



FUNDACIÓN  
RAMÓN ARECES

# Rational Design of Medicated Contact Lenses Using ToF-SIMS for Ocular Drug Delivery

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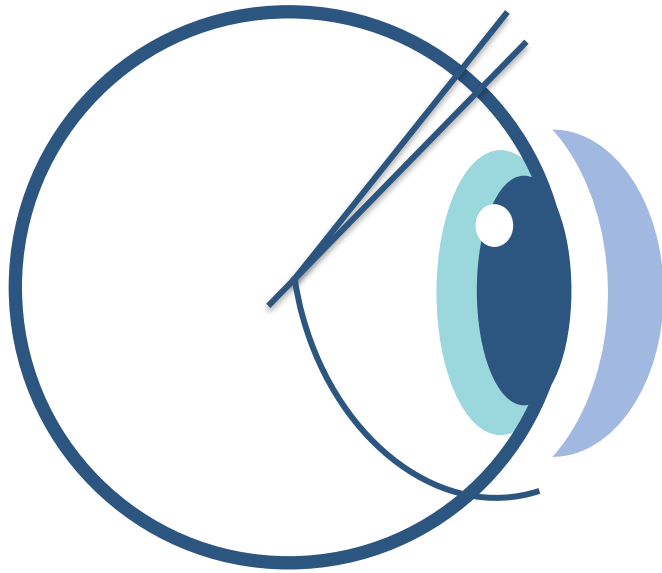


