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# Evaluation of Chemical Aging on Carousel Properties Due to the COVID-19 Anti-Pandemic Measures at Airports

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**Abstract**
The study's research question in the broader context of the fight against the pandemic is the impact of disinfectants on selected surfaces of materials used in air transport. The main scientific goal of this work was to verify the assumption that disinfectant solutions cause degradation of mechanical and physical properties, i.e., chemical aging, in samples from airport conveyors, and to determine the degree of change in the properties of the samples depending on the time spent in solution and on aging. The research methodology was developed based on the ISO 1817: 2011 standard, STN EN ISO 868, and the ISO 283 standard, and applied infrared spectroscopy, specifically the Attenuated Total Reflectance method. Research suggests that constant disinfection of baggage handling systems will require the replacement of carrying parts. Otherwise, there will be significant costly breakdowns (damage to luggage, interruption of its flow, delays/inability to check in the aircraft, and the resulting legal consequences). The longer the samples were left in the disinfectant solution, the higher and more uneven the degradation. The hardness of the samples changed after immersion but was not directly proportional to the change in tensile properties. During disinfection, chemical changes occurred, which varied in length and effect depending on the disinfection used.

**Keywords**
chemical aging, light conveyor belt, Shore hardness, tensile properties, infrared spectroscopy

## Introduction

All Disinfectant solutions, aerosols, and physical disinfection methods can cause various degrees of damage to the materials from which airport conveyor belts are constructed. Baggage and baggage carriage areas may be COVID-19 distribution vectors (ACI, 2020). In particular, luggage transfer and collection points are well-frequented areas that may facilitate the transmission of COVID-19 and other contagious diseases. People can become infected if they touch contaminated areas and then, for example, touch their face, eyes, and mouth, or when the virus is released by airflow from the luggage and the BHS (Baggage Handling System). One of the critical issues with an insufficient solution is the reduction of the possibility of infection from luggage and the BHS system, which is connected to the influence of disinfection procedures on the system's status and lifespan. The airport BHS is a critical component of an airport logistics facility, and it is, therefore, necessary to examine these aspects of the impact of anti-pandemic measures on its operations. In 2018 alone, 4.27 billion pieces of luggage were transported (Baggage IT Insights, 2019). Concerns about the safety of the BHS have increased as research has suggested the potential survival of the virus on various surfaces for up to several days. The virus is detectable on different surfaces for different periods of time. For example, on copper, it can be detected for 4 hours, for more than 24 hours on cardboard, and for more than 2-3 days on plastics and stainless steel (Kampf et al., 2020). As most luggage and parts of the BHS system are made of plastic and metal, comprehensive disinfection of all parts of the system and luggage is required.

The biological protection of airports (Andrejiová et al., 2021) and the airport infrastructure have long been underestimated. The risk of a SARS-like pandemic has been highlighted, for example, in work by Bowen and Laroe (2006). They studied the spread of SARS-CoV using air routes and concluded that spreading was possible by global air links. They recommended thoughtful planning of a response to a future epidemic that may be even more contagious than SARS, drawing draw attention to the need to limit the loss of life and the devastating impact on the global economy (Bowen and Laroe, 2006). However, we have not learned from the previous coronavirus pandemics. Peeri et al. (2020) found that the rapid spread of COVID-19 from Wuhan, China, was achieved thanks to extensive transport infrastructure, especially in relation to railways and international airports. Zhang et al. (2020) came to similar conclusions. They examined various factors affecting the rate and patterns of the spread of COVID-19 in China at the beginning of the pandemic and noted that the flight frequencies and high-speed HST trains from Wuhan were significantly linked to the number of cases in cities with airports and HST stations. The relationship between SARS-COV-2 transmission and air transport was confirmed by a cross-sectional study by Guiski et al. (2020), which took place from 3 to 27 March 2020 on a sample of 1389 laboratory-confirmed cases of COVID-19 in Poland. The largest number of confirmed cases was found in 3 of the 4 largest cities, each of which operates an international airport. The link between the higher volume of air passenger traffic in countries with a higher number of patients with COVID-19 was also investigated by Oztig and Askin (2020), who found that countries with a higher number of airports are associated with a higher number of COVID-19 cases.

The pandemic has also worried passengers on an unprecedented scale. According to an international study of 13,949 respondents from 18 countries, up to 56% of the respondents had health concerns (ACI, 2020). According to another study, 64% of the respondents were concerned about their own health, and 82% were concerned about the health of others (Accenture, 2020). Technical measures may be part of the campaign to reassure the traveling public that their health is not being endangered and that measures are being taken to prevent the transmission of disease. According to research from the OAG (Official Aviation Guide) industry, 65% of respondents said that hygiene measures would be the most important steps needed to get people back "into the air" (Rowland, 2020).

What is novel in the presented approach in the study? The pressure to research and implement anti-pandemic measures at airports is a new topic with an impact on the life of critical units of airport infrastructure, which is unexplored and highly topical. In our literature search, we did not find any research that would deal with the influence of disinfectants on the mechanical properties of airport belts (carousels). Our study fills this gap in knowledge. The prerequisite for successful analysis of the degradation of mechanical properties of conveyor belts (Ambrisko et al., 2017; Grinčová et al., 2019; Ambriško and Marasová, 2020) due to disinfection procedures is a specialized workplace with many years of experience in determining and analyzing physical and mechanical properties of airport conveyor belts (Draganová et al., 2020a), as well as a design methodology for structural analysis of hyper-elastic materials (Draganová et al., 2020b), statistical prediction models of impact damage to airport conveyor belts (Semrád et al., 2020), etc.

There are many works that have been devoted, e.g., to the degradation of the natural and synthetic rubbers in fuels (Chai et al., 2013; Loo et al., 2015; Abu-Abdeen et al., 2008).

The presented study examines the research question in the broader context of the fight against the pandemic, what is the impact of disinfectants on selected surfaces of airport conveyor materials used in air transport?

The main scientific goal of this work was to verify the assumption that disinfectant solutions cause degradation of mechanical and physical properties, i.e., chemical aging, in samples from airport conveyors, and to determine the degree of change in the properties of the samples depending on the time spent in solution and on aging.

The research methodology was developed based on the ISO 1817: 2011 standard, STN EN ISO 868, and the ISO 283 standard, and applied infrared spectroscopy, specifically the Attenuated Total Reflectance method.

Conventional commercially available disinfectant solutions were used for the experiments, with the immersion lengths of the BHS carousel samples in the solution being the sum of the disinfection intensity levels used at the airport terminals. We assumed that the samples would harden after immersing the samples in the disinfectant solution. Instead, they softened. Nevertheless, the assumption was confirmed that the change in pH in the disinfectant solutions would not be directly proportional to the change in the investigated properties of the BHS carousel samples examined. The change in hardness was not directly proportional to the change in tensile properties. However, the longer the samples were left in the disinfectant solution, the greater and more uneven their degradation.

What does this knowledge mean for airport companies as operators of airport conveyors during a pandemic?

The results of the research indicated that the constant disinfection of BHS systems would require the replacement of load-bearing parts. Otherwise, there will be significant costly failures (damage to luggage, interruption of its processing, or delays/impossibility to check in the aircraft and the resulting legal consequences, compensation of passengers, etc.).

It is, therefore, necessary to develop new disinfection methods that will not damage parts of the BHS system while maintaining high standards of biosecurity at airports in the long term, to prevent the transmission of communicable diseases and parasites in the future. This will contribute to the long-term sustainable prevention of another global pandemic. These results will relate to recommendations for the following scientific work, innovative disinfection procedures, new synthetic chemicals, and the design of automated equipment for antibacterial and antiviral protection of surfaces.

