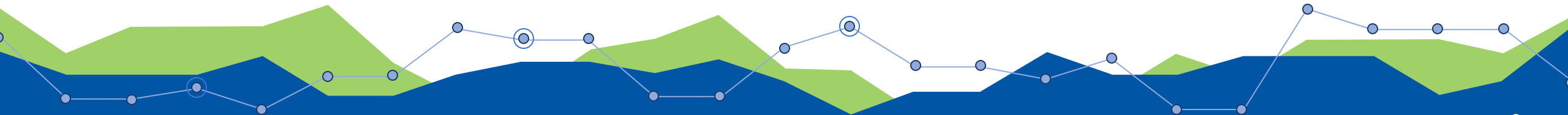


A decorative graphic spanning the width of the slide, positioned above the title. It consists of a dark blue base with a light green, jagged, mountain-like shape on top. A thin blue line with small circular markers and some larger circular callouts meanders across the green shape.

Discussion of SilcoTek's coating technology in HPLC applications

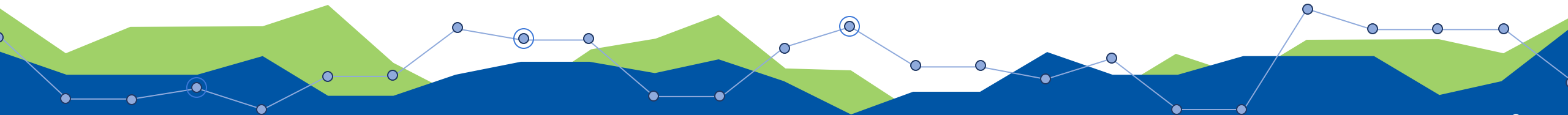
Overview of discussion

- SilcoTek Corporation 101
 - Who are we and what do we do?
- Chemical and physical properties of Dursan[®]
 - Corrosion resistance
 - Protein anti-fouling properties
- Dursan[®] in use for “sticky” molecules
 - Sialylated N-Glycans
 - Small molecule drugs



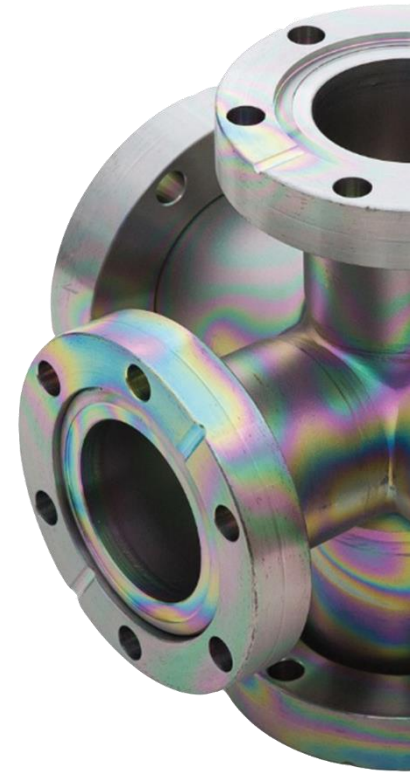
SilcoTek Corporation Key Facts

- Founded in 2009 (currently 60 employees) as a CVD coatings service provider
- Vision: To have the world's best coating technology and service, as told by our customers
- Purpose: To solve our customers' toughest material problems, help them beat the competition, and take their innovations and products to the next level

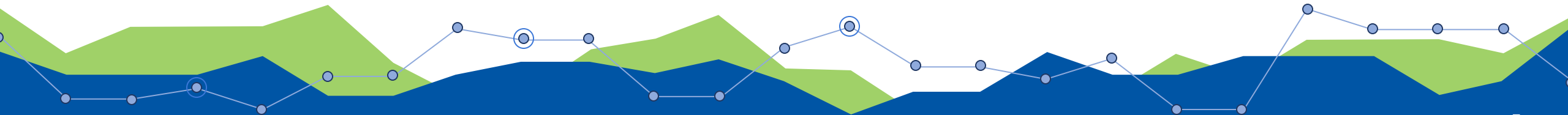


Advantages of CVD Coatings

- Non-line-of-sight deposition; uniformly treats 3D, high aspect ratio part geometries
- Molecular adhesion to base substrate. Won't flake nor delaminate.
- Scalable, versatile, and highly reproducible



The CVD process



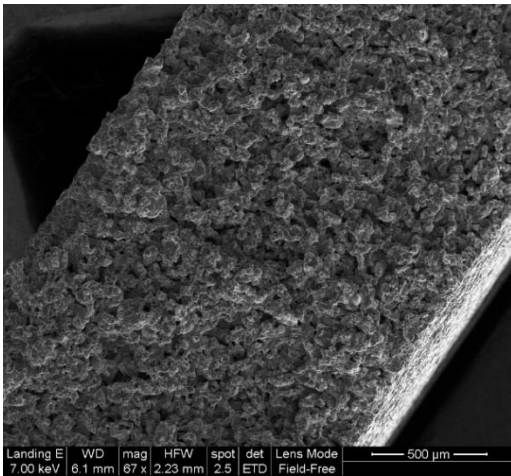
Our HPLC coating of choice: Dursan®

- Non-line of sight coating (can coat frits)
- Usable in wide pH range: 0-14
- Molecularly bound to the substrate: Good adhesion
- Wear: 2x more resistant than 316 Stainless steel
- Inert to most chemicals
- USP Class VI compliant

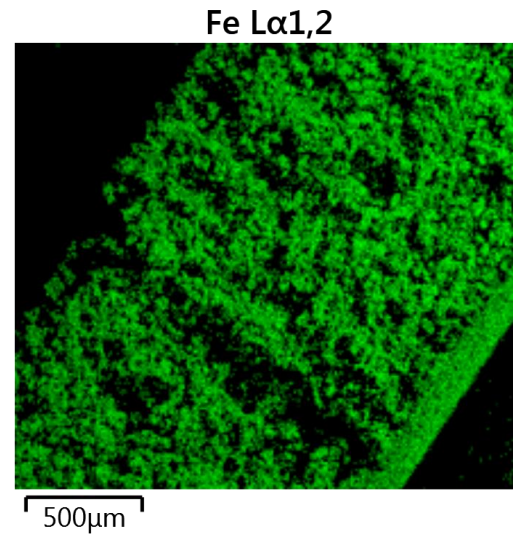


Example of non line of sight coating:

