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Wax or no wax - that is the question

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ABSTRACT

The use of wax on cross-country or alpine skis is a controversially discussed issue. While one part of the experts is of the opinion that wax can be dispensed with, another part of the ski technicians world insists on the application of wax. Since the use of wax must always be seen in interaction with the ski base, mixing effects of wax and polymer molecules play an important role. Using high-resolution electron microscopy, it has been shown that waxing creates an intimate bond between paraffin and polymer, which makes gliding success possible. The techniques of brushing are of great importance here.

1 Introduction

The question of whether or not you need wax for skiing has been on the mind for many years. After the year 2000, when things had become quieter, the discussion was rekindled by Leonid Kuzmin's doctoral thesis [1]. Based on his own measurements and the experiences of his wife - a former cross-country skier - he came to the conclusion that wax is not really necessary for success in competitions. With this written statement he had made many friends among ski wax manufacturers, who naturally see things completely differently. Even if you talk to ski technicians, wax is one of the prerequisites for success. As always in life, the truth is hidden in the middle between the poles. More about that later. But first of all, basic statements about wax and ski base should be made.

2 Results

If skis are prepared for competition, the ski is first cleaned, then wax is applied and spread over a large area with an iron. After the excess wax has been removed, the grooves created by stone grinding must then be exposed again using brushes, see Fig. 1. In the subsequent ski test, the chaff is then separated from the wheat. Whether the ski is running or not, ski technicians report that the quality of the ski base is noticeable in the glide tests despite being covered with wax. There are skis that run very well right from the start and others that are only fun after many wax cycles. But what is the reason for this and how thick is the wax on the base really?

In the SkiMAGAZINE 4/2015 I had the opportunity to write about the ski base as the unknown being [2]. One result of many years of Fraunhofer research into ski bases made of ultra-high molecular weight polyethylene (UHMWPE) was the discovery of molecular fluff structures on the surface of this plastic. These fluffs must not be confused with the threads produced by grinding, as these are about 100 times longer, see Fig. 2 left.

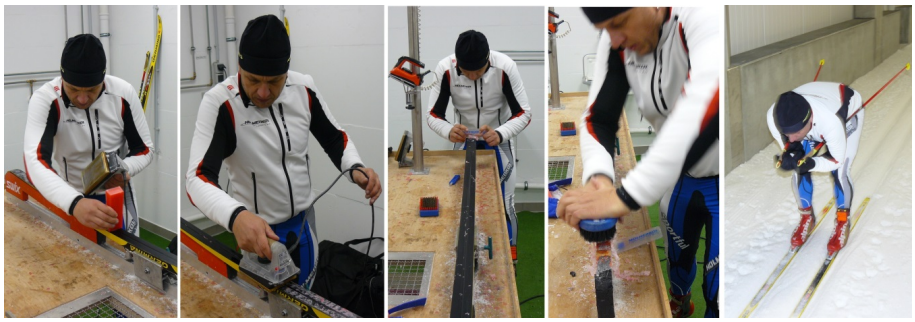

Fig. 1: Ski preparation by waxing, ironing, scraping and brushing, followed by the ski test.

Thermoplastics like UHMWPE are semi-crystalline and consist of long chains of hydrocarbons. In some areas of the polymer, these chains are ordered - i.e. crystalline - while in other areas the chains are completely disordered, one speaks of amorphous. Both structural variants can be clearly seen in Fig. 3 on the right. While ordered areas appear light, the amorphous areas remain dark. The hydrocarbon chains combine to form bundles so that a structure similar to that of a flokati rug is created on the surface of the base. Each bundle of the flokati has lengths between 100 nm and 200 nm (1 nm = 1 billionth of a meter).

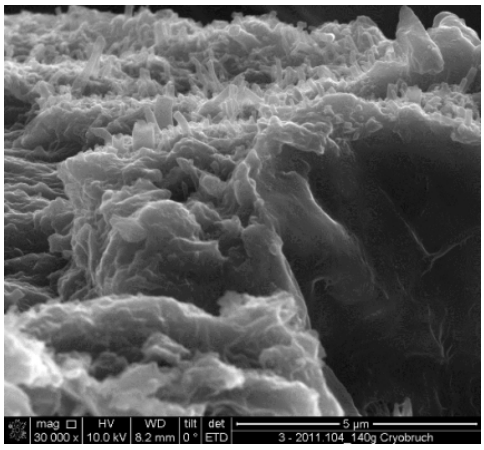

Fig. 2: Structure of UHMWPE after grinding.