This document is arranged as follows. In section 2, we describe the preparation of material for our experiments and research methodology developed based on ISO 1817: 2011, STN EN ISO 868, ISO 283, and applied infrared spectroscopy. In section 3, we present the results of experiments and a discussion of the results of hardness measurements, the development of pH change, and tensile properties. In section 4, we close the document and present the main results. We are expanding ideas for future scientific work and improvements.

## Materials and Methods

The research methodology was developed on the basis of the ISO 1817 (2011) standard. The ISO 1817 describes a method for determining the effects of test fluids by measuring the properties of a material before and after its exposure to the selected test fluids. The absorption of disinfectants into a polymer can cause changes in the physical properties of an airport conveyor belt, in particular in relation to its carrying parts. Therefore, we examined the change in the tensile properties and hardness. The hardness was determined by the Shore method, according to the STN EN ISO 868 (2003) standard, while the methodology for determining the tensile properties was based on ISO 283 (2015) using videoextensometry (Ambrisko et al., 2017). An important part of the research methodology in experiments was applied infrared (IR) spectroscopy, specifically the Attenuated Total Reflectance (ATR) method.

Commercially available disinfectants applied at airports and recommended by international organizations were used for the test. Specifically, these were 70% ethanol, 5% sodium hypochlorite (Savo), 30% hydrogen peroxide, and Sanytol (Kampf et al., 2020, Ecri, 2020, Canada, 2021). The active ingredient in Sanytol is Didecyl dimethyl ammonium chloride. The disinfectant solutions containing this active substance to fight COVID-19 are recommended by the relevant authorities of the ECRI-Emergency Care Research Institute in the USA and Canada. Hydrogen peroxide and Savo (sodium hypochlorite) were used in higher concentrations, at about 10 times as the level recommended by the relevant authorities to examine their possible longer-term effects: a concentration of 0.1-0.5% is recommended for sodium hypochlorite, and 0.5-3% for hydrogen peroxide. The immersion lengths of the BHS system carousel samples in the solution represented the sum of the disinfection intensity levels used at the airport terminals.

Samples for the experiments were cut from a carousel segment of the BHS system at Košice International Airport. This segment was in operation for 5 years and was delivered to the laboratory before the start of sanitary anti-covid measures. The weighted average sample thicknesses for Sanytol were 5.74 mm, with 5.59 mm for ethanol, 5.73 mm for Savo, and 5.75 mm for $H_2O_2$. First, the mechanical properties (hardness and tensile properties) were determined before the application of the disinfectant solutions; then, the samples were exposed to the selected disinfectants. Chemical changes took place during the action of disinfectants, which differed depending on the disinfection used and the duration of its action. IR spectroscopy was used to identify them. An interferometric IR spectrometer was used for the measurements, which were performed in the Joint Chemical Laboratory BovaCHEM, s.r.o. and the Technical University of Košice.

**Preparation of Test Samples for the Hardness Tests**

Samples were prepared from the conveyor carousel of the baggage handling system at Košice Airport. We prepared the test samples using a special cutting knife (Figure 1). The thickness of the test samples was greater than 4 mm for the purpose of determining the Shore hardness.

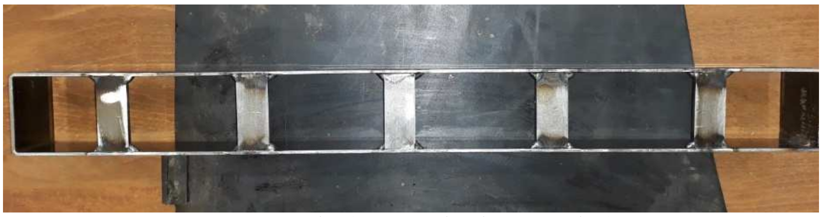


*Fig. 1. Sample of a carousel with a cutting knife*

The samples used for determining the change in hardness had the same dimensions, with mutually parallel surfaces and an average thickness of 5.7 mm. They were cut on an ATMOS SE 25 hydraulic press. The time switch on the knife was set with a rotary switch according to the thickness of the sample. These had the dimensions of 45 x 45 mm for each disinfectant, and 2 pieces were made each time.

**Preparation for Chemical Aging.** ISO 1817 stipulates that a sample must be placed in a container 10 mm from the bottom and 5 mm from the walls of the container. For this purpose, the containers were assembled from glass tubes, rods, and cannula by the method of heat treatment. The samples were then cleaned with ethanol. Holes with a diameter of 4 mm were drilled in the upper part of the samples (Figure 2, on the left).

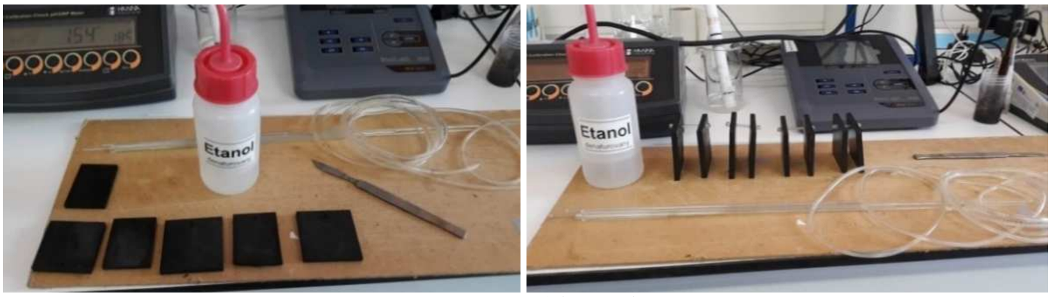



*Fig. 2. Preparation of the sample pairs*

A glass rod was threaded through the holes, which was secured with pieces of MASTERFLEX® capillary (Figure 2, on the right). Over the torch, hooks were made from glass rods to hang the samples in the containers (Figure 3, on the left). The rods were heated until they reached the consistency of honey, then shaped using a metal tool and gravity.

*Fig. 3. Creation of hooks (left) and hanging of the samples in the containers (right)*

The holders on which the samples were hung were similarly made from thicker glass tubes with the help of a torch (Figure 3, on the right). The prepared sample containers were then transferred to an evaporator and were labeled according to the disinfectant solutions: Sanytol, Savo, $H_2O_2$, and ethanol. After pouring in the solutions, the jars were sealed with paraffin foil (Figure 4).


*Fig. 4. Prepared samples placed in the containers; from the left: Savo, ethanol, $H_2O_2$, and Sanytol*

After the first phase of the experiment, after the samples were placed in the disinfectant for one week, Shore hardness tests were performed. This procedure was then repeated after 2, 3, 4, and 5 weeks. Subsequently, natural aging was examined for each group of samples based on the hardness monitoring. This measurement was performed after the 3$^{rd}$ and 6$^{th}$ week.

In order to maintain the greatest possible compliance with the real conditions, a segment of the carousel that had already been exposed to operational wear was used for the tests. The current anti-pandemic measures are applied in the already existing transport infrastructure, so the test temperature was chosen to be normal room temperature, as is common in airport terminals.

**The pH Test.** Using a Hanna HI 4222 pH meter, we measured the pH of the individual disinfectants before inserting the samples and again before their extraction. We repeated this measurement after each sample extraction. Specifically, we immersed the probe into the solution and waited until the value stabilized. After each measurement, we rinsed the probe with distilled water and dried the membrane on the bottom of the probe with a cloth.

After the given time, the samples were taken out, rinsed under running water, dried with a cloth, and allowed to dry fully.

