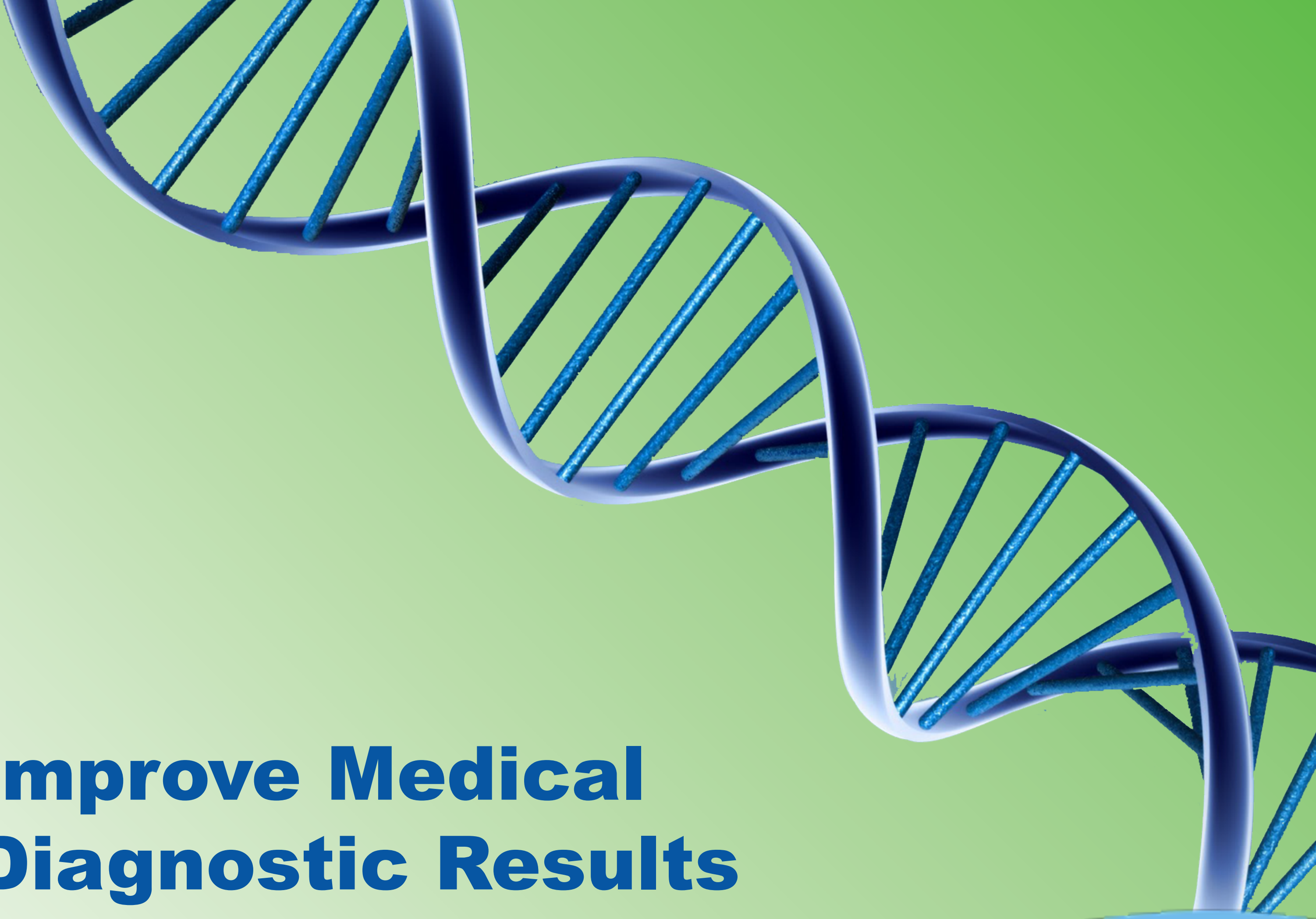


Improve Medical Diagnostic Results with CVD Coatings

An e-book on how to achieve better bioanalytical results with SilcoTek® Coatings

SilcoTek®

Game-Changing Coatings

Table of Contents

Introduction

SilcoTek® is not like other coating companies. Sure, we're manufacturers, but we're also scientists and engineers who share a common interest in diverse fields. We not only understand CVD coating technology, but we also have strong backgrounds and experiences in analytical sampling, process control, life sciences, and both GC and LC chromatography. We understand the importance of sweating the details to make sure our coatings enhance the performance of bioanalytical flow path components consistently within your specifications.

About SilcoTek®

SilcoTek® is a coating technology company dedicated to providing a work environment where "employees enjoy coming to work as much as going home" and are passionate, enjoy working with each other, and work in an atmosphere based on mutual respect and trust.

Our E-book

Over the years, our scientists have discovered new applications and benefits to the life sciences. We're sharing our discoveries in bioanalytical and medical diagnostics in this e-book to help our customers get better, more consistent, analytical results through an understanding of how an inert surface can impact test results by preventing carryover, contamination, adsorption, and corrosion.

Why should I read this e-book?

Because you'll learn how to prevent common sampling and analytical problems and learn ways to save time and money.
You will learn:

- How inert carboxysilicon CVD coatings are applied and how our Dursan® surface can benefit the entire analytical flow path, even in applications featuring small bore tubing and difficult to reach or complex components.
- How hydrophobicity and surface energy affect analytical results and how managing moisture can be important in preventing corrosion, sample adsorption and carryover.
- How Dursan® improves corrosion resistance and prevents pitting which can lead to carryover, contamination, and higher cost.
- How stainless steel can interact with the sample and promote adsorption, fouling and protein binding. Learn how silicon coatings can act as a preventative barrier, stopping false positive results and sample contamination.

Our Trust Guarantee

Our scientists and engineers are dedicated to teaching the customer how to improve the material performance of their products and processes. Science is at the foundation of our coatings. SilcoTek® relies on research and data to formulate our coatings and processes. We'll be the first to tell you if a coating is not appropriate for an application or that we don't know if a coating will work for your process. To that end, the recommendations in this e-book are based on unbiased research or methods adopted by our scientists, engineers, customers, and industry leaders. Read on and benefit from our over 250 years of analytical experience.

