

UNDERSTANDING METAL AND IONIC CONTAMINATION IN ELEVATED TEMPERATURE PHOTOVOLTAIC WET CHEMISTRIES FROM CHEMICAL DELIVERY SYSTEMS

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Abstract

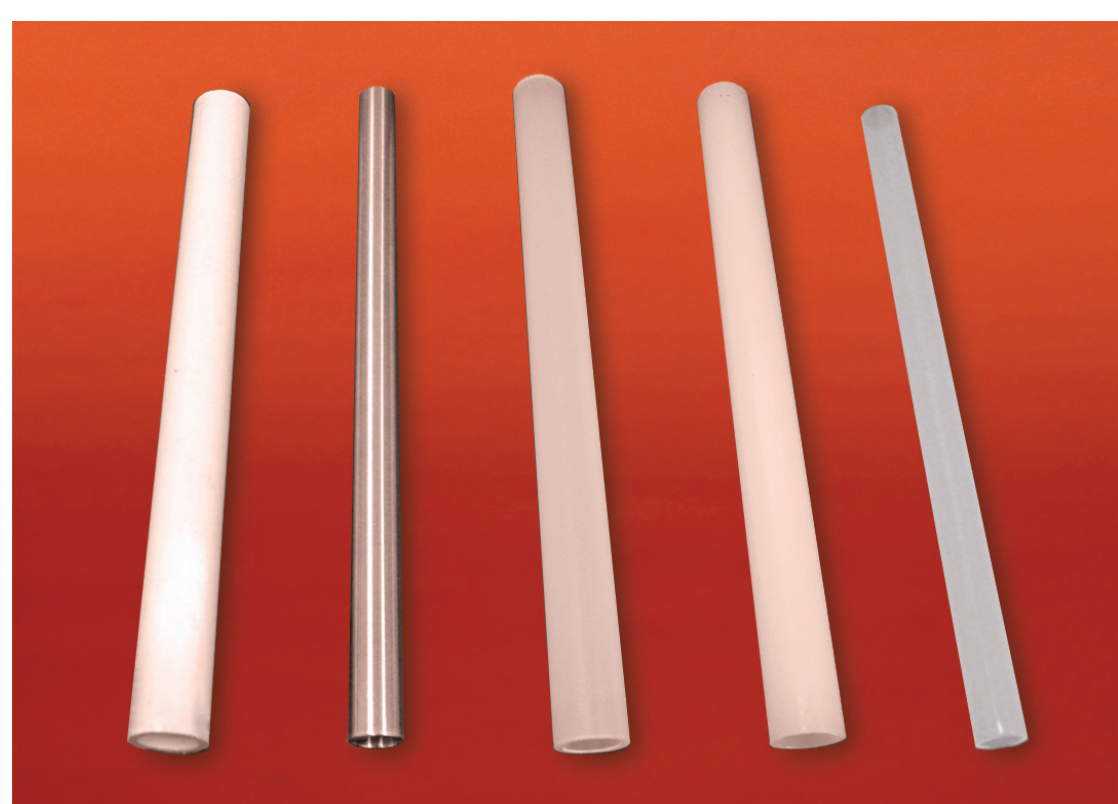
As photovoltaic cell manufacturers strive to improve yield and cell efficiency, it is increasingly important to carefully select the materials of construction used in chemical delivery systems. Low-purity materials of construction are prone not only to chemical degradation but they also contribute metallic and ionic contaminants into critical high-purity process chemistries.

This metallic and ionic contamination study analyzed several materials commonly used as wetted surfaces in photovoltaic chemical delivery systems. Contaminants leached from each material were monitored as a function of time and temperature. Results clearly demonstrate the wide range of contamination contribution into process chemistries from the different materials. This data can be used by engineers to reduce the introduction of metallic and ionic contaminants into their critical process chemistries by carefully selecting the materials of construction used in their chemical delivery system.

