Technical Report

DETAILS		
	Name of organisation	Eco Ninjas Ltd.
	Company number	08157826
	Name of experimenter	Chris Softas (Conduction of experiments, Report writing) Marc Bruggeman (Experiment planning)
	Tests performed	Chemical degradation of polyester badges in different cleaning solutions/tensile strength testing
	Date	30/05/2023 – 31/05/2023

Scope

Eco Ninjas Ltd. has developed a more sustainable, polymer-based option for name badges intended primarily for use in hospitals. These are a digitally-printed badges on a coated polyester substrate, laminated with heat-activated adhesive film. The badges are said to have excellent resistance to industrial laundering, with accreditation for use on flame-retardant and anti-static garments (i.e., tested to 50+ industrial washes at 95°C, including tunnel finishing). The badges are secured to reusable clinical hats using a metallic popper fastening system. The company currently seeks to understand whether the badges are chemically resistant to cleaning agents, as the badges will require daily cleaning to maintain sterility.

The primary objective of this project is to confirm that the badges remain unchanged when exposed to common cleaning products; Actichlor, Clinell and 70% Isopropyl alcohol (IPA) solutions were the products selected by Eco Ninjas Ltd. To accomplish this, the badges' tensile strength was measured before and after exposure to identify any potential chemical degradation that may have resulted in a decrease in their mechanical properties. The badges were fully covered in the cleaning solutions for 25 hours (i.e., 1500 minutes), assuming a

"traditional" cleaning cycle can take up to 2 minutes (i.e., 750 cycles); this aims to reflect accelerated twice-daily cleaning for one year. The solutions were shaken during the period of exposure to mimic a washing-like agitation. Although this approach does not include the mechanical abrasion experienced during manual cleaning, it does allow for a broader investigation into the chemical resistance of the badges to different cleaning agents. Lastly, a visual inspection of the badges was conducted to detect any visible alterations that may have occurred during the exposure process.

Chemical degradation experiment – Exposure to cleaning agents

The aim of this study is to investigate the chemical degradation of 12 polyester-based badges provided by Eco Ninjas Ltd. against cleaning products frequently utilised in hospital environments. More specifically, Eco Ninjas Ltd. chose three commercial products employing different cleaning agents in their formulations, as presented in Table 1.

Table 1: Cleaning products (inc. cleaning agent information) tested in this study.

Product	Cleaning agent
Medisanitize – 70% Alcohol IPA Spray	Isopropyl alcohol (70 vol%)
Actichlor Disinfectant Tablets	NaDCC/Chlorine (1000 ppm of available Cl_2)
Clinell – Disinfectant Spray	Benzalkonium chloride ≤ 0.5% Didecyl dimethyl ammonium chloride ≤ 0.5% Polyhexamethylene biguanide (PHMB) ≤0.10%

The badges were sorted in sets of three in four categories, one for each cleaning solution and one that would serve as the control group, as presented in Table 2 and Figure 1.

Table 2: Polyester badges specifications and test groups.

Description	Group	Colour
Birthing	Control	White
Jonathan	Control	White
Alexandra	Control	Yellow
Benjamin	70% IPA	Blue
Andrew	70% IPA	Green
Mohammed	70% IPA	Orange
Julia	Actichlor	Blue
Victoria	Actichlor	Green
Julie	Actichlor	Orange
Rebecca	Clinell	Blue
Amy	Clinell	Light blue
Danielle	Clinell	Red

Figure 1: Polyester badges sorted in test groups.

Each individual badge (excluding the control test group) was placed within borosilicate glass beakers, as it can be seen in Figure 2, Figure 3, Figure 4 and Figure 5. Subsequently, the cleaning solutions were poured in their respective beakers until the badges were completely covered. The top of each beaker was sealed with Parafilm tape and all the beakers were securely fastened on the bed of an orbital shaker[1] (KS-260 basic, IKA) that was placed inside a fume hood, as presented in Figure 6 and Figure 7. The orbital shaker speed was set to 50 rpm and the experiment ran for 25 hours to mimic the cumulative effect of "traditional" cleaning cycles over the course of a year, twice per day.