**Hardness Measurement.** The hardness was determined using the ISO 868 standard (ISO 868, 2003, Rodríguez-Prieto et al., 2021). Specifically, the hardness of the material was measured using the Shore method on a Bareiss HPE II Type A hardness tester.

First, the thickness of each sample was measured at 3 locations with a micrometer. From these measurements, we calculated the arithmetic mean. The thickness was larger than 4 mm (ISO 868, 2003) as required by the standard. Before the measurement, the following values were entered into the computer: arithmetic mean of the sample thickness, temperature, and type of measurement. The sample was then placed on the workbench of a Bareiss HPE II hardness tester. Five punctures were made at least 9 mm from the edge and 6 mm from the other punctures on each sample. Each measurement lasted 15 seconds, and Hardtest software automatically calculated the average value, which was entered into the table. Due to anti-pandemic measures (social distancing), later measurements were performed without access to the software and were read from the measuring device and recorded in MS Excel, where the values were recalculated._All the measuring points ran counterclockwise, with the 5$^{th}$ measurement point in the middle. Thus, it was possible to monitor changes in the hardness in individual areas over time. The standard deviations were determined from the 5 measured values on each sample and were plotted using error bars.

**Tensile Properties.** The methodology was based on the ISO 283 (2015). Using a cutting tool, we cut test samples in the shape of a blade on an ATOM SE 25 hydraulic press for 2 series of tests to determine the change in properties caused by natural aging from the test of 02/2018 to the time of our measurement on 12/2020, and to determine the effects of the action of the disinfectant solutions on the tensile properties. Here, due to the slow change in hardness, we performed the tests after 5 weeks.

Before the tests, we measured the thickness of the test samples at 3 points. We then entered the arithmetic mean of the thicknesses into the software to determine the tension value. To determine the tension, the width was also needed, which was measured in the narrowest part of the body with a caliper. We also made reference marks on the samples that we marked using a template, where the value 0 was in the center of the body and at the same time perpendicular to its longitudinal axis. At a distance of "100mm" or "50mm" from the center, 2 contrast lines were marked.

The jaws of the Zwick Roell Z030 are pneumatically driven and powered by a compressor. The test sample was clamped into the jaws of the Zwick Roell Z030 test rig. Prior to the test itself, it was necessary to reset the force on the bursting device.

We also adjusted the position of the video extensometer to measure the elongation correctly. It was loaded at the prescribed constant speed of 100 ± 10 mm/min, and the maximum force and elongation were recorded.
Mathematical relations:
Elongation (fracture deformation). The ductility of the test sample was calculated according to the relation (Marasová et al., 2018):

$$\varepsilon_r = \frac{L_2 - L_1}{L_1} * 100 \qquad (1)$$

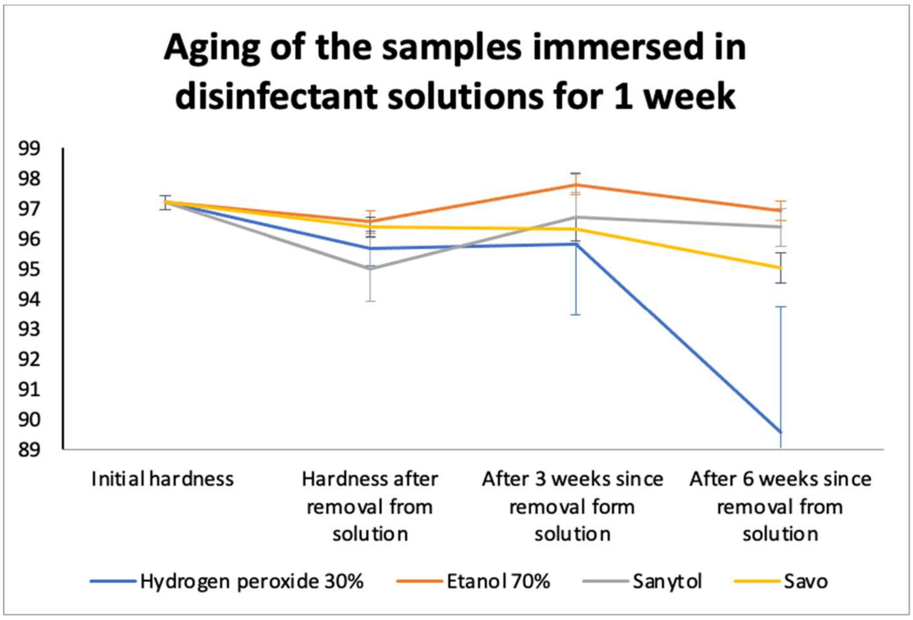
where
$\varepsilon_r$ – ductility [%];
$L_1$ – initial length, or distance between reference lines before the test [mm];
$L_2$ – the distance between reference lines at the body failure [mm].

## Results and Discussion

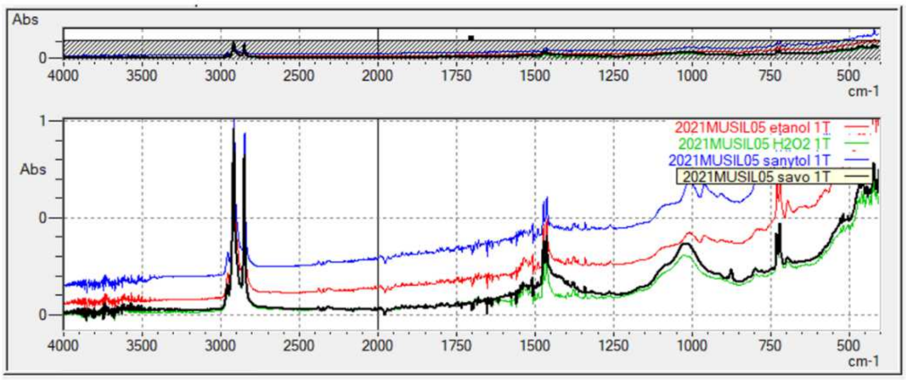
The airport carousel is not made of conventional rubber but is composed of a polymer with a multilayer structure. Therefore, it has a different composition and contains various additives and fillers that define its physical and mechanical properties. The overall properties of the component are derived from them. IR spectroscopy was applied for identification, specifically the ATR method. We examined the individual layers, which consist of polyethylene, with a different compositions. After comparison with the database, we found that the inner material is chlorinated polyethylene with Talc, basic magnesium silicate - $Mg_3Si_4O_{10}(OH)_2$. This serves to reduce the shrinkage of parts after production. The outer surface, both the top and bottom, is oxidized polyethylene.

### Hardness Measurement Results

The experimental research was focused on an evaluation of changes in the mechanical properties, specifically the Shore hardness, of the carousel material. In the initial phase, we decided to determine whether there were relevant changes in the mechanical properties after 1 week of placement in the disinfectant solutions. As can be seen from Figure 5a, significant changes had taken place, and therefore the research continued in the subsequent phases. Changes in composition induce different shapes of absorption bands in the range 1100-800 cm$^{-1}$ (Figure 5b).