Approach

1. Identify commonly used materials in photovoltaic chemical and water distribution systems

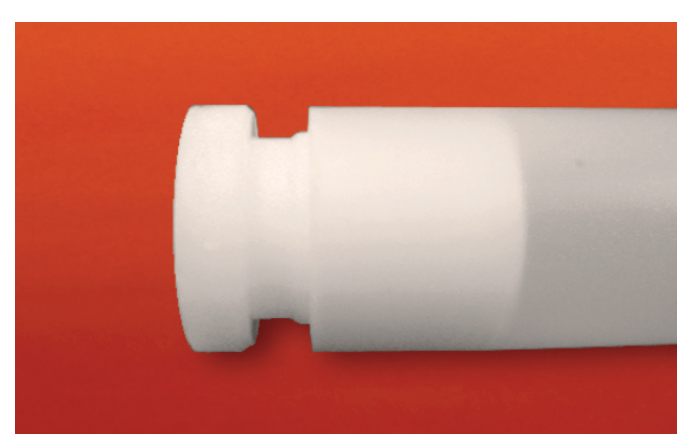
- Polyvinyl chloride (PVC)
- Polyvinylidene fluoride (PVDF)
- 316L stainless steel
- Perfluoroalkoxy (PFA)
- Polypropylene (PP)



2. Cut 12" lengths of tubing or pipe for each material evaluated



3. Cap bottom of sample using pre-leached PFA plugs designed with an interference fit to seal against the internal diameter of sample



4. Flush tubing with deionized (DI) water to remove loose debris and dust

5. Fill samples with leaching solution

- 5% nitric acid (HNO₃) to test for metallic contamination
- 18 MΩ DI water to test for ionic contamination



6. Cap top end of sample using pre-leached PFA plugs designed with an interference fit to seal against inside diameter (ID) of sample

7. Place samples into appropriate environmental condition

- Elevated temperature of 60°C

8. Pull 10 mL samples of leaching solution at the following intervals:

- 1 hour
- 6 hours
- 24 hours
- 7 days



9. Test technique

- HNO₃ samples were evaluated for metallic contamination using inductively coupled plasma mass spectrometry
- DI water samples were evaluated for ionic contamination using ion chromatography

Results

Extractables Evaluated

Trace Metals			Anions			Cations		
Ag	Cu	Ni	Fluoride			Sodium		
Al	Fe	Pb	Chloride			Ammonium		
As	Ga	Pt	Nitrite			Potassium		
Au	Ge	Sb	Bromide			Magnesium		
B	Hg	Sn	Nitrate			Calcium		
Ba	K	Sr	Phosphate					
Be	Li	Ta	Sulfate					
Bi	Mg	Ti						
Ca	Mn	Tl						
Cd	Mo	V						
Co	Na	Zn						
Cr	Nb	Z						

