APPLICATION NOTE

What are your gloves leaving behind?

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INTRODUCTION

Disposable gloves are essential for maintaining a clean and sterile laboratory environment. Disposable gloves act as a protective barrier from chemical contact and are also indispensable for limiting potential contamination of samples. However, all disposable gloves tend to leave behind residues, which can affect the cleanliness of the surfaces the gloves touch, and thus possibly affect the analytical results. To avoid mistaking glove residue for sample chemistry, it is vital to understand its composition. To this end, we examined glove residues from three types of commonly used nitrile gloves and one latex glove using Fourier Transform Infrared (FTIR) Spectroscopy and Gas Chromatography Mass Spectrometry (GCMS).

In addition to investigating the residues, we also evaluated the glove composition using a combination of FTIR and X-Ray Fluorescence (XRF). We also attempted to remove the glove residue using soap or 70% isopropyl alcohol (IPA). We then compared the concentrations of volatile and semi-volatile species before and after washing. Overall, this study provides some useful information on residues and volatiles left behind by disposable gloves and the best measures to avoid or reduce this contamination.

EXPERIMENTAL

XRF

The gloves were analyzed directly (as-received) on a Rigaku Primus II WDXRF using a helium atmosphere. Quantification was performed using the Fundamental Parameters (FP) standardless quantification software associated with the system. The FP approach uses x-ray physics coupled with established sensitivity factors for pure elements.

FTIR

The surface of each glove was examined in attenuated total reflection (ATR) mode using a Thermo-Nicolet iS50 (FTIR spectrometer. A diamond crystal was used with a typical depth of penetration in the range of 2 microns. The analytical spot size was approximately ~5 mm in diameter. OMNIC 9.12 software was used to perform data analysis.

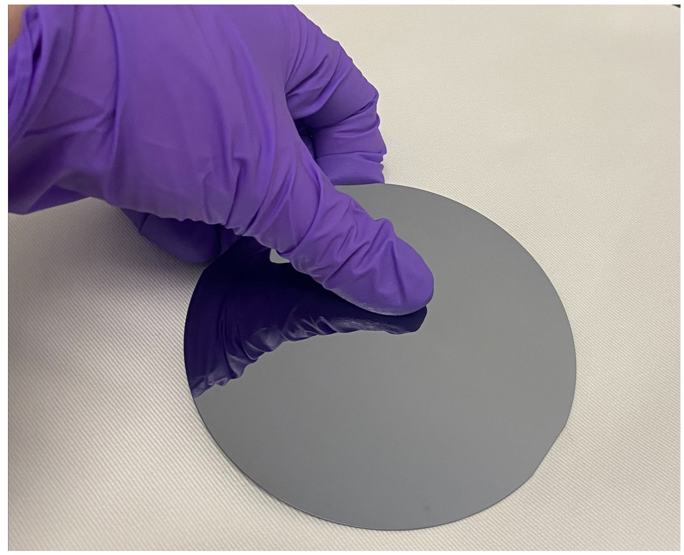

Figure 1: Disposable glove residue can affect test results.

In addition to evaluating the glove itself, any surface residue that transferred onto the ATR crystal was also evaluated by removing the glove from the crystal and measuring only the transferred residue.

GCMS Method 1: Material Transfer

A clean silicon wafer was cleaved into several parts with an area of 5 cm by 3 cm. The residue from each glove was transferred onto the wafer by pressing the glove against the wafer surface as shown in Figure 1. The samples were loaded into a 1½” diameter chamber of the dynamic headspace sampling system (CDS 8400 Autosampler).

The samples were heated under a flow of helium, during which time the outgassed species were automatically collected for analysis. The samples were analyzed on an Agilent 7890A Gas Chromatograph/ Agilent 5975 Mass Spectrometer.

GCMS Method 2: Outgassing

The gloves were weighed on an analytical balance and placed into 20 mL heated headspace glass vials. The samples were analyzed on an Agilent 6890A Gas Chromatograph/ Agilent 5973 Mass Spectrometer. An instrument blank was measured by running the GCMS cycle with carrier gas only (i.e., no “injection”) prior to running any samples.

