GETTING RID OF THE UNPLEASANT ODOR IN NEW ARTIFICIAL LEATHER USING NATURAL AND SYNTHETIC FRAGRANCES

Article Highlights

• Removal of unpleasant odor is important in the production of fresh artificial leather
• The use of essential oil is an expensive solution since high concentrations are needed
• The use of synthetic fragrance combined with paraffin oil is an effective solution
• Fragrance concentration and mixture are optimized to be efficient and economical

Abstract

Usually, new artificial leather items are very smelly because they have been created using numerous chemicals. Their full smell remains until they become old enough. Removal of unpleasant chemical odor is important to preserve the safety and health at workplaces, to meet the demands of consumers and to develop marketing strategies. In this work, we focus on studying odor abatement using natural and synthetic fragrances. We have found that, in well-defined conditions, both types of fragrances efficiently hide the chemical odor. However, the use of the synthetic one combined with paraffin oil was more effective and cheaper.

Keywords: artificial leather, unpleasant odor, coating, fragrance, thermal stability.

Artificial leather is generally a coated textile substrate made by covering a textile fabric base with a soft polyurethane (PU) or polyvinyl chloride (PVC) layer. This leather-like fabric is used in many industries such as clothing, footwear, automotive and upholstery and it is increasingly demanded to substitute natural leather which is costly and available in irregular pieces [1].

Certainly, leather-like materials are cost effective, more versatile and animal-friendly. However, both PU and PVC artificial leather have commonly been associated with an unpleasant chemical odor, which comes out during the coating at high temperature, from evolved volatile organic compounds like hydrogen chloride, substituted benzenes, aldehydes and phthalic anhydride [2-4]. These chemicals dissipate over time, but their smells don’t go away completely.

A long-term exposure to these smells could pose health problems, especially for workers [2,5]. Unpleasant and toxic odor issue is misleading to consumers. It has a negative influence over how they perceive products. In addition, this odor highly impacts their purchasing intentions. One of the biggest challenges of artificial leather industries is to overcome this problem and to produce more fresh materials in order to hit a widespread market.

For many years, fragrance compounds have been added to clothes and fabrics through quick and simple methods, usually in the form of scented softeners in wash, natural and synthetic fabric conditioners during drying and storage stages [6] and fabric fresheners during use. Essential oils were also applied to impart durable fragrances to textile substrates. They are highly concentrated substances extracted from plant organs such as flowers, leaves, bark and seeds [7]. These natural odorant products have interesting characteristics like their biological activities and their energy specific character, as their potency is not lost with time [8].

In recent years, numerous techniques like microencapsulation [9], spray-drying, coacervation, filam-
ent-infusing [10] and cyclodextrin inclusion complexes [11] are being applied to impart perfumed compounds directly to textile substrates. These techniques offer the advantage to be able to reduce the evaporation rate of volatile ingredients of used compounds which would prolong the lifetime of fresh odors [12]. Fragrances have shown effective results when applied using most of the above-mentioned methods. However, their application for coated textiles is not a trivial issue. The most difficult task is related to their thermal stability since the coating process operates at high temperature. It has been reported that the incorporation of flavors inside the internal cavity of cyclodextrins, a family of cyclic oligosaccharides, is an effective technique for the stabilization of numerous organic flavors like vanillin and menthol [11,13]. Despite its importance, this technology cannot be applied in the coating process during the production of artificial leather with PVC. In fact, the dispersion of cyclodextrins with different hydrophobic constituents of the PVC paste, also known as plastisol, was found to be very difficult. In addition, the formation of agglomerates was concluded to occur [14]. These agglomerates could seriously deteriorate the coated surface quality.

After fragrance application, odor characterization is not an easy task. Sensory perception is employed often for odor assessment. Sensory measurements characterize odors in terms of their perceived effects employing the human nose as an instrument [15]. Several test methods were applied for measuring sensory response to a sample: classification, grading, ranking and scaling [16].

Persistence of unpleasant odor after artificial leather production was previously reported in several research studies. However, no investigation has been performed to produce fresh leather-like fabrics. This study aims to investigate, for the first time, the use of jasmine essential oil and limonene-based synthetic fragrance to produce fresh PVC artificial leather. These odorant compounds could be potentially added to the plastisol, and assure pleasant smell. The effect of essential oil and synthetic perfume concentration on the freshness of artificial leather was examined. Synthetic perfume was mixed with some additives in order to enhance stability. For all tests conducted, a psychophysical assessment was investigated to evaluate the freshness of test samples.