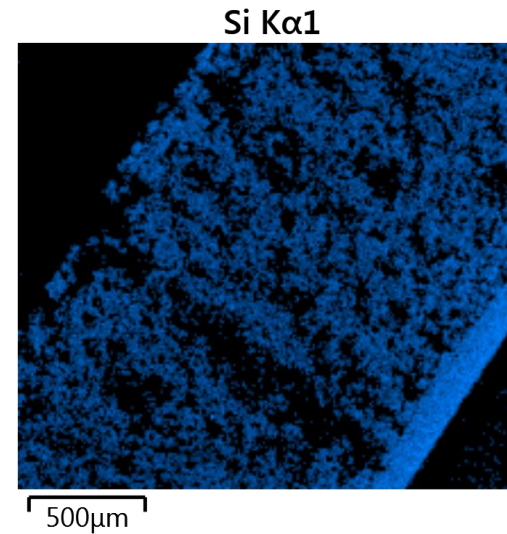
- Cross section of a 2 μ m nominal pore size frit after Dursan® coating:



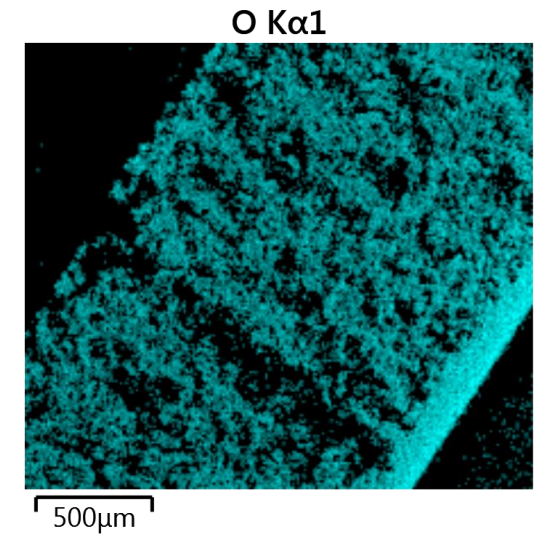
SEM micrograph



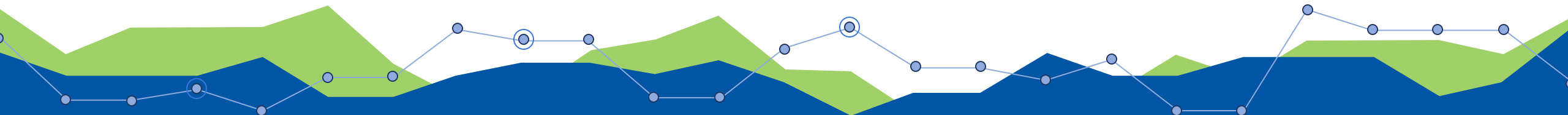
Iron EDS map



Silicon EDS map

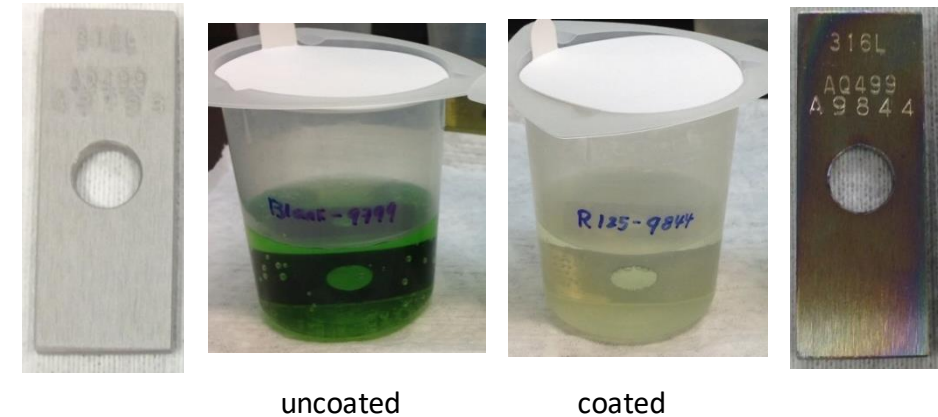


Oxygen EDS map



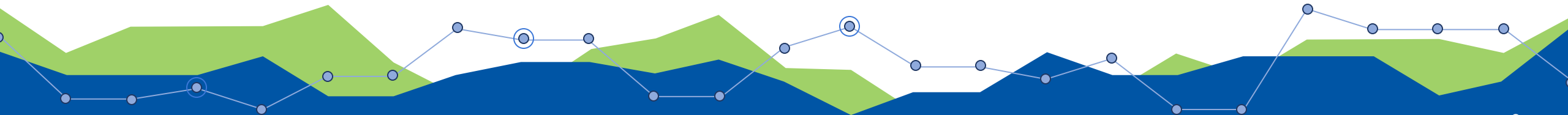
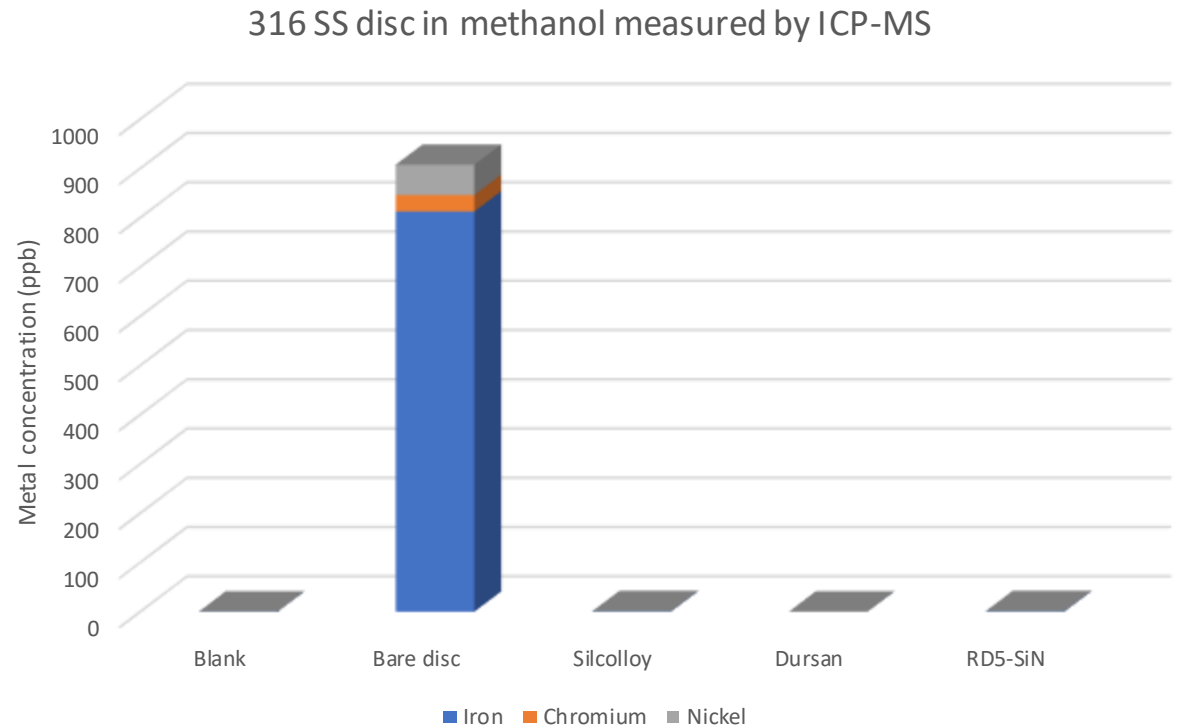
Corrosion resistance in harsh conditions