[1] Due to space restrictions on the orbital shaker's bed, two badges from the Clinell group (Rebekka and Amy) were combined in one beaker. All the necessary measures were put in place to prevent any contact between the two badges that could potentially affect the experiment.

Figure 2: 70% IPA, Actichlor and Clinell test groups, prior to the chemical degradation experiment.

Figure 3: 70% IPA test group, prior to the chemical degradation experiment.

Figure 4: Actichlor test group, prior to the chemical degradation experiment.

Figure 5: Clinell test group, prior to the chemical degradation experiment.

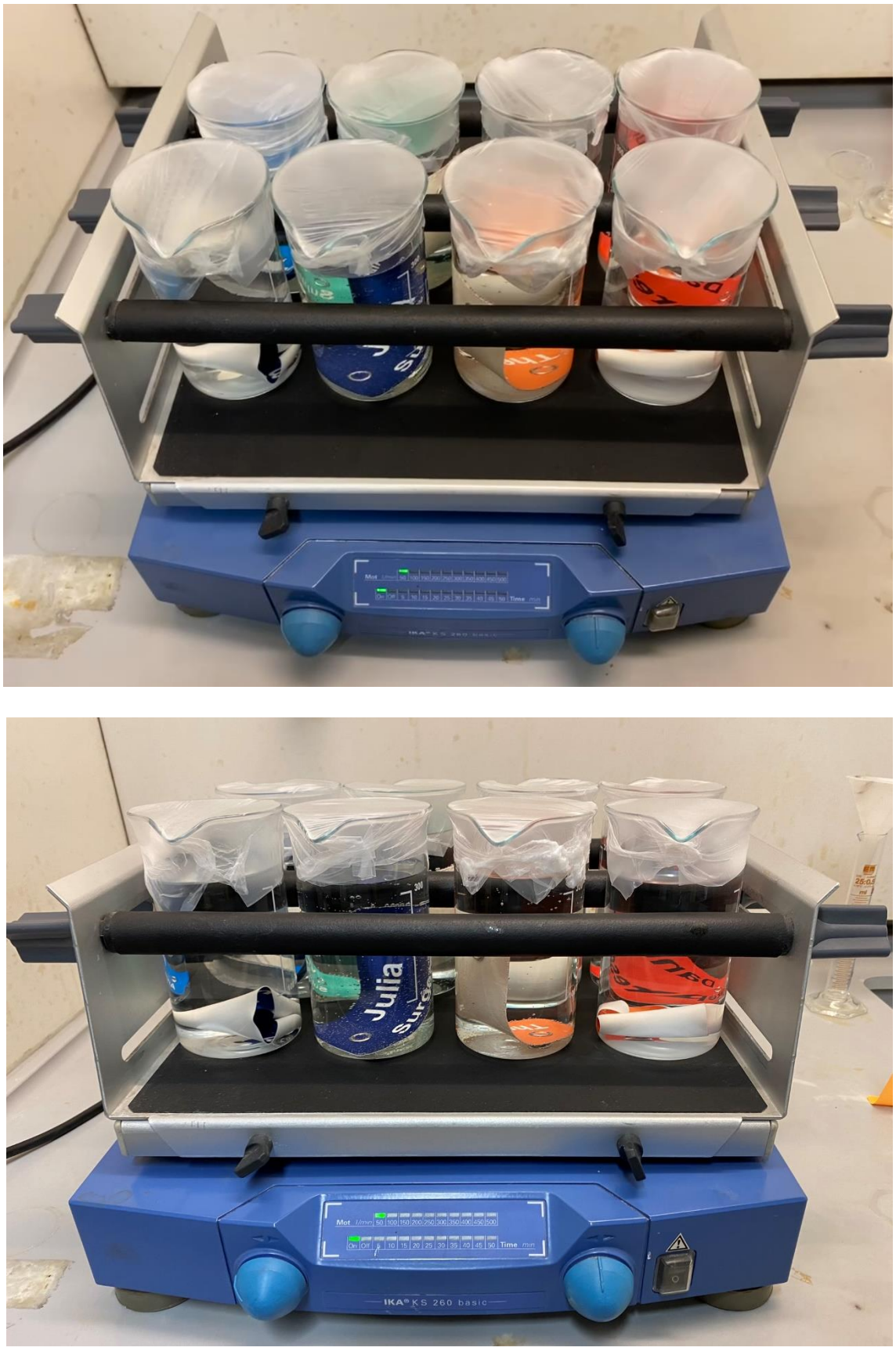

Figure 6: Chemical degradation experiment - Orbital shaker top (up) and front (down) view.

Figure 7: Chemical degradation experiment running inside the fume hood.

At the 25-hour mark, the orbital shaker was turned off and the beakers were visually inspected for pigment leaching or any other form of chemical degradation. No pigment leaching was observed in none of the test groups, since the cleaning solutions were transparent, as it can be seen in Figure 8. Additionally, no deformations were observed on the Clinell and Actichlor test groups. However, that was not the case for the 70% IPA test group since all the badges exhibited severe warping.

The badges were removed from the beakers and were patted dried with tissue paper to remove any excess solution potentially left on the surface. No discoloration was observed on the front of the badges for all the test groups, as presented in Figure 9. Similar observations were recorded for the back of the Clinell and 70% IPA test groups, whereas limited yellowing was observed on the back of the Actichlor test group, as presented in Figure 10. Lastly, no damage was observed on the metallic popper fastening system throughout this study.

Figure 8: Clinell (up), Actichlor (mid) and 70% IPA (bottom) test groups, post the chemical degradation experiment.

Figure 9: Front side of the polyester badges, post the chemical degradation experiment.

Figure 10: Back side of the polyester badges, post the chemical degradation experiment.

Chemical degradation experiment – Tensile strength testing

In order to assess the chemical degradation that may have resulted from the previously described experimental procedure, tensile strength tests were carried out for all test groups, including the control group. An Instron 5566 (High Wycombe, UK) mechanical tester, equipped with a 1 KN load cell, was utilised for the tensile strength tests with a strain rate of 20 mm/s. The badges were mounted on the clamps of the instrument, as presented in Figure 11. More specifically, the clamps grasped the outer parts of the badge (i.e., fabric above and below the poppers).

