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Using Desorption Electrospray Ionization with Mass Spectrometry (DESI-MS) to Identify Silicone Oil Contamination on Components

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OUTLINE

OBJECTIVE

- Help production facility determine if silicone oil contamination is causing issues they are experiencing with material compatibility and bonding.
- Develop a method for identifying silicone oil contamination on component surfaces using DESI-MS.
- Test actual components for silicone oil contamination.

METHODS

- Use oil contaminated sample coupons to verify DESI-MS capability.
- Once capability and best parameters are established, analyze actual components from production facility to determine if any silicone oil contamination is present.

RESULTS

- Successful identification of silicone oil contamination on surfaces of production parts.
- Other contamination also identified on production parts including hydrocarbon oil.
- Differences in the silicone oil based on date and batch were also discovered.

INTRODUCTION

Silicone oils are used in many lubrication applications, especially when elevated temperatures may be involved. The oils also have good electrical insulating properties making them ideal when both lubrication and electrical insulation are required. However, contamination of other parts or non-oiled surfaces is undesirable, potentially leading to unwanted reactions. Furthermore, oil on outer surfaces can disrupt adhesion to another surface. The parts can be cleaned with a wipe and solvent but enough oil residue remains to affect adhesion. DESI-MS is ideal for analyzing surface contamination, and was selected to develop silicone oil detection methods even after basic cleaning practices. MS data from silicone oil contamination can help solve production problems that were previously an enigma.

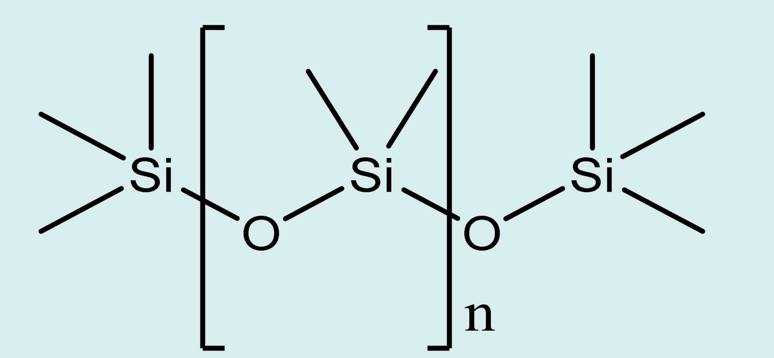


Figure 1. Structure of Polydimethylsiloxane (PDMS) silicone oil. Bracketed area is a repeating structure of mass 74.

METHODS

- The DESI source is the Omni-Spray 2D® by Prosolia Inc. Electrospray solvent is Acetonitrile:Water:Formic Acid (80:20:01% v/v/v) at 1.5µL/min with 2.85 kV voltage. DESI-MS experiments were analyzed using a Waters Synapt G2-HDMS™ time-of-flight, high definition mass spectrometer. Mass analysis was performed in sensitivity mode with positive ionization.
- The components from the production environment include stainless steel, aluminum, Viton®, Buna-N, and fluorocarbon rubber materials. Some materials are from components where silicone oil is used but no oil should be on the surface. Other materials are present in the same production space but are not from oil containing components. The components were of various size and shape. Therefore, manual or automated movement of the DESI stage was done depending on the sample. The samples require no preparation prior to undergoing DESI-MS analysis.