PHILADELPHIA, PA  
JULY 13-18, 2025

**NEXT-GENERATION  
DELIVERY INNOVATIONS**



# INTRODUCTION



- 150 million users
- \$18.6 billion 2023

Daily disposable

Two weekly

Monthly disposable

Silicone hydrogel

Coloured and tinted

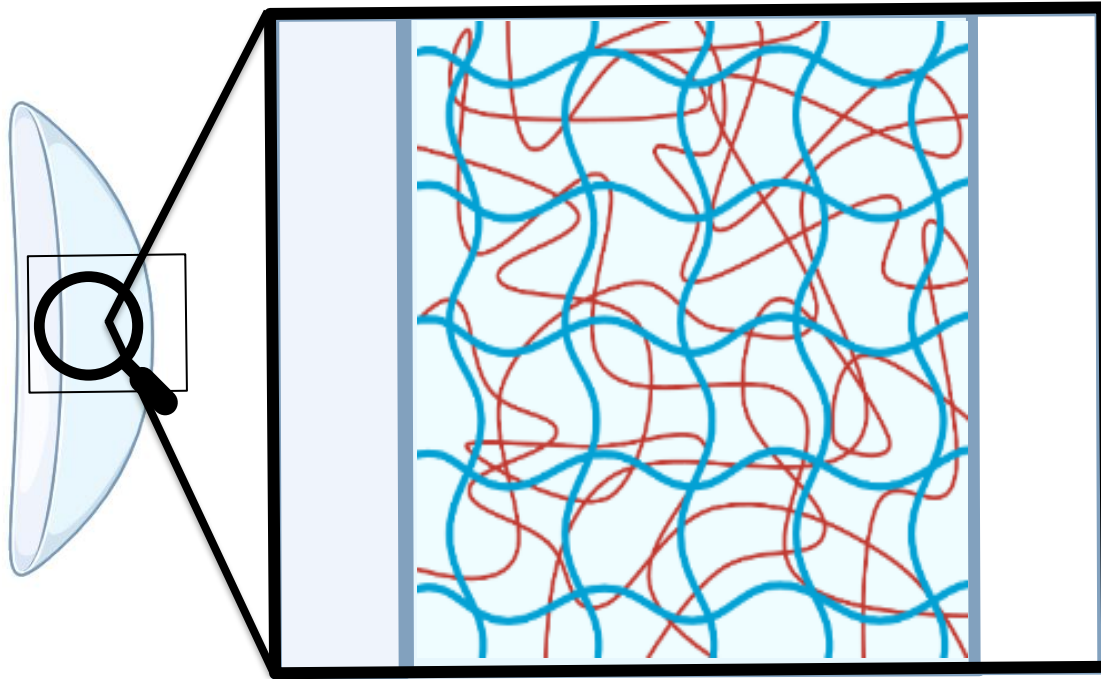
Continues wearing

Toric and Astigmatic

Varifocal and Multifocal



# INTRODUCTION



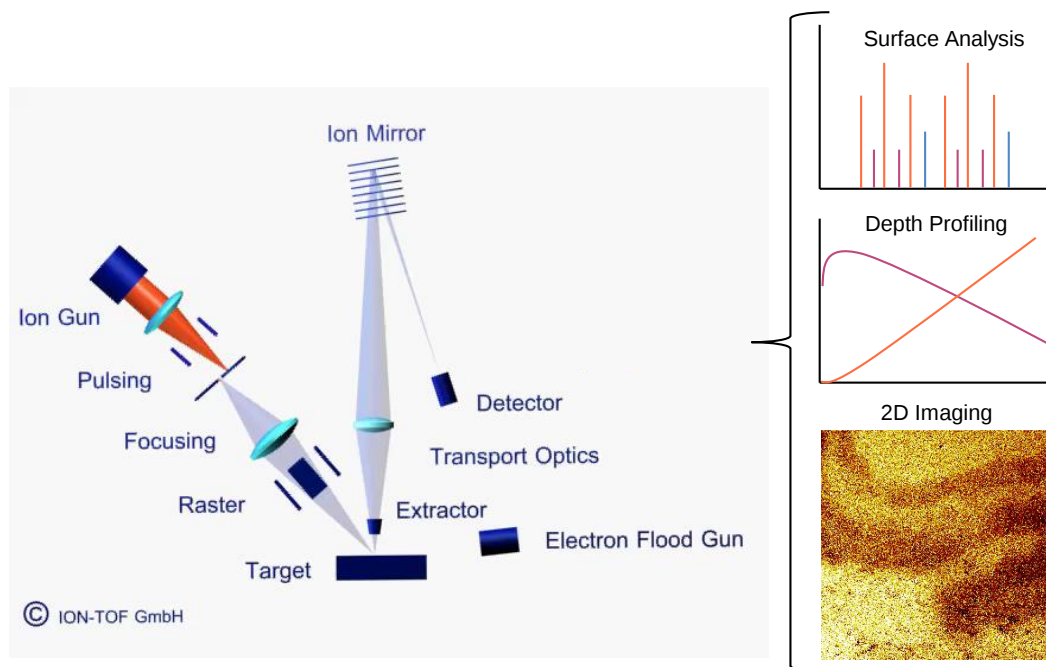
- Complex compositions
- Patent restrictions



Complicate predictions of the release profile of impregnated actives



- **Develop a powerful and reliable analytical platform** for detailed chemical characterization of complex silicone hydrogel contact lenses.
- **Advance the design of medicated contact lenses** for ocular therapies, combining vision correction and drug delivery.

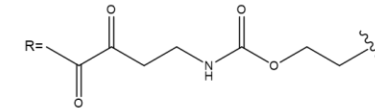
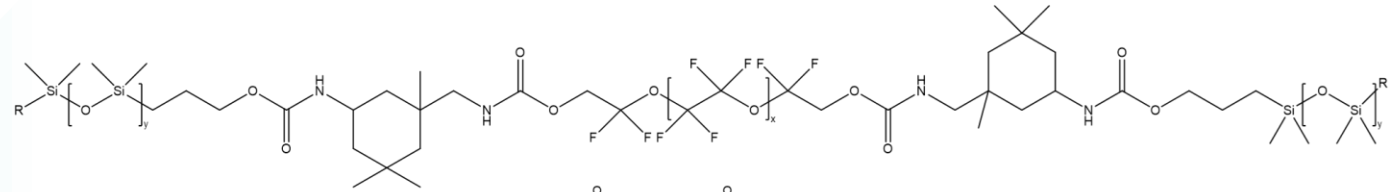




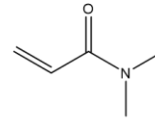
# CONTACT LENSES



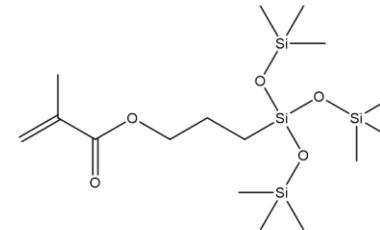
Highly breathable layered  
silicone-based contact lens