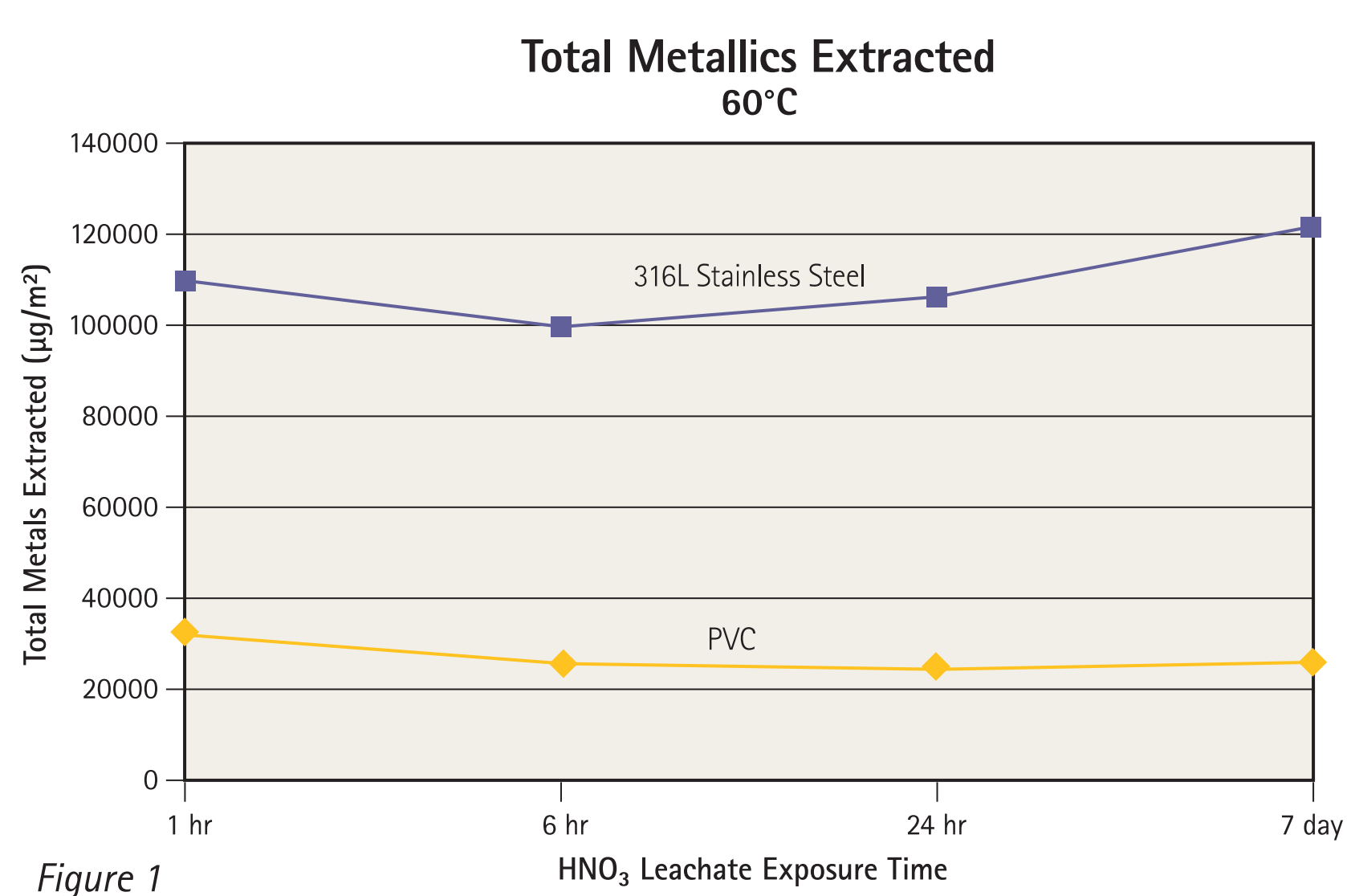


Figure 1

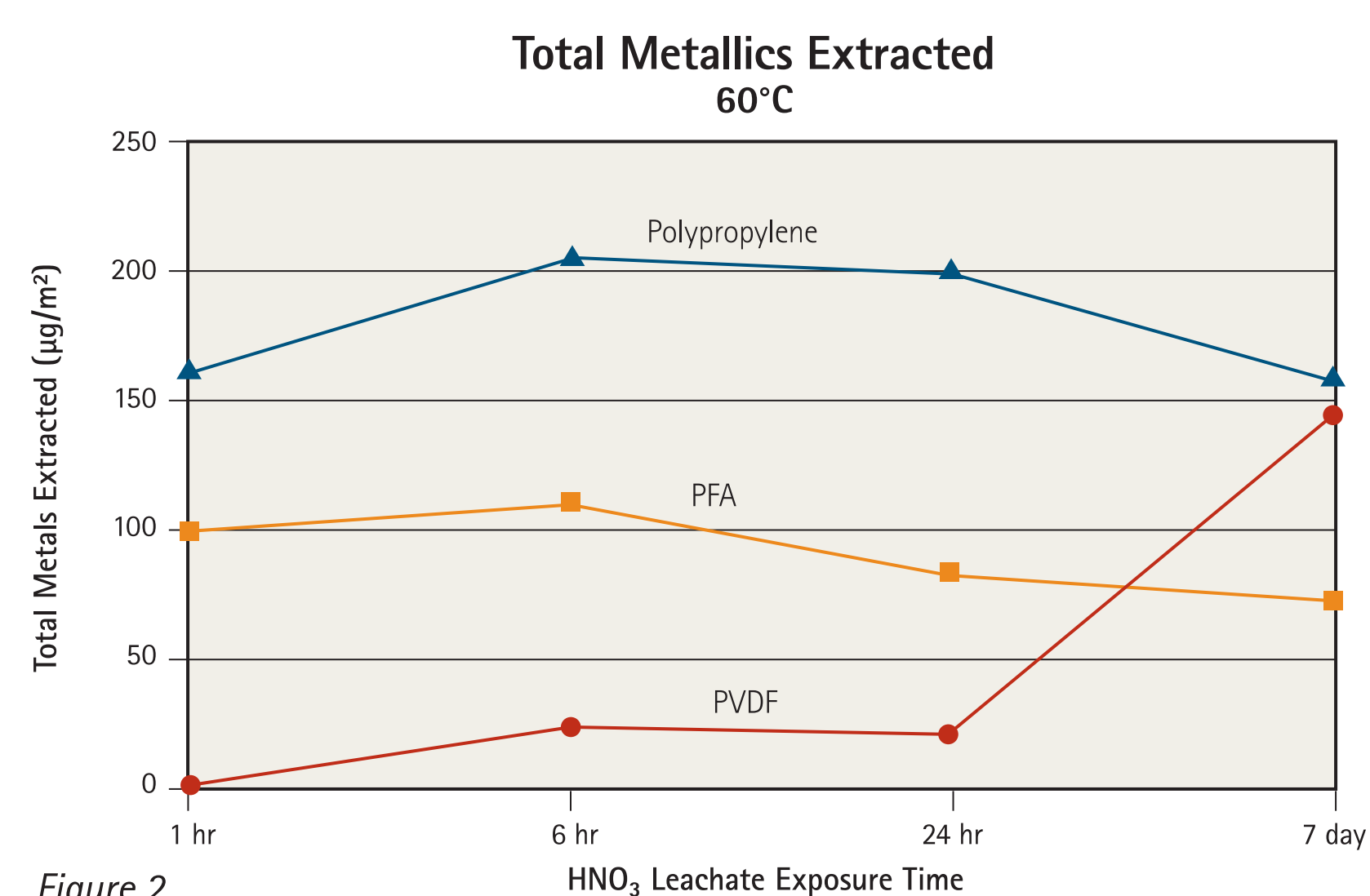


