Sofia University
"St. Kliment Ohridski"
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Experimental study of microhardness and wettability of hard multilayer coatings of CR-39 spectacle lenses

Laboratory "Resonant Droplet Tensiometry"
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1. Introduction

This research aimed to study and compare the surface properties of organic spectacle lenses for everyday use, based on CR-39 (Poly(allyl diglycol carbonate) (PADC), from different manufacturers. The objects of this research are lenses from three different manufacturers. Each brand is represented by a reference uncoated lens and three other lenses with different types of protective coating. Each sample has been characterized in laboratory conditions according to three indicators of the surface: **microhardness, roughness,** and **wetting properties**.

2. Materials and methods

Three different brands are selected. Each brand is represented by a reference uncoated lens and three other lenses with different types of protective coatings:

Lenses parameters						
Lens type	*Diameter*	*Curvature*	*n*	*Thickness*	*Density*	*Abbe number*
UC	70mm	6 (83.33mm)	1.50	2.0mm	1.32g/cm^3	58
HC	70mm	6 (83.33mm)	1.50	2.0mm	1.32g/cm^3	58
HMC	70mm	6 (83.33mm)	1.50	2.0mm	1.32g/cm^3	58
SHMC	70mm	6 (83.33mm)	1.50	2.0mm	1.32g/cm^3	58

- UC – Uncoated
- HC – Hard Coating
- HMC – Hard Multilayer Coating
- SHMC – Super Hard Multilayer Coating

Each sample of 70 mm brand new spectacle lens has been carefully cut into 20 mm wide strips. Each strips had been cut into smaller pieces (segments) designed for the different measurements fig.1, forming a measurement set fig 2.

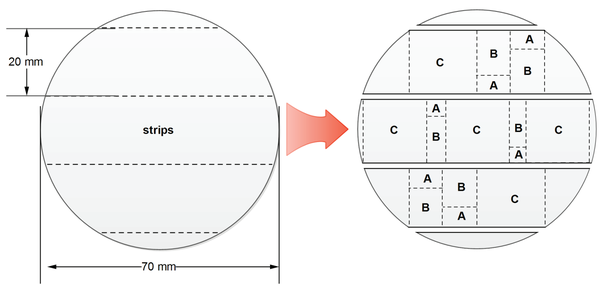


Figure 1: Lens, cut into segments

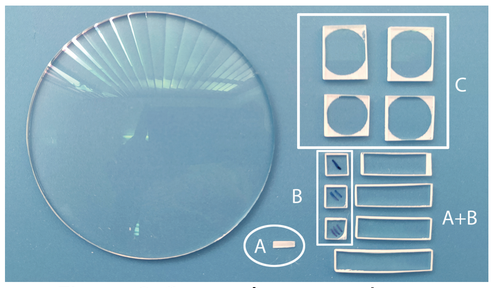


Figure 2: Source lenses and a sets of prepared A, B and C segments

Microhardness measurements

The 0,3 mm thin "A" segments are used for microhardness measurements, with the classical Vickers indentation method. For that purpose, we used a robust instrument PMT-3, equipped with micrometric eyepiece MOB-1-15. multiple indents resultant of different loads on UC and HC lens surface, are shown on fig. 3 and fig. 4

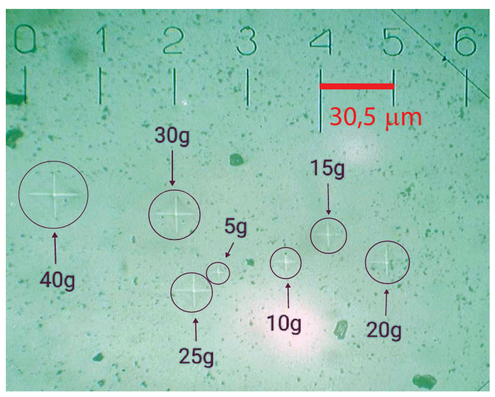


Figure 3: Microscopic image of Vickers indents under different loads on UC lens surface (Brand 3)

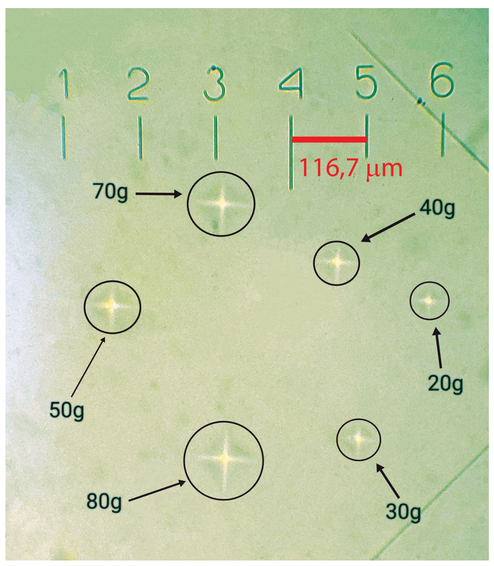


Figure 4: Microscopic image of Vickers indents under different loads on HC lens surface (Brand 2)