Chapter 1

About Dursan® carboxysilicon CVD coatings and how they're ideal for bioanalytical and medical diagnostic applications

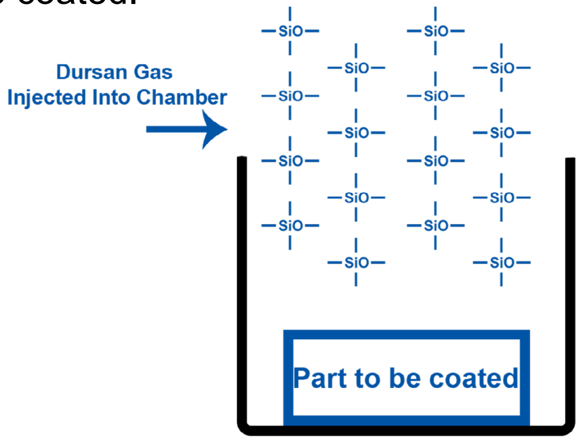
In medical diagnostics, it's all about getting it right the first time, every time. No one wants to receive a false positive report on a cancer diagnosis because of protein cross-contamination in an auto sampler needle. That's why instrument companies go to great lengths to minimize the risk of contamination and errors caused by protein binding and carryover.

Today, new surface technology applied by chemical vapor deposition (CVD) further reduces the risk of test error. SilcoTek®'s silicon CVD coatings, like Dursan®, improve instrument durability and corrosion resistance preventing protein carryover and contamination. In this chapter we'll discuss the process used to apply innovative silicon-based coatings like Dursan®, and their benefits to bioanalysis and medical diagnostic instruments.

The Chemical Vapor Deposition Process. How Dursan® is Applied to a Surface.

Unlike traditional dip or spray coatings that simply stick to the surface, a chemical vapor deposition (CVD) process bonds inert silicon-based material into the metal surface for better durability and adhesion. Here's how CVD coatings are applied:

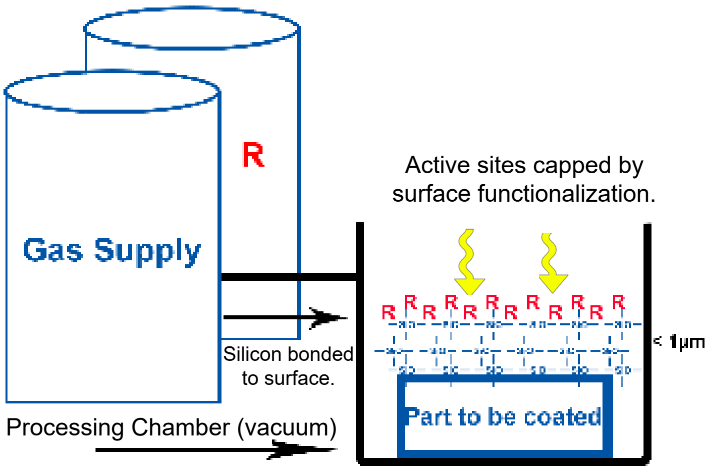
1. First, the part is heated in a reaction chamber under vacuum.
2. Then our Dursan® gas consisting of inert silicon (Si),carbon, and oxygen gas is injected into the chamber.
3. The super inert Dursan® compound fills the entirety of the space in the chamber, coating internal and external part surfaces. Even extremely small diameter needles and sintered metal frits can be coated.



Dursan® gas is injected into the chamber

The Result?

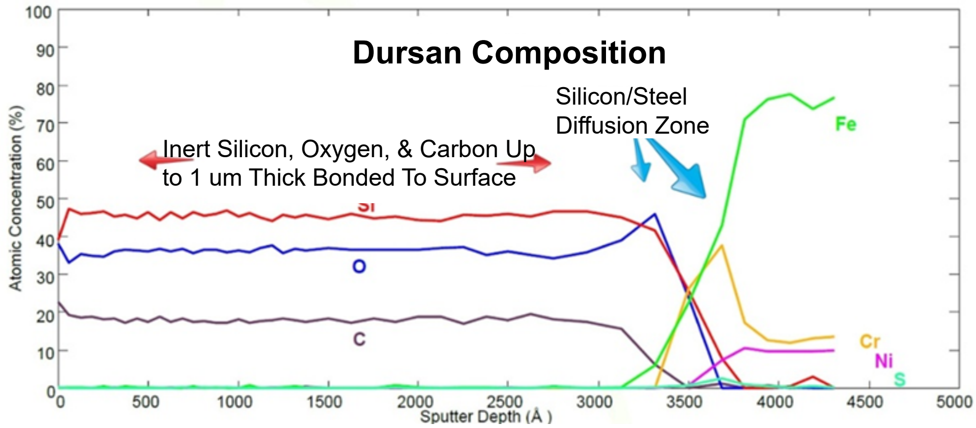
The inert Dursan® gas bonds to and diffuses into the part surface, creating a robust barrier coating on 100% of the part. Proprietary surface functionalization (R) may be added to Dursan® to enhance inertness, hydrophobicity, anti-stick properties or other customer-specified performance properties.



Dursan® s bonded to the surface and functionalized to enhance performance

The three-dimensional, non-line-of-sight coating process results in a uniform barrier layer. Even complex part geometries can be uniformly treated. Dursan® is thin (~1 μm) and will not significantly impact design tolerances. A high tolerance coating like Dursan® will benefit the user by allowing the user to coat existing parts without costly re-engineering.

Auger electron spectroscopy (AES) sputter depth profile analysis quantifies the material composition and the surface-to-part bond or diffusion zone characteristic of the Dursan® coating process. Up to 1 micron of the silicon, oxygen, and carbon material, along with any specified surface functionalization, is bonded to the surface. The AES profile shows a 500 angstrom area where the Dursan® gas intermingles and mixes with the steel surface. That diffusion zone improves the attachment of the Dursan® layer compared to plated or "painted on" surfaces.



Watch our process video and see for yourself how we coat parts.

Key Factors to Consider When Selecting a Coating for Bionert Applications

Stainless steel, a common medical diagnostic flow path material, is an active surface that can cause protein retention, chemical adsorption and is susceptible to corrosion when bleach or acids are used as a cleaning or rinse agent. That's why various types of coatings have been used to improve the surface properties of medical diagnostic instruments for decades, but none have been completely successful in reducing protein retention and carryover.

Instrument manufacturers have gone to great lengths to evaluate alternative materials to solve non-specific protein binding, protein carryover, fouling and rust problems. Unfortunately, commonly used fluoroploymers, like AF1600, are not acceptable in high durability applications. Small bore surfaces like needles, valves, or fittings are also challenging for polymer-based or other line-of-sight surface treatments. To address durability and form factor concerns, manufacturers take into account several key factors when selecting bio-inert materials.

Factors to consider when selecting bio-inert materials:

- Improved analytical sensitivity, eliminating interaction with flow path surfaces
- Prevents non-specific protein binding for many target proteins, preventing false positive results
- Corrosion resistant and durable
- Able to be applied to surfaces without changing part tolerance or performance
- Meets FDA regulatory compliance for coatings

Dursan® meets all the criteria and is NSF and FDA compliant; making it worth consideration when selecting a bio-inert material.