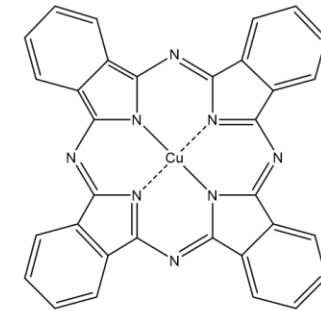
Fluorether silicone macromer



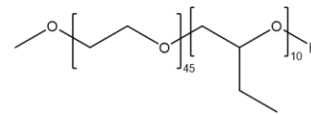
N,N-dimethylacrylamide  
(DMAA)



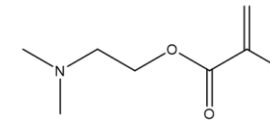
3-Methacryloyloxypropyl)tris(trimethylsiloxy)silane



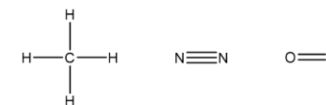
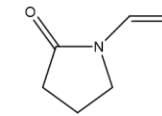
Copper phthalocyanine  
(CuPc)



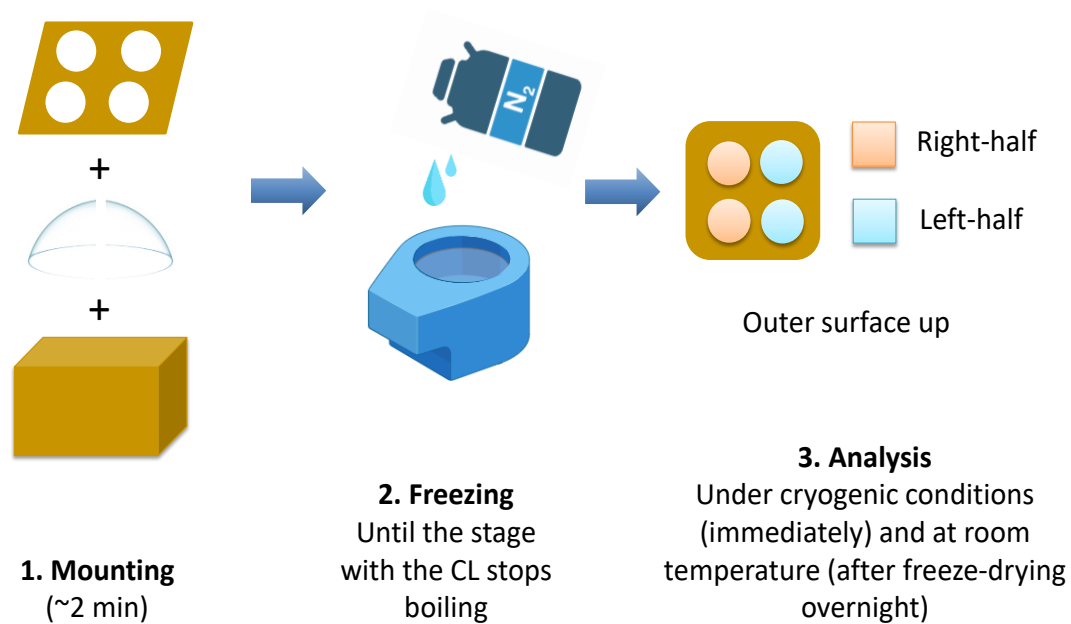
Poly(oxyethylene)-poly(oxybutylene)  
(EO<sub>45</sub>BO<sub>10</sub>)