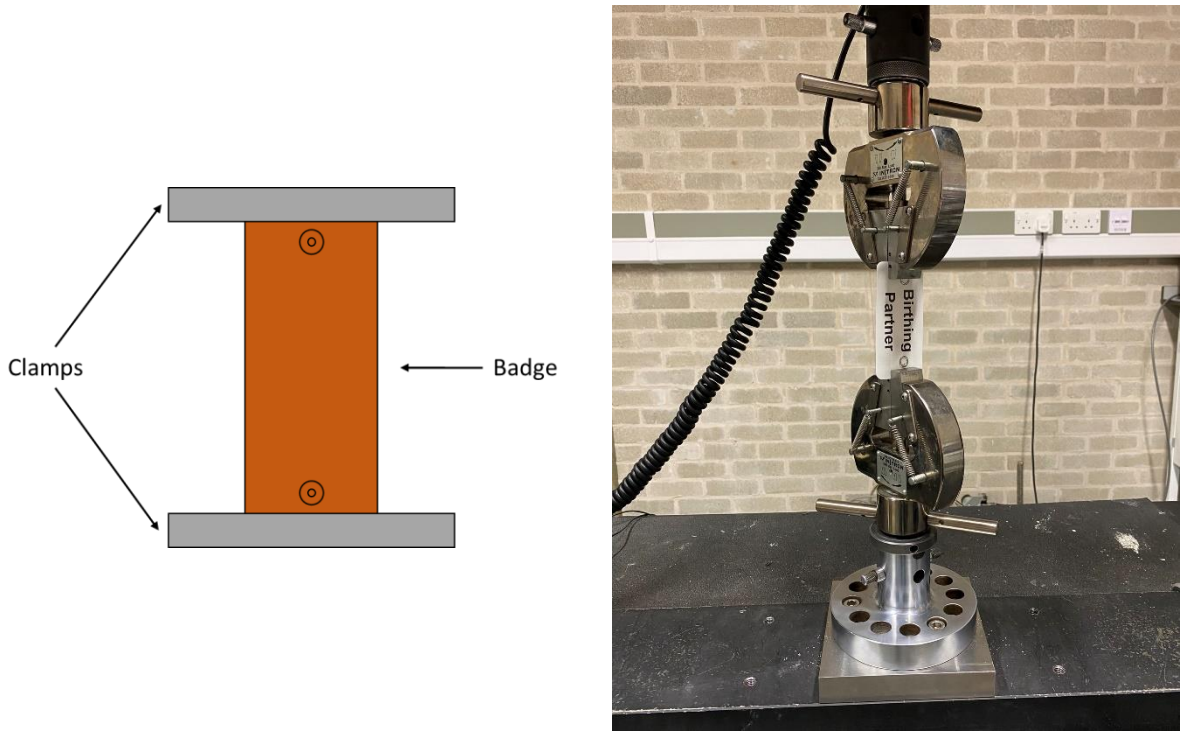

Figure 11: Schematic representation of the tensile strength setup (left) and a picture of the Instron 5566 instrument with a mounted badge ready to be tested (right).

The results from the tensile strength experiments for all test groups are presented in Table 3 and Figure 12. Additionally, representative graphs from the tensile strength experiments are presented in Figure 13.

Table 3: Tensile strength data for all test groups.

Description	Group	Colour	Tensile strength (MPa)
Birthing[2]	Control	White	7.1
Jonathan	Control	White	13.0
Alexandra	Control	Yellow	11.0
Benjamin	70% IPA	Blue	10.1
Andrew	70% IPA	Green	12.1
Mohammed	70% IPA	Orange	13.3
Julia	Actichlor	Blue	12.8
Victoria	Actichlor	Green	11.2
Julie	Actichlor	Orange	11.1
Rebecca	Clinell	Blue	13.4
Amy	Clinell	Light blue	14.6
Danielle	Clinell	Red	10.5