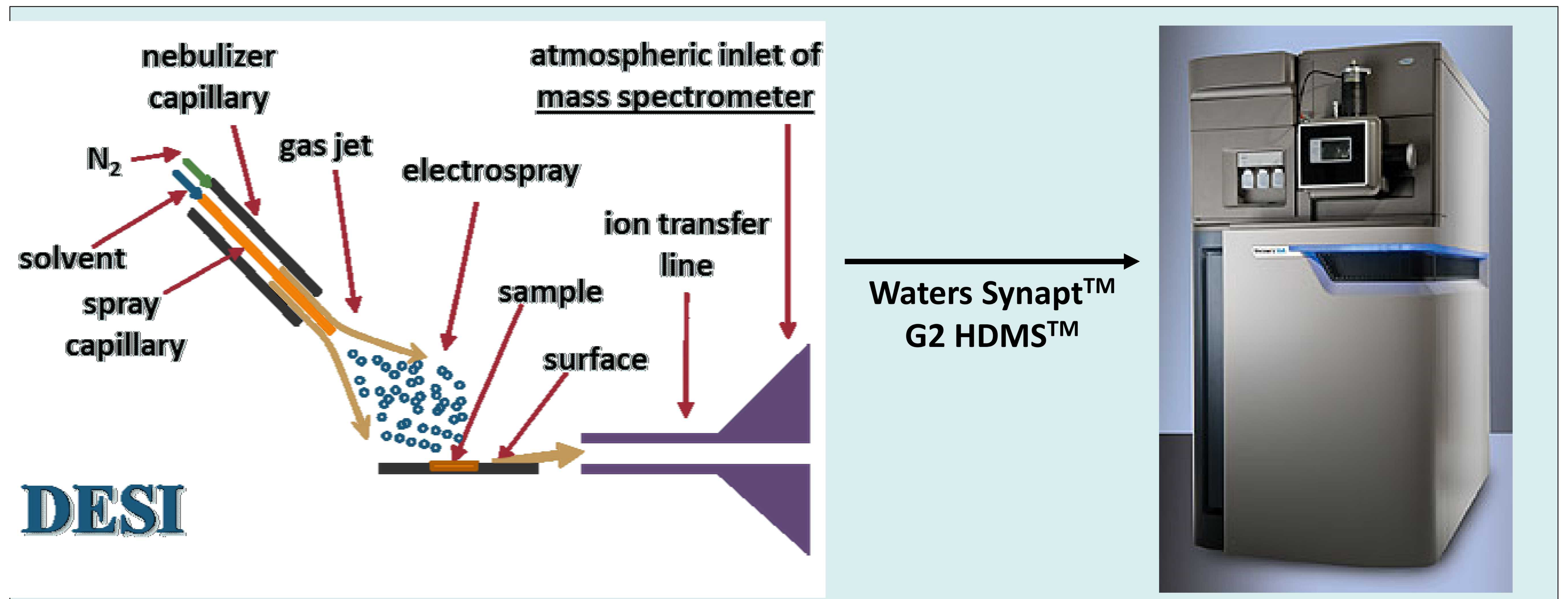
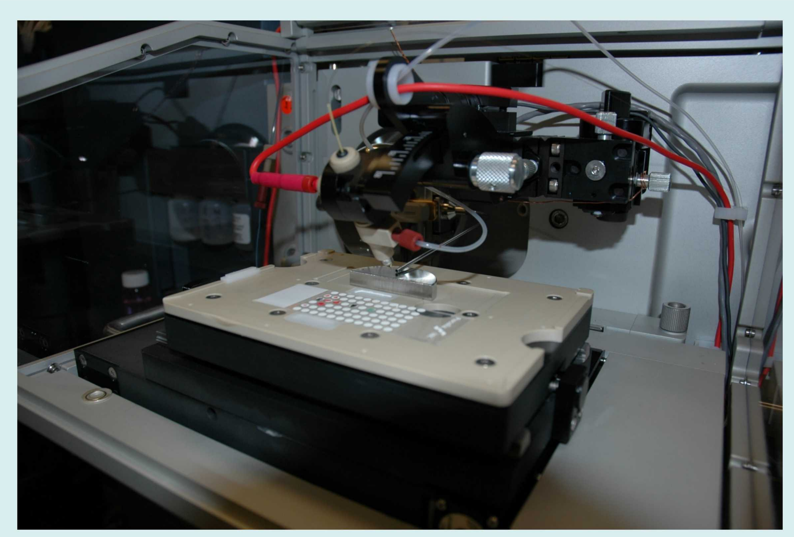


Figure 2. A graphical depiction of Desorption Electrospray Ionization (DESI) as combined with a Waters Synapt™ G2 HDMS™, which was used to analyze silicone oil contaminated parts in positive ionization mode.

Figure 3. A sample of materials analyzed with DESI-MS



F[illegible] with DESI-MS

RESULTS

Experiments

•To verify the ability of DESI-MS for silicone oil detection, samples were made using material coupons and lightly visible smears of 20 centistoke silicone oil. The materials used were the same as those from production components. The silicone oil smear was easily detected on all sample coupons. (Figure 5 is representative of data)

•The sample coupons were then cleaned using a basic procedure of wiping with a paper wipe moistened with isopropanol. The only material where the silicone oil was not detected after the basic cleaning was the aluminum. The believed reason for this is that the aluminum is absorbing the oil as well as some of the electrospray. Therefore, when the oil contamination is very low, the DESI cannot pick-up the oil away from the aluminum. (No figure for null data)

•Samples from the production environment were then analyzed with DESI-MS. Prior to analysis, the samples were cleaned by the production facility using their normal process. Silicone oil was detected on 100% of the components brought to the laboratory.