Copolymer 845



Plasma coating precursors

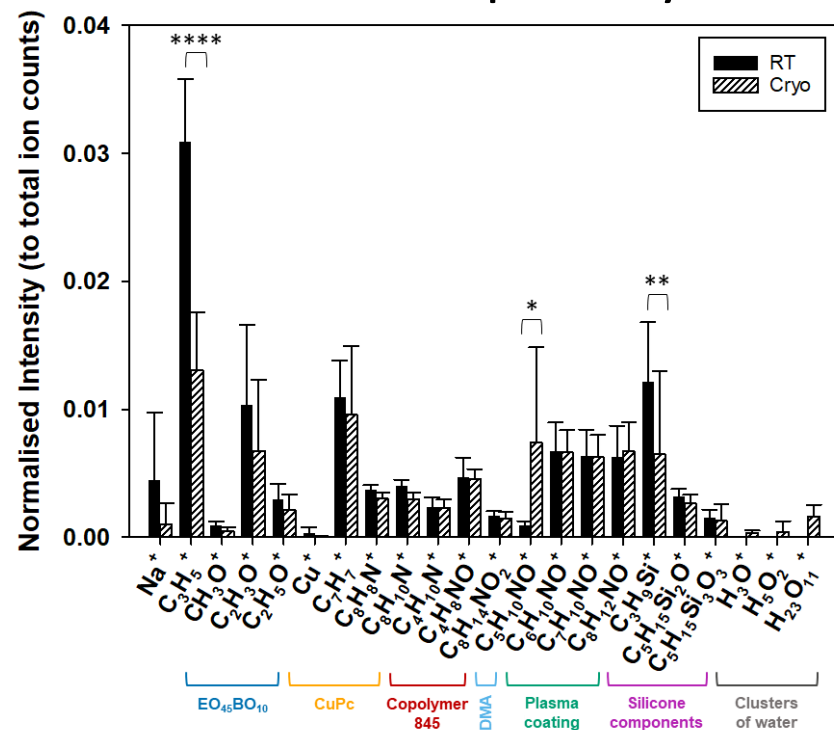


|                                 | Surface Analysis         | Depth Profile                 | OrbiSIMS                      |
|---------------------------------|--------------------------|-------------------------------|-------------------------------|
| Polarity                        | (+) (-)                  | (+) (-)                       |                               |
| Sputter area ( $\mu\text{m}$ )  | N/A                      | 500 x 500                     | 285.7 x 285.7                 |
| Analysis area ( $\mu\text{m}$ ) | 500 x 500                | 400 x 400                     | 200 x 200                     |
| Analysis beam                   | $\text{Bi}_3^+$ (30 keV) | $\text{Bi}_3^+$ (30 keV)      | $\text{Ar}_{3000}^+$ (20 keV) |
| Sputter beam                    | N/A                      | $\text{Ar}_{2072}^+$ (20 keV) | N/A                           |