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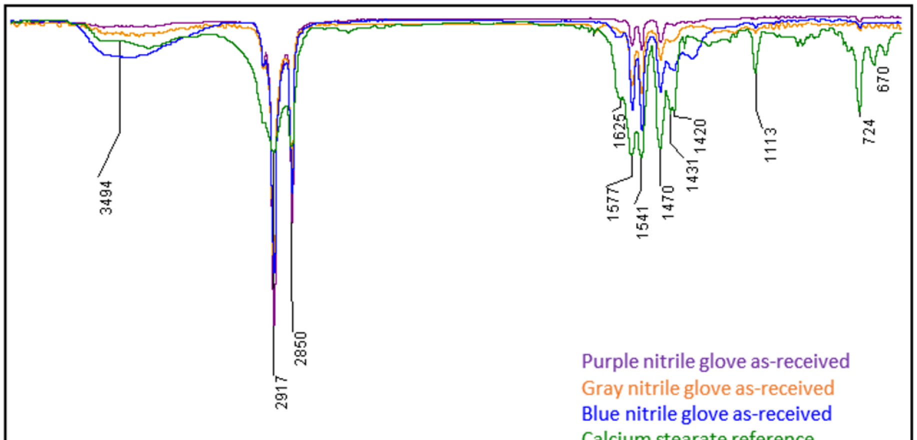

Figure 2

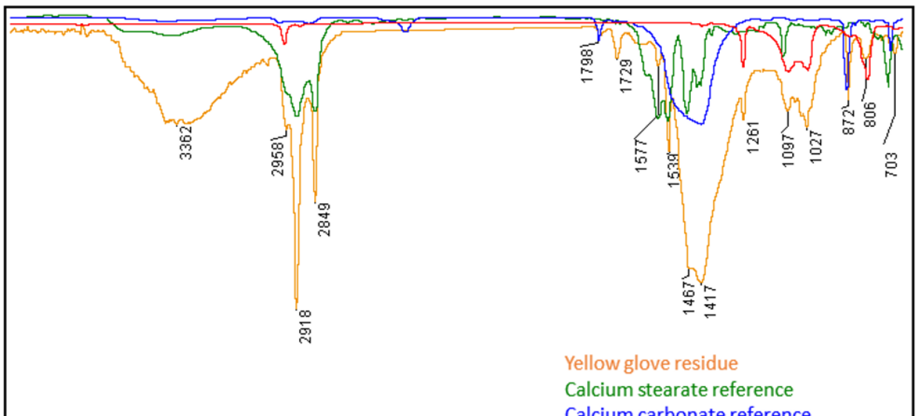

Figure 3

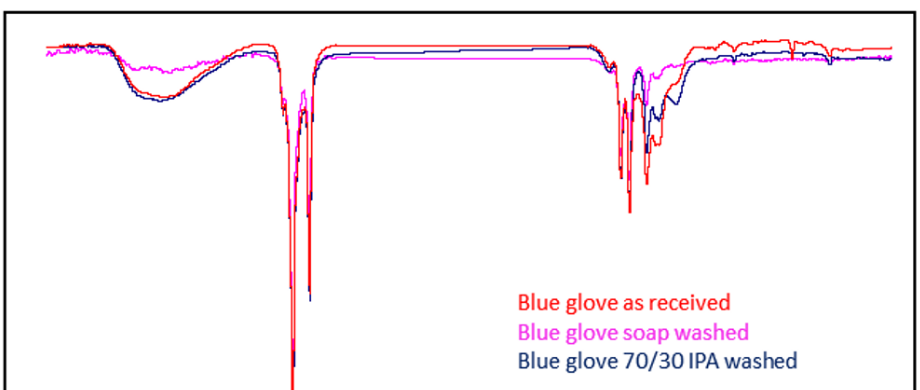

Figure 4

RESULTS & DISCUSSION

The glove composition was evaluated using FTIR and XRF and the results are represented in the graphs on this page (figures 2-4) and the glove graphics on the next page (figures 5-8). All three nitrile gloves are consistent with acrylonitrile and butadiene copolymer, whereas the yellow glove is poly(isoprene) containing aluminum silicate and titanium dioxide. The purple gloves contain talc as the additive, whereas the blue gloves contain aluminum silicate and the grey gloves calcium carbonate. The FTIR results are consistent with the XRF findings on the inorganic additives.