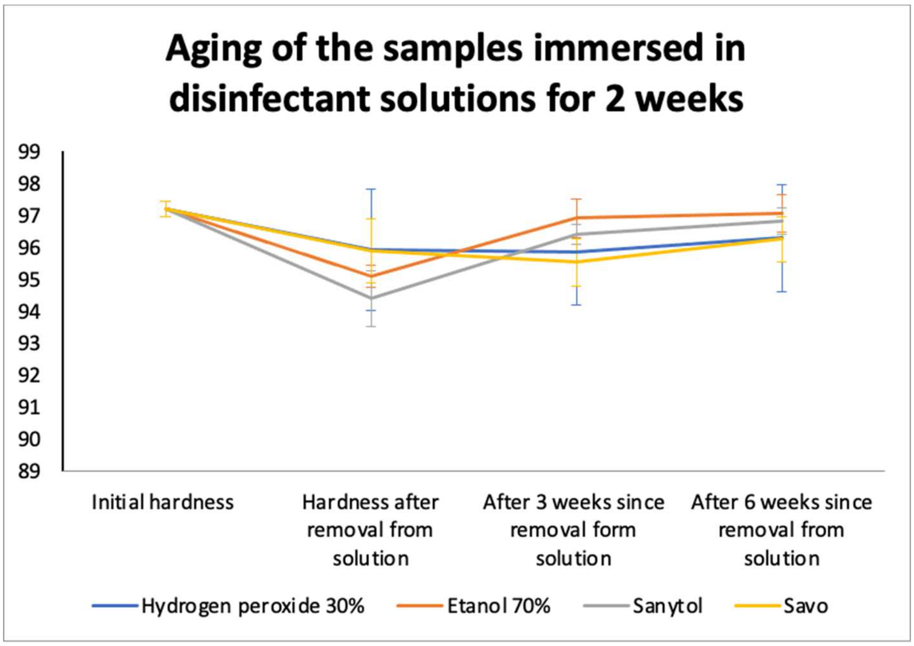

*(a)*




*(b)*

*Fig. 5. (a) Aging of the samples immersed in disinfectant solutions for 1 week; (b) IR spectra of samples immersed for 1 week*

The effect of the disinfectant solutions changed the hardness, which mostly decreased (Figure 5a). After checking the samples taken after 1 week from the disinfectant solution (after 3 weeks of natural aging) for ethanol and Sanytol, the hardness increased to a higher value. However, after 6 weeks, the hardness began to decrease. We did not expect to find that a decrease in hardness occurred during aging, and a significant decrease in the case of $H_2O_2$ was all the more surprising.

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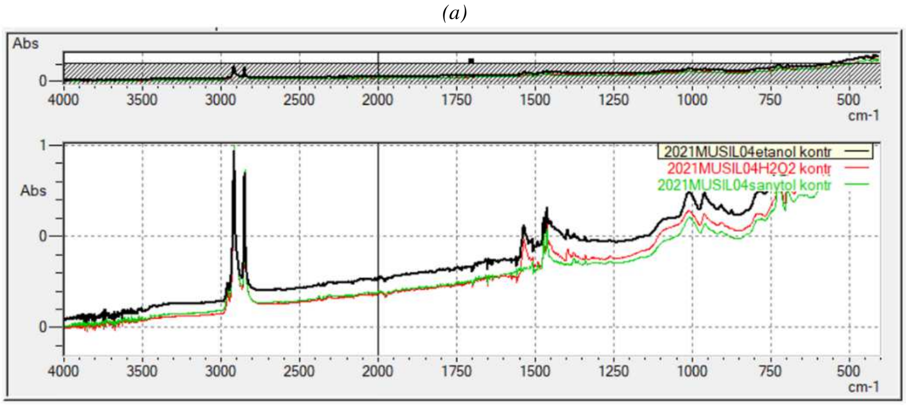
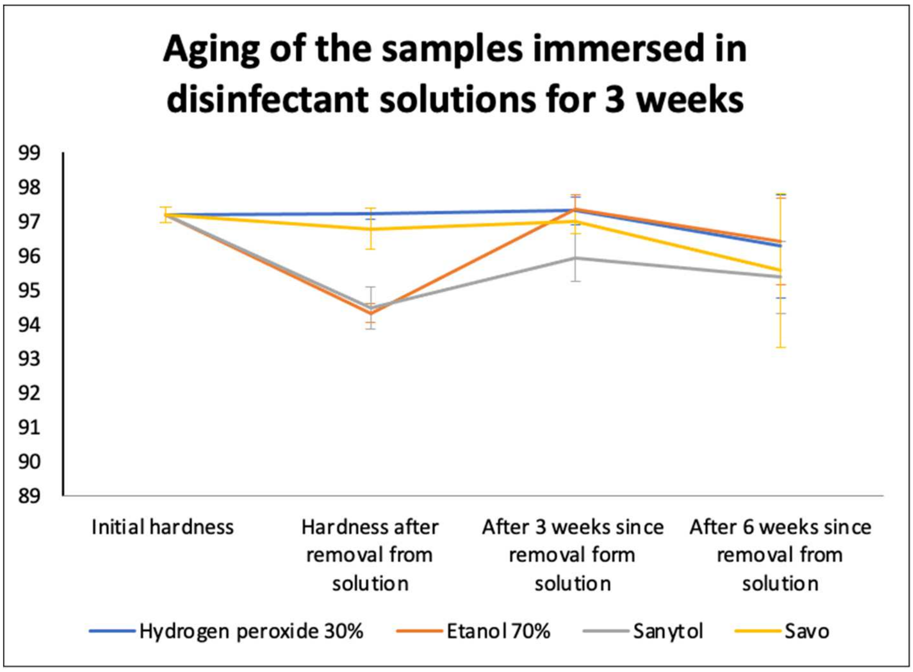



*(b)*

*Fig. 6. (a) Aging of the samples immersed in disinfectant solutions for 2 weeks; (b) IR spectra of samples immersed for 2 weeks*

The samples placed in disinfectant solutions for 2 weeks showed a decrease in hardness. As can be seen from Figure 6a, in the case of ethanol and also Sanytol, the hardness returned to the original value 6 weeks after the samples' removal from the solutions. For control samples immersed for 2 weeks (Figure 6b), only slight to negligible changes in the surface structure of the material can be observed, similar to samples immersed for 1 week.

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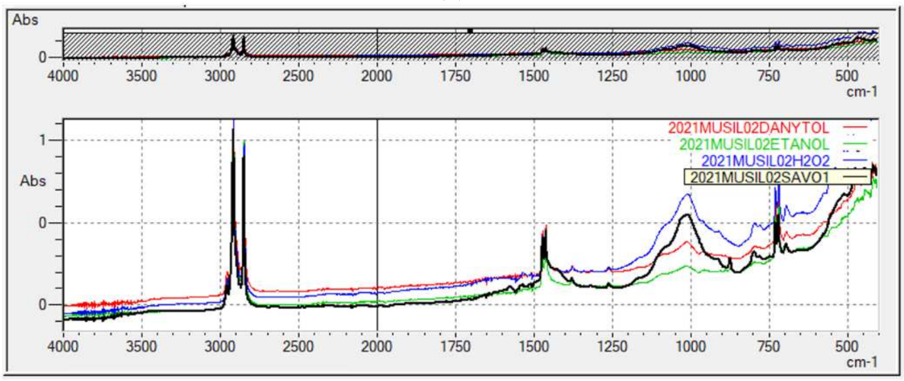



*(b)*

*Fig. 7. (a) Aging of the samples immersed in disinfectant solutions for 3 weeks; (b) IR spectra of samples immersed for 3 weeks*

The samples shown in Figure 7a showed the largest decrease in hardness, especially in the case of ethanol and Sanytol. However, the hardness values of these samples began to return to their original values with natural aging after 3 weeks, and the re-softening with natural aging after 6 weeks was striking.