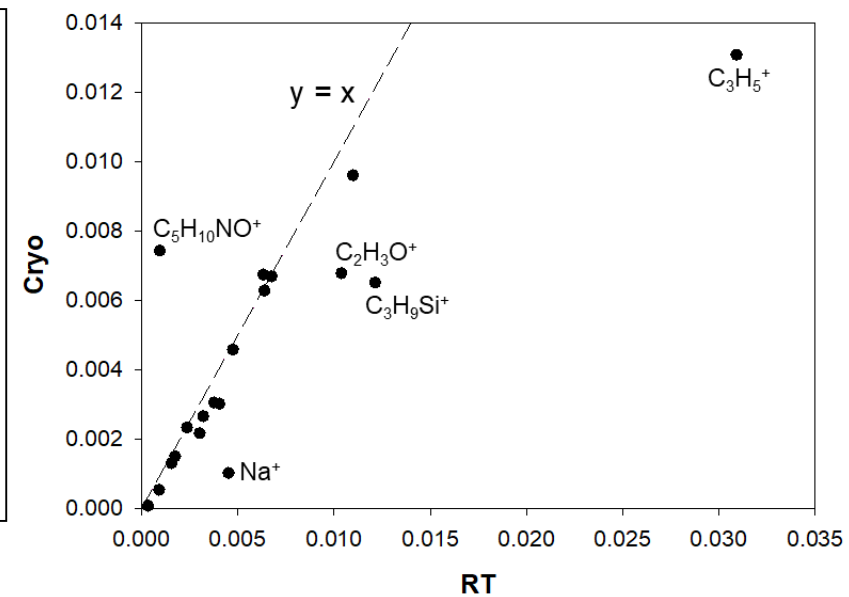
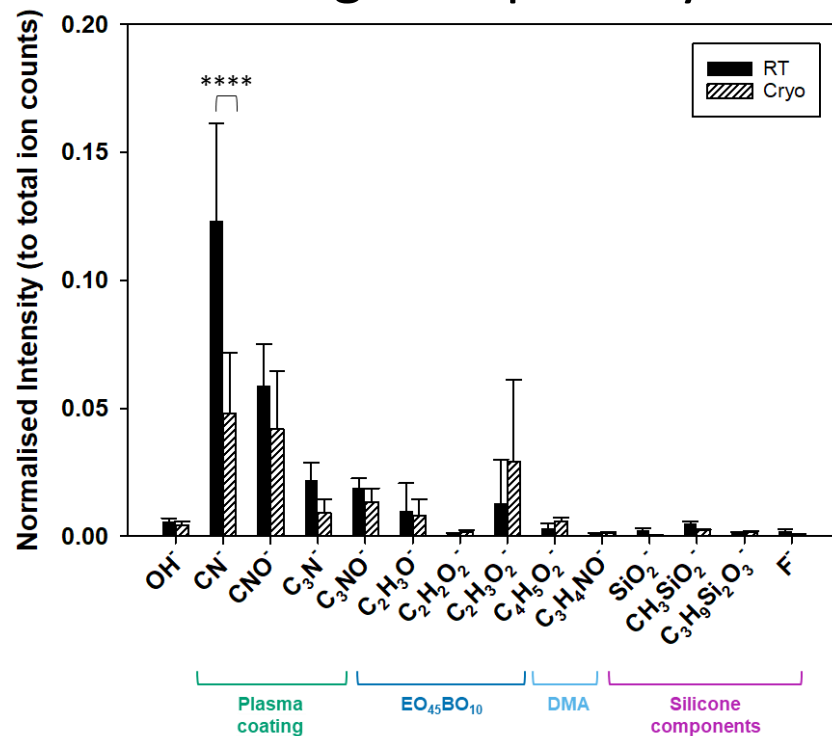