Figure 2

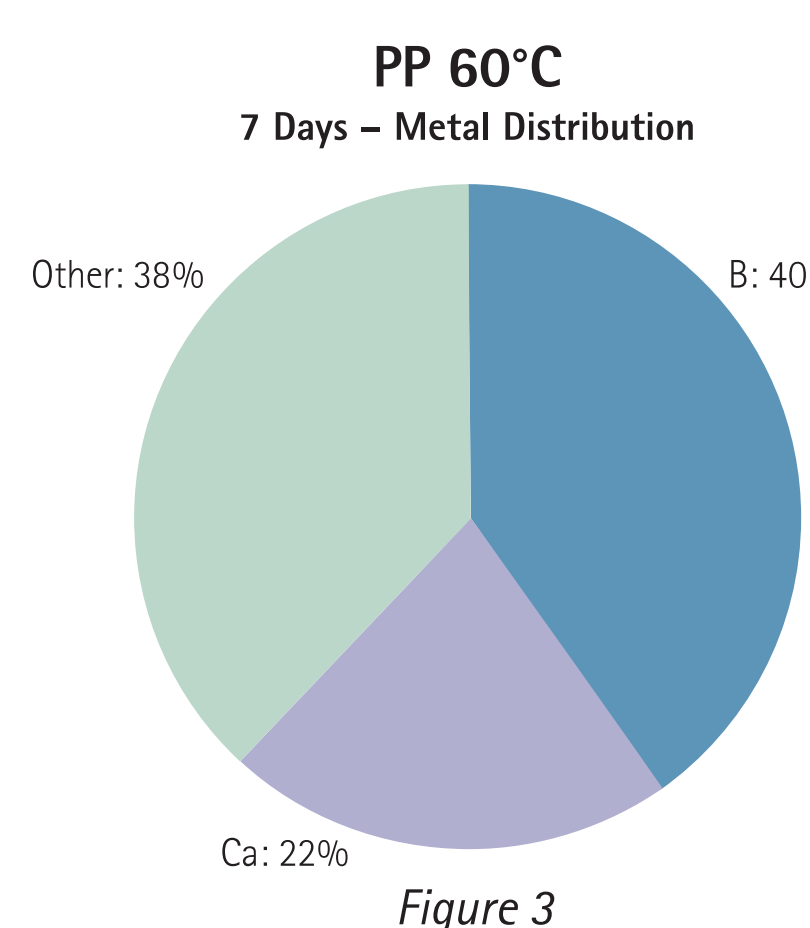


Figure 3