EXPERIMENTAL

Materials

Dry PVC resin, diisononyl phthalate (DINP), mixed-metal heat stabilizer, puffing agent, calcium carbonate filler, pigment, transfer paper and polyester knitted fabric base were kindly provided by Plastiss Company (Monastir, Sayada, Tunisia). Jasmine essential oil, paraffin oil, glycerol (50% glycerol) and limonene-based synthetic perfume (50% limonene) were purchased from S2C (Sousse, Tunisia). All chemicals were used as received without further purification.

Preparation of synthetic perfume mixtures

Four different fragrance compositions were used during this study: pure essential oil (PEO), pure synthetic perfume (PSP), synthetic perfume mixed with glycerol (SPG) and synthetic perfume mixed with paraffin oil (SPO). Glycerol and paraffin oil were used as additives at different levels of concentration in order to enhance the stability of synthetic perfume. Additive proportions representing a fraction of additive percentage are summarized in Table 1. The mixtures were prepared by slowly adding the perfume to the additive. A mechanical stirrer was used for homogenization.

<table>
<thead>
<tr>
<th>Perfume mixture</th>
<th>Additive proportions and corresponding mixture names</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPG</td>
<td>Glycerol, vol.%</td>
</tr>
<tr>
<td></td>
<td>10 20 30 40 50</td>
</tr>
<tr>
<td>SPG1 SPG2 SPG3 SPG4 SPG5</td>
<td></td>
</tr>
<tr>
<td>SPO</td>
<td>Paraffin oil, vol.%</td>
</tr>
<tr>
<td></td>
<td>10 20 30 40 50</td>
</tr>
<tr>
<td>SPO1 SPO2 SPO3 SPO4 SPO5</td>
<td></td>
</tr>
</tbody>
</table>

Scented plastisol formulation

The plastisol was prepared using dry PVC resin, DINP plasticizer, calcium carbonate filler, heat stabilizer and pigment. The fragrance was incorporated with DINP. The plasticizer and the other additives were slowly added to the dry resin, PVC and then homogenized using a mechanical stirrer. After mixing, the air bubbles in the mixture were removed using vacuum. Puffing agent was added with additives when producing the expanded layers.

Production of the coated fabrics

The coating process (Figure 1) involves the transfer of plastisol from the transfer paper to the textile fabric base. First, the transfer paper part to be covered with plastisol was preheated at 220 °C for a few seconds. Then, the preheated paper was removed from the oven and immediately covered with the liquid plastisol, by the coating blade, while being run at tension and the coating is then dried at 220 °C for
about 40 seconds. Finally, the knitted fabric was released and laminated onto the coating which was separated from the paper and transferred to the backing fabric after drying.

**Thermal stability characterization**

Thermal stability of fragrances was detected using differential scanning calorimetry (DSC, Mettler, Toledo 832e). The sample mass was ranging from 9 to 10 mg. The samples were subjected to a heating-cooling-heating cycle between 40 to 300 °C at a scan rate of 10 °C/min. The results of the first heating run were reported.

**Odor pleasantness assessment**

The odor assessment was performed by 10 subjects (minimum age: 20, maximum age 47, 6 men, 4 women). The participants were workers in an artificial leather industry. They are the population directly affected by the unpleasant odor problem. Preliminary testing was conducted in 16 subjects to explore possible risks of reduced olfactory performance. Among them, 6 participants were excluded since they were unable to clearly perceive odors during different pretests. Informed consent was provided by all participants and the study was approved by occupational medicine (a hospital in Tunisia).

During the study, a series of 10 artificial leather samples, produced using different concentrations and mixtures of natural and synthetic fragrances, were evaluated by the 10 previously chosen subjects. Through this sensory evaluation, we wanted to know if the perceived odor pleasantness (dependent variable) is related to the fragrance type combined with the plastisol (independent variable). The fragrance type concerns its nature, its concentration and its final composition.

The artificial leather samples, used in sensory evaluation, were prepared using previously mentioned pure and mixed fragrances at different levels of concentration (Table 2).

The scented samples were delivered in separate paper folders which were numbered from 1 to 10. A visual analog scale (VAS) was applied as it is a reliable technique widely used for the assessment of odors [17]. A five-point rating scale, denoting 1 = "extremely unpleasant", 2 = "moderately unpleasant", 3 = "neither extremely pleasant nor extremely unpleasant", 4 = "moderately pleasant" and 5 = "extremely pleasant", was used according to Cumming et al. [18].