AFM measurements

In order to determine the surface roughness, we used an advanced AFM instrument - Oxford Instruments MFP-3D Origin™ features Asylum Research. The studied surface areas are within size 20x20 µm and 30x30 µm, in AC mode of the AFM instrument. Every lens type was studied with three different segments multiple times.

Wetting properties measurements

Surface coating wetting properties are studied using a static contact angle measurement of a sessile droplet deposited on the surface. The contact angles are determined by Kruss DSA30S tensiometer.

3. Experimental results

Microhardness

The microhardness of UC and HC lenses of all three brands were successfully measured with accuracy of 2 ÷ 3%. A typical microhardness curve is obtained for UC and HC, represented on fig.5 and 6. The summarized results are on fig. 7

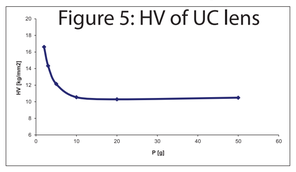


Figure 5: HV of UC lens

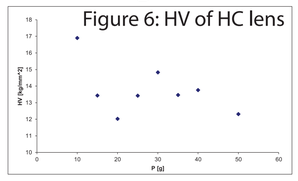
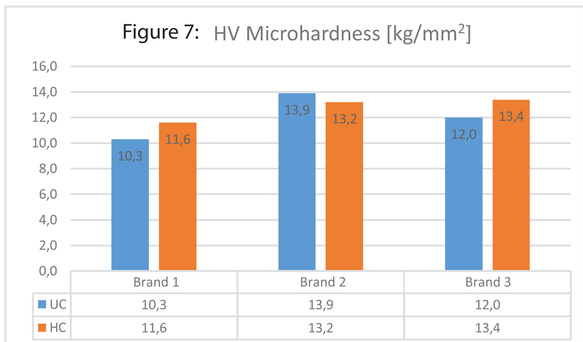


Figure 6: HV of HC lens

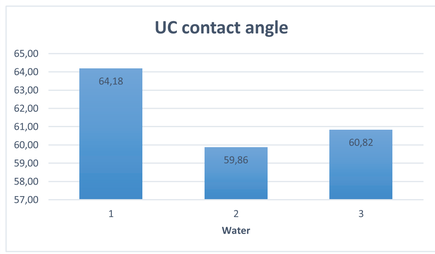
Although we obtained microhardness results for MHC and SMHC material, it is very hard to be studied systematically with our equipment. The main reason is the feint and smooth contours of the resultant Vickers indents caused by the hardness of the protective multilayer coating.

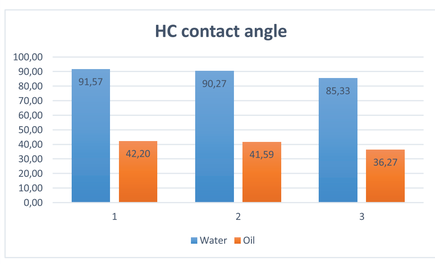


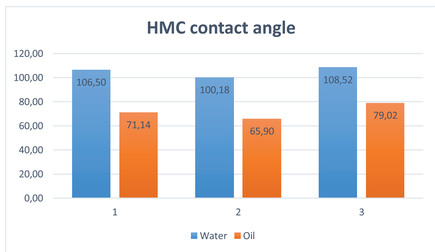
AFM study

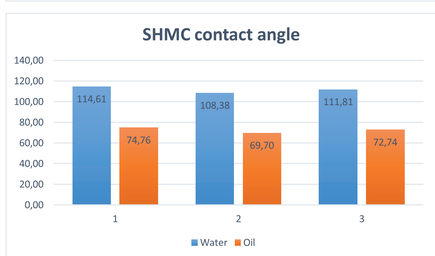
Average roughness [nm]			
lens type	Brand 1	Brand 2	Brand 3
UC	5.077	1.308	1.535
HC	0.725	0.771	0.386
HMC	3.281	2.274	4.563
SHMC	0.777	1.668	0.599