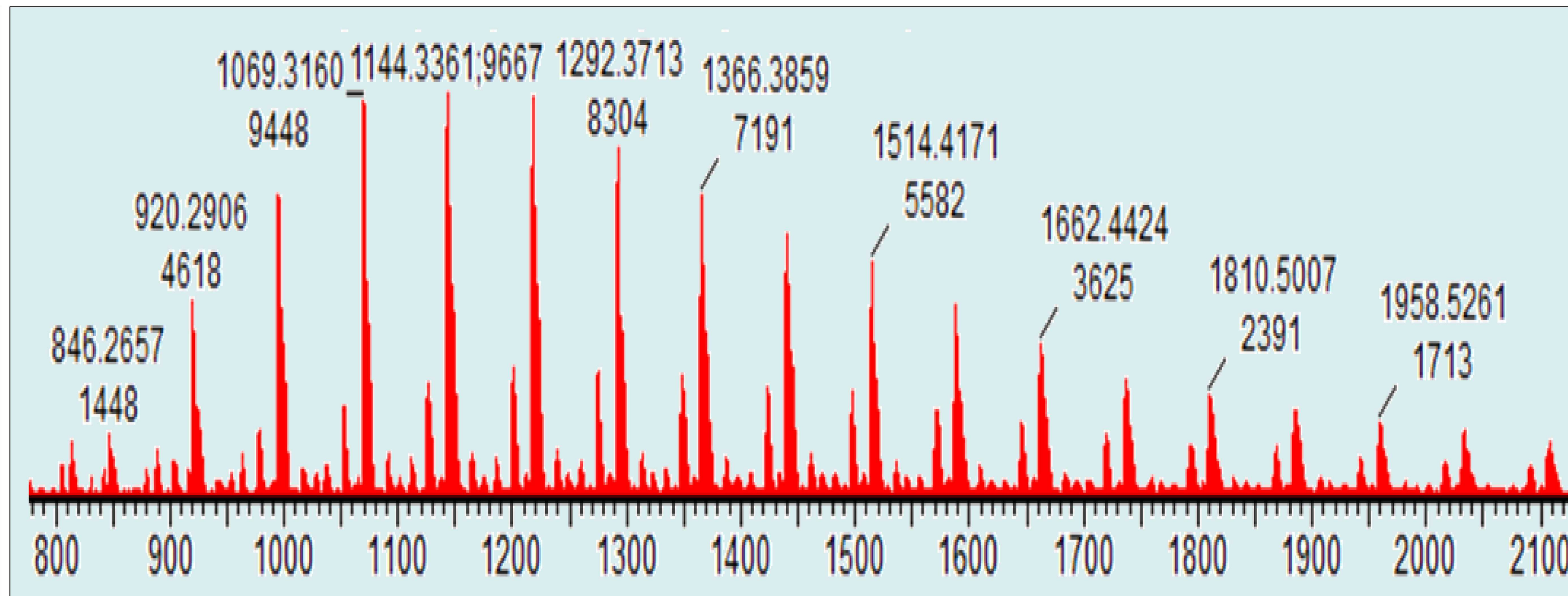


Figure 5. DESI Mass spectrum of silicone oil found to be contamination on components. Matches silicone oil from sample coupons.