For individual disinfections (Figure 7b), an oxidizing effect can be observed at a wavelength of 1100 $cm^{-1}$ and a narrowing of the maximum at a wavenumber of 1400 $cm^{-1}$. Sanytol and $H_2O_2$ also lost a maximum of about 870 $cm^{-1}$. However, a new bond of 800 $cm^{-1}$ was formed for $H_2O_2$ and Savo.

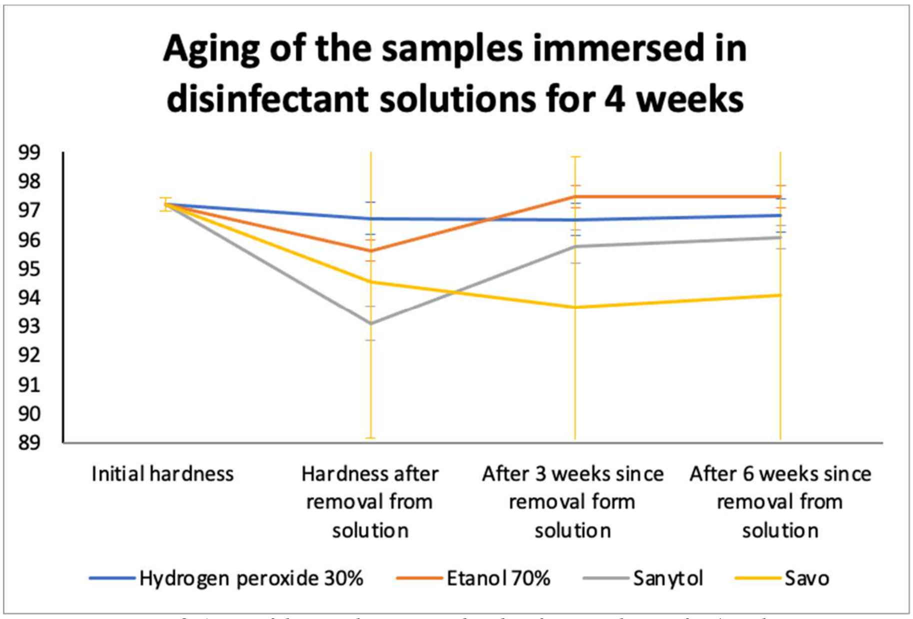
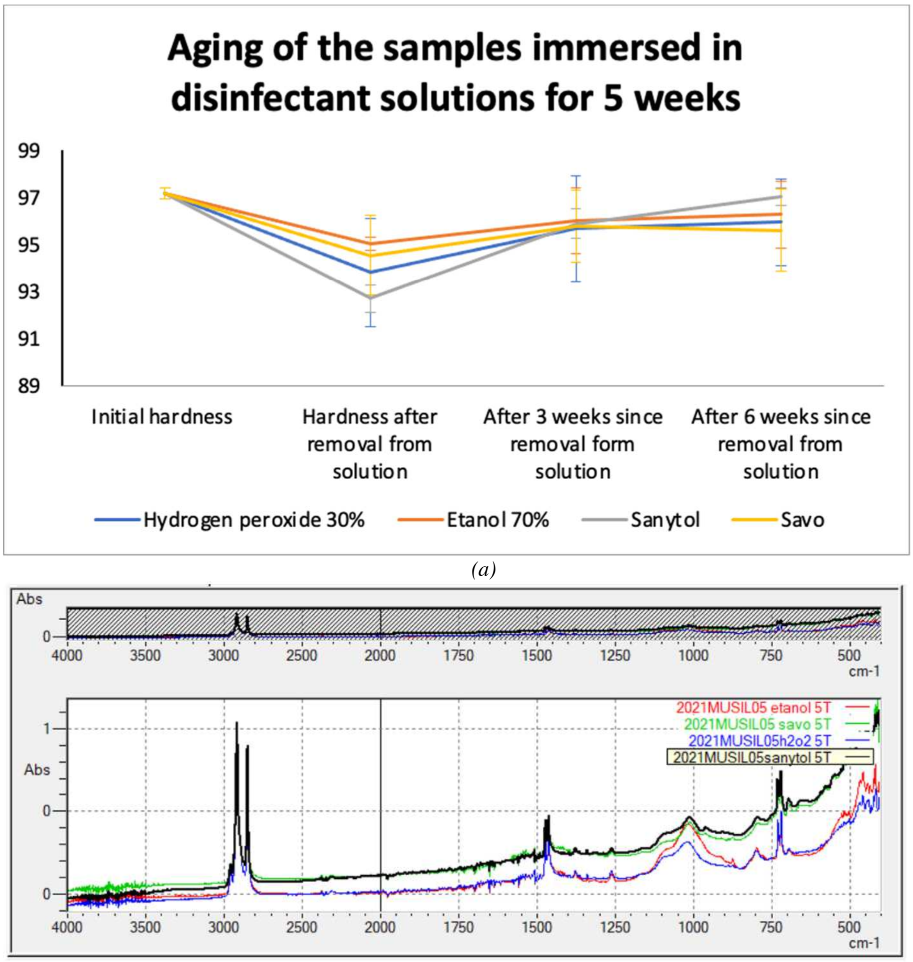



*Fig. 8. Aging of the samples immersed in disinfectant solutions for 4 weeks*

The natural aging of the samples that were placed in disinfectant solutions for 4 weeks (Figure 8) showed a return to the original hardness in the case of ethanol, Sanytol, and $H_2O_2$.



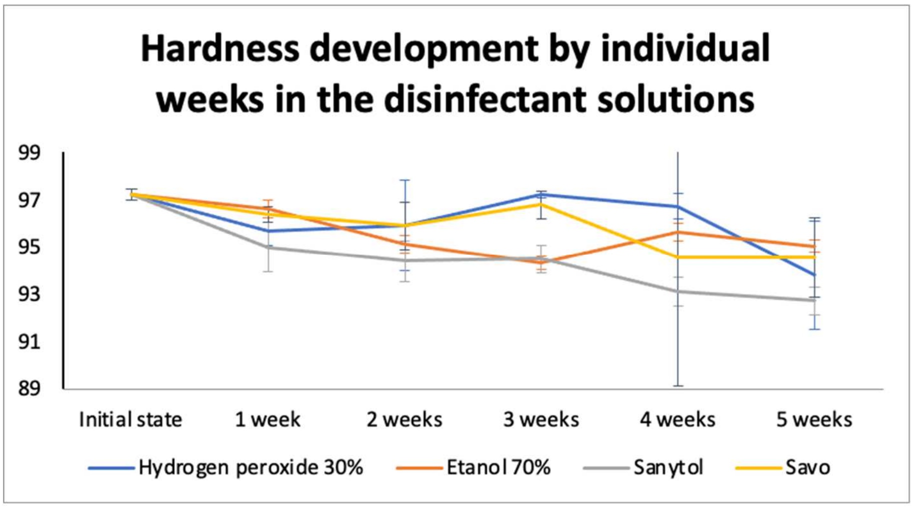

*(a)*

*(b)*

*Fig. 9. (a) Aging of the samples immersed in disinfectant solutions for 5 weeks; (b) IR spectra of samples immersed for 5 weeks*

The development of the hardness of the samples immersed in the disinfectant solutions for 5 weeks (Figure 9a) indicated a decrease in the hardness in the case of all the disinfectant solutions, but with aging, these values were relatively stabilized, with the Sanytol sample even returning to the original value.

For samples immersed for 5 weeks (Figure 9b), we observed the strongest degradation effect with Savo and Sanytol. The maximum at about 870 $cm^{-1}$ disappeared in all samples except ethanol.