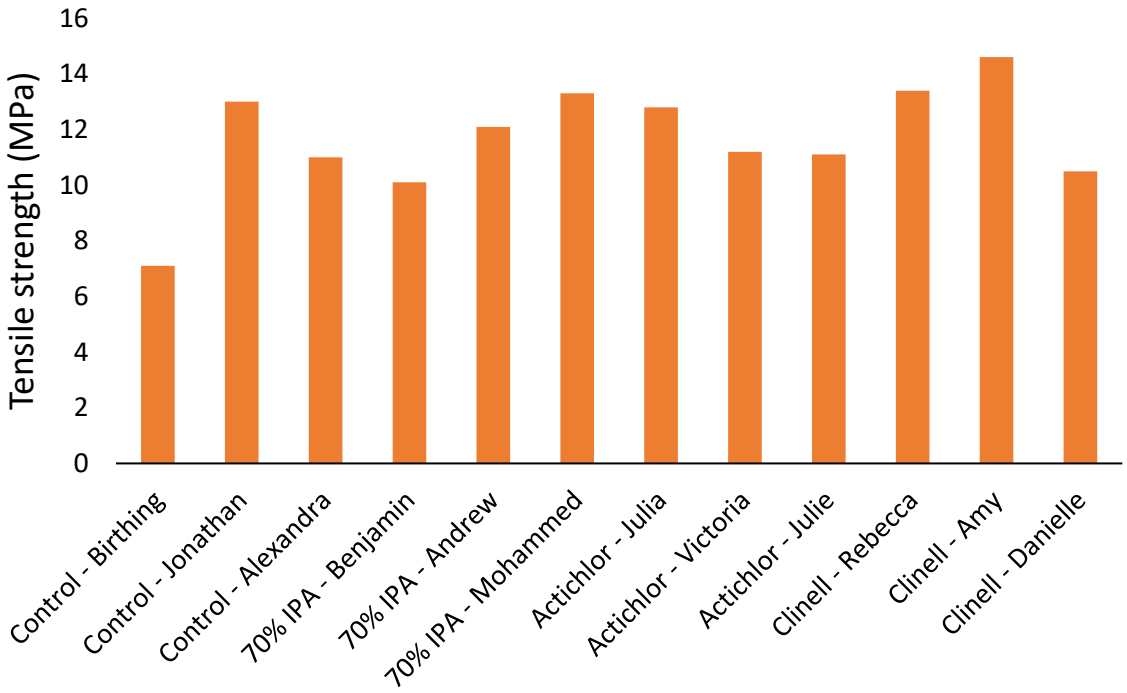

Figure 12: Tensile strength for all test groups

[2] The tensile strength values for the "Birthing" control badge are significantly different compared to the rest of the data points, due to a mounting issue while testing. The outskirts of the badge's popper were clamped instead of the fabric on the outer part of the badge, leading to a different form of failure compared to the rest of the badges. In this specimen the failure was observed on the lower part of the popper instead of the upper part, as per all the other samples.

