HYSITRON BRUKER **Ubi-1**

APPLICATION NOTE | Effect of disinfectant chemistry on polymers

In the healthcare industry, hygienic patient environment of care is of critical importance to prevent spread of infectious disease. Primarily, this is achieved through routine cleaning and disinfection of surfaces and objects in healthcare facilities. The periodicity of disinfection protocol can vary from several times per hour or daily/weekly treatments using disinfectants with varied chemistry. To date, very limited work has been explored to assess best practices for determining surface damage due to chemistry compatibility of surfaces found in patient care facilities. This report presents the use of nanoindentation to quantitatively assess surface damage and change in viscoelastic properties of bulk acrylic polymer after soaking in a variety of ready-to-use disinfectants.

In this study, samples of bulk acrylic polymer were soaked in an array of common, ready-to-use disinfectant chemicals. Small sections of acrylic were cut and half-way immersed in disinfectant for 24 hours, then rinsed with DI water and allowed to air dry for 24 hours. Figure 1 shows one sample of acrylic, and the dotted line signifies where the sample was soaked up to. The names of each disinfectant are kept confidential due to the ongoing nature of the study. Small sections of each sample were cut and mounted to magnetic pucks with cyanoacrylate after priming the mating surfaces with a plastics bonding agent as seen in Figure 1.

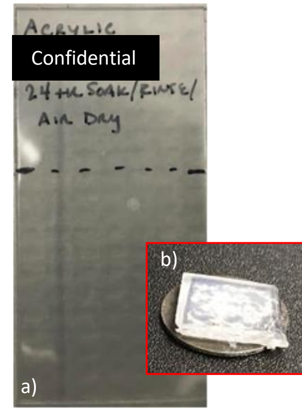

Figure 1. a) Acrylic sample after soaking and b) specimen prepared for nanoindentation

In nanoindentation, the vertical displacement of a rigid probe of known geometry and modulus is measured during controlled loading and unloading of an applied forced. The output of the experiment is a plot of the measured force vs. displacement of the probe (Figure 2).

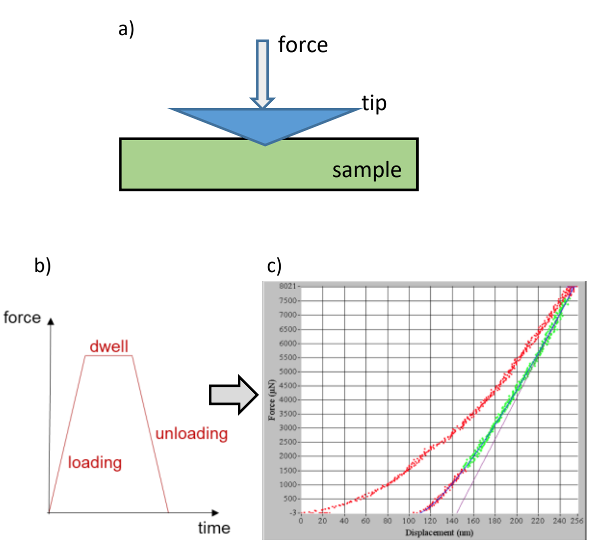

Figure 2. a) Basic concept of indentation, b) set to some parameter of controlled force over time, where the output is c) measured force vs displacement of the probe into a sample

Viscoelastic properties like hardness (H) and modulus (Er) are then calculated based on stiffness (S), contact area of the probe $(A(h_c))$ at peak force (P_{max}) based on the following formulae:

$$E_r = \frac{\sqrt{\pi}}{2}\frac{S}{\sqrt{A(h_c)}} \qquad H = \frac{P_{\max}}{A(h_c)}$$

In total, 4 samples were tested:

- Acrylic (Untreated)
- Acrylic, soaked in Disinfectant A
- Acrylic, soaked in Disinfectant B
- Acrylic, soaked in Disinfectant C

Each sample was indented 10 times using the parameters shown in Figure 3 using the Hysitron Ubi-1 nanoindenter at AIF with a 1um radius of curvature diamond conical tip