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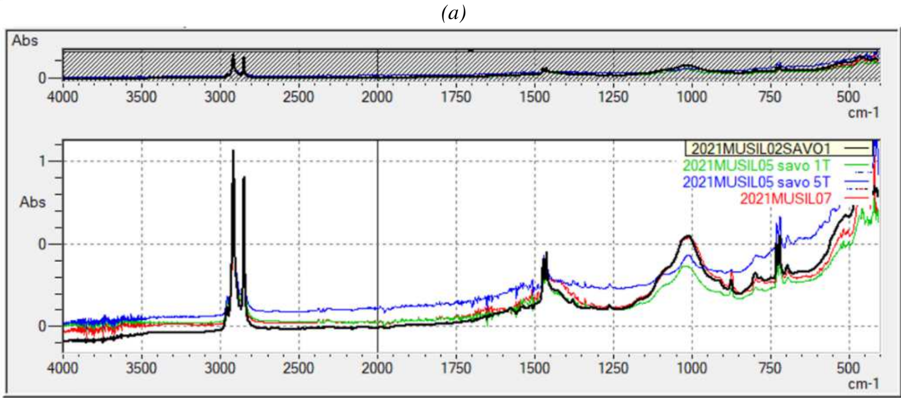


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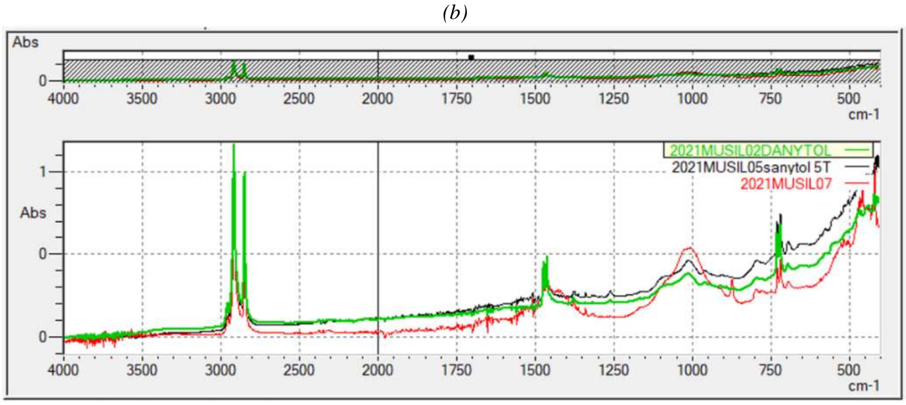


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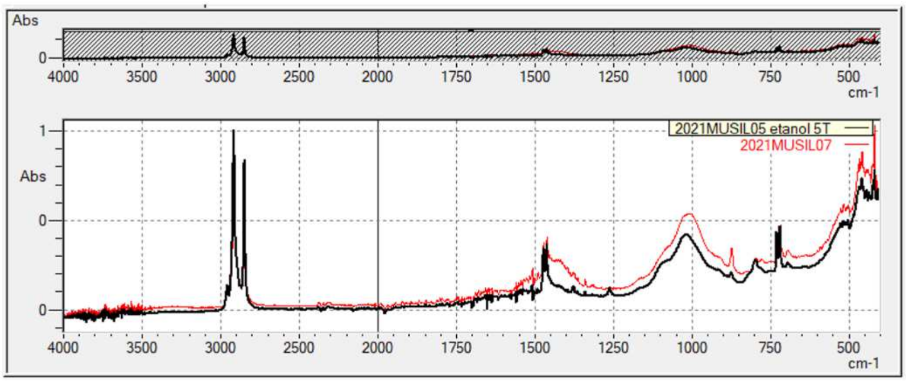


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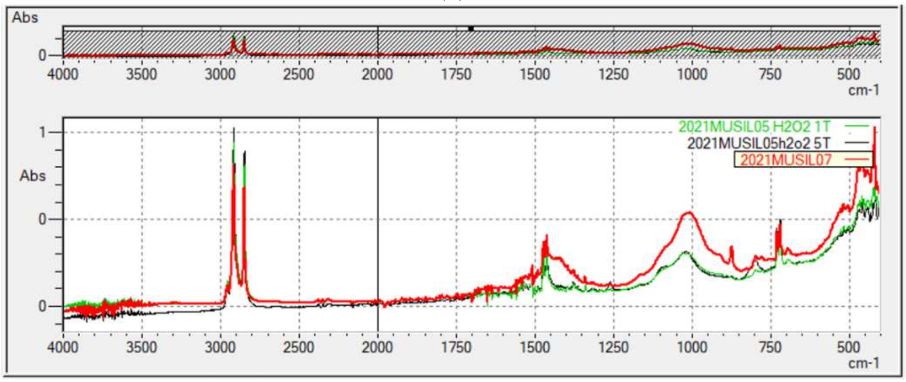



*(e)*

*Fig. 10. (a) Hardness development for individual weeks in the disinfectant solutions; (b) IR spectra of samples immersed in Savo; (c) IR spectra of samples immersed in Sanytol; (d) IR spectra of samples immersed in ethanol; (e) IR spectra of samples immersed in hydrogen peroxide*

The results of the research on the changes in hardness can be summarised as follows (Figure 10a): contrary to the original hypothesis, the samples gradually softened due to the solutions that were used. In Week 3, the opposite trend began to appear in the case of $H_2O_2$ and Savo; however, these samples began to soften again at 4 weeks. Sanytol caused the maximum hardness change, while ethanol caused the minimum change – this occurred during the 5$^{th}$ week. Overall, there was a clear trend of decreasing hardness during the disinfection, but during aging, changes in the hardness occurred, which were characteristic of the particular solutions.

During the action of Savo, changes in composition induce different shapes of absorption bands in the area of deformation vibrations, especially in the range of 1100-800 $cm^{-1}$ (Figure 10b). As in the case of Savo, changes in composition for the action of Sanytol induce different shapes of the absorption bands in the region of deformation vibrations, especially in the range 1100-800 $cm^{-1}$ (Figure 10c). The treatment of ethanol (Figure 10d) in 1$^{st}$ and 3$^{rd}$ week shows a negligible difference compared to the reference sample; the result is the same spectrum, with a small change only after 5 weeks. Under the action of hydrogen peroxide (Figure 10e), the deductive effect starts immediately after 1 week and does not change within 5 weeks. The changes are similar in nature to Sanytol and Savo.

Disinfectant solutions, like any liquid, drain into the gaps of materials, for example, the areas where pieces of the carousel fit together (Figure 11). There, they actually act as if they were in a closed container, which can lead to considerable degradation. These are also the places that undergo the maximum damage. The standard deviations are related to uneven degradation due to different degrees of operational damage. A disinfectant solution that has penetrated into the cracks and splits could act inside the sample even after its removal from the solution.