# SURFACE ANALYSIS

## Positive polarity

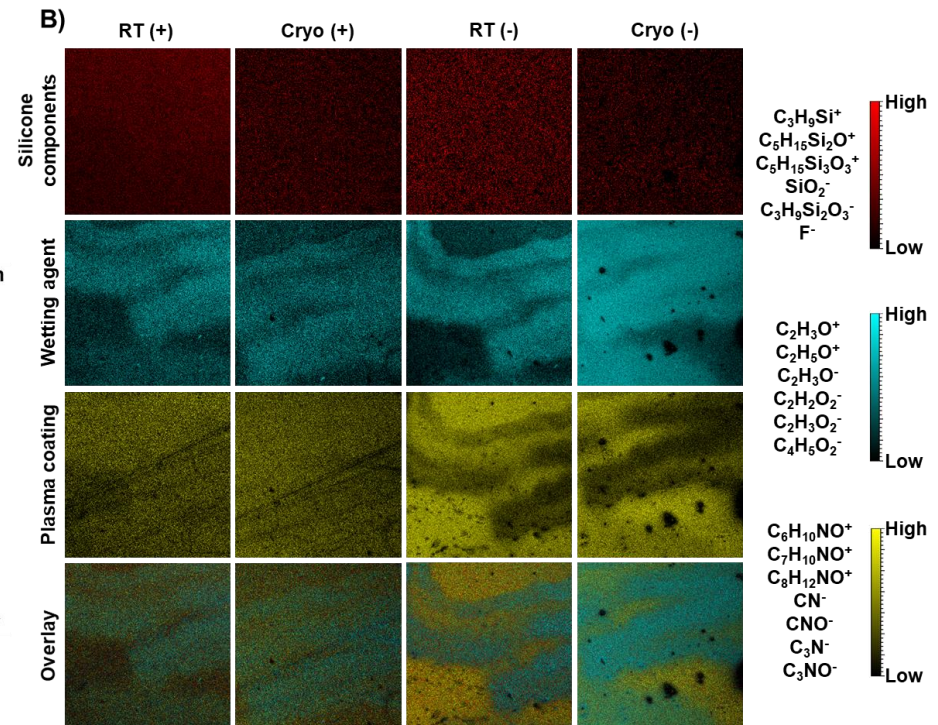
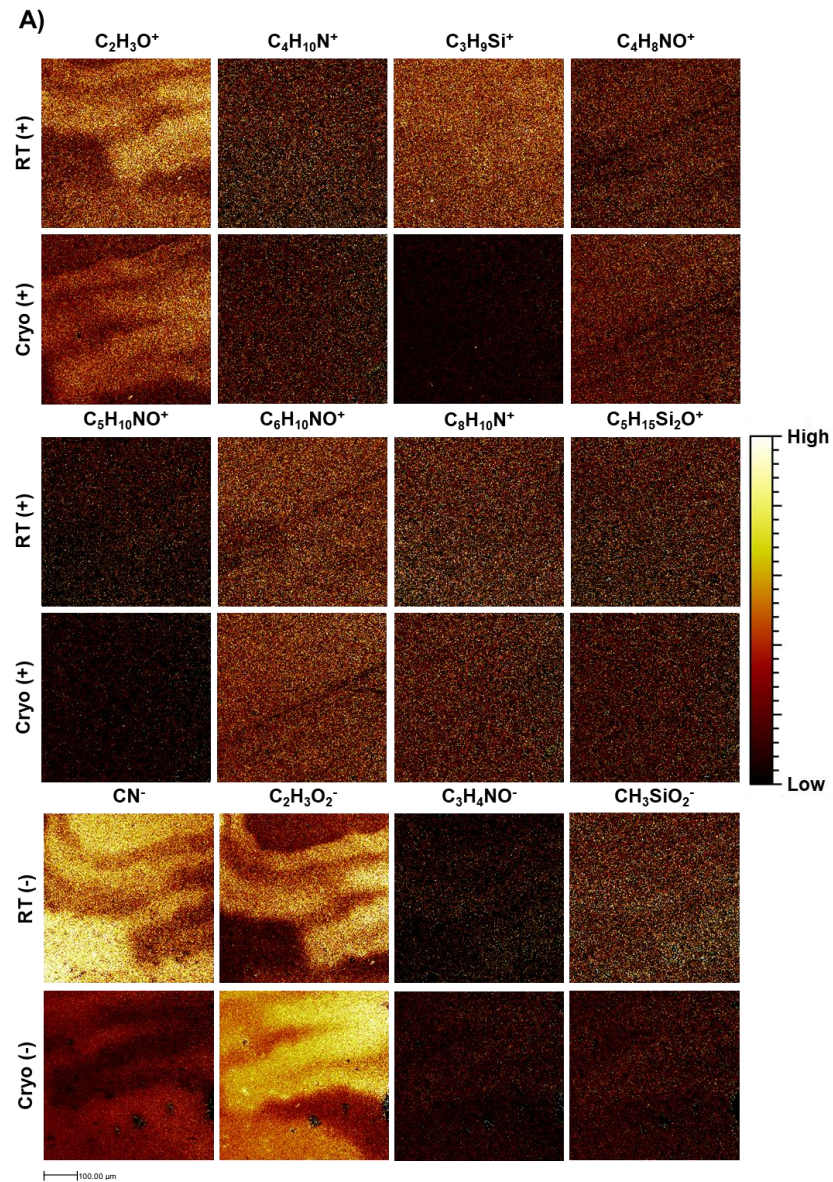


