Case Study: Frictional Degradation of Latex from Goalkeeper Gloves

Background

Latex foam materials are used to make goalkeeper gloves for soccer players. There are two general types of latex: smooth and embossed (see Fig. 1).

Fig.1 a) smooth b) embossed c) shiny

Smooth latex goalkeeper gloves tend to wear down quicker because there is a larger contact area with the soccer ball compared to the embossed latex. This larger contact area contributes to a higher frictional force. This is beneficial for goalkeepers because it assists them in catching the soccer ball, but it is detrimental to the goalkeeper gloves because they wear down faster than their embossed counterparts. This case study will investigate the hypothesis that smooth latex gloves degrade faster than embossed latex gloves. This study will also investigate the composition of the different types of latex to determine if composition can explain the difference in degradation rate. This study is limited by both the time and equipment available, but much more work needs to be done to improve the latex used in goalkeeper gloves.

Methods

The first test was Fourier Transform Infrared (FTIR) Spectroscopy on the latex of the goalkeeper gloves. This test revealed the chemical composition of the latex on the goalkeeper gloves by determining the bonds present in the sample. As shown in Fig. 2, the thumb of a goalkeeper glove was placed latex-side-down on the FTIR machine. FTIR was also performed on the “finger-saves” in the goalkeeper gloves (see Fig. 3).

Fig. 2 FTIR setup

Fig. 3 finger-saves

As for the destructive methods, the goalkeeper gloves were subjected to a frictional force via an insert into the heal of a shoe, as shown in Fig. 4. Walking on the goalkeeper gloves, latex-side-down, simulated a similar frictional force as a soccer ball hitting the gloves.

Fig. 4 a) cut gloves b) shoe inserts c) shoes with inserts

Goalkeeper gloves were given to female goalkeepers to investigate where on the latex the gloves fail first following real-life use.

Results

Optical Imaging

After three weeks of walking, optical images were taken of the latex side of the inserts. The optical images revealed that three weeks of walking was not long enough to cause any damage to the latex of the gloves. The optical images also demonstrated the difference in topography of the embossed and smooth latex surfaces.

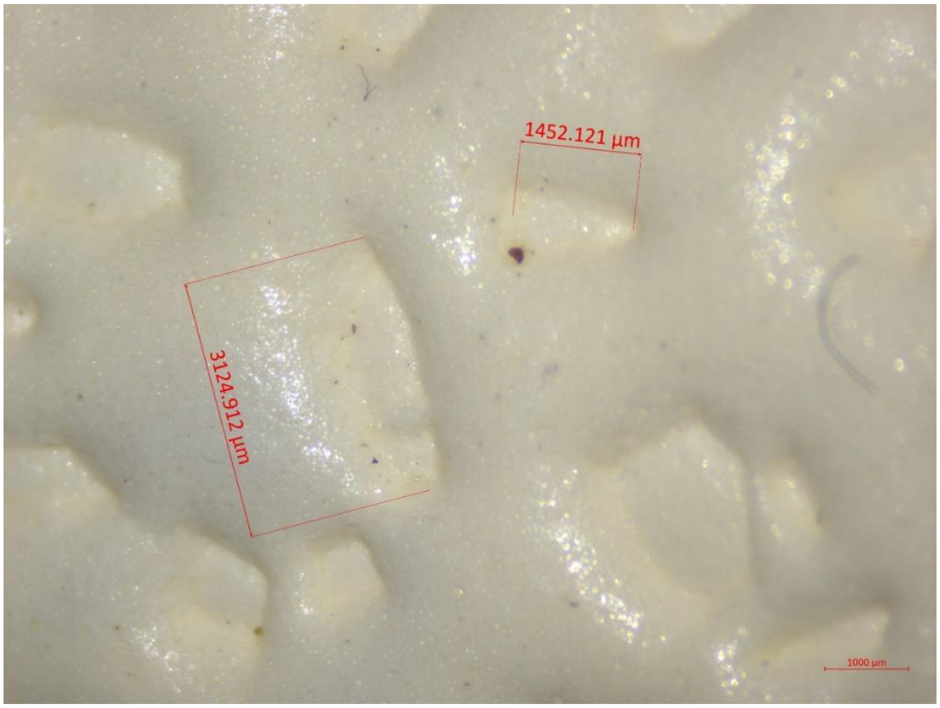
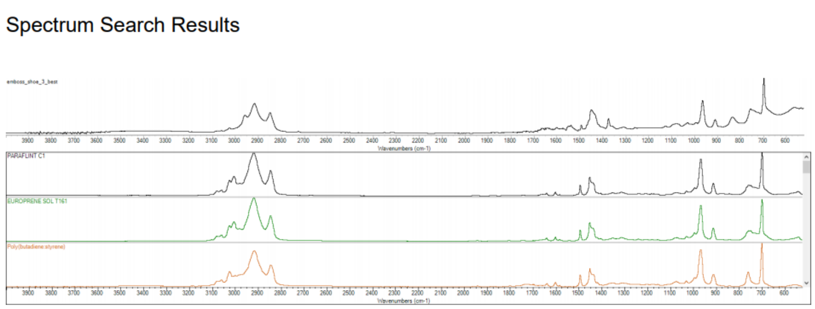