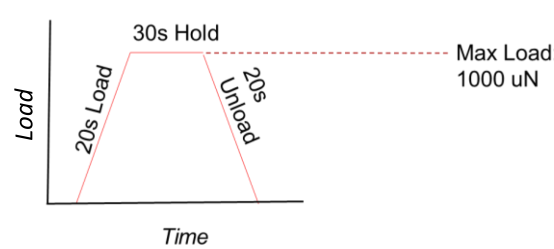

Figure 3. Nanoindentation parameter for this study, repeated 10 times per sample

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The average results with standard deviation for each sample type are shown in Figure 4. Single force-displacement curves measured through nanoindentation for each sample type are shown in Figure 5. Comparing these curves and the average measured hardness & modulus shows that Disinfectant C had a much more dramatic effect on the viscoelastic properties of than the other disinfectants. The Ubi-1 nanoindenter at AIF also functions as a Scanning Probe Microscope (SPM), which is critical for post-analysis of indentation profiles and is also useful for other surface analysis. Figure 6 shows the surface of the bulk acrylic sample post-indentation.

	Reduced Modulus (GPa)	Hardness (MPa)
Acrylic Untreated	**5.20 GPa** ± 0.03	**356.5 MPa** ± 6.09
Acrylic Disinfectant A	**4.97 GPa** ± 0.03	**335.1 MPa** ± 1.53
Acrylic Disinfectant B	**5.28 GPa** ± 0.05	**355.3 MPa** ± 3.26
Acrylic Disinfectant C	**4.50 GPa** ± 0.04	**256.0 MPa** ± 3.26

Figure 4. Average modulus and hardness measured for each sample

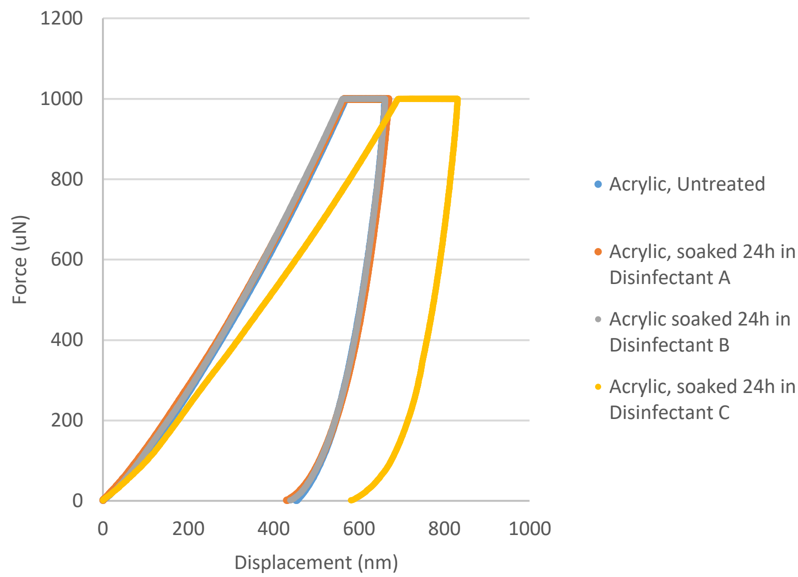

Figure 5. Single force-displacement curve of each sample overlaid as measured in this study

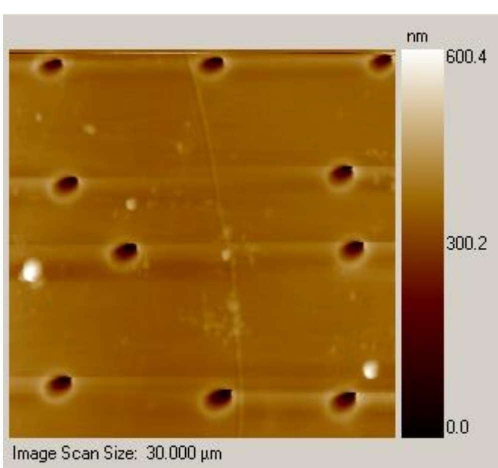

Figure 6. Scanned Probe Microscopy (SPM) Image of acrylic sample post-indentation

While soaking for 24 hours is a worst-case scenario, this study confirms that certain disinfection chemistries can have more dramatic effects than others on polymer surfaces. Measured viscoelastic properties through nanoindentation clearly shows Disinfectant C has a much stronger impact on the properties of acrylic than the other disinfectants. This information and other studies like this can be used as a basis to inform best practices for disinfection of surfaces and equipment in healthcare, or give a basis to further tailor chemistries to specific products or surfaces found in healthcare.

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