**Table 2. Fragrances used to produce samples for sensory evaluation**

<table>
<thead>
<tr>
<th></th>
<th>Pure essential oil (PEO)</th>
<th>Pure synthetic perfume (PSP)</th>
<th>Synthetic perfume combined with 50% glycerol (SPG5)</th>
<th>Synthetic perfume combined with 50% paraffin oil (SPO5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample1 (PEO-1)</td>
<td>1%</td>
<td></td>
<td>Sample6 (SPG5-1)</td>
<td>Sample9(SPO5-1)</td>
</tr>
<tr>
<td>Sample2 (PEO-2)</td>
<td>3%</td>
<td></td>
<td>Sample7(SPG5-2)</td>
<td>Sample10(SPO5-2)</td>
</tr>
<tr>
<td>Sample3(PEO-4)</td>
<td>4%</td>
<td></td>
<td>Sample8(SPG5-3)</td>
<td></td>
</tr>
<tr>
<td>Sample4 (PSP-1)</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample5 (PSP-2)</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample6 (SPG5-1)</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample7(SPG5-2)</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample8(SPG5-3)</td>
<td>3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample9(SPO5-1)</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample10(SPO5-2)</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All participants were invited to join in a conditioned room (temperature: 22 °C and RH: 65%), to shut down their phones, to sit down in the indicated chair, to keep the samples in the presented order and to carefully read the paper in front of them which contains the different ratings for all the samples. Then, they were asked to make a preference judgement and to tick the box that corresponds to their rating for every sample. Prior to the experiment, three practice trials were conducted using standard samples in order to explain how to tick the appropriate box in the paper. Subjects completed their assessments within 39 min. For every sample, 3 min were allowed to rate it for odor pleasantness and then, a 1 min break was given to participants to breathe deeply in order to reduce the effect of olfactory adaptation. The time period between the artificial leather production and odor assessment was 28 days.
Statistical analyses

Statistical analyses were made using the software package SPSS version 20 for Windows (SPSS Inc). We applied a non-parametric statistical test (Friedman test) since normal distribution could not be assumed for all the data. The Kolmogorov-Smirnov test was used to test for normal distribution of the data. The results were considered to be significant at $P < 0.05$.

Determination of volatile loss

The volatile loss is an important parameter to carry out odor intensity quantification. Inspired by the standard test ASTM D 1203-94, a simple method was used for the determination of the volatile loss. The test method involves absorption of volatiles from the sample by active carbon at defined conditions of time and temperature and measuring the weight loss. A metal container was taken and activated carbon was spread evenly on the bottom of the container. A weighed test sample was placed over the carbon layer, followed by another layer of active carbon. Three samples were placed in the container. The active carbon layer was thus at the top, the bottom and in between artificial leather samples. The container was then closed and placed in a laboratory oven (Memmert) at 60°C for 48 h. Tests were realized following artificial leather samples preconditioning in a standard atmosphere (20±2°C, 65±2% RH). The evaporation rate was then calculated as percent weight loss of the samples by substitution in Eq. (1):

$$\text{Weight loss, } % = 100 \frac{W_0 - W_f}{W_0}$$

where: $W_0$ = initial weight of test sample, and $W_f$ = final weight of test sample.

Before weighing, the samples were reconditioned at room temperature for 1 h. The applied method was particularly useful for quantitative comparative analysis between different samples.

Fourier transform infrared characterization

Attenuated total reflectance Fourier-transform infrared (ATR-FTIR) spectroscopy was used to characterize artificial leather fabrics. FTIR spectra were recorded using a commercial ATR-FTIR attachment (Spectrum Two™ FTIR, Perkin Elmer). Spectra were recorded between 4000 and 400 cm$^{-1}$.

Ultraviolet-Visible spectrophotometry characterization

Inspired by the works of Xiao et al. [19], UV-Vis spectrophotometer (Specord 210 plus, Germany) was used to determine total VOCs of different samples. The samples were heated to 80°C, in a necked flask, to accelerate the VOCs emission. All necks of the flask were stoppered and an air flow of inert-gas (nitrogen) was created from the first flask containing the sample to a second stoppered flask containing 50 mL of cyclohexane, as shown in Figure 2. Cyclohexane was used to absorb VOCs. The sampling time was 24 h. The Beer-Lambert law was used to measure the concentration of VOCs. A calibration curve of toluene (used as VOCs standard) in the solution of cyclohexane was first defined then the measurements of VOCs concentrations were carried out. The wavelength of 262 nm was selected for all the measurements ($\lambda_{\text{max}} = 262$ nm of toluene in cyclohexane).