Corrosive media	Bare Stainless Steel (MPY)	Dursan coated steel (MPY)	Improvement multiplier
6M HCl @ room temp	190.4	1.1	170x
6M HCl @ 50°C	3116.1	23.5	133x
Concentrated H ₂ SO ₄	78.45	0.15	523x
48% HBr	2.05	0.29	7x
Bleach	1.70	0.10	17x
Concentrated H ₃ PO ₄ @ 80°C	2.14	0.53	4x
2% TFA	No corrosion, change in CA	Unaffected	-



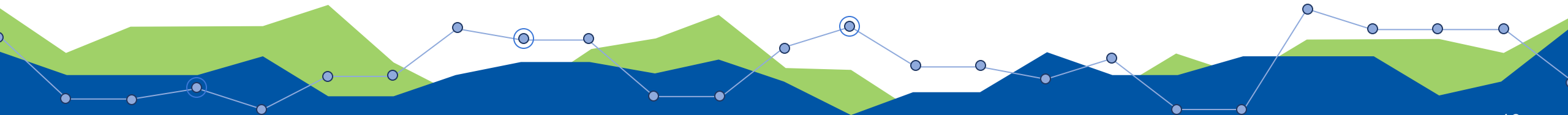
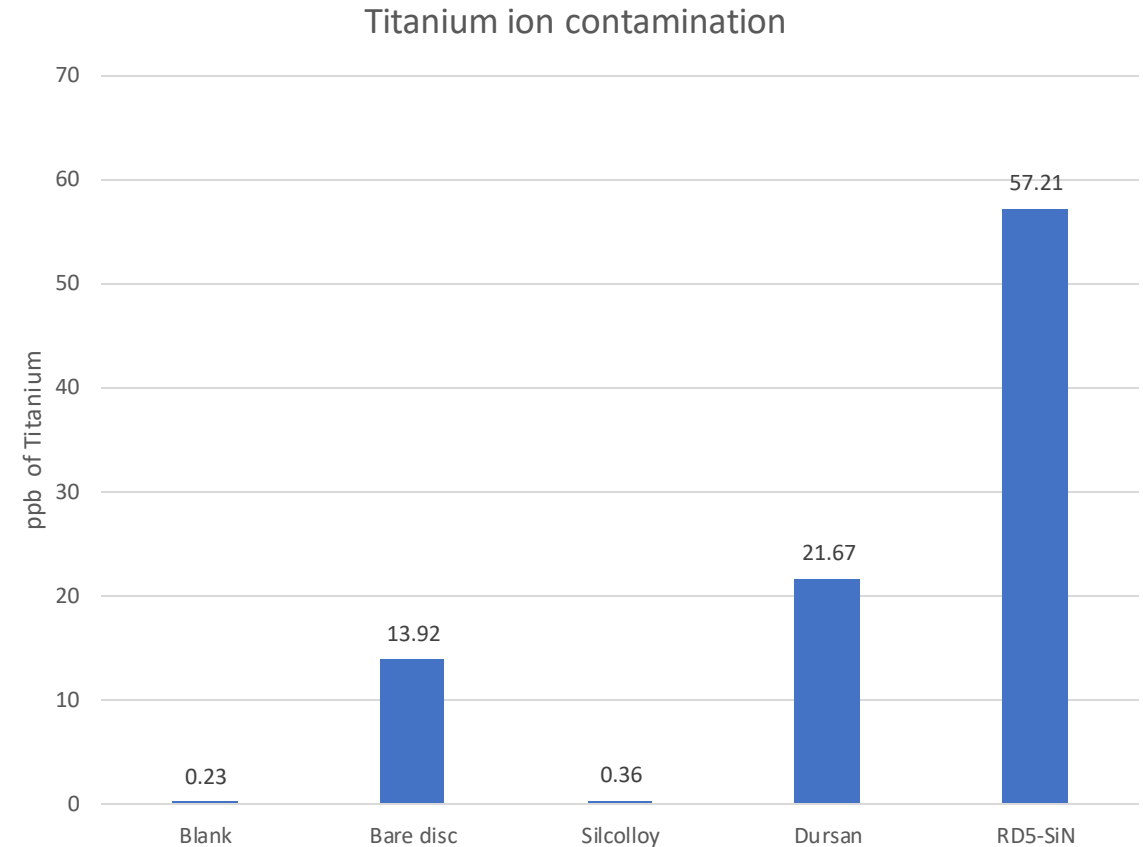
Protection against organic solvents