An experiment was performed by pressing the glove against an ATR crystal. The sample was then removed from the ATR crystal and the residue that transferred onto the crystal was measured. As shown in the top graph, the residue from all three gloves is consistent with a fatty acid cationic species with metallic counter ions similar to calcium stearate as indicated by the excellent overlap of peaks at 2917, 2850, 1577, 1541, 1470, 1431, 1420, 1113 and 724 cm^{-1} and those of the calcium stearate library reference. In fact, it is very difficult to obtain a pure spectrum of a glove in ATR mode without also detecting this calcium stearate compound. Note that the calcium content of all the gloves is 1-1.8 wt% according to XRF.

The composition of the latex glove residue is a bit different from that of the nitrile gloves, but it also contains calcium stearate. The middle graph compares the latex glove residue with reference spectra. In addition to the stearate at 2918, 2849, 1577, 1539, 1467 and 1097 cm^{-1}, an inorganic carbonate was also detected (1798, 1417 and 872 cm^{-1}) along with a silicone (2958, 1261, 1097, 1027 and 806 cm^{-1}) and an ester (1729 cm^{-1}).

Next, the gloves were washed with soap or IPA and the ATR experiment was repeated. Neither method resulted in a change in the residue composition. As shown in the bottom graph, the as-received blue glove residue matched very well with the IPA and

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soap washed glove residue – i.e., the same stearate species can be clearly observed in all three samples. Similar results were observed with the yellow gloves.

GCMS Results Method 1: Material Transfer

In the first experiment, the glove was pressed against a silicon wafer (see figure 1 on first page) and the resulting wafer was analyzed using a dynamic headspace sampling system. The GCMS results of the volatile organics are shown in Table 1 on the next page. The compounds observed in all four gloves include n-hexadecenoic acid, octadecanoic acid, and dihydro-5-tetradecyl furanone. All three compounds are closely related to stearic acid, with a similar long hydrocarbon chain and polar functional group (see Figure 9). These compounds support the presence of a stearate species detected by FTIR.

GCMS Results Method 2: Outgassing

In the second experiment, the glove finger was cut and placed in an outgassing vial and analyzed using a Gerstal static headspace sampling system. A similar experiment was repeated after washing the gloves with soap and IPA. The total volatiles from the as-received and washed gloves are shown in the bar graph on the next page. The yellow latex gloves showed the lowest volatiles with only 107 ppm compared to 371-653 ppm for the nitrile gloves. Moreover, IPA washing was the most effecting at decreasing amount of outgassed species. For all samples, the volatile content reduced more than 2-fold after an IPA wash.

In contrast, soap washing showed similar results for the blue and a small decrease for the yellow gloves. Only the gray glove released significantly less volatiles after the soap washed method. Thus, washing gloves with IPA is more effective than washing with water in terms of reducing total volatiles. Note that washing with IPA could potentially change some physical and chemical properties of the gloves, so it should be performed with caution.