NSF approved and FDA Compliant

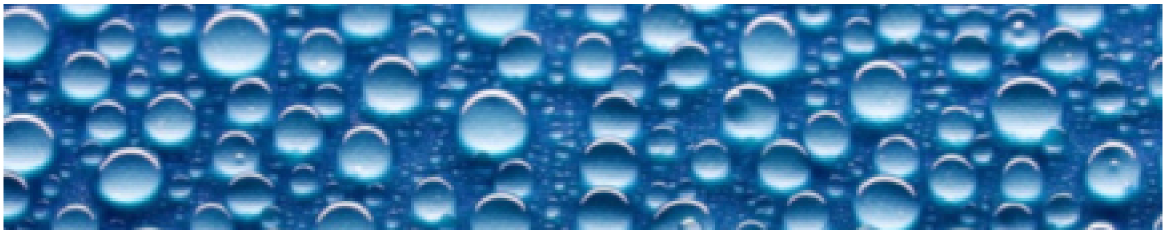
Our Dursan® coating is compliant with NSF/ANSI 51 and all applicable requirements. That means that it is safe for food contact and also meets the FDA's requirements for compliance. FDA regulates coatings via the Code of Federal Regulations (CFR), specifically 21 CFR 175.300 which lists what raw materials are acceptable and unacceptable for the formulation of coatings.
According to the FDA, a coating must:

1. Pass the solvent extraction tests listed in 21 CFR 175.300.
2. Contain no heavy metals.
3. All coating components must conform to the materials listed by the FDA in order to be compliant.

These stipulations are also required for NSF/ANSI 51 certification. Dursan® successfully meets these requirements.

[Click here to view our NSF certificate](#)

Why is Dursan® Ideal for Bioseparations and Medical Diagnostics?



A bio-inert sampling flow path is critical for achieving consistent bioseparations in medical diagnostics and HPLC analysis. Over time inert surfaces degrade and test flow paths corrode due to frequent rinse cycles from aggressive chemicals like bleach. The corroded and pitted surfaces are perfect hiding places for sticky compounds like proteins, making carryover and contamination a real concern. Dursan® solves these problems and improves versatility and performance of the analytical flow path. Coating properties that will improve instrument flow paths include:

- Anti-stick
- Non-reactive/inert
- High temperature resistance
- Oxidation protection
- Corrosion resistance
- Wear & abrasion resistance
- Hydrophobicity
- Oleophobicity

How do coatings benefit medical diagnostic and bioseparation components?

The bio-inert Dursan® prevents interaction of reactive, corrosive, or sticky compounds in analytical flow paths. Benefits include:

- Extend the life of needles and flow path components
- Prevent protein carryover and binding
- Improve test consistency
- Prevent false positive results

We'll be presenting data and discussing each of the benefits highlighted above in chapters 2 through 4. If you want to learn more about our coatings and how they improve flow path performance:

Download our Coatings Guide

Chapter 2

Managing Moisture: How Hydrophobicity and Surface Energy Impact Analytical Results

They say opposites attract; not so much when comparing hydrophobic and hydrophilic surfaces. In this chapter we'll discuss hydrophobic coating surfaces and the benefits of moisture management in analytical systems. In this chapter you will learn:

- How a hydrophobic surface can benefit medical diagnostic performance
- How a hydrophilic surface can also have benefits in some applications
- How to change surface energy to manage hydrophobicity
- The benefits of repelling low surface tension liquids

The Benefit of Hydrophobicity

A hydrophobic material is a water repelling, low surface energy surface that resists wetting. Moisture contact angle measurements will classify a surface as hydrophobic when the contact angle mark and the surface will be classified as super hydrophobic. Water will jump right off the surface as seen in this video.

A bouncing drop is not just a neat trick. There are many benefits of a super hydrophobic surface in medical diagnostics applications including:

- Provide a surface air gap which impedes interaction
- Reduce surface interaction of the analyte with the surface
- Eliminate surface retention and adsorption of proteins
- Reduce cellular surface growth and interaction
- Impede bacterial growth

Super hydrophobic surfaces promote an air-liquid gap between the flow path surface and the analyte. This gap impedes protein and cellular surface binding and growth which contribute to fouling and carryover. If the surface can prevent the interaction, then test failures resulting form carryover, contamination and fouling will be reduced[1].

Applications for super hydrophobic surfaces in medical diagnostics include:

- Needles
- Tubing
- Lab-on-chip diagnostics
- Antibacterial/infection prevention
- Blood compatible diagnostic tools
- Cell bioanalysis surfaces

Learn How To Improve Moisture Resistance, Fouling Resistance, and Corrosion Resistance.

View Our Presentation!

Hydrophilic Surfaces

Not to be outdone, hydrophilic surfaces have benefits as well. What are hydrophilic surfaces? They are high surface energy substrates that attract water and allow wetting of the surface. They typically have a droplet contact angle measurement of less than 90 degrees. Lots of surfaces tend to be more water friendly, including glass, steel, or stainless steel, and many coatings and paints. Of course, test results can depend on the surface roughness and surface energy of the material you're testing.

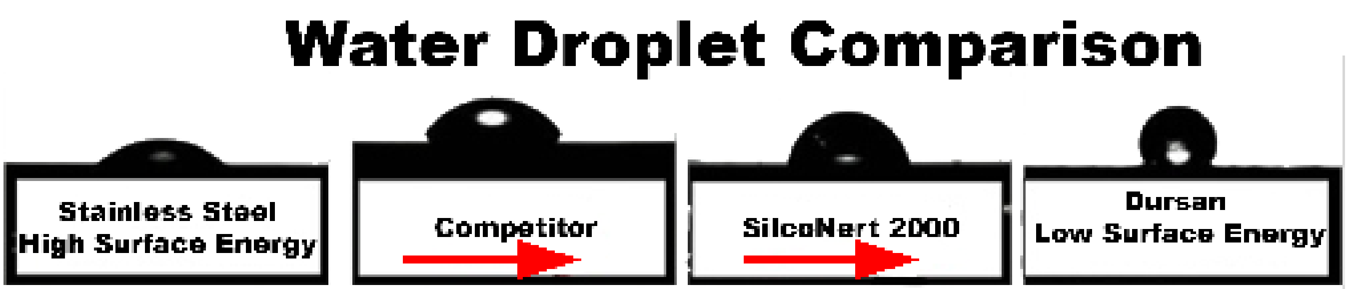
Benefits of a hydrophilic surface include:

- Higher acceptance of in-body devices
- Improved efficiency in heat transfer devices and heat exchangers (application dependent)
- Better surface interaction in filtration devices (application dependent)
- Improved separation in medical diagnostics (application dependent)

For these applications, our Dursox® coating can increase the hydrophilicity of uncoated stainless steel by 3x.

How to change surface energy to manage hydrophobicity and improve results.

