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Note from the field

Power ultrasound in fatliquor preparation based on vegetable oil for leather application

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Abstract

In recent years, power ultrasound has taken a significant place in chemical and physical activities of the process industries as an effective and non-polluting method of activation. Oil in water emulsions known as fatliquors are used for the lubrication of tanned leather fibres to get softness and also to improve the strength properties. In the present study, ultrasound has been used as a tool for the preparation of fatliquor emulsion for application in leather fatliquoring process. An emulsion is a fine dispersion of one liquid in another liquid. Sulphation is one of the common methods followed to prepare fatliquor emulsion where sulphuric acid is used. In the conventional process, emulsifying agent is also added to increase the stability of oil in water emulsions. The emulsifying agents generally used are chemicals or metal soaps. The potential use of ultrasound in the preparation of stable oil in water emulsions dispensing with sulphation process and with the minimum use of emulsifying agent has been studied and reported in this paper. This process enjoys the benefit of less pollution load in the form of chemical entities. The studies included the effect of process parameters such as ultrasonic output power and amount of oil used. Fatliquor emulsion prepared using ultrasound has been applied in leather fatliquoring process and the strength properties of the leathers were assessed. Emulsion particle size, which is another important parameter for diffusion through leather, has been measured using Laser Diffraction Technique. The stability of the ultrasonically prepared fatliquor emulsion has been found to be good. The results indicate that ultrasound could be effectively utilized in the preparation of non-ionic fatliquor emulsion eliminating sulphuric acid and impart required properties in leather.

Keywords: Power ultrasound; Leather lubrication; Fatliquoring; Fatliquor emulsion preparation; Vegetable oil

1. Introduction

An emulsion is a fine dispersion of one liquid in another liquid with which it is immiscible. Surface-active or other agents that are added to an emulsion to increase its stability by interfacial action is known as emulsifiers or emulsifying agents. In the fatliquoring process, oils/fats are employed as oil in water emulsion known as fatliquor. Fatliquor may be anionic, cationic or non-ionic. Anionic fatliquors are commonly employed for fat binding with chrome-tanned leather, which is cationically charged. Anionic fatliquors are commonly prepared by sulphation, sulphonation or bi-sulphitation of oils/fats. Depending upon the source of the oils/fats used, the fatliquor can be classified as vegetable, synthetic and semi synthetic. Generally, castor oil is used as a source for vegetable based fatliquors. The synthetic fatliquors are usually obtained by sulphochlorination of C_{10}–C_{20} fractions obtained through the Fischer-Tropsch method of paraffin synthesis or from the petroleum industry [1]. Semi-synthetic fatliquors are prepared from both the vegetable and synthetic sources. Characterization and possible use of oil extracted from Seal Hides as leather fatliquor has also been studied [2].

1.1. Ultrasound – application

The application of power ultrasound in process industries has a significant role in the concept of ‘clean technology’.

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Ultrasound is a sound wave with a frequency above the human audible range (16 Hz to 16 kHz). Ultrasound having frequency range of 20 kHz to 100 kHz is termed as power ultrasound [3] and commonly employed for improving the efficiency of physical processes such as cleaning, emulsification, degassing, crystallization, extraction, etc., and for accelerating/performing chemical reactions [4,5]. Ultrasound having frequency range of 1–10 MHz is termed as diagnostic ultrasound and used in medical field and non-destructive testing. The main advantage of physical methods such as use of power ultrasound over chemical means of activation of reactions is that they do not contribute to pollution load in the form of chemical entities. The potential use of ultrasound in process industries such as leather with the aim to improve the quality, improve diffusion rate, reduce process time and pollution load have been investigated extensively [6–12].

Fatliquoring emulsion was earlier prepared using natural and sulphated fats and by exposing the mixture to ultrasonic waves for 10–15 min [13]. Fat emulsion of alkyl phenol ethylene oxide condensates and surface-active agents was prepared using ultrasound [14], which lowers the sulphated oil requirement for fatliquoring by 25–30%. Fatliquor emulsion was also successfully prepared quickly and economically using ultrasound [15,16]. In this paper, fatliquor emulsion preparation based on castor oil using ultrasound has been discussed. The use of ultrasound for enhancing the fatliquoring process has also been studied [12]. Due to the growing demand for the good quality leather auxiliary chemicals, newer processing techniques are gaining importance. Although earlier work has been carried out, some of the important aspects have not been addressed so far. The aspects in the present study include, influence of process parameters such as ultrasonic output power, time of emulsion formation, emulsion particle size, stability of the emulsion and suitability of the emulsion for application to leather. Vegetable oil–water emulsion based on castor oil has been studied in this paper. The ultrasonically prepared fatliquor has been employed to leather and their applicability has been studied through the strength properties of fatliquored leather.

1.2. Need for power ultrasound in emulsification process

- Sulphation is the general method followed to prepare fatliquor emulsion based on castor oil where sulphuric acid is used. The use of sulphuric acid in fatliquor preparation reduces the neutral oil component in fatliquor, which is very essential for imparting good feel and better properties to leather.
- Therefore, alternate method, which uses sulphation free process for the preparation of fatliquor, would be beneficial.
- An emulsifying agent is required to increase the stability of oil in water emulsions. The emulsifying agents generally used are chemicals or metal soaps which result in increased pollution.
- The potential use of ultrasound in the preparation of stable oil in water emulsion (as non-ionic vegetable fatliquor) without sulphation process and with minimum use of additional emulsifying agents has been studied in this paper.
- The possible benefits in leather due to the use of the fatliquor so prepared using ultrasound have also been investigated.

1.3. Relevant sonochemistry

The sonochemical activity arises mainly from acoustic cavitation in liquid media, which are nucleation, growth and explosive collapse of microbubbles on a microsecond timescale. The cavitational collapses occurring near a solid surface will generate micro jets and shock waves [17]. Moreover, in the liquid phase surrounding the particles, high micro mixing will increase the heat and mass transfer and even the diffusion of species inside the pores of the solid. The intense agitation and dispersion effect, which is brought on by the effects of cavitation, results in an increase in the number of collisions between the oil droplet and water and hence better emulsification of oil in water.

2. Experimental section

2.1. Experimental set-up

Experiments were carried out using ultrasonic processor VCX 400, 0–400 W, 20 kHz, Sonics & Materials, USA as described [9].

2.2. Materials and methods

Castor oil (*LR grade*, *SD Fine chemicals Ltd*., India) has been used for the emulsion preparation. Ratio of castor oil and water were varied from 50 to 80% keeping the total weight of oil and water as 20 and 40 g. About 4% of non-ionic wetting agent (*Luwet 40*, *Textan chemicals Ltd*.) was used on the basis of castor oil weight in order to aid in the process of emulsification. In order to optimize the ultrasonic output power, ultrasonic power was varied from 60 to 100 W. Time taken for complete oil–water emulsification was noted. Complete emulsification of oil and water was ascertained from the oil–water phase miscibility, formation of milky white emulsion and absence of any separation of two layers.

2.3. Preparation of fatliquor emulsion ‘US LIQ’

Experiment has been carried out for the preparation of fatliquor emulsion ‘US LIQ’ with 80% castor oil for application to leather fatliquoring process. The details of the experiment are as follows:

- Total amount of vegetable oil and water = 80 g,
- Composition of vegetable oil = 80% (64 g),
- Composition of water = 20% (16 g),
- Ultrasound output power = 100 W.

Time taken for complete emulsification was recorded.