- Frits were left to soak in methanol for 1 month
- Results showed significantly higher levels of iron, chromium, and nickel in the uncoated frit container (908 ppb total metal content)
- Coated frits were all ± 0.5 ppb total metal of the blank



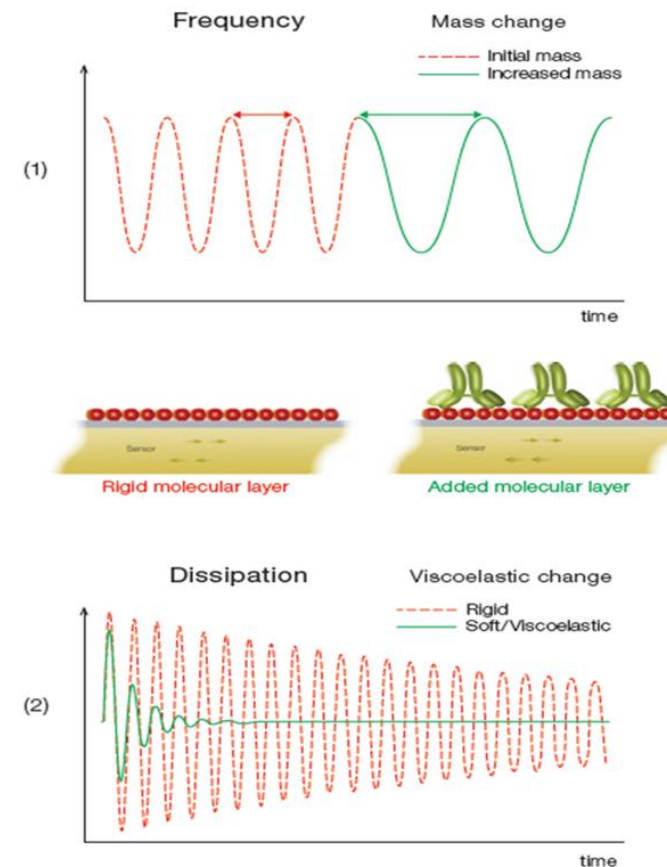
Coated titanium shows a different story:

- Silcolloy coating seems to work well where others fail
- Dursan and RD5-SiN both have an oxidation step in the process, and titanium is very sensitive to high temperature oxidation where Silcolloy (an amorphous silicon coating) is an oxidative barrier and protects the titanium



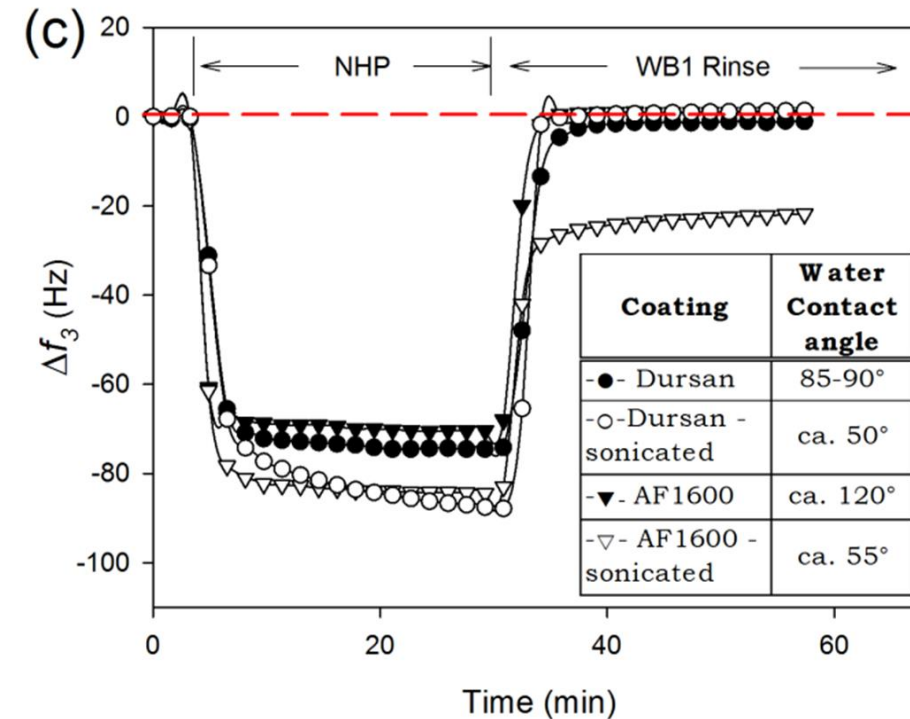
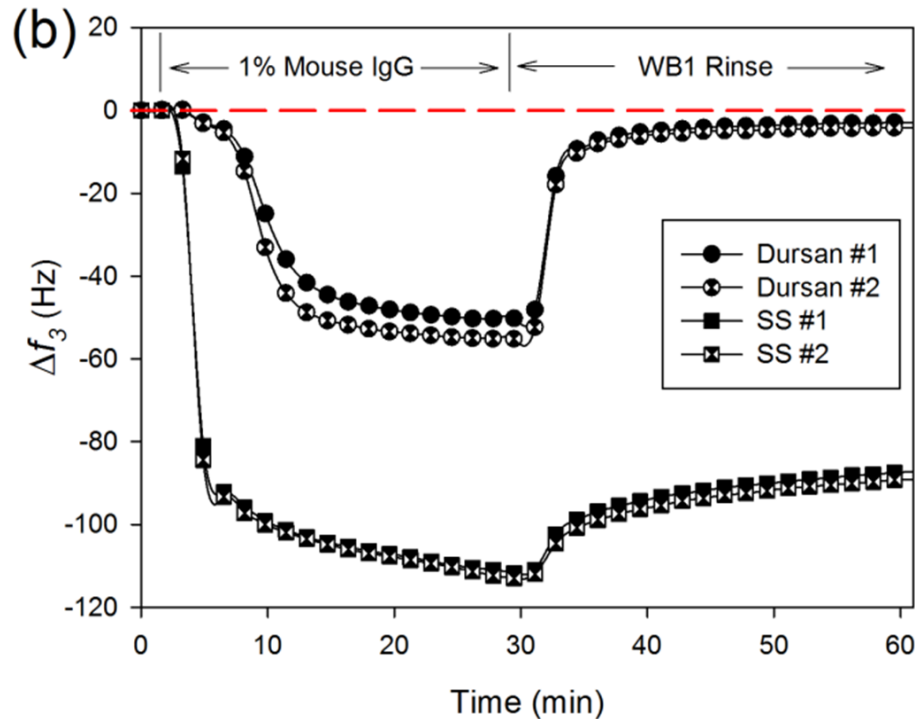
Bio-Inertness: Non-specific protein adsorption studies

