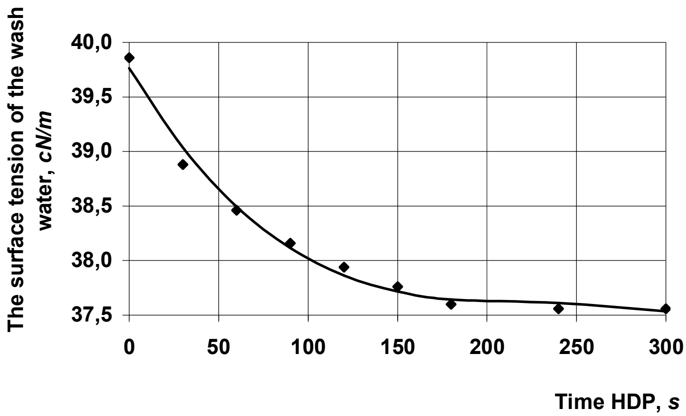


Fig. 4. Effect of the HDP, on ST wash water

Determination results of ST showed that its maximum decline from 39.75 cN/m to 37.70 cN/m is observed when the duration of treatment with 180 s. With further increase of the HDP, ST does not change significantly. This can be explained by the fact that as a result of high discrete exposure hydrogen bonds break water associates forces of attraction between molecules within the clusters and the surface layer are weakened, which leads to reduction in ST.

Comprehensive analysis of the results of the determination of physical and chemical properties wash water indicates that the action of HDP occur chemical and structural transformations that change the properties of all the components of the lipid-system.

The most important chemical and structural changes occur in the washings at 180 s with treatment duration.

Conclusions

1. To improve the efficiency of extraction of wool grease are proposed use of HDP wool-washing water.
2. Influenced HDP in fat-containing wool-washing waters going changes in the physical and chemical properties, namely: lowering conductivity and the total content of ions, increase RedOx-potential, temperature, pH and concentration of free radicals.
3. Reduced viscosity and surface tension of the wash water by the action of HDP leads to structural transformations lipid-system.
4. The most significant changes in the washings occur after 180 s HDP.
5. Chemical and structural transformations wool-washing water, which occur under the influence of HDP promote intensification of the process of extraction of wool grease.

Further studies will be aimed at studying the effect of HDP on the extraction efficiency of wool grease extraction and wash water separator means.

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