## Negative polarity





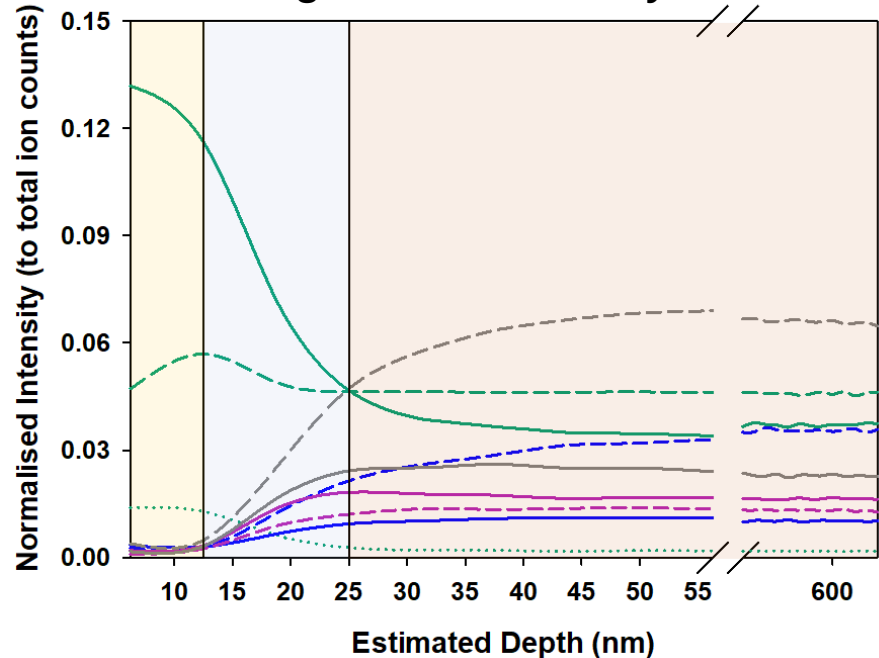
# SURFACE IMAGING





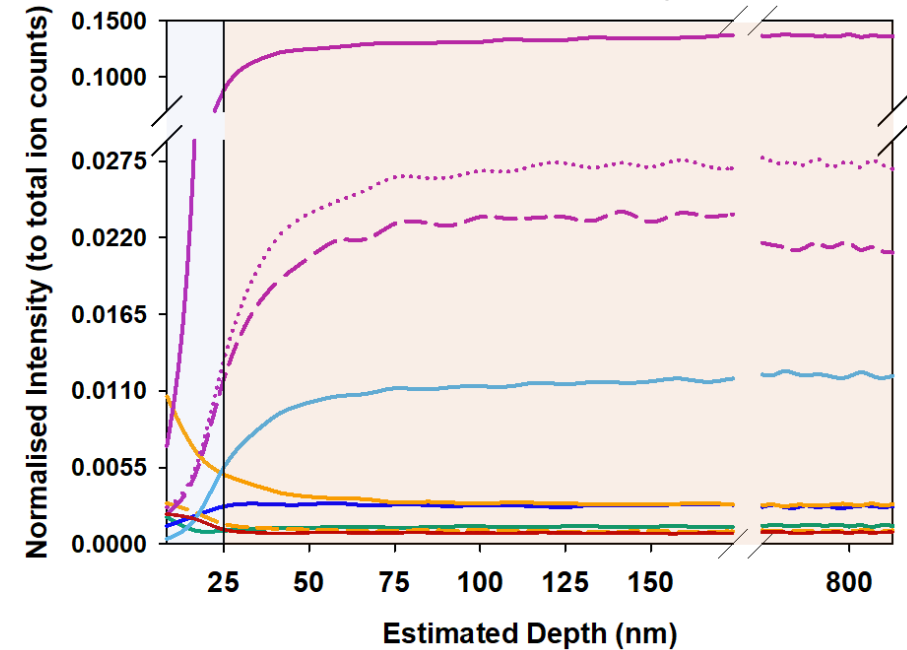
# DEPTH PROFILING

## Negative secondary ions



- m/z 26.00  $\text{CN}^-$  Dev -45.9 ppm (Plasma coating)
- - - m/z 42.00  $\text{CNO}^-$  Dev 46.7 ppm (Plasma coating)
- ..... m/z 66.00  $\text{C}_3\text{NO}^-$  Dev -28.2 ppm (Plasma coating)
- m/z 59.01  $\text{C}_2\text{H}_3\text{O}_2^-$  Dev 14.6 ppm (Wetting agent)
- - - m/z 85.04  $\text{C}_4\text{H}_5\text{O}_2^-$  Dev 67.8 ppm (Wetting agent)
- m/z 75.00  $\text{CH}_3\text{SiO}_2^-$  Dev 5.2 ppm (Silicone components)
- - - m/z 149.04  $\text{C}_3\text{H}_9\text{Si}_2\text{O}_3^-$  Dev 183.0 ppm (Silicone components)
- m/z 18.99  $\text{F}^-$  Dev -3.2 ppm (Silicone macromer)
- - - m/z 113.00  $\text{C}_2\text{H}_3\text{O}_3\text{F}_2^-$  Dev -35.5 ppm (Silicone macromer)