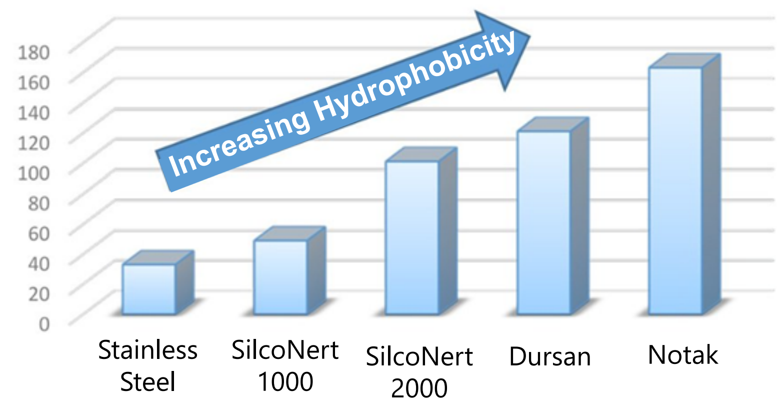
You don't have to make a radical change to material or product construction in order to change the surface energy or hydrophobicity of a flow path. SilcoTek® CVD silicon barrier coatings offer a wide range of hydrophobic or hydrophilic capabilities. The image below compares a high energy surface (stainless steel) to various materials with lower energy. As the surface energy decreases, the water droplet contact angle increases. The higher the contact angle, the greater the hydrophobic (water repelling) property and greater resistance to protein carryover and fouling.



Matching Hydrophobicity with Performance

Of course, hydrophobicity alone may not get you the total performance you need. The specific surface enhancement needed may play a role in coating selection. For example, there are several coating choices available that combine performance enhancements like corrosion resistance, inertness, fouling resistance, and improved durability.

Want a more corrosion resistant or inert coating with low surface contact angle? Try SilcoNert® 1000 or Silcolloy® or Dursox®. If you're looking for an inert coating that's not too moisture repelling, go with SilcoNert® 2000. Need maximum water repelling properties, improved durability and fouling resistance? Dursan® and our new Notak™ coating may do the trick. Contact our technical service team to discuss your application and we'll be happy to make a coating recommendation.

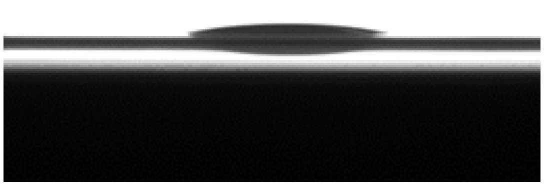


The comparative graph above highlights the water repelling properties of each of our coatings compared to stainless steel; each coating has specific applications and benefits. Go to our applications guide or more information on our coatings.

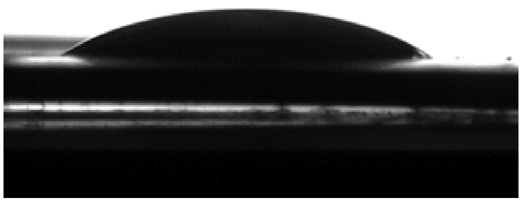
It's not all about water you know!

Low surface tension liquids like oils, organic solvents, or soaps are designed to wet the surface for maximum lubrication or solvation. But what if you're separating organics in a membrane or don't want the surface to wet? Water repelling materials like PTFE are not effective in repelling organics. Here's what oil and hexadecane look like when placed on a PTFE surface. The hexadecane and oil wet the surface completely.

Hexadecane on PTFE
29.7°



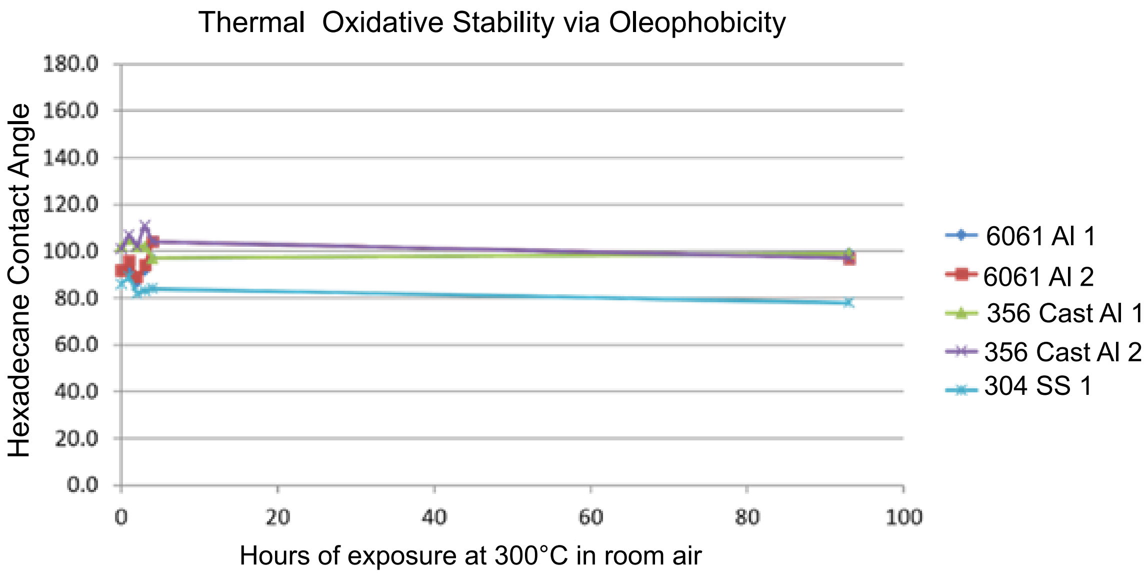
Oil on PTFE
48.5°



We bonded our new Notak™ coating to a rough stainless steel surface to see if the surface would repel organics and increase contact angle. Notak made a big difference in contact angle, making the stainless steel an oleophobic surface. What's the benefit? An oleophobic filter or membrane, for example, would enhance the separation effectiveness for soaps and oils.

Temperature Effects

Under some test conditions devices can be exposed to elevated temperatures. Fluoropolymers like PTFE are temperature-limited and can fail in many high temperature applications. We exposed the Notak™ coating to elevated temperature (300°C) for several hours to gauge the impact to wettability and contact angle on various surfaces. The graph below shows consistent contact angle readings over the 90+ hour test. PTFE would have failed at 250°C.



The contribution of surface energy and its relationship to process fluids can have far ranging impacts. Surface interaction can impact corrosion, fouling, analytical sampling results, filtration and medical device performance. So it's important to understand how to manage the energy of critical flow path surfaces.

Get some really informative and helpful tips on ways to prevent fouling, change surface energy and improve surface performance. Watch our surface fouling webinar.