RESULTS AND DISCUSSION

Experiments with essential oil

Preliminary tests were performed to define the different volume concentrations (1, 3 and 4%) of pure...
jasmine essential oil (PEO-1, PEO-3 and PEO-4) combined with plastisol. Percentage frequencies as a function of rating pleasantness are presented in Table 3. The subjects gave three different ratings. For the three groups, extremely pleasant was the most chosen rating with 50% of total subjects for PEO-1, 60% for PEO-3 and 80% for PEO-4. Moderately pleasant was the second most common choice with 20% for PEO-1, 40% for PEO-3 and 20% for PEO-4. 30% of subjects had a neutral preference for pleasantness of fabrics treated with the fragrance PEO-1. 100% of subjects have found the control sample (without fragrance) extremely unpleasant. Through analyses, we have shown that the use of jasmine oil has successfully hidden the unpleasant odor of artificial leather and has released variable jasmine smell intensity depending on the oil concentration combined with the plastisol.

The results of experiments were consistent with the idea that oils have a significant slow combustion rate [20] leading to a slow evaporation rate and a slow transformation in the perfume composition under heat. Jasmine oil smell was persistent after the coating process which was conducted at high temperature (around 200 °C). Pleasantness ratings of perfumed fabrics were tested for variance between the predefined three concentrations. The Friedman test revealed a significant difference, $\chi^2(2) = 8.37$, $P = 0.015$, <0.05.

Comparative box plots have been generated to compare the defined three fragrance groups and to make the difference more comprehensive through graphical information (Figure 3). The median of PEO-3 and PEO-4 (5) is greater than that of PEO-1 (4.5) implying that the fabrics perfumed using high jasmine oil concentrations exhibit more intense smell and attract high preference from participants. The difference between the upper and lower quartiles, called inter-quartile range (IQR), of the respondents from PEO-4 (IQR=0) is shorter than that of PEO-3 (IQR=1) and PEO-1 (IQR=2) importing that the variability of respondents with PEO-1 is the highest. Consequently, we conclude that high concentration is needed to obtain artificial leather fabrics with pleasant jasmine odor. The box plot of PEO-4 presented an extreme value (outlier) which deviates from the rest of the respondents. This value may be due to the non-normal distribution. Even though jasmine essential oil had efficiently hidden the chemical odor, its use was not approved on an industrial scale. It was considered as an expensive solution since high concentrations were needed, based on the high price of jasmine essential oil [21].

![Figure 3. Box plot of three groups (PEO-1, PEO-3 and PEO-4) as a function of pleasantness rating.](image)

### Experiments with synthetic perfume

Synthetic perfumes are manufactured by chemical synthesis. Generally, they are cheaper than natural ones and their quality and consistency can be more easily controlled. In series 2 of experiments, we combined plastisol with different mixtures and concentrations of an efficient low-cost synthetic perfume.

### Pure synthetic perfume (PSP)

First, we applied pure synthetic perfume. According to added percentage (1 and 2% volume concentration), two fragrance groups, PSP-1 (1%) and PSP-2 (2%), have been considered for different analyses. The subjects gave similar pleasantness ratings for the two groups. Extremely unpleasant was chosen by 100% of total subjects for both PSP-1 and PSP-2. The addition of synthetic perfume wasn't efficient to hide the bad smell of the artificial leather. In addition, a release of white smoke and an unpleasant

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**Table 3. Percentage frequency (%) as a function of rating pleasantness (PEO)**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Extremely unpleasant</th>
<th>Neither extremely pleasant nor extremely unpleasant</th>
<th>Moderately pleasant</th>
<th>Extremely pleasant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control sample</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(PEO-1)</td>
<td>-</td>
<td>30</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>(PEO-3)</td>
<td>-</td>
<td>-</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>(PEO-4)</td>
<td>-</td>
<td>-</td>
<td>20</td>
<td>80</td>
</tr>
</tbody>
</table>
sant smell was noticed during the coating process. These findings were explained by the fact that organic flavors are unstable and highly volatile at high coating temperature and they emit volatile organic compounds VOCs having more or less characteristic odors. Among the most odorous compounds we found amines, sulfur compounds, oxygenated derivatives (aldehydes, ketones) and some aromatic compounds such as benzene [22,23].