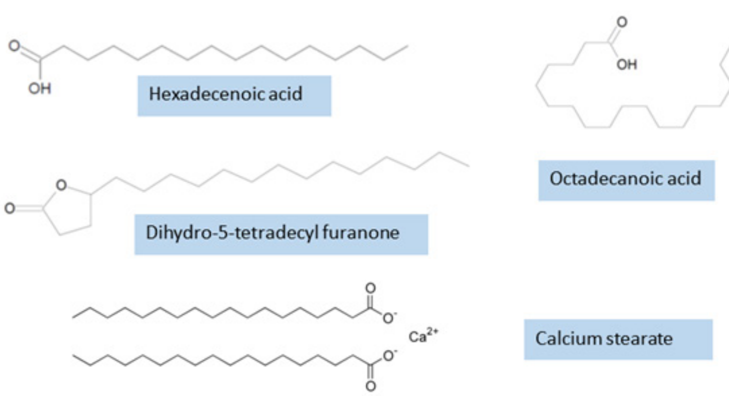

Figure 9: Chemical structures of compounds detected in glove residues

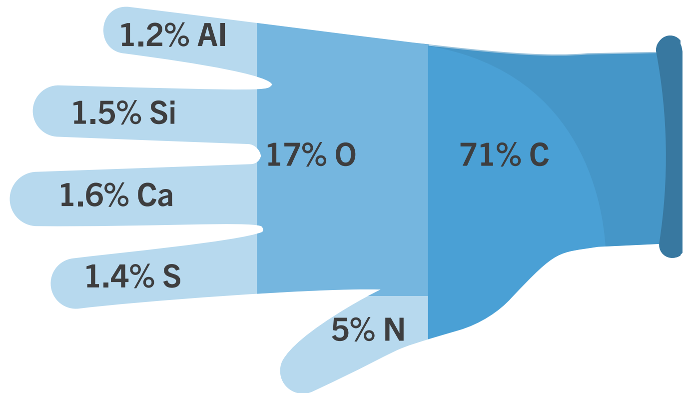

Figure 5: XRF Blue Glove Composition

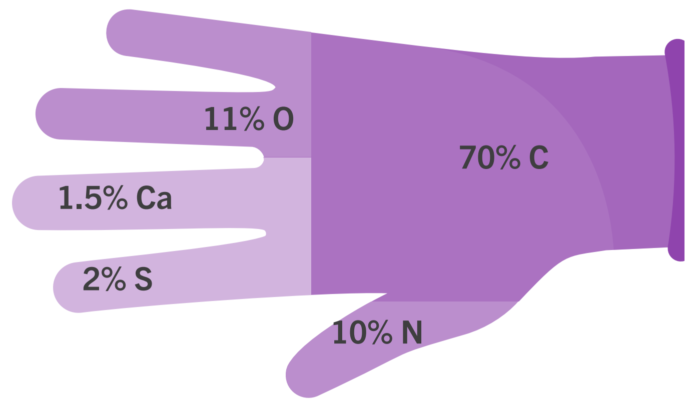

Figure 6: XRF Purple Glove Composition

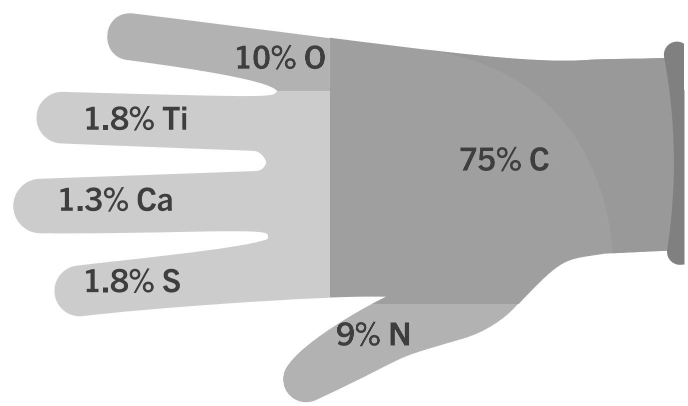

Figure 7: XRF Gray Glove Composition

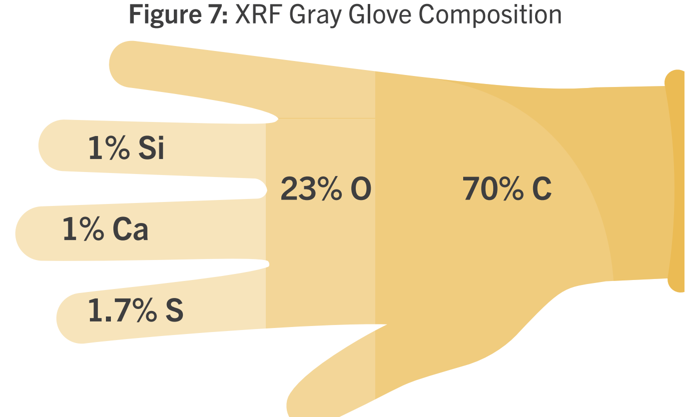

Figure 8: XRF Yellow Glove Composition

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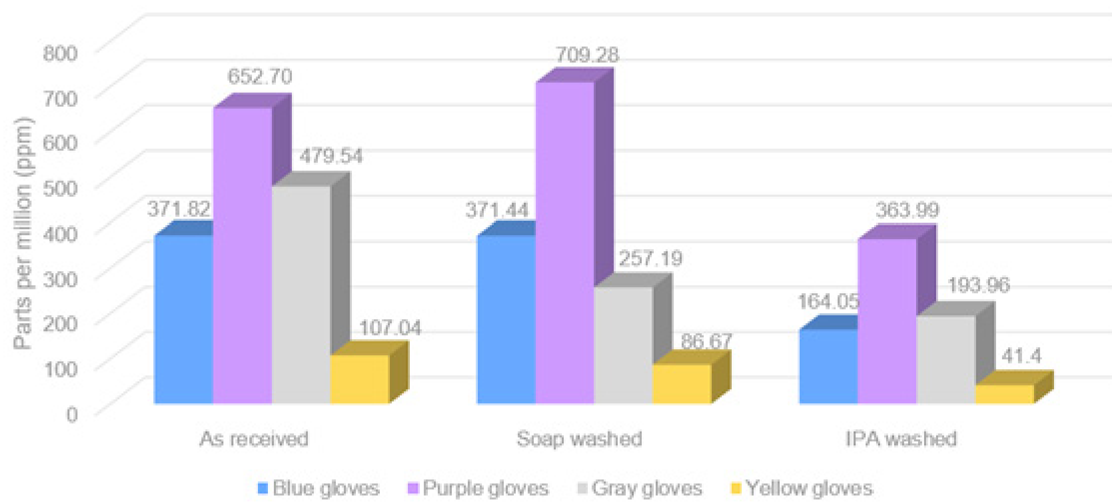
Figure 10: Total Volatiles Comparison between Wash Methods



CONCLUSION

FTIR, XRF, and GCMS were used to determine the composition and concentration of the residues left behind by several disposable gloves.

From FTIR, the composition of the nitrile and latex gloves along with their residues were identified. The composition of all the nitrile gloves included an acrylonitrile/butadiene copolymer while the latex glove included Poly(isoprene) 1,4 cis and Kaolin (aluminum silicate). Following glove analysis, residue analysis was performed, and the presence of calcium soap of stearic acid was detected in all four glove residues. According to FTIR, wash method does not change the composition of the gloves nor the residues.

Table 1: GCMS Method 1 Results

Purple Gloves (ng)*	Blue Gloves (ng)*	Grey Gloves (ng)*	Yellow Gloves (ng)*	Compound Identification
ND	ND	79.79	119.56	Decamethylcyclopentasiloxane
ND	ND	ND	4,101.10	Dodecanoic acid
137.80	212.43	135.32	ND	1-Pentadecanal
ND	ND	80.16	177.38	Tetradecanoic acid