[1] Super Hydrophobic Materials for Biomedical Applications Eric J. Falde, Stefan T. Yohe, Yolanda L. Colson, and Mark W. Grinstaff; https://www.ncbi.nlm.nih.gob/pmc/articles/PMC5136454/

Chapter 3

How Improving Flow Path Corrosion Resistance Can Prevent Test Failures and Improve Purity

In this chapter you will learn:

- How a corrosion resistant surface will benefit analytical flow path purity and help make it biologically inert
- How adding an inert, high durability protective coating can protect against surface pitting
- How to improve the rust resistance of intricate precision stainless steel components
- Review comparative corrosion data of commonly used cleaning agents and acids

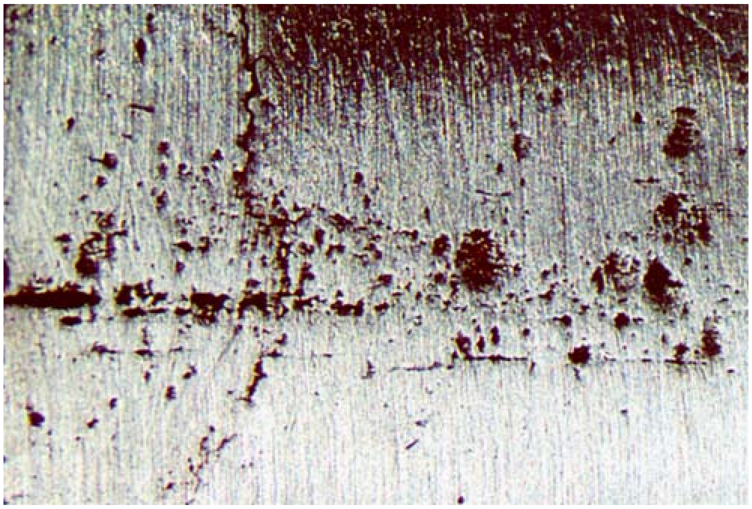


Figure 3.1

The use of corrosive analytes and cleaners in medical diagnostic applications can damage the flow path surface and result in test failures. A pitted flow path surface can cause test failures in several ways.

- Rust particles and metal ions can contaminate the sample.
- A rough pitted surface can hide trace contaminants which can lead to carryover and contaminate other samples, causing false positive tests and make the flow path less biologically inert.
- Corrosion can result in excessive maintenance and frequent system failures.

Figure 3.1 illustrates the impact severe pitting can have on a flow path surface. Not only does corrosive attack compromise the integrity of the stainless steel, but it also makes a great place for particulates and sticky biomolecules, like proteins, to hide. A biomolecule can remain in a pit even after several rinses with bleach. Later, that molecule may become dislodged and contaminate the next test cycle.

Want to take a shortcut and get lots of comparative corrosion resistance data?

Go to our latest corrosion solutions presentation

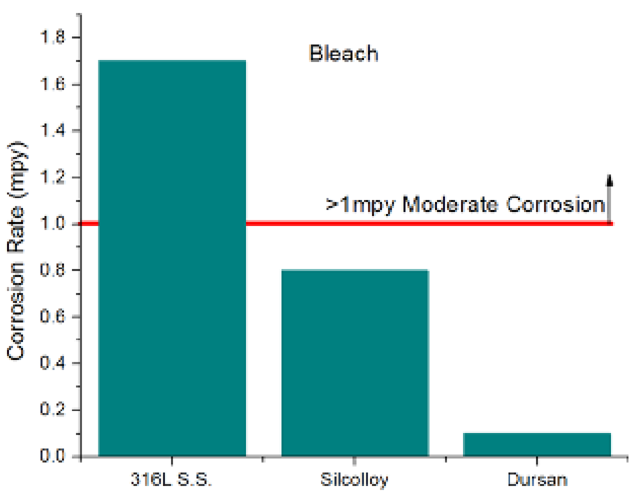
Often, the rinse agent that is intended to remove contaminants from the surface can be the very substance that will corrode the surface and lead to contamination. Comparative ASTM G31 test sample coupon immersion tests demonstrate the corrosive damage that bleach can cause on stainless steel flow paths. The test coupon at left is severely pitted after only a few hours of exposure.

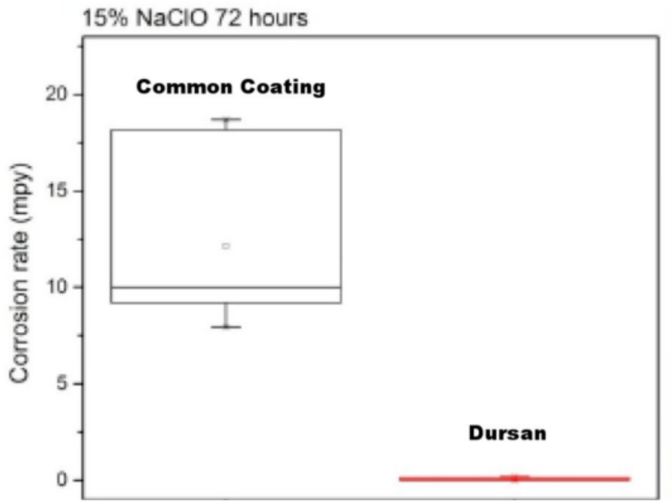
A corrosion resistant precision coating like Dursan® acts as a barrier to prevent the bleach from interacting with the stainless steel surface. The silicon (Si)-based coating allows corrosive rinse agents to remove contaminants without corroding the surface. The coupon at left shows no corrosion after several hours of bleach exposure.

The Data

Comparative ASTM bleach immersion studies show Dursan® inhibits corrosive attack by preventing interaction of analytes or cleaning agents with the surface outperforming other coatings or stainless steel surfaces by an order of magnitude.

ASTM G31 72 hour comparative bleach immersion studies prove Dursan® significantly reduces the risk of corrosion in analytical flow paths as seen in the graph below (left).

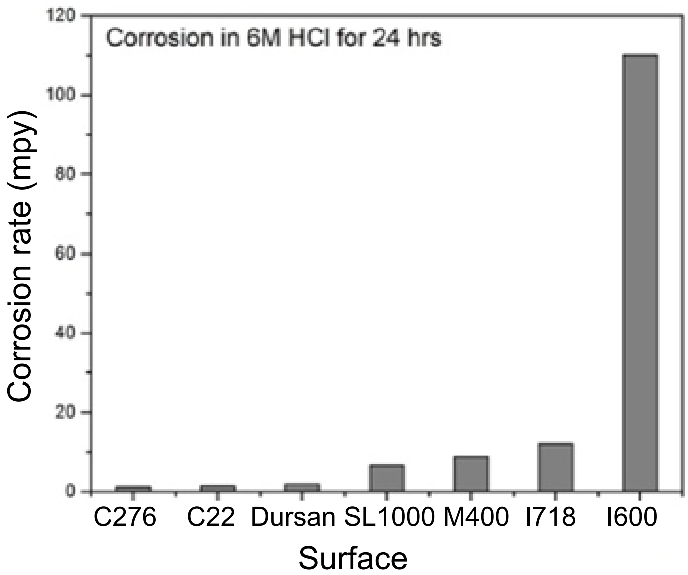




Compared to other coatings, Dursan® also shows less variability in results, making for a more reliable surface. The graph above (right) shows that after 5 sample replicates, the "common coating" test coupons show significant differences in bleach corrosion rate as noted by the error bars. The Dursan® test coupons all performed with little variation.

