Metal ion leaching study in pure methanol part 3: C-22 Hastelloy

Technical Insight

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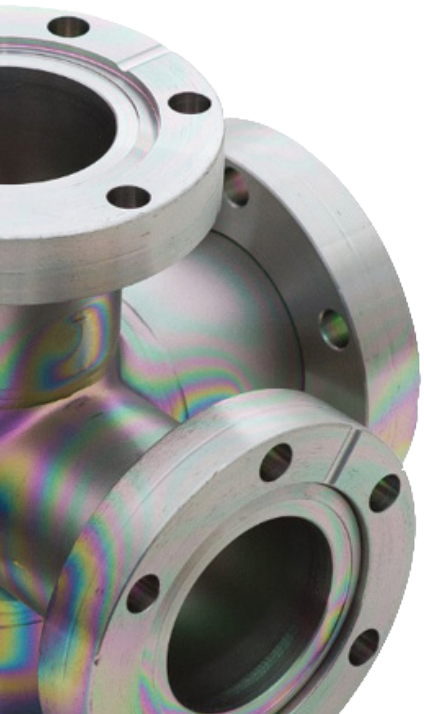

Synopsis

Corrosion encompasses a large variety of material degradation. It can be large enough to see visually such as the numerous examples in harsh acids or salt fog chamber experiments that SilcoTek has performed, or corrosion can be at trace levels that are not detected visually or by weight loss. We previously investigated both Titanium and 316 Stainless Steel in pure methanol and monitored their corrosion via ICP-MS. Exotic alloys, such as Hastelloy, are often used for harsh corrosion conditions. In this TI we investigate the corrosion of C-22 in pure methanol and the impact that SilcoTek's coating portfolio can have on this corrosion.

Background

Two previous Technical Insights (seen here for the initial study of stainless steel and here for the follow up study on stainless steel and an investigation into titanium) discussed the issues involved with using pure organic solvent in contact with metal alloys such as stainless steel and titanium. In those studies, 316 SS and titanium sintered discs were exposed to pure methanol for one month. The resulting solution was then examined via ICP-MS for metal ion contamination. The results showed that Silcolloy, Dursan, and RD5-SiN were all suitable coatings to protect stainless steel from the methanol attack, while only Silcolloy effectively stopped titanium ions from being leached into solution. In this study Hastelloy (specifically C-22) is similarly investigated as a substrate for SilcoTek's coatings.

Hastelloy alloys were developed for severe corrosion conditions. These high nickel exotic alloys typically work well to battle halide and other acid corrosion. They also have great resistance to oxidation which make them an appealing substrate for semiconductor, aerospace, and oil and natural gas industries. There is a wealth of literature supporting their use for visual or severe corrosion conditions, but when it comes to trace levels of corrosion, very little is known.

Here we find that a bare C-22 sintered disc when exposed to pure methanol can leach over 1 ppm total metal into solution, where the same discs coated with Silcolloy, Dursan, and RD5-SiN showed no measurable loss of metal ions, indicating only baseline levels of leaching relative to experimental controls.

Data and Discussion

Porous C-22 Hastelloy discs with 10 µm nominal pore sizes were purchased from Mott Corporation. They were coated with Dursan, Silcolloy, and RD5-SiN. After coating, the discs were placed in 50 mL of HPLC grade methanol and sealed. An uncoated disc as well as a container with no disc (a solvent blank to establish baseline response) were also filled with methanol and sealed. After one month of soak time, the porous disks were removed from the methanol and the samples were delivered to the Energy and Environmental Sustainability Laboratories at Penn State University. Samples were then prepared by evaporating 10 mL of the methanol in a PTFA vial. The remains were dissolved in 5 mL of dilute nitric acid which was then analyzed using a Thermo Fisher iCap RQ ICP-MS.

Figure 1 shows the total metal ion concentrations from the solution of each container. The blank represents the level of metal ions in the methanol bottle, leached from the sealed container, sample preparation, or absorbed via environmental sources. The bare disc represents the level of metal ions leached into the methanol without any coating protection provided by processing at SilcoTek Corporation. Table 1 shows the raw values from each sample along with the total metal ion content. For reference, Table 2 is the composition of C-22 Hastelloy from Haynes International, the producer of Hastelloy materials.

Due to the bare disc total metal ion value being so high, Figure 2 shows the blank solution as compared to the three coated discs. It should be noted that these values are very close to the detection limits of the ICP-MS for these elements (0.1-0.5 ppb) and are significantly lower than the total metal contamination from the uncoated disc, 1235 ppb.

Sample	Ni	Cr	Mo	Fe	W	Co	Cu	Mn	V	Total metal content
Blank (methanol only)	0.5	0.01	0.03	0.66	0.05	0.00	0.14	0.14	0.01	1.54
Bare disc	902.54	151.16	49.88	101.04	3.46	0.60	24.53	1.36	1.00	1235.57
Dursan	0.32	0.02	0.08	0.91	0.03	0.01	0.32	0.23	0.02	2.02
RD5-SiN	0.91	0.02	0.15	0.33	0.03	0.01	0.34	0.21	0.01	2.01
Silcolloy	0.15	0.02	0.05	0.83	0.11	0.01	0.15	0.16	0.18	1.66

Table 1: Metal content in methanol measured via ICP-MS. All units are ppb.