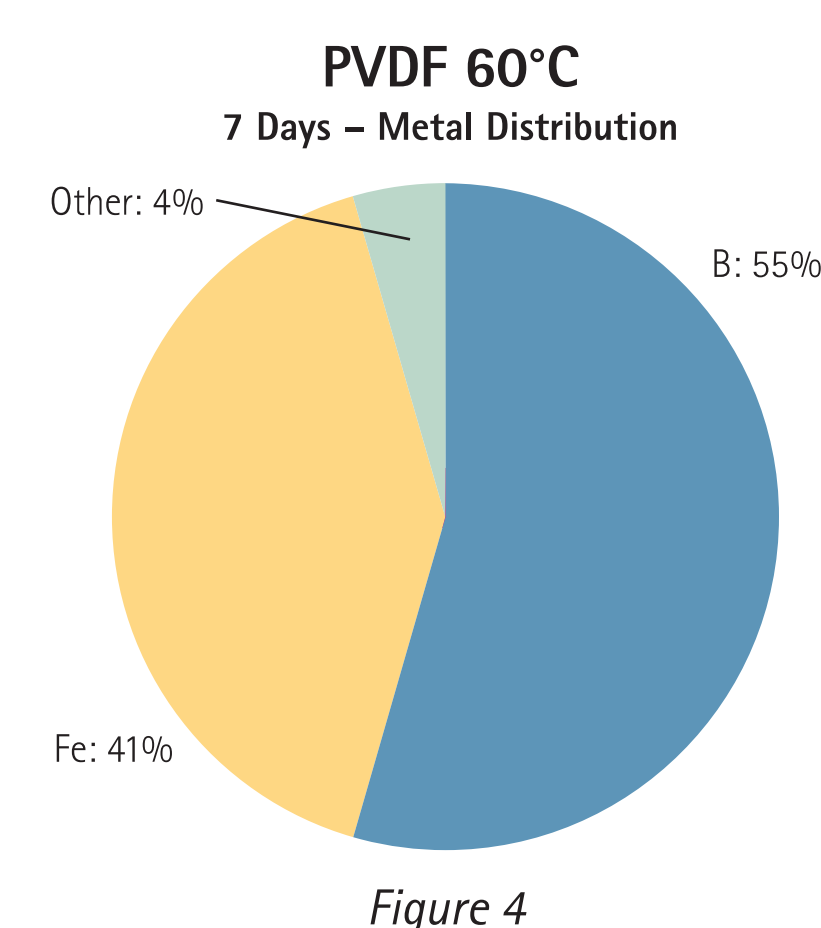


Figure 4

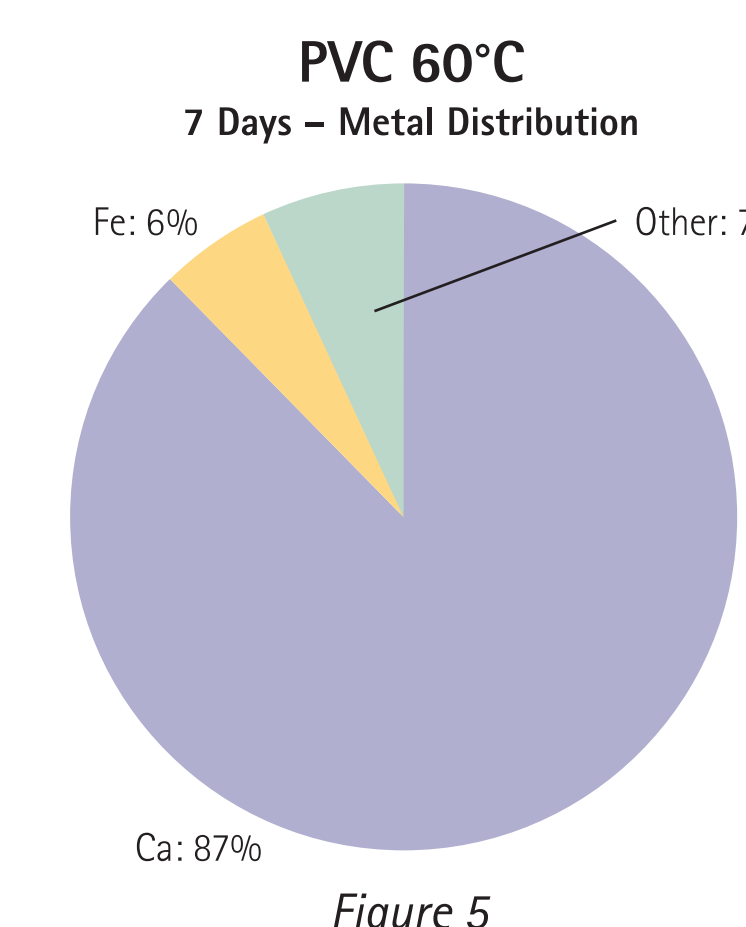