Comparative Super Alloy Performance

Comparative hydrochloric acid immersion testing show SilcoTek® coatings (Dursan® and Silcolloy®) offer comparable corrosion rates to super alloys and exceed the performance of Alloy M400, I718 and I600.

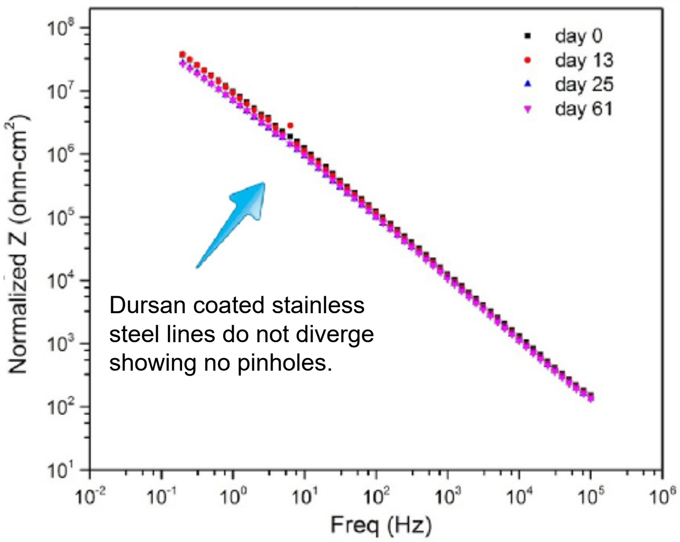


C276 C22 Dursan SL1000 M400 I718 I600

Salt water exposure

After 8000 hours of salt spray testing (per ASTM G85) the SilcoTek® coatings (Dursan® and Silcolloy®) are not corroded. The stainless steel coupon (below) shows significant corrosion, making Dursan® an ideal coating for salt based or chloride based analytes.

Uncoated SL1000-coated Dursan-coated



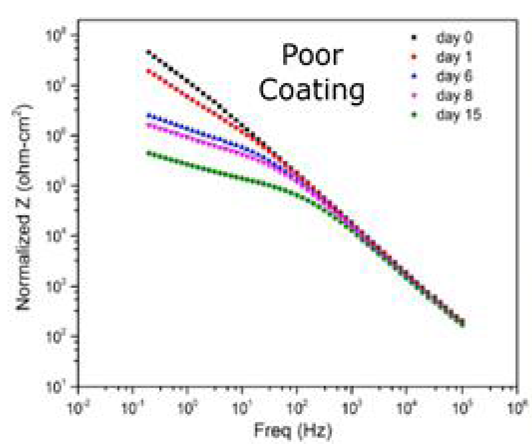
[Electrochemical Impedance Spectroscopy](#) (EIS) testing of the Dursan coupon shows stability of the coated stainless steel exposed to salt water, indicating a good protective coating with few pinholes. The graph below shows little divergence in the impedance value even after 61 days of exposure.

About EIS

Electrochemical impedance spectroscopy (EIS) is a powerful and mostly non-destructive tool used to assess the quality of a barrier coating by applying an electric voltage over a wide range of frequencies (e.g. 100 kHz to 100 mHz) in an electrolyte (5% sodium chloride solution was used here). EIS measures the impedance, i.e. the ability to oppose electrical current flow, of the coated specimen under an AC potential. Impedance is an extension of the simple "resistance" concept to an AC circuit, and is a complex quantity that possesses both magnitude and phase (resistance has only magnitude). A good barrier coating shows pure capacitive behavior, and usually displays very high impedance values at low frequencies.

The graph above is a Bode plot that shows the log frequency as the x-axis, and the magnitude of the impedance in ohm as the y-axis. As the frequency decreases, the impedance magnitude increases steadily in a straight line, which is an excellent agreement with the behavior of an ideal protective coating. We tested coated coupons over a 60 day period, day 0=black dot, day 13=red dot, day 25=blue dot, and day 61=pink dotted line. Notice the dotted lines for each test day are very similar and don't diverge. The day 61 line is nearly identical to day 0 meaning that after exposure to the sodium chloride solution for 60 days, there was little change in the impedance curve.

A less protective coating would allow solution penetration through the pinholes, which adds a resistor component to the electrochemical system, and as a result the impedance magnitude loses its linear characteristics when the slope starts to change at lower frequencies, as seen in the graph to the right. This indicates the permeation of the coating by the NaCl solution and initiation of corrosion reactions under the coating.



Coat places most coatings can't reach

SilcoTek® coatings protect against corrosion, but can they work within medical diagnostic system tolerance and architecture? That means being able to coat needles, tubing, fittings and precision components without negatively impacting the flow, function, or capability of the instrument. SilcoTek® precision CVD coatings can coat the entire flow path, including needle IDs.
Benefits of CVD coatings include:

- Coat the interior and exterior of narrow bore needles and tubing, complex component designs, etc.. Customers now have the ability to improve inertness and protect the entire sample flow path.
- CVD coatings do not significantly change part dimensions or tolerances. The user can coat existing components and significantly improve performance without part redesign.

Coating applications for optimizing bioseparation

Typical uses for high durability bio-inert coatings in analytical and diagnostic applications include:

• Clinical chemistry and immunoassay analyzers • Precision stainless steel tubing • Mandrels, plungers, extrusion tips, dies • Chemical vessels/ containers • Wires, wire coils, wire forms	• Guide wires • Curettes • Cannulas • Screws, prostheses, plates • Needles	• Syringes • Sensor probes • Catheters • Knives, surgical tools, lab surfaces

Dursan® offers three critical surface properties in one along with a chemical vapor deposition (CVD) coating process that makes application easy and effective, even on complex geometry components.