Differential scanning calorimetry measurements (DSC) scan of synthetic perfume is shown in Figure 4. We noticed the presence of a sharp endothermic peak at 105°C which is attributed to vaporization and a weak exothermic peak at 65°C which is associated with transformation in the perfume composition. As expected, synthetic perfume was found unstable under high temperature. This unsatisfied property gives limitation to the use of this fragrance compound in artificial leather industry. In the next sections, we have addressed this limitation by introducing a new strategy that combines synthetic perfume with additives in order to slow the rate of combustion.

**Synthetic perfume mixed with glycerol**

Glycerol is characterized by high boiling temperature and thermal stability [24]. During preliminary tests, we have produced coated fabrics using plastisol combined with synthetic perfume having glycerol content 10, 30, 40 and 50 vol.%. It was concluded that an increase in the amount of glycerol from 50% results in a rise of a pleasant odor of the produced fabrics and below this percentage the fragrance was not detected. Choosing the odor assessment of coated fabrics as a criterion to evaluate the effect of glycerol as an additive was investigated. Different volume concentrations (1, 2 and 3%) of synthetic perfume mixture having a glycerol content of 50% were applied. Based on the concentration, three perfume mixture groups were considered: SPG5-1 (1%), SPG5-2 (2%) and SPG5-3 (3%).

Through percentage frequencies presented in Table 4, we deduced that “extremely pleasant” was the most chosen rating with 40% of total subjects for SPG5-1, 50% for SPG5-2 and 80% for SPG5-3. “Moderately pleasant” was the second most common choice with 50% for SPG5-1, 20% for SPG5-2 and 20% for SPG5-3. 40% of subjects had a neutral preference for pleasantness of fabrics treated with SPG5-2 and SPG5-3. “Moderately unpleasant” was chosen by 10% of subjects who evaluated samples treated with SPG5-2. We concluded that the use of synthetic perfume combined with glycerol has hidden the unpleasant odor. The DSC profile of the perfume mixture SPG5 was examined (Figure 5). No peaks were observed. The complete disappearance of previous detected peaks was indicative of an enhanced thermal stability of the synthetic perfume. The reason behind the thermal stability induced by glycerol remained unclear.

The Friedman test revealed no significant difference between the predefined three concentrations, $\chi^2(2) = 5.25, P = 0.072, >0.05$.

Even though synthetic perfume having a glycerol content of 50% has shown effective results, glycerol was rejected as perfume additive since its use has led to the formation of relatively rigid agglomerates on the coated surface which was considered deteriorated compared to the normal one (Figure 6). The agglomerate appearance phenomenon is related to the high hygroscopicity of glycerol [25].

![Figure 4. Differential scanning calorimetry (DSC) scan of Pure Synthetic Perfume (PSP).](image-url)
Synthetic perfume mixed with paraffin oil

Commercial paraffin oils are cheap, with interesting thermal properties. Applying the same previous approach, we have produced coated fabrics using plastisol combined with synthetic perfume having paraffin oil content 10, 30, 40 and 50 vol.%. The unpleasant odor was hidden using perfume mixture containing 50% of paraffin oil (SPO5).

Based on volume concentrations (0.1 and 0.3%), two perfume mixture groups SPO5-1 and SPO5-3 were considered in the pleasantness rating assessment. We concluded from the data presented in Table 5 that the use of synthetic perfume combined with paraffin oil has successfully hidden the unpleasant odor. “Extremely pleasant” was the most chosen rating with 80% of total subjects for SPO5-1 and 100% for SPO5-3.

From the DSC thermogram of the perfume mixture SPO5 (Figure 7b), we concluded there was the disappearance of the exothermic peak of PSP. This means that no transformation occurs in the perfume composition. However, DSC studies cannot be used to conclusively determine this composition. A slight variation in the endothermic peak between PSP and SPO5 samples is explained by slow evaporation rate of the perfume once combined with paraffin oil. The Friedman test revealed no significant difference between the predefined three concentrations, $\chi^2(1) = 2$, $P = 0.15$, >0.05 (Figure 7a).