- Collaborative study between Abbott Laboratories and SilcoTek on protein adsorption
- QCM-D with a thin layer of 316L SS was coated with Dursan
- Protein solutions were flowed over the sensor and the frequency was monitored over time



Vaidya, S.V.; Yuan, M.; Narvaez, A.R.; Daghfal, D.; Mattzela, J.; Smith, D. *Appl. Surf. Sci.* **2016**, 364, 896-908.

Mouse immunoglobulins and normal human plasma adsorption

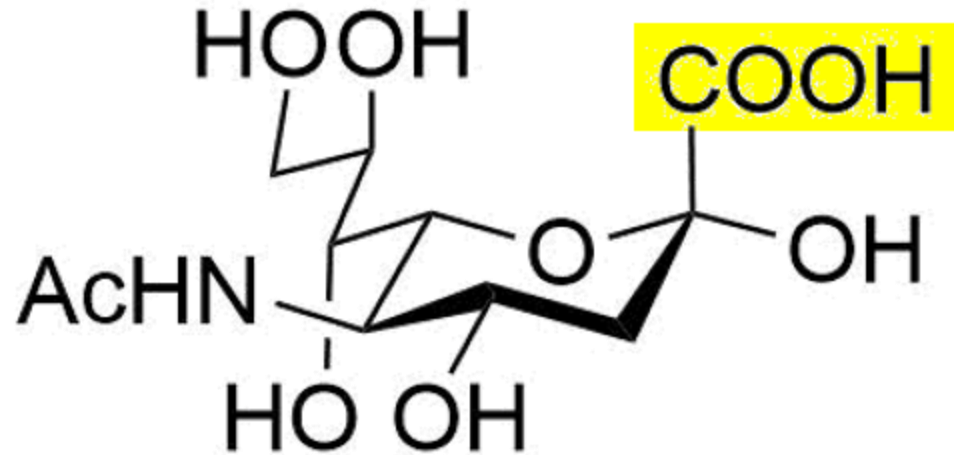


Vaidya, S.V.; Yuan, M.; Narvaez, A.R.; Daghfal, D.; Mattzela, J.; Smith, D. *Appl. Surf. Sci.* **2016**, *364*, 896-908.