Fig. 5: Optical image of embossed latex showing the varied surface topography.

Fig 6: Optical image of the smooth latex, on the same scale as the optical image of the embossed latex.

FTIR

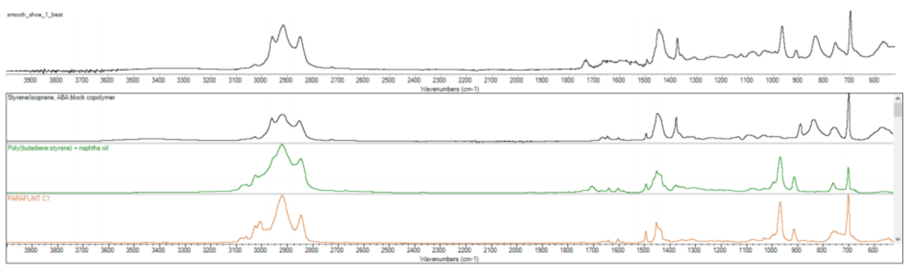
Fourier Transform Infrared Spectroscopy (FTIR) is a common technique used to determine the identity of an unknown polymer. The unknown polymer is subjected to infrared radiation, and the machine measures how much of that radiation is absorbed by the unknown polymer. The machine then uses computer software to match the absorbance spectra of the unknown polymer with those of known polymers in online databases. Fig. 7 and Fig. 8 show the top three matches for the embossed latex and the smooth latex, respectively. FTIR was also performed on the finger-saves; the results are in Fig. 9.



	Match	Title	Range	Folder	Filename	Index
1	88.43	PARAFLINT C1	4000.0-525.0	HR Industrial Coatings	c:\my documents\omnic\libs\sea431.lbd	1458
2	87.85	EUROPRENE SOL T161	4000.0-525.0	HR Industrial Coatings	c:\my documents\omnic\libs\sea431.lbd	1292
3	87.01	Poly(butadiene:styrene)	4000.0-525.0	HR Hummel Polymer and Additives	c:\my documents\omnic\libs\sea406.lbd	283

Fig 7: FTIR spectra of the embossed latex showing the three top matches from online databases.