Download our Coatings Guide

Chapter 4

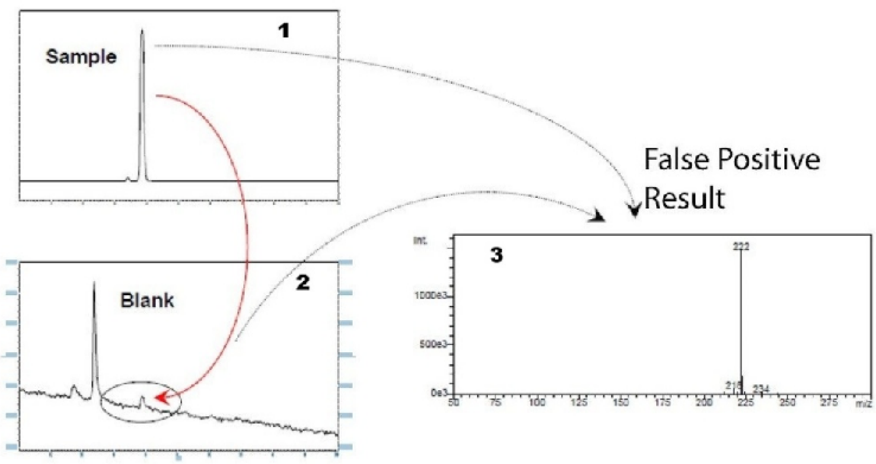
Prevent Protein Adsorption and Carryover and Contamination With Anti-fouling Surfaces

In this chapter we'll discuss:

- How protein adsorption or sticking can result in sample carryover and contamination of samples.
- How carryover can cause false positive sample peaks which can result in additional testing or an incorrect diagnosis.
- How to prevent sticking and sample errors through the use of a non-stick coating and surfactants.

What is sample carryover?

Carryover is the result of a sample binding to the flow path surface which then releases or elutes during a later sampling event. The chromatograph below exemplifies how a false positive test can occur. In the first graph, a test sample peak can be clearly seen. After rinsing and injection with the blank solution (2), some of the original sample peak remains which leads to a false positive result in the subsequent test (3).



Stop carryover, change the surface

Because certain proteins and other "sticky" compounds can adhere to stainless steel and cause test failures, it's important to change the flowpath surface to a more non-stick and inert material. But stainless steel is cheap, durable, and easily formed into tubes, valves, fittings, and needles, so it's difficult to find an economic replacement material. The solution? Keep the stainless steel but change the surface by bonding an inert silicon based coating, like Dursan, to the stainless steel flow path.

[Dursan is a metal free coating] that prevents protein carryover and fouling which can lead to carryover. Because proteins don't stick to Dursan, rinse and sonication becomes much more effective. And because Dursan does not significantly change part tolerance or functionality, it can be applied to stainless steel flow path surfaces without going to the expense of changing the part design or material construction. Let's take a look at some comparative studies by Abbott Laboratories and see how Dursan can impact the quality of test results and prevent protein carryover.

To evaluate the effectiveness of Dursan in protein analysis applications, a collaborative study between Abbott Laboratories and Silcotek examined the effectiveness of medical diagnostic surfaces under typical test conditions including:

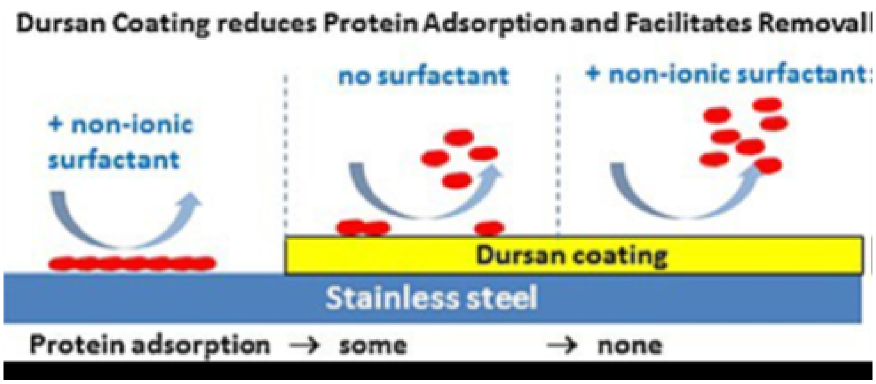
- Effectiveness of surfactants
- Durability under frequent sonication conditions
- Resistance to protein binding

Read the data and get the benefits of Silcotek coated flow paths for protein analysis

Dursan and Surfactants, a Powerful Combination in Carryover Prevention

Comparative rinse studies by Abbott show that the combination of a non-stick surface like Dursan and a non-ionic surfactant significantly reduces protein sticking and the potential of carryover contamination. Key takeaways from the study were:

- Bovine serum albumin (test protein) was evaluated with Brij 35 surfactant.
- The test protein adhered to the stainless steel surface.
- A surfactant rinse had no effect on the bare stainless steel.
- A rinse without surfactant on the Dursan coated surface removed a significant amount of the test protein.
- A rinse coupled with the use of a non-ionic surfactant when combined with a Dursan



Why Prevention of Protein Adsorption is Important

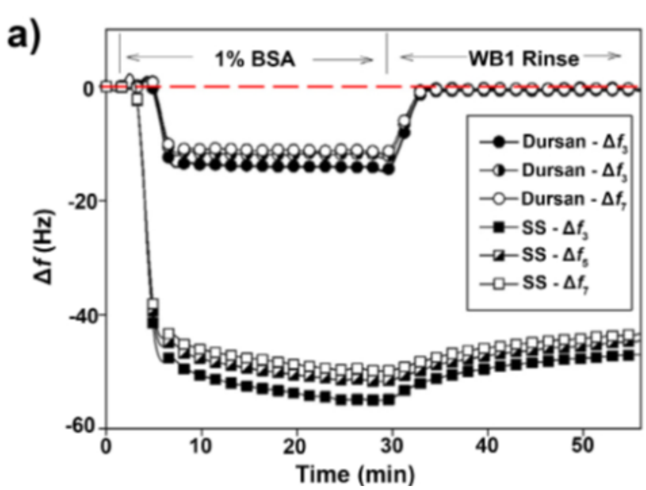
Prevention of non-specific protein adsorption to surfaces is highly important for many industries such as food, marine, and medical industries. For example, modern medical devices can suffer from the interference of unwanted molecules binding to the solid surfaces surrounding the antibodies, which leads to poorer detection limit because of a lower signal to noise ratio and can lead to test failure.

Existing coating solutions that impart protein adsorption resistance or facilitate fouling release properties experience either chemical instability issues in oxidative environments (e.g. air), or physical degradation (e.g. delamination) during use and wear. The Abbott study examined Dursan as an alternative coating solution that may provide better stability and durability in such applications.

Experimental:

Quartz crystal microbalance with dissipation monitoring (QCM-D) was used to characterize the anti-biofouling properties of Dursan on a stainless steel surface. QCM-D monitors changes in oscillation frequency and dissipation of a planar crystal substrate upon adsorption of macromolecules. The authors compared 3 surfaces: uncoated 316L stainless steel (SS), Dursan-coated 316L SS, and AF1600-coated 316L SS (AF1600 is an amorphous fluoropolymer). Sonication was introduced in the test to induce rapid mechanical wear so durability of the coatings can be assessed.