103.00	ND	106.65	ND	1-Pentadecanal
3,650.25	**6,449.14**	**9,529.67**	**5,862.28**	**n-Hexadecanoic acid**
ND	ND	156.82	214.64	Oleic Acid
917.98	**1,089.19**	**3,507.49**	**1,925.18**	**Octadecanoic acid**
ND	398.47	ND	ND	Heneicosane
145.07	**232.70**	**172.96**	**111.11**	**Dihydro-5-tetradecyl furanone**
ND	535.30	ND	ND	Heneicosane
ND	632.58	ND	ND	Pentacosane
119.50	520.65	ND	ND	Heptacosane
119.31	ND	ND	ND	Di-n-decylsulfone

XRF provided elemental composition of each glove, with the major and minor elements highlighted. These major and minor elements confirmed FTIR results, with the minor elements relating closely to additives detected in the gloves by FTIR.

Lastly, GCMS revealed concentration changes of the residues based on wash methods. Regardless of wash method, the yellow latex glove consistently released the least number of volatiles compared to the nitrile gloves. Comparing wash methods, the total number of volatiles remained relatively unchanged between "as received" and "soap washed" gloves. However, there was a noticeable reduction in volatiles for "IPA washed" gloves, with the volatiles being reduced to half the amounts seen in the "as received" and "soap washed" gloves. As a result, it can be concluded that gloves washed with IPA provide the greatest reduction in volatiles, with the yellow latex glove releasing the least number of volatiles overall.

Overall, this study establishes how three complementary techniques can be used in tandem to examine composition and concentration changes of glove residues based on wash methods.