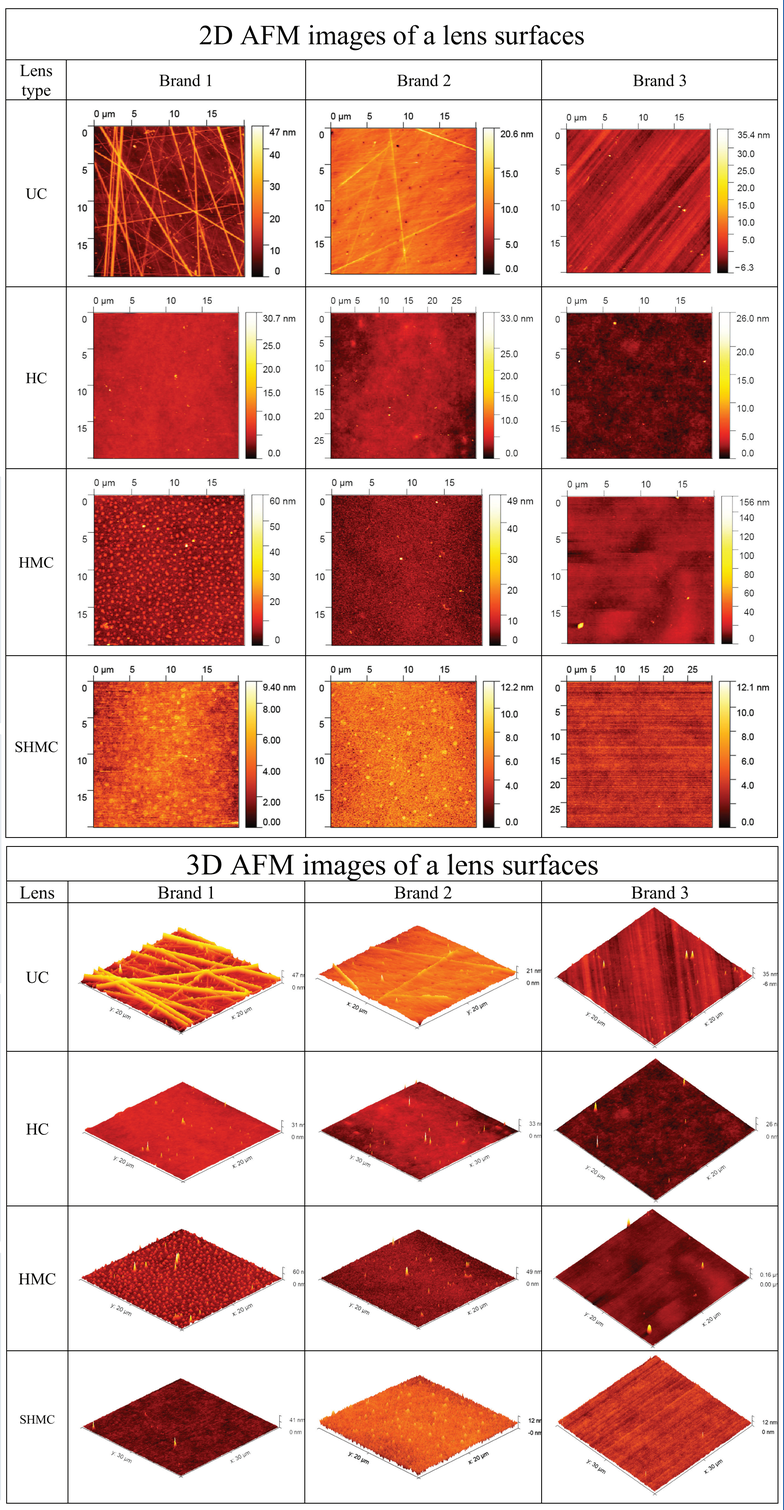
Wetting properties



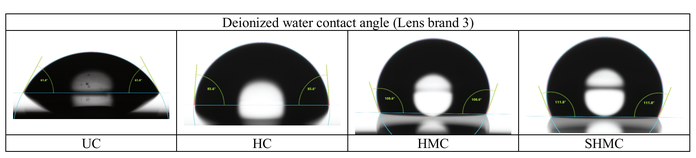




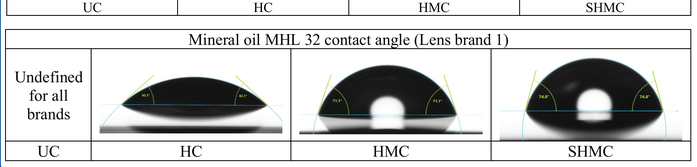




Deionized water contact angle (Lens brand 3)



Mineral oil MHL 32 contact angle (Lens brand 1)



Conclusion

The obtained results impartially compare the performance of the three lens brands as well as the quality differences between the coatings within the same brand.

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