Experimental baseline for the QCM-D measurement was determined by flowing a wash buffer, referred to as WB1, over all sensors for ~ 4 minutes to clean the surfaces and priming them for protein exposure. Protein solution of interest was then flowed over the sensors for 20~25 minutes, followed by another rinse using WB1 for 25 minutes. A minimum of two distinct measurements were carried out for each protein-surface system. A change in the oscillation frequency Δf of the QCM-D sensor indicates protein adsorption onto the sensor surface.



Panel A) Comparison of BSA adsorption on Dursan-coated (circle) and bare SS (square) sensors. Panel (a) depicts sensor frequency change vs. time.

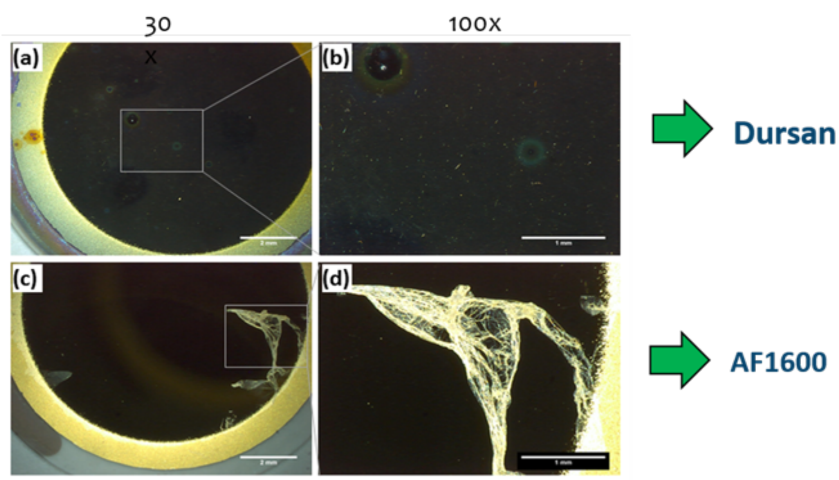
Panel a) on page 20 shows the comparison between uncoated stainless steel (SS, square) vs. Dursan-coated stainless sensors (circle) when exposed to bovine serum albumin (BSA). Both sensors experienced an immediate decrease in their resonance frequency upon initial exposure to the protein solution, indicating protein adsorption to the sensor surfaces.*

The frequency drop for the bare stainless steel surface was 4 times higher than that of the Dursan surface, due to more mass adsorption. When the sensors were rinsed with the wash buffer WB1, the bare stainless steel surface saw a slight increase of the frequency, whereas the Dursan surface reverted back to the baseline level, indicating near complete desorption of the BSA protein molecules. This shows that the Dursan coated stainless steel surface greatly improved fouling release characteristics and carryover prevention compared to the bare stainless steel surface.

Effect of sonication on coating performance

Medical diagnostic flow path components are often sonicated to remove contaminants from the surface. Unfortunately protein resistant coatings like AF1600 can be damaged by sonication. A comparative wear resistance test using sonication demonstrates the robustness of the Dursan® coating.

In order to assess and compare the physical durability of different coatings during use, two types of coatings, Dursan® and AF1600, were exposed to 10 minutes of sonication in ethanol. Multiple sensors of each coating were sonicated. Test results show all of the Dursan® coated sensors remained intact after the treatment. The sonicated AF1600-coated sensors exhibited coating delamination as shown in the photos on page 21.



Optical micrograph of the post-sonication QCM-D sensors showed intact Dursan® coating (a and b), compared to delaminated AF1600 coating (c and d).

The Coating Solution

The combination of the durable and inert Dursan® surface, and an effective wash buffer that contains a non-ionic surfactant, proves to be a step in the right direction towards solving the complex problem of protein adsorption. But can Dursan® coat medical diagnostic components? Yes! Dursan® can be applied to diagnostic components such as:

- Needles
- Probes
- Narrow and wide bore tubing
- Valves
- Regulators
- Fittings
- Sintered metal frits
- Glass surfaces like slides and liners
- Rotary valves
- Other stainless steel, alloy, glass & ceramic surfaces

Get more details on how Dursan® improves the performance of medical diagnostic equipment.

Read our Life Sciences presentation

*Reference:
Vaidya, S. V., Yuan, M., Narváez, A. R., Daghfal, D., Mattzela, J., and Smith, D. “Protein-resistant properties of a chemical vapor deposited alkyl-functional carboxysilane coating characterized using quartz crystal microbalance” Applied Surface Science 2016, 364, 896-908.

Summary and Conclusion

We hope our e-book was informative and offered ideas on how to improve the consistency, accuracy, and durability of medical diagnostic instrumentation.

In **Chapter 1** of this book you learned:

- How Dursan®, can be applied by chemical vapor deposition to equipment flow path surfaces to improve surface inertness. Dursan® can be applied to precision surfaces, even frits and narrow bore tubing and needles.
- How key factors like sensitivity, reactivity, non-stick properties and corrosion resistance should be considered when selecting medical diagnostic materials.
- How Dursan® benefits bioseparation and medical diagnostic equipment performance by extending component life, preventing false positive tests, improving test consistency and improving component corrosion resistance.

In **Chapter 2** we discussed how changing the analytical flow path surface energy can impact moisture retention. We learned:

- How a hydrophobic surface can benefit medical diagnostic performance by promoting an air gap that prevents surface interaction.
- How a hydrophilic surface can also have benefits in some applications by promoting surface interaction for separation or filtration applications.
- How to change surface energy to manage hydrophobicity by applying coatings like Dursan® or Notak™ to the surface.
- The benefits of repelling low surface tension liquids like organics in cleaning applications.

In **Chapter 3** we explored how flow path corrosion can limit component life and will also cause test failures due to analyte retention, carryover and contamination. We learned:

- How a corrosion resistant coating improves bio-inertness by preventing pitting, contamination and carryover due to surface pitting.
- How a protective coating like Dursan® can prevent surface pitting by acting as an inert protective barrier.
- How to improve the corrosion resistance of intricate precision stainless steel components without significant change in dimensional tolerance.
- Reviewed corrosion data relating to commonly used cleaning agents and discussed how Dursan® can improve corrosion resistance by orders of magnitude.

Finally, in **Chapter 4** we discussed how protein adsorption or sticking can result in sample carryover and contamination of samples. Carryover can cause false positive sample peaks which can result in additional testing or a false diagnosis. We discussed the mechanism of carryover and ways to prevent sticking and sample errors through the use of a non-stick coating and surfactants.

If you'd like to learn more about how our coatings can benefit medical diagnostic test results or would like to discuss your application in detail, contact our Technical Service Team. Our team of engineers and PhD scientists are here to help you discover how inert CVD coatings can make your product better.

Contact our Technical Service Team

If you're interested in learning more about or coatings and how they can improve the performance of your products, read our other e-books. Subjects range from coating basics to improving corrosion resistance and process test quality.

Get Our E-books