Based on percentage frequencies presented in Tables 3-5, we concluded that PEO, SPG5 and SPO5 are efficient odorant compounds for removing unpleasant odor of new artificial leather items. However, SPO5 was found to be the most effective since 80% of subjects found that odor is extremely pleasant, using only 1% of this product.

Volatile loss results

In order to quantitatively assess the evaporation rate of different odors, tests were performed for the control sample and the samples prepared using different fragrances. These tests establish the relationship between the fragrance composition and concentration and the odor intensity. As shown in Table 6, quantifiable volatility is noted for all tested samples. Higher volatilities were observed in the case of the control sample and the samples prepared using pure synthetic perfume. The volatility of the samples prepared using synthetic perfume mixed with paraffin oil was found to come next. Samples treated with high concentrations of essential oil and synthetic perfume mixed with glycerol were in third position. It is clear that the percent loss in weight of the tested samples
was found to be generally higher upon using high concentration in case of all fragrances used. We conclude that the results of the volatile loss are in agreement with those of the psychophysical assessment.

The very close agreement between the subjective and quantitative evaluation is not surprising considering that our subjective evaluation, carried out by the psychophysical assessment has involved participants working in artificial leather industry. Such a population is most familiar with the unpleasant odor of artificial leather and thus can give more reliable assessment.

ATR-FTIR analysis

Quantitative evaluation has shown that all samples present volatility. However, the volatile substituents remain unknown. FTIR analysis of the different samples was carried out to analyze the chemical structure. It can be observed from Figure 8 that most of the peaks in the spectra are identical (Figure 8a). The main peaks corresponding to carbonyl group (around 1728 cm\(^{-1}\)), C-H stretching vibration (2875-2961 cm\(^{-1}\)), -CH\(_2\) deformation (1379-1433 cm\(^{-1}\)), C-H rocking (1127-1280 cm\(^{-1}\)), trans C-H wagging (1041-1078 cm\(^{-1}\)), C-Cl stretching vibration (710-968 cm\(^{-1}\)) and cis-C-H wagging (630 cm\(^{-1}\)) [26] were observed. Some other peaks at 1600 and 1587 cm\(^{-1}\) are specific to phthalates (plasticizer DINP) [27]. These peaks are due to the aromatic ring quadrant stretching vibration. According to Figure 8b-d, the sample prepared using jasmine essential oil (PEO-4) gives significant intensification of some absorption peaks. These peaks probably indicate the presence of Jasmine (-CH\(_3\) peaks at 1382, 1425, 2957 and 2925 cm\(^{-1}\) and C=O peak at 1724 cm\(^{-1}\)) [28]. Figure 8c shows that samples prepared using synthetic perfume mixed with glycerol and synthetic perfume mixed with paraffin oil present slight intensification of peaks at 1382 and 1425 cm\(^{-1}\). The characteristic peaks for -CH\(_3\) (1382 cm\(^{-1}\)) and C-H in-plane bend (1430 cm\(^{-1}\)) suggests the formation of hydrocarbon fragments on the fabric surface due to the presence of limonene [29].

For the control sample and the sample treated with pure synthetic perfume, overlapping peaks of VOCs appears at 1728 cm\(^{-1}\) (aldehydes) and 630-710 cm\(^{-1}\) (substituted benzenes).

Table 6. Percent loss of weight of artificial leather samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Average weight loss</th>
<th>Jasmine essential oil</th>
<th>Pure synthetic perfume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control sample</td>
<td></td>
<td></td>
<td>1.92</td>
</tr>
<tr>
<td>Sample</td>
<td>PEO-1</td>
<td>PEO-3</td>
<td>PEO-4</td>
</tr>
<tr>
<td>Average weight loss</td>
<td>1.74</td>
<td>1.79</td>
<td>1.85</td>
</tr>
<tr>
<td></td>
<td>PSP-1</td>
<td>PSP-2</td>
<td></td>
</tr>
<tr>
<td>Average weight loss</td>
<td>1.85</td>
<td>1.96</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Synthetic perfume mixtures

<table>
<thead>
<tr>
<th>Additive</th>
<th>Glycerol</th>
<th>Paraffin oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>SPG5-1</td>
<td>SPO5-1</td>
</tr>
<tr>
<td>Average weight loss</td>
<td>1.51</td>
<td>1.86</td>
</tr>
<tr>
<td></td>
<td>SPG5-2</td>
<td>SPO5-2</td>
</tr>
<tr>
<td></td>
<td>1.72</td>
<td>1.89</td>
</tr>
</tbody>
</table>
Characterization of VOCs emissions amounts