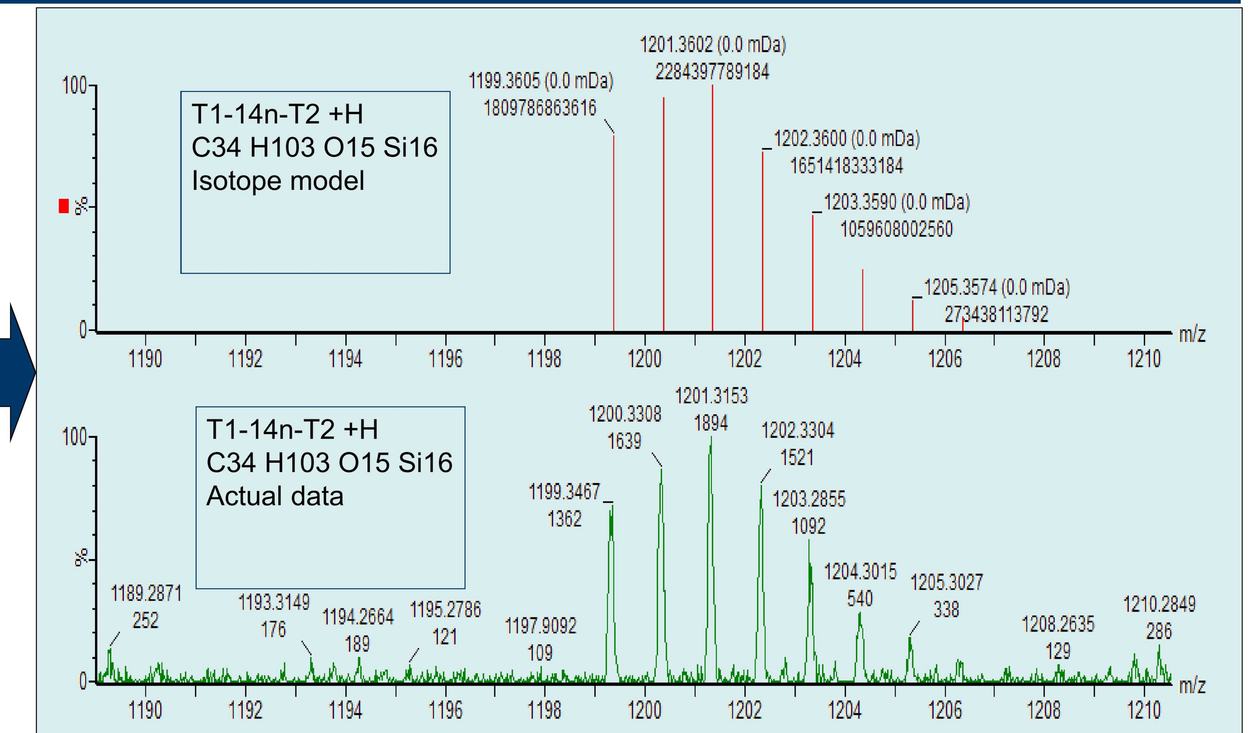


Figure 6. Mass spectrum zoomed in to PDMS molecule n=14 (m=1199). Top shows the isotope model for the formula, and the bottom actual DESI-MS data is a positive match.