Figure 5

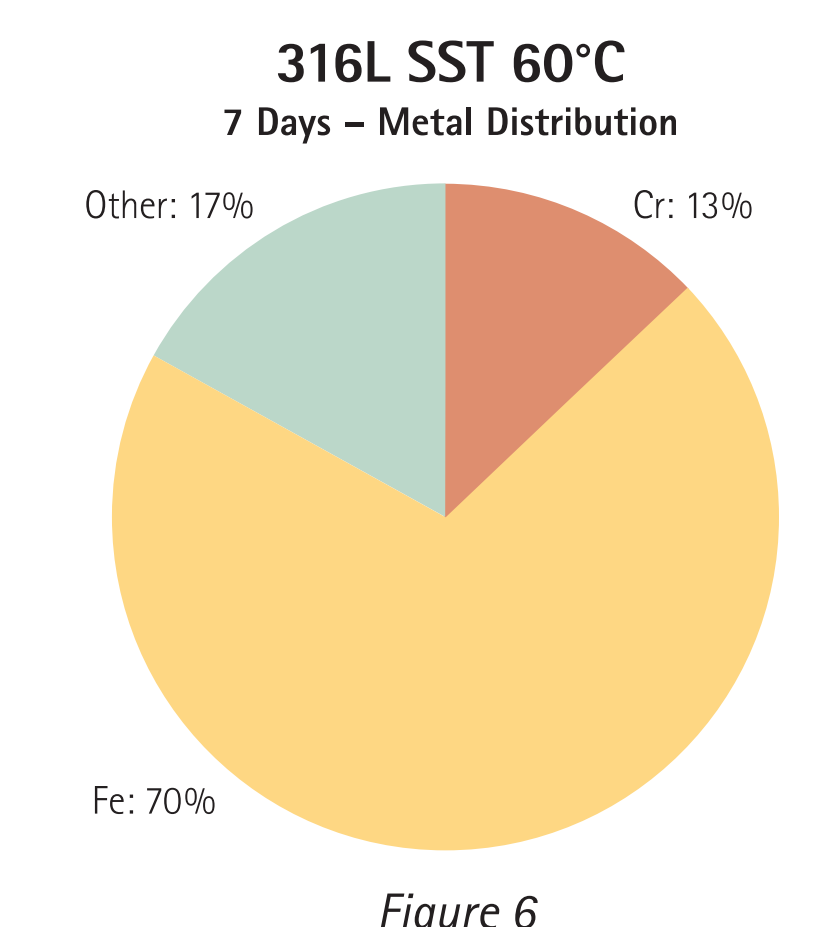


Figure 6