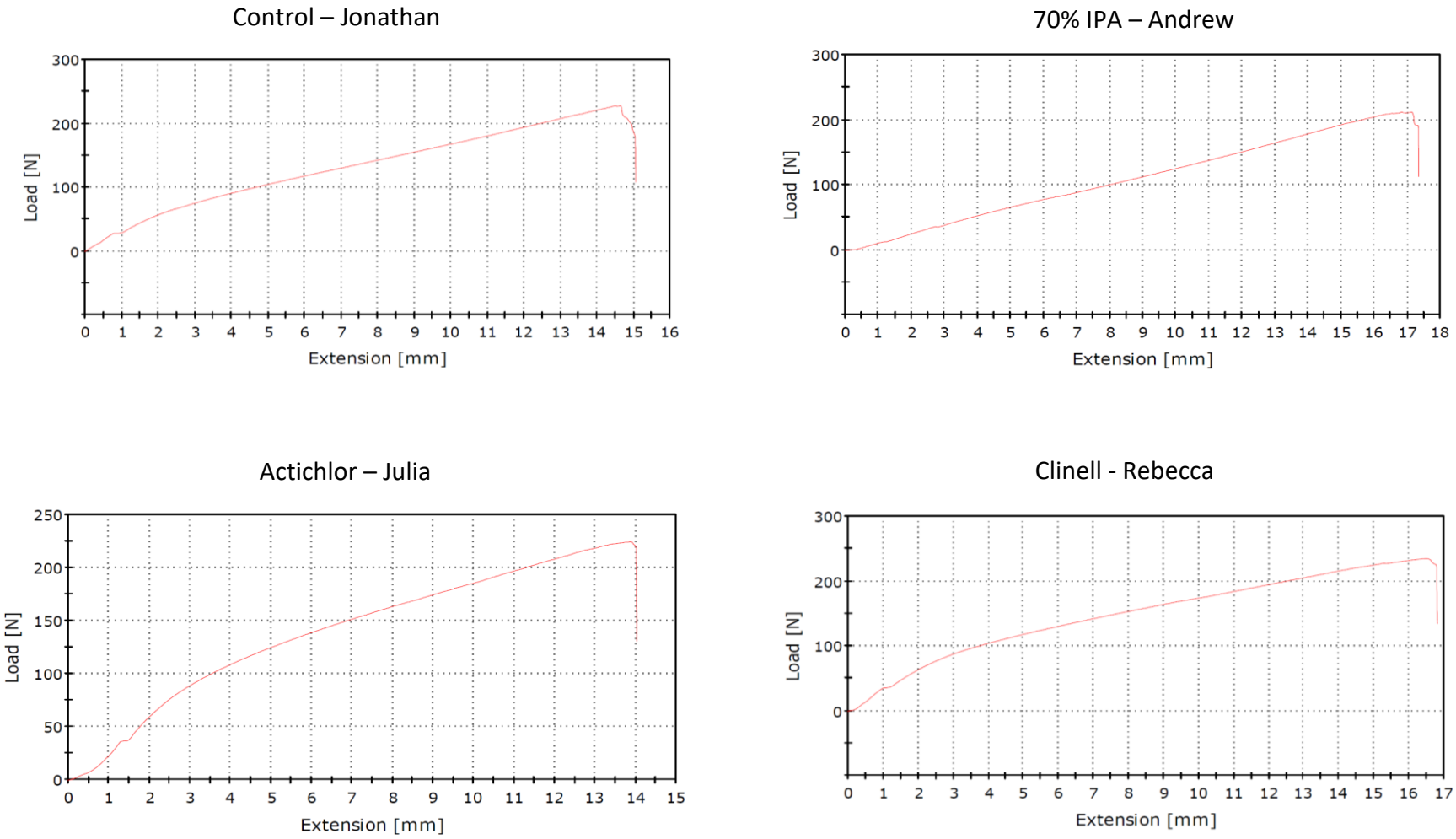

Figure 13: Selected tensile strength graphs for all test groups, pre (control – Jonathan) and post the chemical degradation experiments (70% IPA – Andrew, Actichlor – Julia & Clinell – Rebecca).

No significant difference was detected in terms of the tensile strength recorded between the badges in the control group and the chemically treated ones. All the badges exhibited similar behaviour, as previously seen in the graphs presented in Figure 12 and Figure 13. The tensile strength recorded for the control group ranged between 11 – 13 MPa. Similar values were recorded for the chemically treated samples (i.e., 70% IPA: 10 – 13 MPa, Actichlor: 11 – 13 MPa, Clinell: 11 – 15 MPa). Therefore, the mechanical performance of the badges did not deteriorate due to the exposure in the cleaning solutions.

The visual inspection of the tested samples confirmed that all of the badges failed in a similar manner. More specifically, each badge exhibited one or two horizontal tears above the popper closer to the short end, as presented in Figure 14 and Figure 15.

Figure 14: Failure point during tensile strength test.

Figure 15: Front side of the polyester badges, post the tensile strength tests.

Conclusions

Following the experimental procedure stated in the scope of this report, the following conclusions were drawn regarding the chemical degradation of the Eco Ninjas Ltd. polyester badges when exposed in cleaning solutions utilised in hospital environments:

1. The badges tested in the 70% IPA cleaning solution were significantly warped, by the end of the 25-hour immersion period.
2. The badges tested in Actichlor cleaning solution (1000 ppm of available Cl_2) exhibited a slight discoloration/yellowing on their back, by the end of the 25-hour immersion period.
3. The badges tested in the Clinell cleaning solution did not exhibit any discoloration or deformation, by the end of the 25-hour immersion period.
4. No pigment leaching was observed throughout the 25-hour immersion period, regardless of the cleaning solution (i.e., 70% IPA, Actichlor, Clinell).
5. No damage was observed on the metallic popper fastening system, regardless of the cleaning solution (i.e., 70% IPA, Actichlor, Clinell).
6. The mechanical performance of the treated polyester badges was not affected by the exposure in the selected cleaning solutions (i.e., 70% IPA, Actichlor, Clinell).
    a. No significant difference was detected in terms of the tensile strength recorded between the badges in the control group and the chemically treated ones.