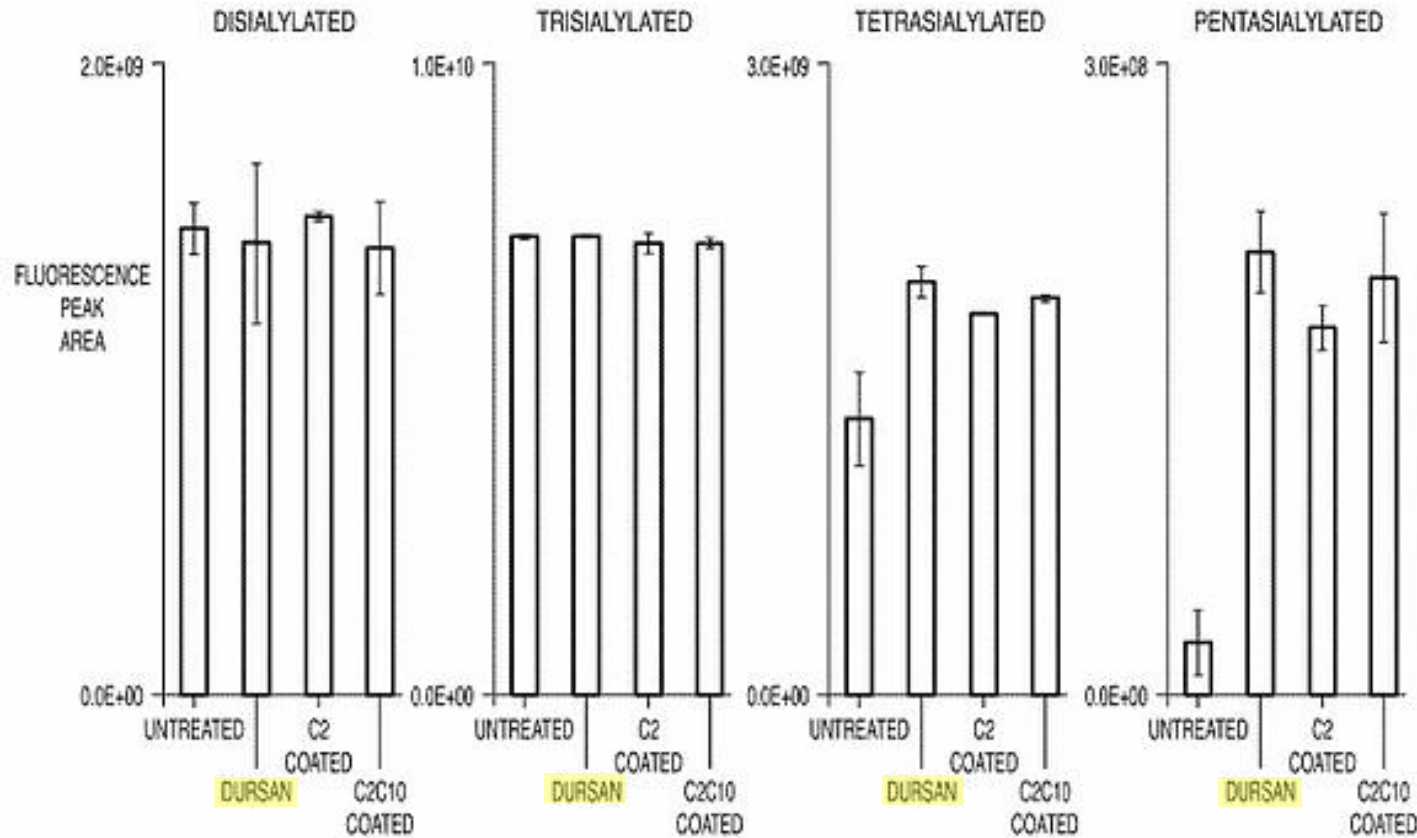
Analysis of N-Glycans

- Deglycosylation of a protein is standard in protein and biologic analysis
- Sialylated glycans contain carboxylic acids that have weak affinity toward metals

N-Acetylneuraminic acid:



Analysis of multiple sialic acid residues:

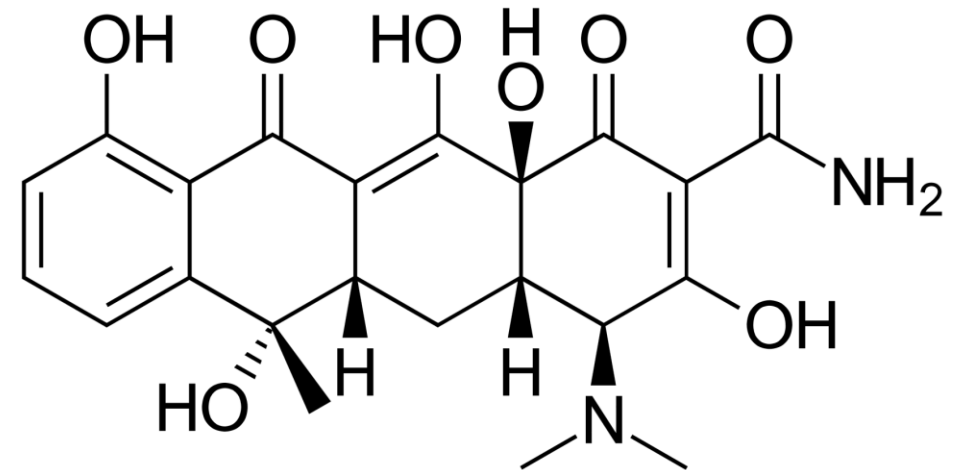


Lauber, Matthew A., et al. "Use of vapor deposition coated flow paths for improved chromatography of metal interacting analytes." U.S. Patent Application No. 16/133,089.

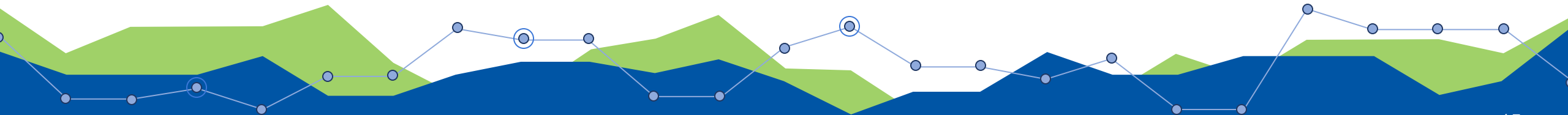
This patent has been harshly rejected by the patent office, but provides some great data on what coatings can do in HPLC equipment

Tetracycline

- Tetracycline is an antibiotic, commonly used for acne and skin infections
- The molecule has numerous chelating groups that bind readily to metal sites
- Dursan can make the steel column more inert toward metal loving molecules like tetracycline



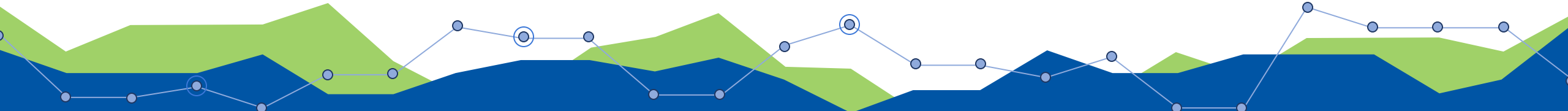
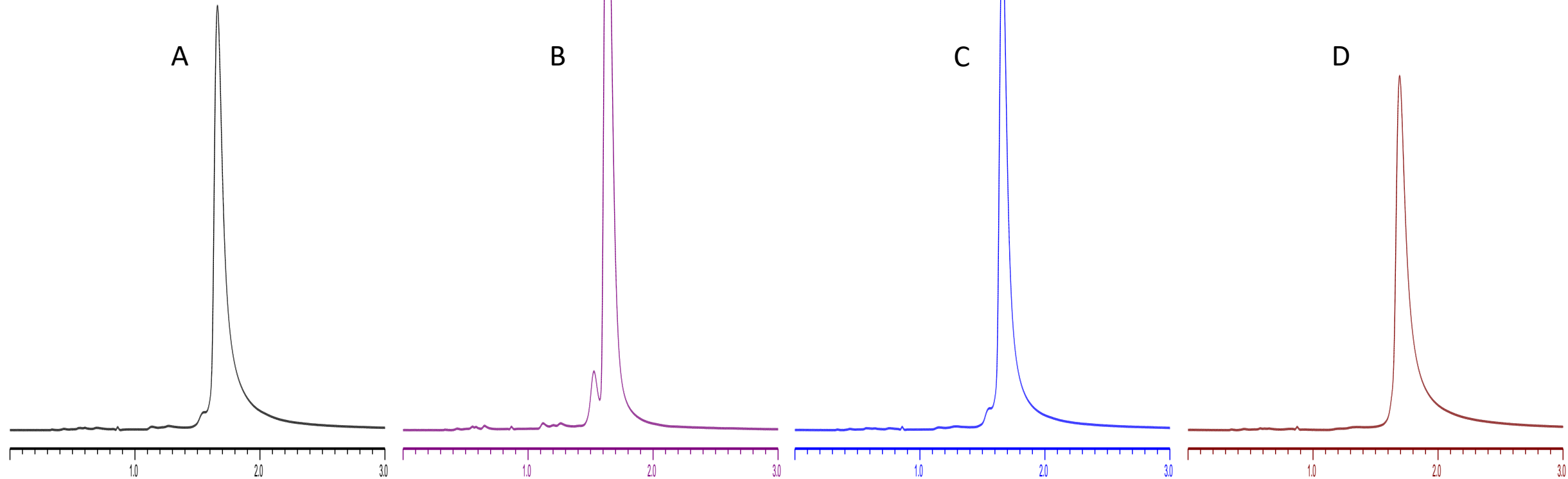
Molecular structure of tetracycline