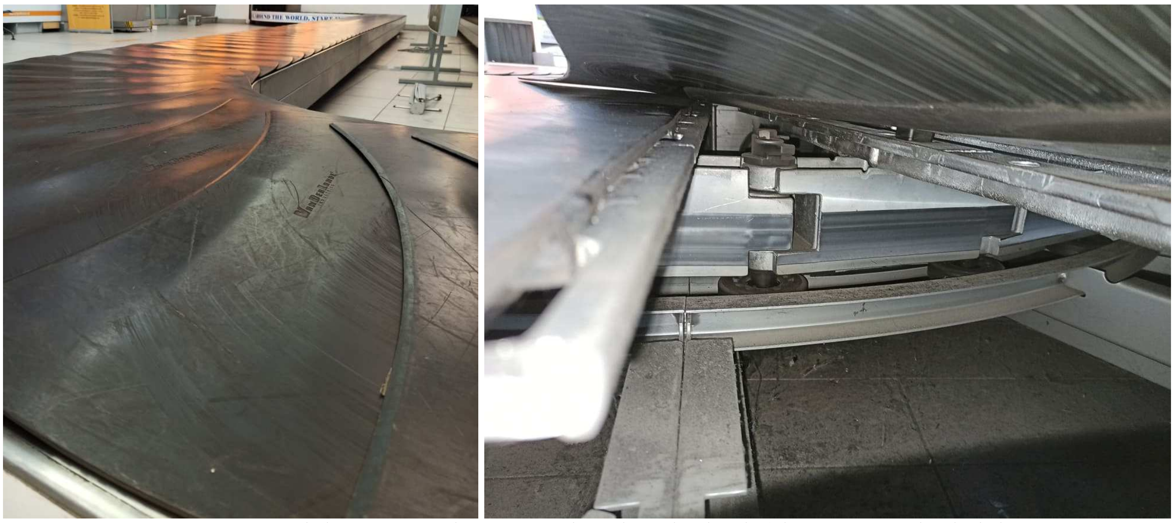
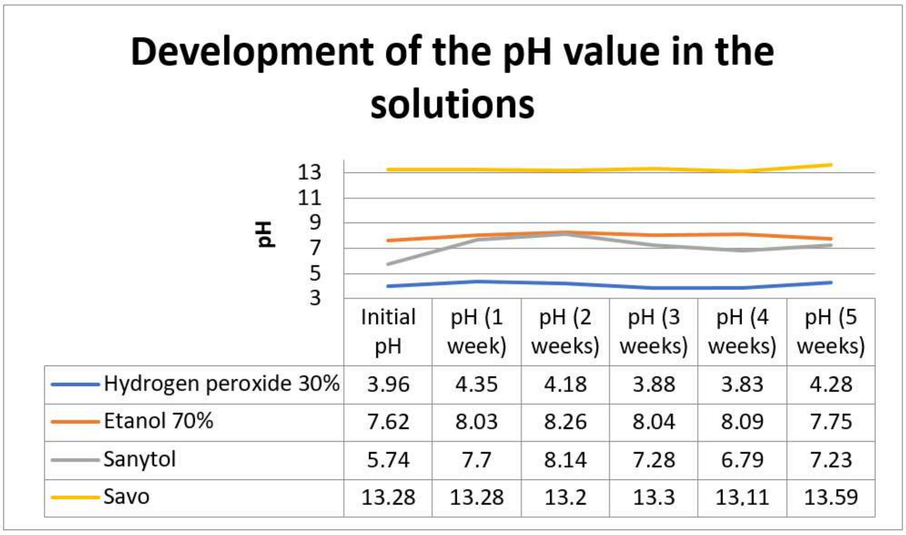


*Fig. 11. Baggage belt conveyor in the airport and (on the right) detail of the conveyor under the belt*

**Development of the pH Change**

The hypothesis that the hardness does not depend on the pH value can be considered to have been confirmed (Figure 12). For example, even the max. (Savo) and min. ($H_2O_2$) pH values did not affect the hardness at all – this was confirmed by almost identical hardness profiles after the 3rd and 4th weeks.




| | Initial pH | pH (1 week) | pH (2 weeks) | pH (3 weeks) | pH (4 weeks) | pH (5 weeks) |
|---|---|---|---|---|---|---|
| Hydrogen peroxide 30% | 3.96 | 4.35 | 4.18 | 3.88 | 3.83 | 4.28 |
| Etanol 70% | 7.62 | 8.03 | 8.26 | 8.04 | 8.09 | 7.75 |
| Sanytol | 5.74 | 7.7 | 8.14 | 7.28 | 6.79 | 7.23 |
| Savo | 13.28 | 13.28 | 13.2 | 13.3 | 13,11 | 13.59 |

*Fig. 12. Development of the pH value in the solutions*

**Discoloration of the Disinfectant Solutions after Sampling.** A change in the color of the solutions was observed after each week (Figure 13). This change was not continuous. In addition, the degradation processes caused a different change in the color of the disinfectant solutions depending on their chemical composition.

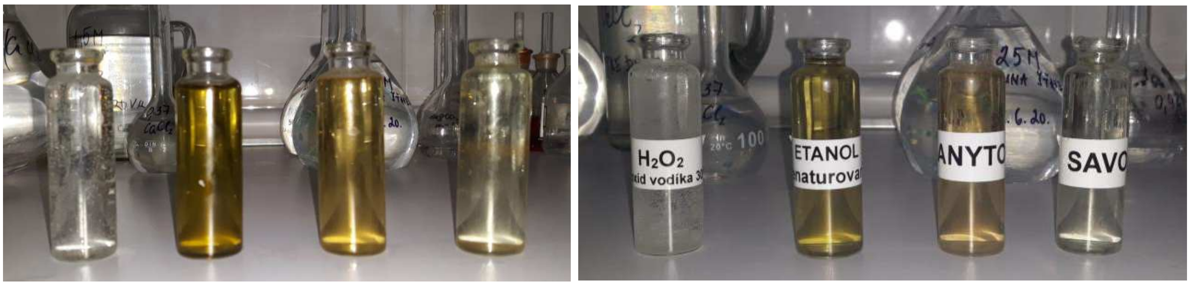



*Fig. 13. Disinfection after 3 weeks (top) and after 4 weeks (bottom); from the left: $H_2O_2$, ethanol, Sanytol and Savo*

## Tensile Properties

Tab. 1 shows the tensile properties of a carousel, including the thickness *h* and the width of the bodies B. After comparing the baseline samples (tested on 02/2018) and the aged samples (tested on 12/2020), natural aging (Tcharkhtchi et al., 2014) was clearly evident after 34 months (Tab. 1, Figures 14 and 15). In addition, the tensile strength $\sigma_M$ (STN EN ISO 21183-1, 2005) increased, and the ductility (fracture deformation) $\varepsilon_r$ decreased.

*Tab. 1. Changes in the tensile properties*

| State | $\sigma_M$ [N/mm] | $\varepsilon_r$ [%] | h [mm] | B [mm] |
|---|---|---|---|---|
| **Baseline** | 42.9 | 170.4 | 5.59 | 25.65 |
| **Aged** | 43.2 | 145.7 | 5.94 | 25.25 |
| **$H_2O_2$** | 37.4 | 125.2 | 5.94 | 25.25 |
| **Ethanol** | 31.1 | 126.2 | 5.59 | 25.25 |
| **Savo** | 36.9 | 118.6 | 5.59 | 25.25 |
| **Sanytol** | 32.9 | 246 | 5.58 | 25.25 |