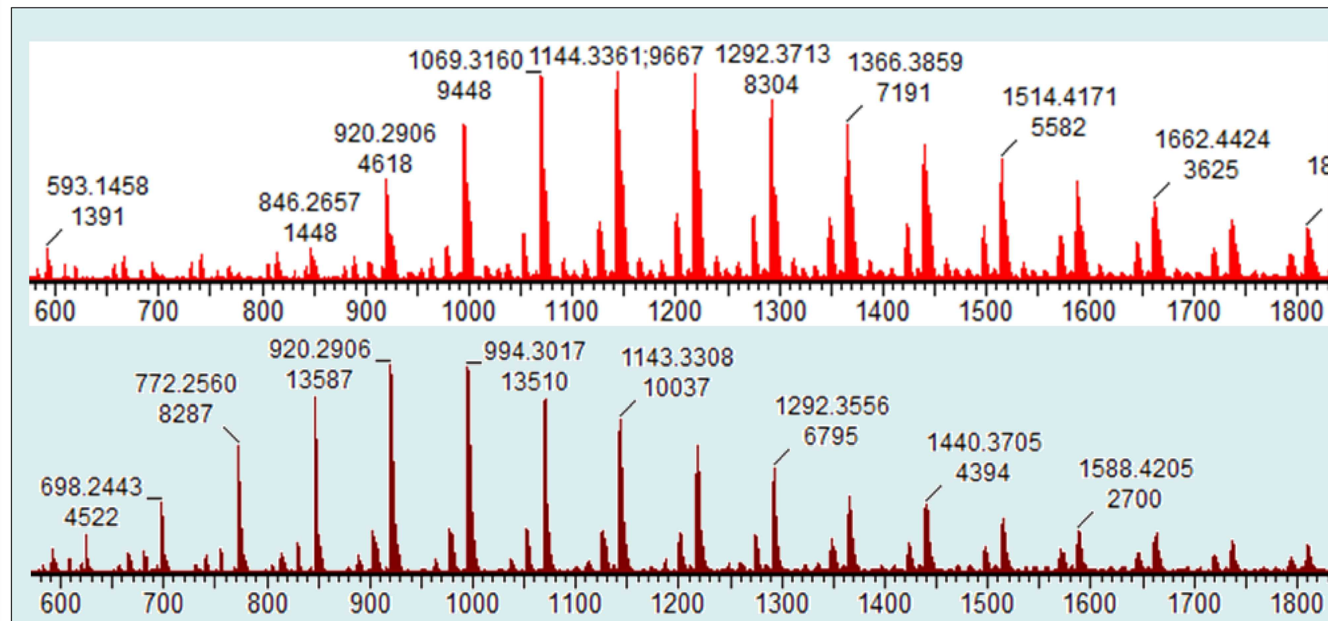


Figure 7. Mass spectra showing two distinct patterns of silicone oil (the top spectra is shifted to higher masses than the bottom spectra). The data was correlated to two different batches of identically labeled 20 centistoke oil. Findings could explain observed differences in component behaviors based on oil used.

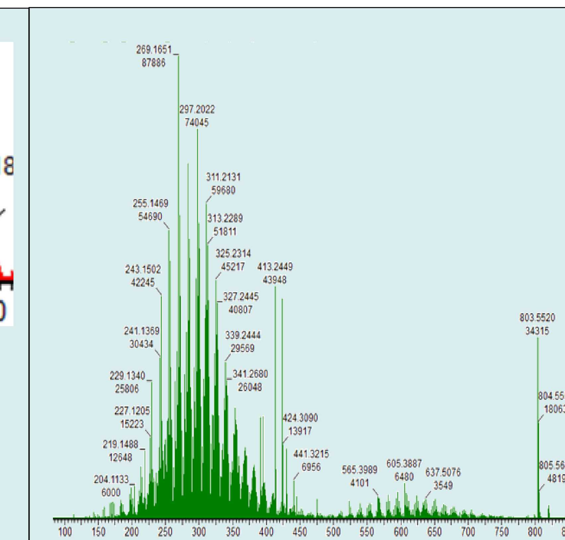


Figure 8. Mass spectrum of additional contamination seen on components using DESI. The data corresponds with hydrocarbon oil used in facility vacuum pumps.

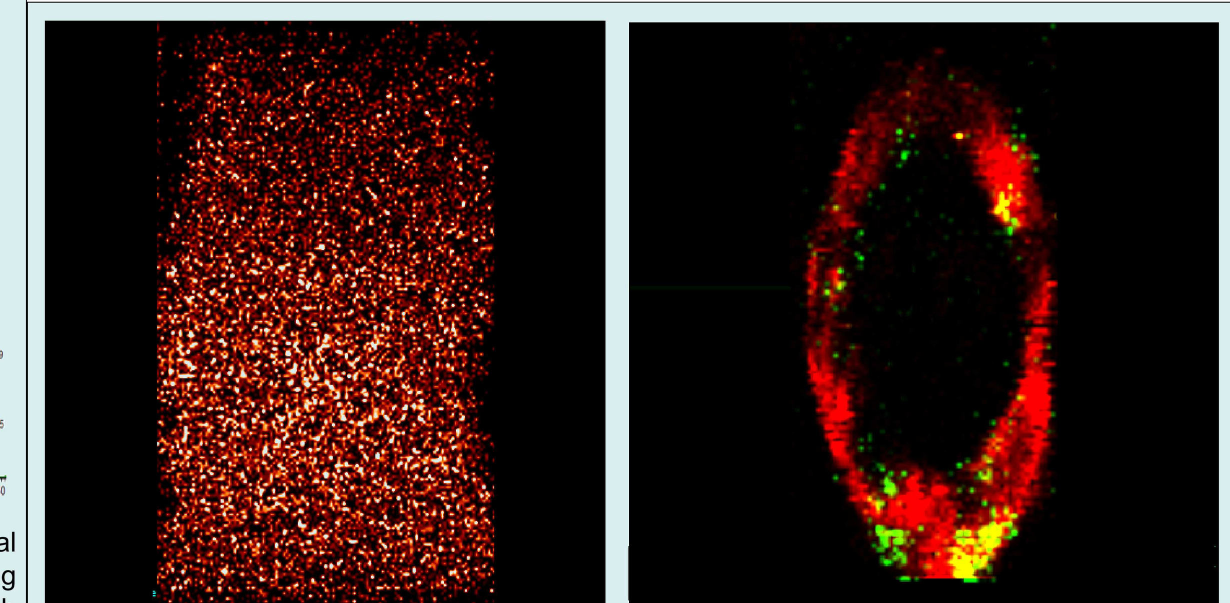


Figure 9. (Left) DESI-MS image of contamination (red) on an anodized aluminum surface. (Right) Image of contamination (green and yellow) on Buna-N O-ring (red).