Results:

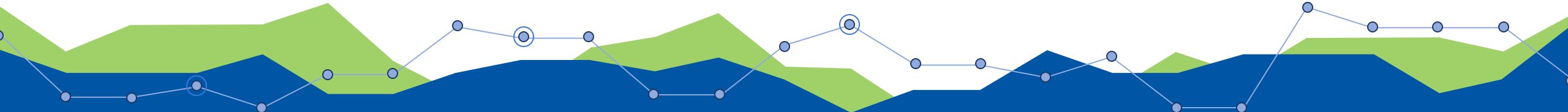
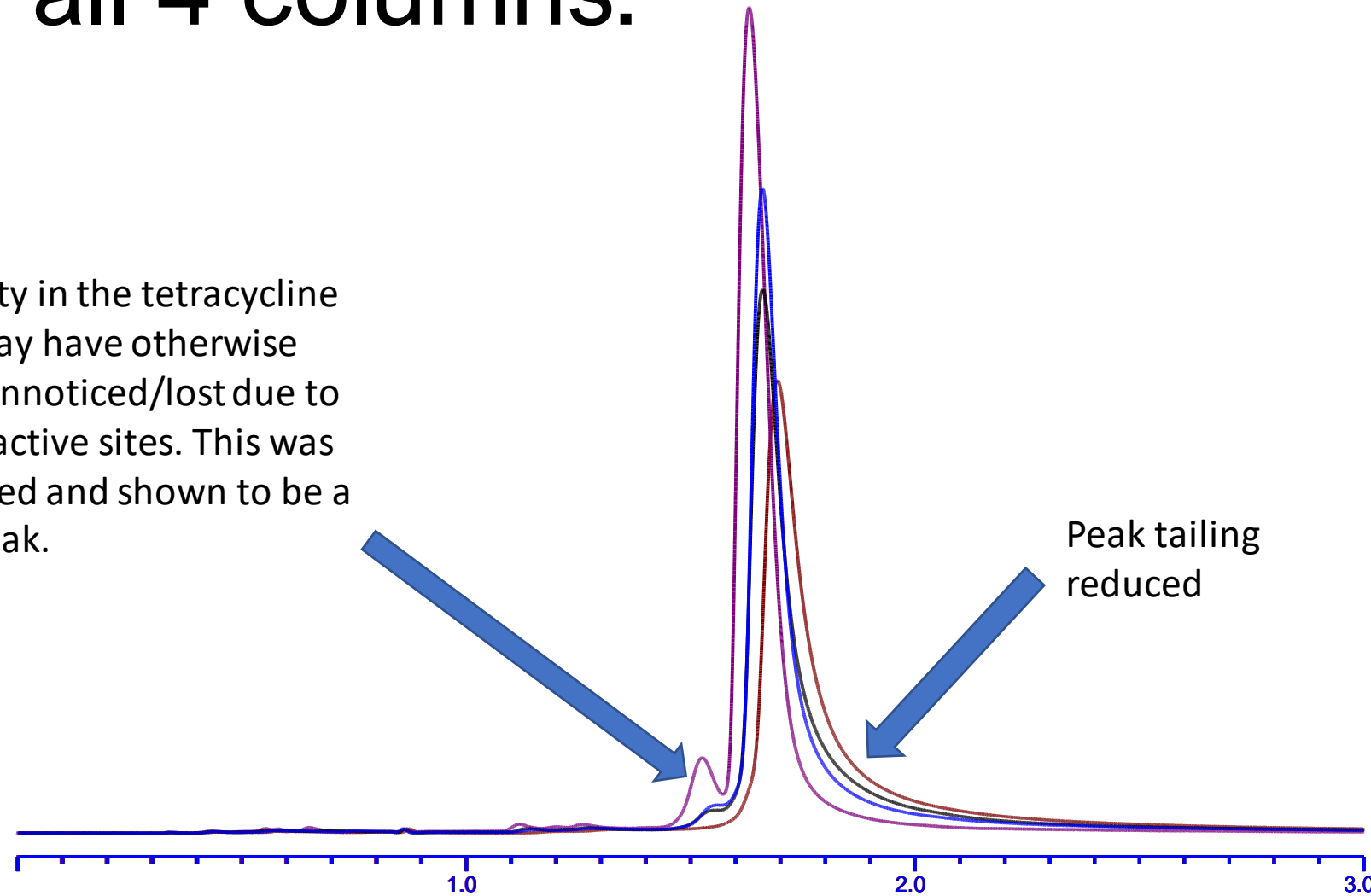
Mobile Phase A: Water
Mobile Phase B: Methanol
40% B
Flow: 0.3mL/min
Detection: 265nm

Group	Frit	Column
A	SS	SS
B	Dursan	Dursan
C	Dursan	SS
D	Ti	SS



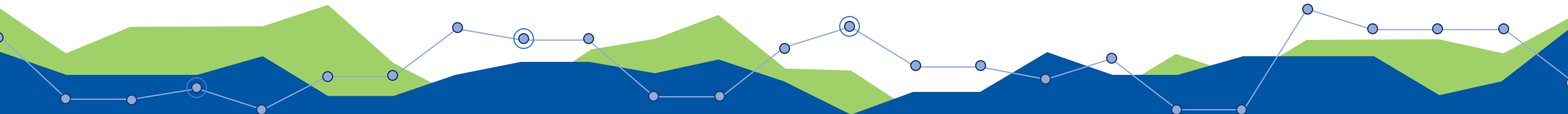
Overlay of all 4 columns:

Impurity in the tetracycline that may have otherwise gone unnoticed/lost due to metal active sites. This was repeated and shown to be a real peak.