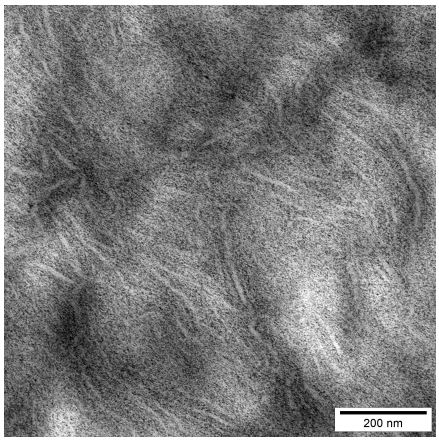

Fig. 3: Structure of polyethylene on the bulk.

Between the bundles of the flokati there is a lot of space for wax, because the individual paraffin molecules are small compared to the polymer chains built up from many millions of atoms. This wax absorbency has led to the misinterpretation that UHMWPE must have pores that open during waxing to swallow the paraffin. However, ultra-high resolution electron microscopy showed that high density polyethylene does not have any pores. The wax has therefore become part of the flokati. The wax absorption is promoted by the heat during ironing. However, UHMWPE melts at temperatures between 130°C and 145°C. Before melting, the mobility of the polymer molecule chains increases, so there is more space for the wax molecules. This leads to 2 consequences: a) If the temperature during waxing is too high, the polymer melts, which is a known fact. Before this happens, however, the filigree polymer bundles begin to melt or, in extreme cases, burn off. Both effects make the ski slower. b) With the introduction of the flokati rug model, brushing the ski also takes on a whole new value.

For brushing, a micro steel brush is often used in the last step. During the brushing process, a large number of the individual steel bristles come into contact with the ski base, engage in it and pull on the polymer bundles. As a result, the flokati rug forms and is ready to absorb wax. Gliding is thus made possible by a nanometer-thin composite of polymer bundles and wax. There may well be external conditions, e.g. if the snow is very cold, that the flokati rug alone is sufficient. As a rule, however, wax is always required, as this is much more water-repellent (hydrophobic) than the plastic, see Fig. 4. If the ski base is not able to form the wax-filled flokati, whether due to poor UHMWPE quality or excessive brushing (keyword: rotor brushing at high speeds), there is no sliding pleasure.

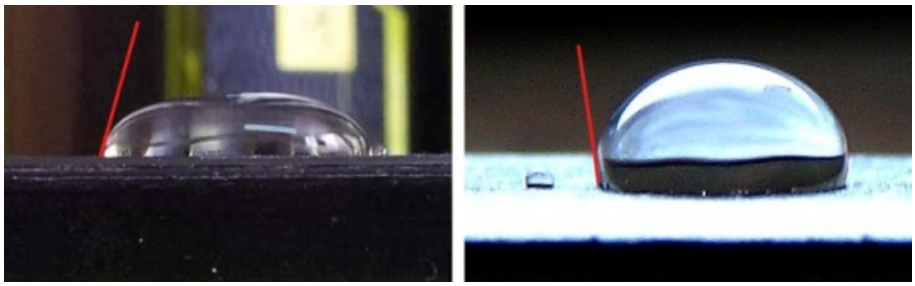

Fig. 4: Different degrees of water repulsion. Left: Unwaxed ski with a wetting angle (angle between the horizontal and the tangent to the drops) smaller 90°. Right: Waxed ski with a wetting angle larger 90°.

3 Summary

The success in gliding is significantly influenced by the wax. However, the wax alone is not the key to success, because with optimal ski preparation, the wax forms an intimate connection with the ski base, it bonds with it. This process is strongly influenced by the temperature during waxing and the way the ski is mechanically treated. Brushing is the main part of this process. The type of brushing as well as brushing time and pressure are the decisive factors.

So what are the conclusions for the ambitious skier?

1. Keep your eyes open when choosing your base! Watch out for signs of greying as an indicator of poor quality and degradation.
2. Be patient while brushing. The right pressure is important.
3. Observe how the wax bonds with the coating.

4 References

[1] Kuzmin, L., Doctoral thesis, Mid Sweden University, Faculty of Science, Technology and Media, Department of Engineering and Sustainable Development, 2010 (English), comprehensive summary.
[2] Scherge, M., Bonk, C., Der Skibelag - Das unbekannte Wesen, SkiMAGAZIN No. 04 / 2015.