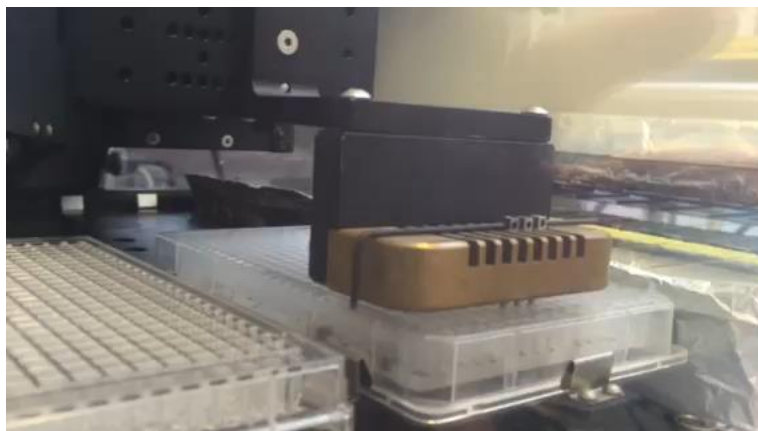
## Positive secondary ions



- m/z 138.08  $\text{C}_8\text{H}_{12}\text{NO}^+$  Dev -49.3 ppm (Plasma coating)
- m/z 45.03  $\text{C}_2\text{H}_5\text{O}^+$  Dev -83.3 ppm (Wetting agent)
- m/z 91.06  $\text{C}_7\text{H}_7^+$  13.4 ppm (CuPc)
- - - m/z 120.08  $\text{C}_8\text{H}_{10}\text{N}^+$  Dev -0.9 ppm (CuPc)
- m/z 73.05  $\text{C}_3\text{H}_9\text{Si}^+$  Dev 35.4 ppm (Silicone components)
- - - m/z 147.06  $\text{C}_5\text{H}_{15}\text{Si}_2\text{O}^+$  Dev -40.0 (Silicone components)
- ..... m/z 207.03  $\text{C}_5\text{H}_{15}\text{Si}_3\text{O}_3^+$  Dev -46.6 ppm (Silicone components)
- m/z 100.07  $\text{C}_5\text{H}_{10}\text{NO}^+$  Dev -33.2 ppm (DMA)
- m/z 156.08  $\text{C}_8\text{H}_{14}\text{NO}_2^+$  Dev -146.9 ppm (Copolymer 845)



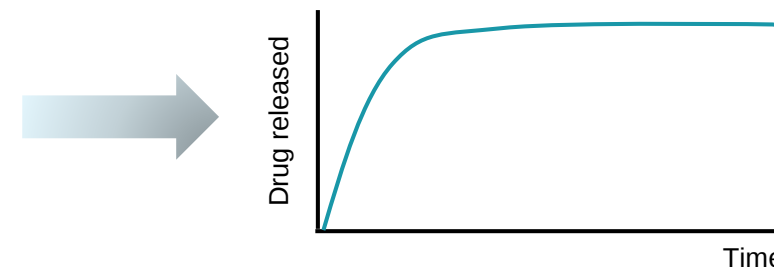
# DRUG-LOADED CONTACT LENSES



**1. High-throughput screening** of hundreds of contact lens compositions



**2. Evaluation of antibiofilm performance**



**3. Loading and release studies**



# CONCLUSIONS

- Surface analysis rapidly detected and assigned fragment ions associated with lens components.
- OrbiSIMS analysis confirmed these assignments.
- Depth profiling identified a surface layer and a transition interface supported by the bulk of the material.
- Comparative analysis identified freeze-dried sample analysis as a practical and effective alternative to cryogenic method.

**The combination of ToF-SIMS and OrbiSIMS constitutes a powerful and reliable analytical platform for detailed chemical characterization of complex silicone hydrogel contact lenses, enabling an optimized workflow to accelerate the development of lenses for vision correction and drug delivery, potentially revolutionising eye care in future.**



# THANK YOU VERY MUCH FOR LISTENING!



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