- Another contaminant that can be seen using DESI-MS is skin oil.
- Even skin oil in an unwanted location can lead to production issues with high reliability components

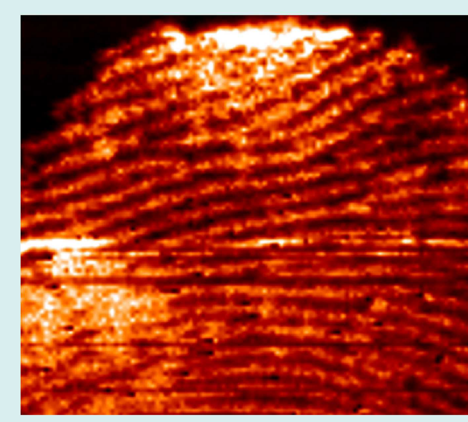


Figure 10. DESI-MS image of skin oil from a fingerprint.

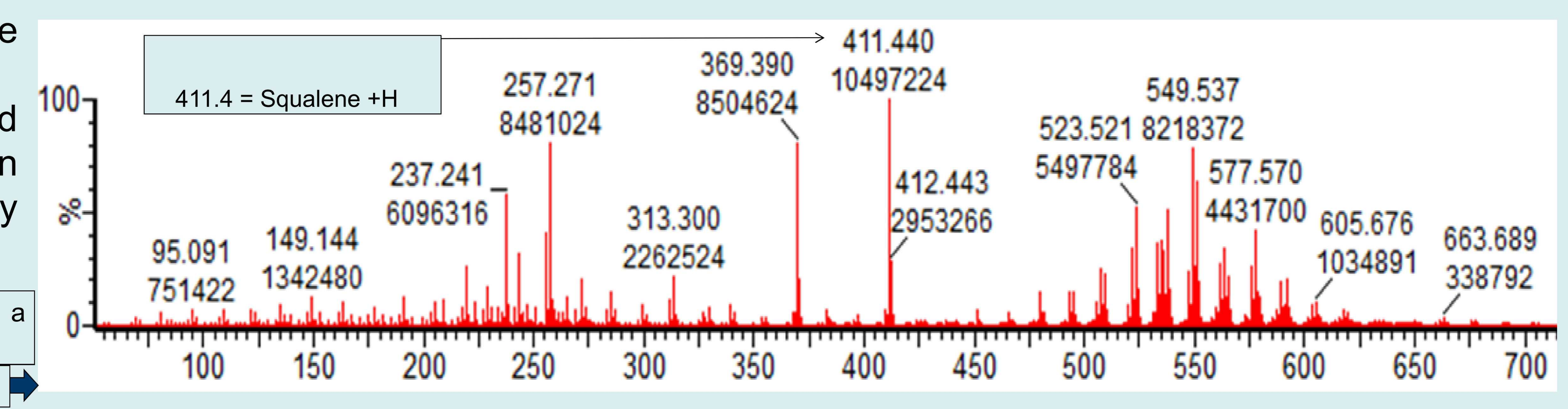


Figure 11. Mass Spectrum of skin oil

CONCLUSIONS

- ➢DESI-MS is a viable option for detecting silicone oil contamination on many material surfaces.
- ➢DESI-MS may also be used to detect additional surface contaminants.
- ➢Silicone oil contamination may help explain production problems with component behavior and material adhesions.
- ➢Many of the samples were those not used in or with components that contain silicone oil.
  - ➢This oil contamination is believed to be occurring solely because of proximity to the silicone oil.
  - ➢This information can be used by the production environment to improve cleaning procedures and to realize the potential of parts being contaminated just by being in the same working environment.
  - ➢Processes for handling silicone oil may also be reevaluated.
- ➢Future work may also use repeated DESI experiments to verify appropriate cleaning techniques.

ACKNOWLEDGEMENTS

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