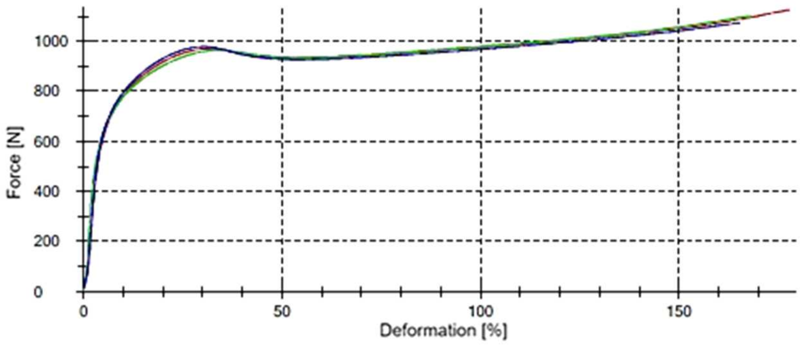



*Fig. 14. Baseline ductility chart*

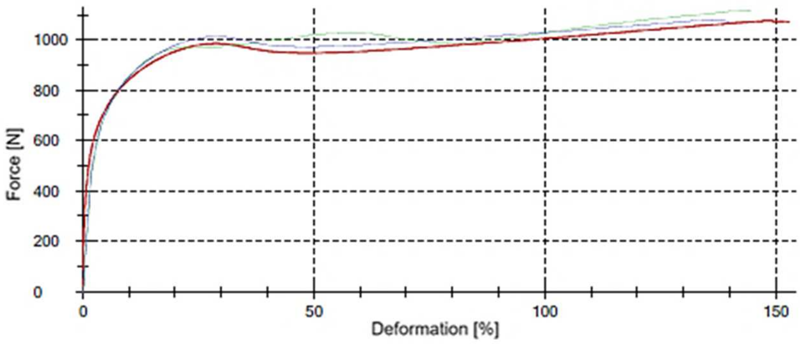



*Fig. 15. Ductility chart after natural aging*

The value of the deformations $\varepsilon_B$ changed considerably due to the action of the disinfectants. The tensile strength $\sigma_M$ decreased in all the bodies immersed in disinfectant solutions for 5 weeks, which corresponded to a decrease in hardness (Figure 16).

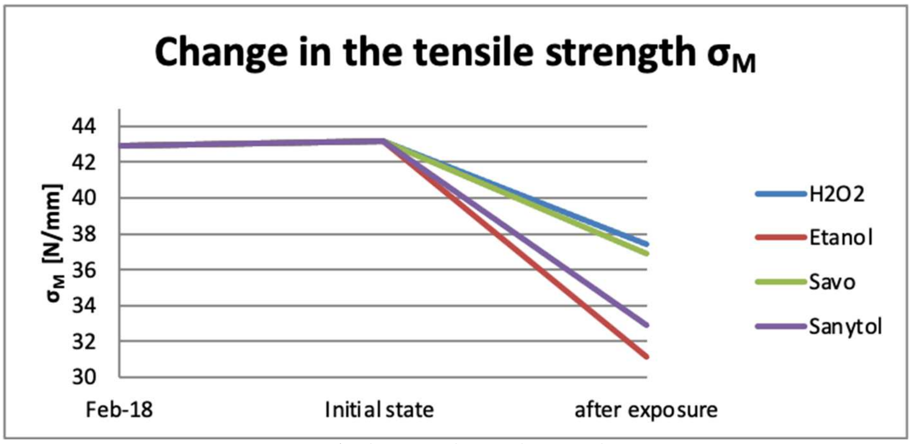



*Fig. 16. Change in the tensile strength $\sigma_M$*

The values of fracture deformations for Savo, hydrogen peroxide, and ethanol decreased. However, for Sanytol, the value of the deformations $\varepsilon_B$ was many times higher (Figure 17). Figure 18 shows a torn carousel body after its degradation by a disinfectant solution.

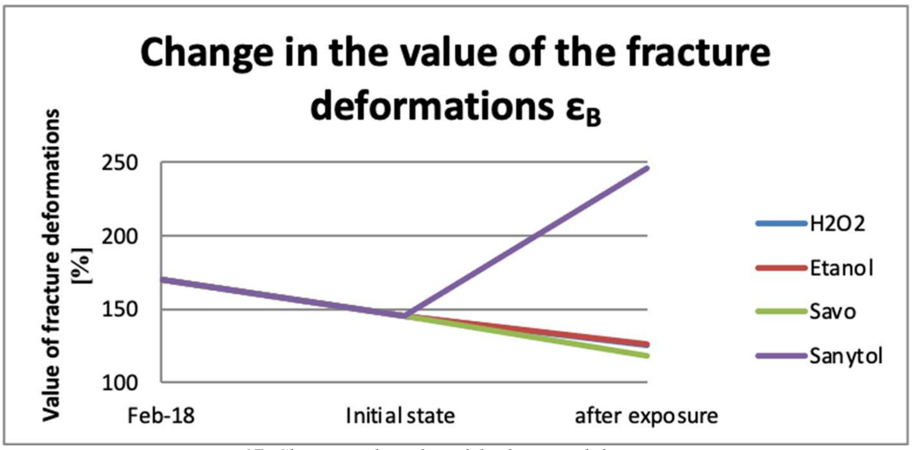



*Fig. 17. Change in the value of the fracture deformations $\varepsilon_B$*

*Fig. 18. Degraded, torn sample*

**Summary**

The use of disinfectants caused the chemical aging of the airport conveyor belts. The action of disinfectants caused a change in mechanical properties but also chemical changes in the carousel, which were confirmed by IR spectroscopy, specifically the ATR method. The research focused on the changes in the mechanical properties, specifically the Shore hardness and tensile properties, of a carousel due to the COVID-19 virus prevention measures employed at airports. In relation to the hardness, it was possible to highlight the actions of ethanol. If we compare the degradation with that of freshly selected samples, as well as the natural aging of the sample, the values were best maintained after the treatment in ethanol. However, the tensile test showed a significant decrease in the tensile strength $\sigma_M$ and the deformation value $\varepsilon_B$.

The hardness of the sample tested in Sanytol decreased continuously. As the samples aged, the original hardness value returned to baseline. The tensile test showed a significant decrease in the tensile strength $\sigma_M$, but unlike with the other disinfectants, the value of deformation $\varepsilon_B$ increased significantly.

The Savo samples fluctuated considerably with degradation, but with aging, the hardness values did not fluctuate significantly. The tensile test showed the second-lowest, although it was still a significant decrease in the tensile strength $\sigma_M$ but the highest decrease in the deformation $\varepsilon_B$. As it is corrosive, this product is unsuitable for metallic materials and electronics.

The change in the hardness values for $H_2O_2$ was probably the most volatile. During the tensile test, the lowest decrease in the tensile strength $\sigma_M$ was observed, but there was a decrease in the deformation value $\varepsilon_B$.

The pH values did not depend on the hardness. This was confirmed by the hardness curves for Savo and $H_2O_2$ after the 3rd /4th weeks.

In 5 weeks, the Sanytol caused the maximum hardness change, which was minimal for ethanol. However, a surprising finding was a decrease in the hardness with aging. For $H_2O_2$, the loss of hardness after 6 weeks of natural aging after taking the sample out of the solution was severe. The uneven degradation was interesting and is probably related to operational damage.

RECOMMENDATIONS: We can state that the material from which the carousel is composed is a polymer with a multilayer structure. Each layer has a different composition, containing various additives and fillers that define their mechanical and physical properties, as well as the overall properties of the component. The authors are convinced that, through further research, it would be correct to perform a deeper chemical and microscopic analysis of degraded and non-degraded samples to gain a deeper understanding of the chemical processes themselves.

We can also recommend the following:

- Do not use $H_2O_2$ for the disinfection of airport carousels;
- Verify the belts and carousels of the BHS system for the effects of disinfection;
- Perform tests on various types of airport belts and carousels;
- Extend the tests to include innovative physical disinfection methods, such as UV and binary plasma, and follow-up scientific work on innovative disinfection techniques, new synthetic chemicals injected into the cold binary plasma stream, and the design of automated equipment for antibacterial and antiviral surface protection;
- Perform comparative experiments with a belt that is new and a belt that has predefined damage;
- Perform comparative experiments with equally old belts, one of which has been disinfected during its operation and the second one that was not, etc.;
- Examine the chemical phenomena in more depth.

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