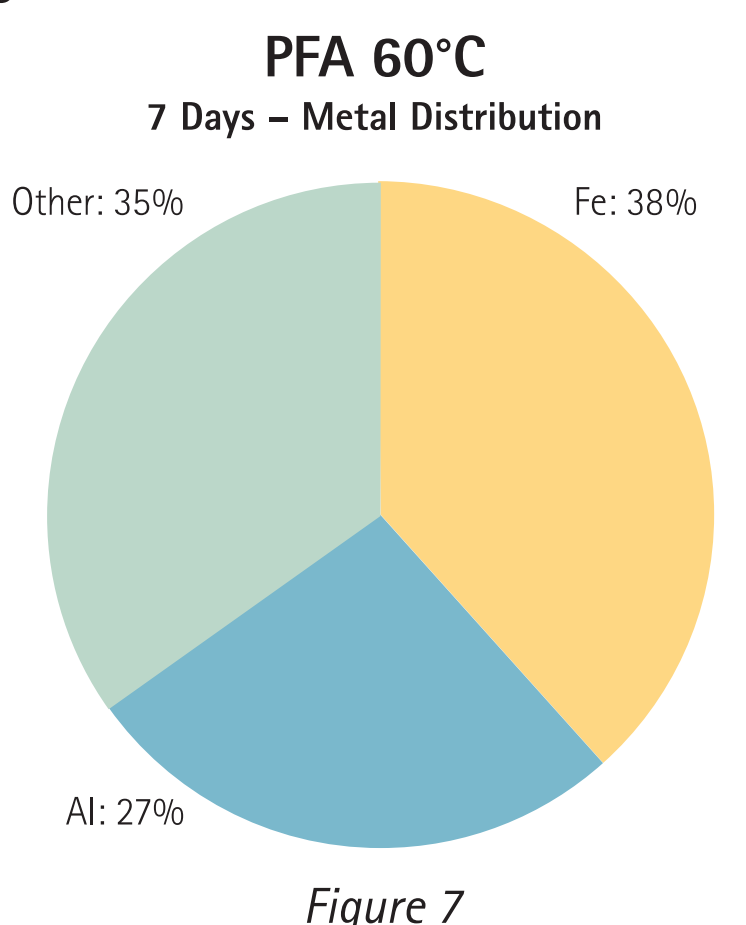


Figure 7

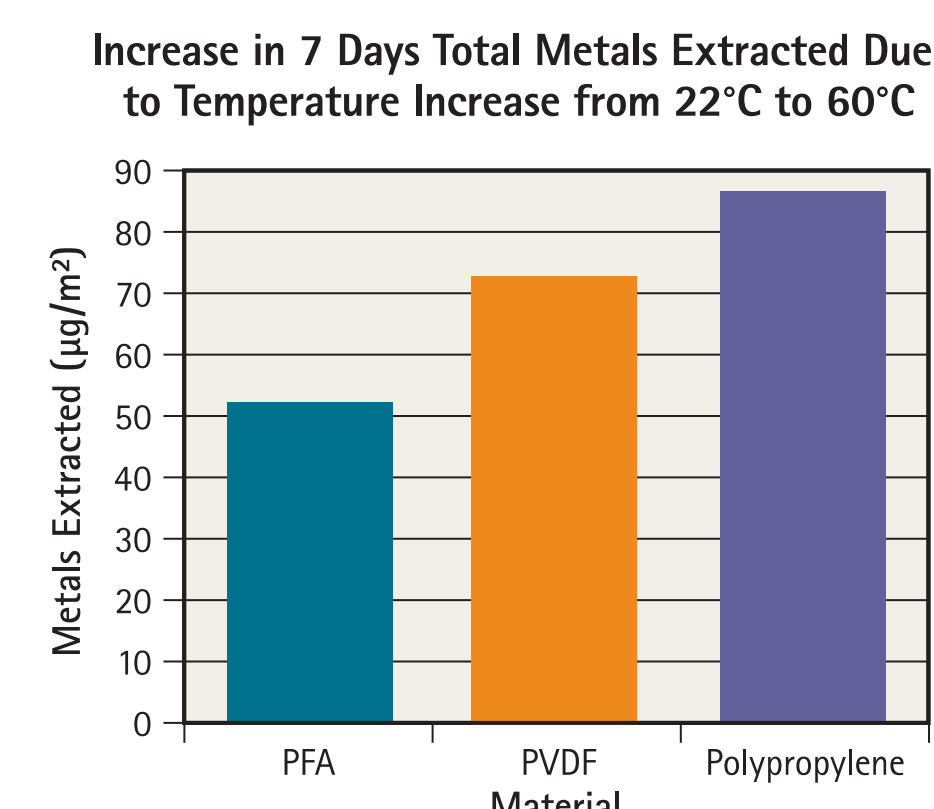