Element	Weight %
Nickel	56% (balance)
Chromium	22%
Molybdenum	13%
Iron	3%
Tungsten	3%
Cobalt	2.5% max
Copper	0.5% max
Manganese	0.5% max
Vanadium	0.35% max
Silicon	0.08% max
Carbon	0.01% max

Table 2: Composition of C-22 Hastelloy according to Haynes International.

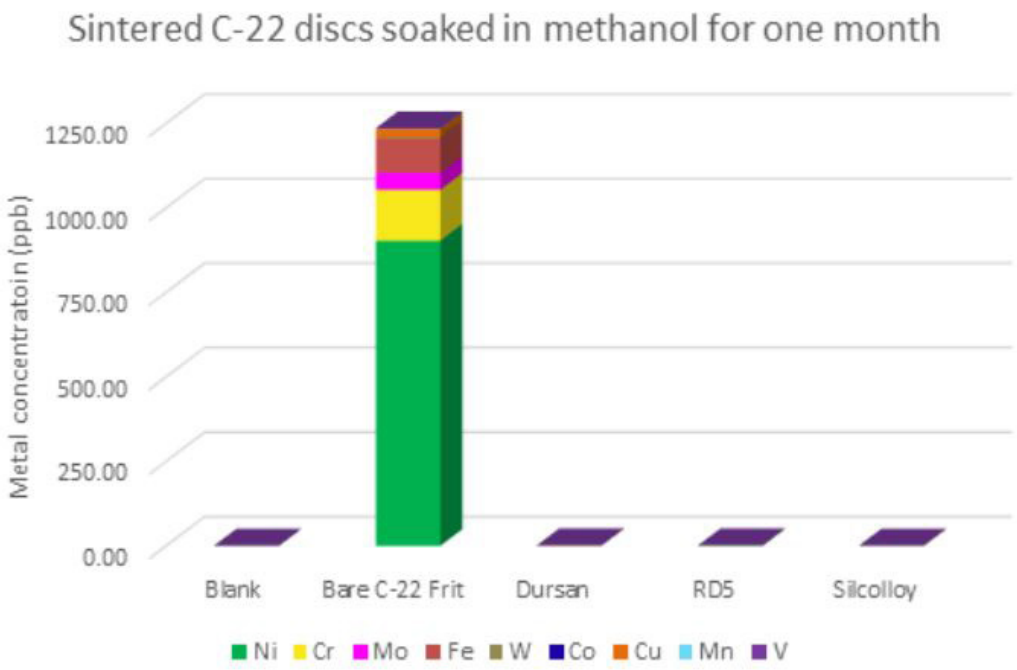

Figure 1: Metal ion concentrations in methanol. The blank is methanol from the bottle with no disc. The four others are a bare disc, and three SilcoTek corrosion coatings on a C-22 disc soaked in methanol for 1 month at room temperature.

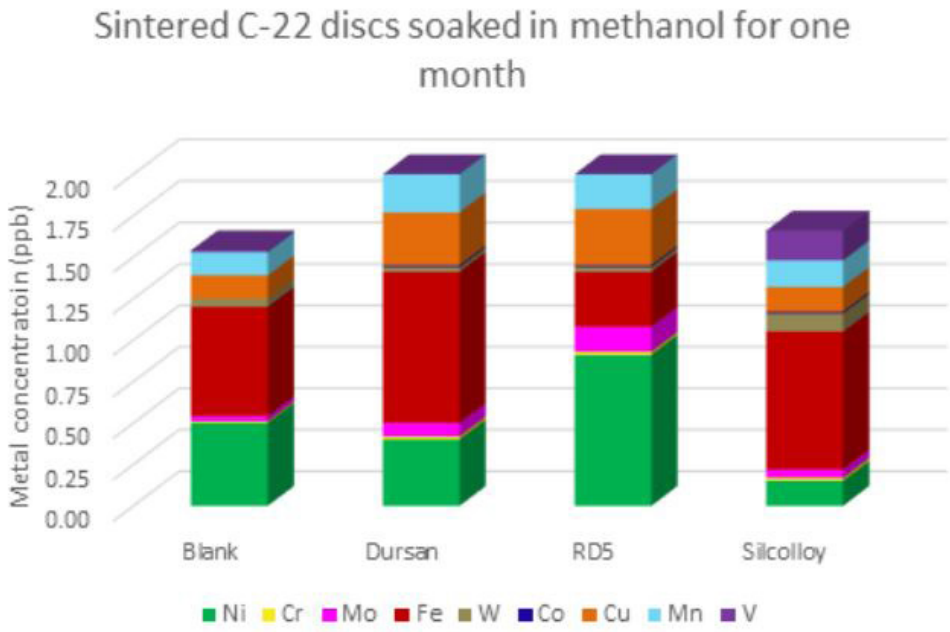

Figure 2: This is data transposed from Figure 1, but with the bare disc removed for better resolution of the coated discs.

Conclusion

All three coatings (Dursan, RD5-SiN, and Silcolloy) provided sufficient protection against metal ions leaching into the methanol during a one-month exposure at room temperature. It should be noted that while these sintered discs are often used for filtering solvents and will experience solvent flow, this experiment was done under static conditions. The metal ionic states as well as the solubility limits of those metal ions in methanol are not readily available through our experiments nor in the literature. It is possible that utilizing these uncoated porous discs for their intended purpose will result in larger quantities of metal ions leached into flow paths as they provide a constant supply of uncontaminated solvent and are in flow conditions rather than static.