2-pyridinol-1-oxide

- Ciclopirox is an antifungal agent typically used in topical fingernail and toenail infections
- 2-pyridinol-1-oxide is the chelating part of this antifungal agent
 - It is a very powerful metal chelating agent
- The chromatograms show significant loss of signal due to metal interactions in the separation
 - This highlights the interaction that the column wall has with the analyte and there is a need for column coating as this interaction is not negligible.

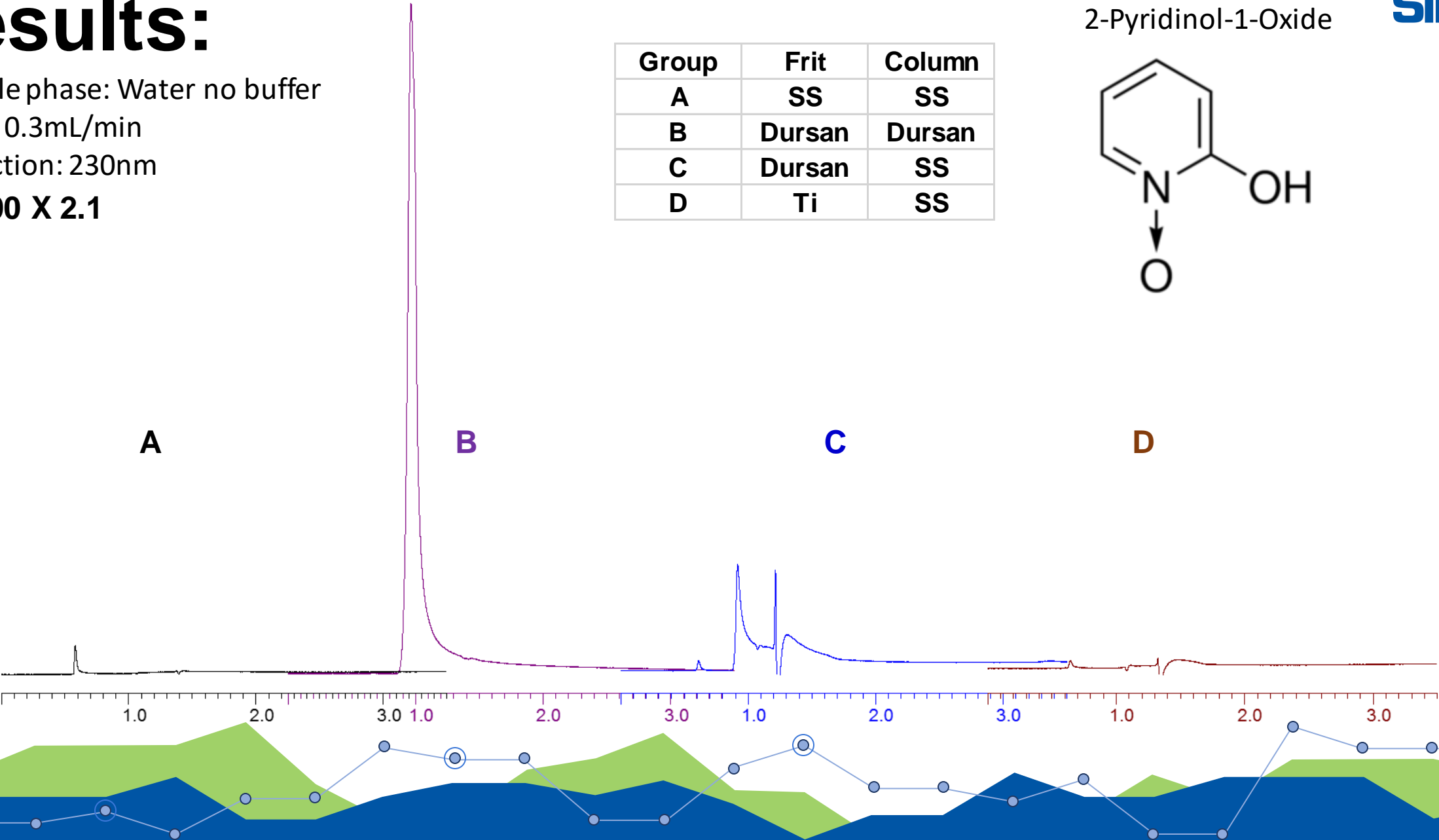
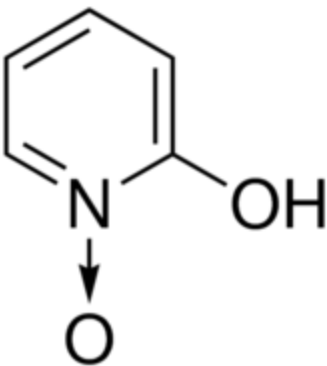


Results:

Mobile phase: Water no buffer
Flow: 0.3mL/min
Detection: 230nm
100 X 2.1

Group	Frit	Column
A	SS	SS
B	Dursan	Dursan
C	Dursan	SS
D	Ti	SS

2-Pyridinol-1-Oxide



Conclusion

- Dursan[®] can provide a bio-inert coating to all as-built stainless steel components
- Increased corrosion resistance without the possibility of swelling and delamination due to various solvents
- Decreased non-specific protein and chelating agent adsorption while still having the robustness of stainless steel
- No need for priming or passivation. A protective, barrier layer allows for reliable, reproducible data.