The solutions with VOCs absorbed from different samples were evaluated by UV-Vis as previously described. Based on the defined calibration curve, the amount of VOCs (W) from 4 g of artificial leather sample was calculated according to the following equation [19]:

\[ W(\mu g/g) = \frac{A - bV}{a/M} \]  \hspace{1cm} (2)

where \( A \) is the absorbance of the cyclohexane solution at 262 nm, \( M \) is the weight of the sample (g), \( a \) and \( b \) are constant parameters defined by the calibration curve (\( a = 0.0157, b = -0.2 \)) and \( V \) is the volume of cyclohexane used to absorb VOCs (50 mL).

Table 7 shows that a significant VOCs amount was detected when pure synthetic perfume was introduced into the plastisol composition. Compared to the control sample, the weight of VOCs increased by about 31%. This result is due to the emission of varying levels of pollutants such as benzene, ketones, alkanes and alkenes, which are components of most synthetic fragrances derived from petroleum. Additives were found to reduce the emission of these pollutants since VOCs weight has decreased considerably when using synthetic perfume combined with either paraffin oil or glycerol. With the exception of the sample treated with pure synthetic perfume, VOCs amounts of all other samples are close.

CONCLUSIONS

Removal of artificial leather chemical odor was investigated in this paper. Different perfume concentrations and mixtures were applied and a psychological assessment was carried out to evaluate the unpleasant odor remove. First, we have shown that jasmine essential oil has successfully hidden the chemical odor of artificial leather and that variable jasmine smell intensities were obtained depending on the oil concentration combined with the plastisol.

Table 7. VOCs weight of artificial leather samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Control sample</th>
<th>PEO-4</th>
<th>SPO5-2</th>
<th>PSP-2</th>
<th>SPG5-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs Weight (µg/g)</td>
<td>182.88</td>
<td>181.36</td>
<td>190.76</td>
<td>240.44</td>
<td>177.07</td>
</tr>
</tbody>
</table>

Figure 8. ATR-FTIR spectra of different samples.
However, the use of essential oil as fragrance was considered as an expensive solution since high concentrations were needed. Second, we have explored the use of synthetic perfume to hide the chemical odor. The bad smell wasn’t hidden using the pure synthetic perfume. Given that synthetic odorant compounds are unstable and highly volatile at high coating temperature, we have combined pure synthetic perfume with additives in order to slow the rate of combustion. Both glycerol and paraffin oil, used as additives, have removed the unpleasant odor. However, glycerol was rejected as perfume additive since its use has led to the formation of a rigid surface. Pure synthetic perfume combined with paraffin oil was found to be an effective fragrance to overcome the problem of unpleasant odor from both technical and economical points of view. Further experimental investigations are, however, needed to find alternatives which can eliminate or reduce toxic VOCs off gas resulting in an unpleasant odor. Natural and synthetic fragrances were found efficient to mask this odor but not to eliminate its source.

Acknowledgments

This research was supported by Plastiss Company. The authors are grateful to the people at the company, and especially to Houda Bouderbela, for their participation and technical support. The authors would also like to express their deepest gratitude to all the members of the LIMA laboratory (Laboratoire des Interfaces et Matériaux Avancés) and especially to professor Mustapha Majdoub for their collaboration on the performance of VOCs characterization experiments and their technical assistance.

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UKLANJANJE NEPRIJATNOG MIRISA NOVE VEŠTAČKE KOŽE POMOĆU PRIRODNIH I SINTETIČKIH MIRISA

Obično, nove stvari od veštačke kože su veoma neprijatnog miris a jer su kreirane pomoću brojnih hemikalija. Takav miris ostaje dok one ne postanu dovoljno stare. Uklanjanje neprijatnog mirisa je važno za očuvanje bezbednosti i zdravlja na radnim mestima, da bi se zadovoljili zahtevi potrošača i razvile marketinške strategije. U ovom radu je proučavano smanjenje mirisa upotrebom prirodnih i sintetičkih mirisa. Ustanovljeno je da, u dobro definisanim uslovima, obe vrste mirisa efikasno pokrivaju neprijatan miris. Međutim, upotreba sintetičkog mirisa, u kombinaciji sa parafinski uljem, bila je efikasnija.

Kljucne reči: veštačka koža, neugodan miris, premaz, miris, termička stabilnost.