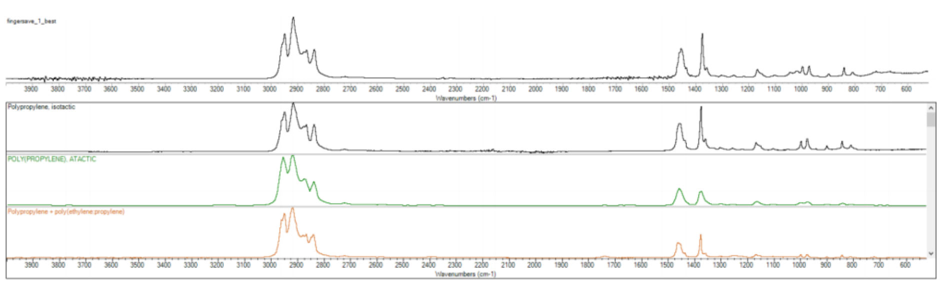
Spectrum Search Results



	Match	Title	Range	Folder	Filename	Index
1	82.94	Styrene/isoprene, ABA block copolymer	4000.0-525.0	HR Specta Polymers and Plasticizers by ATR	c:\my documents\omnic\libs\sea464.lbd	88
2	79.98	Poly(butadiene:styrene) + naphtha oil	4000.0-525.0	HR Hummel Polymer and Additives	c:\my documents\omnic\libs\sea406.lbd	259
3	79.85	PARAFLINT C1	4000.0-525.0	HR Industrial Coatings	c:\my documents\omnic\libs\sea431.lbd	1458

Fig. 8: FTIR spectra of the smooth latex showing the top three matches from online databases.

Spectrum Search Results



	Match	Title	Range	Folder	Filename	Index
1	93.31	Polypropylene, isotactic	4000.0-525.0	HR Specta Polymers and Plasticizers by ATR	c:\my documents\omnic\libs\sea464.lbd	67
2	89.15	POLY(PROPYLENE), ATACTIC	4000.0-525.0	Hummel Polymer Sample Library	c:\my documents\omnic\libs\sea006d.lbd	41
3	87.70	Polypropylene + poly(ethylene:propylene)	4000.0-525.0	HR Hummel Polymer and Additives	c:\my documents\omnic\libs\sea406.lbd	324

Fig. 9: FTIR spectra of the fingersaves showing the top three matches from online databases.

Tensile Testing

Tensile testing was performed on the finger-saves. The tensile test demonstrated that the finger-saves are assemblies made up of two components of the same material. Following this realization, no further tensile testing was conducted.

Real-Life Use

After 1 week of use by a female college goalkeeper, some wear was observed on the thumb of smooth latex gloves, as well as on the outer palm (Fig. 10).

Fig. 10: Real-life wear after 1 week of use

Conclusion & Recommendations

The smooth latex is made from a synthetic rubber, styrene/isoprene, which makes sense because synthetic rubbers are lightweight and easy to manufacture. However, synthetic rubbers wear down faster than natural rubbers, which explains why the smooth latex gloves wear down so quickly. I wouldn't look into manufacturing with natural rubbers though, because the manufacturing process is very toxic and the gloves will also be noticeably heavier. In the coming months I would like to look into the different types of synthetic rubbers to see if there's one with more resistance to wear. I would also like to look into different manufacturing techniques to see if there is a way to apply synthetic latex to the gloves that minimizes the rate of degradation.

The embossed latex is made from a more durable polymer, poly(butadiene:styrene), and the varied topography of its surface also helps distribute the frictional force well. Based on these two factors the embossed latex should last the longest. In the coming months I would like to continue walking on the inserts and taking optical images to see the difference in wear between the embossed and smooth latexes.

The finger-saves are made out of a stiff polymer, polypropylene, which is also one of the cheapest polymers to manufacture. In the coming months I would like to conduct tensile testing on the finger-save assembly to investigate which part of the assembly is the weakest. I would also like to look into the forces experience by finger-saves in real-life use to see if there is a cheaper polymer that could be used for the finger-saves that could still withstand the forces they experience.

In the coming months I would also like to look into the different structures these polymers to have to see if there is a specific structure that has the best performance. Finally, I would like to perform compression testing on the gloves to see how the areas near the base of the fingers respond to a compressive force like the compressive force they experience from someone making their hand into a fist. This is a common technique used by goalkeepers to punch the ball far away from the goal, and I think it may contribute to the wear observed in the gloves I gave to a real-life goalkeeper.