Figure 8

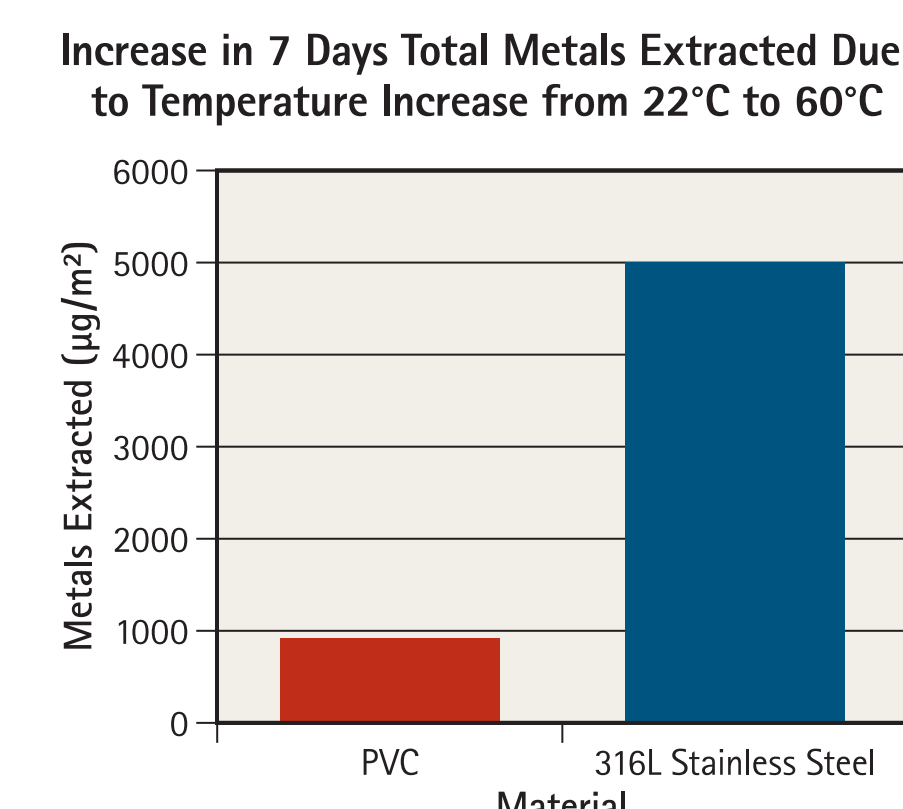


Figure 9

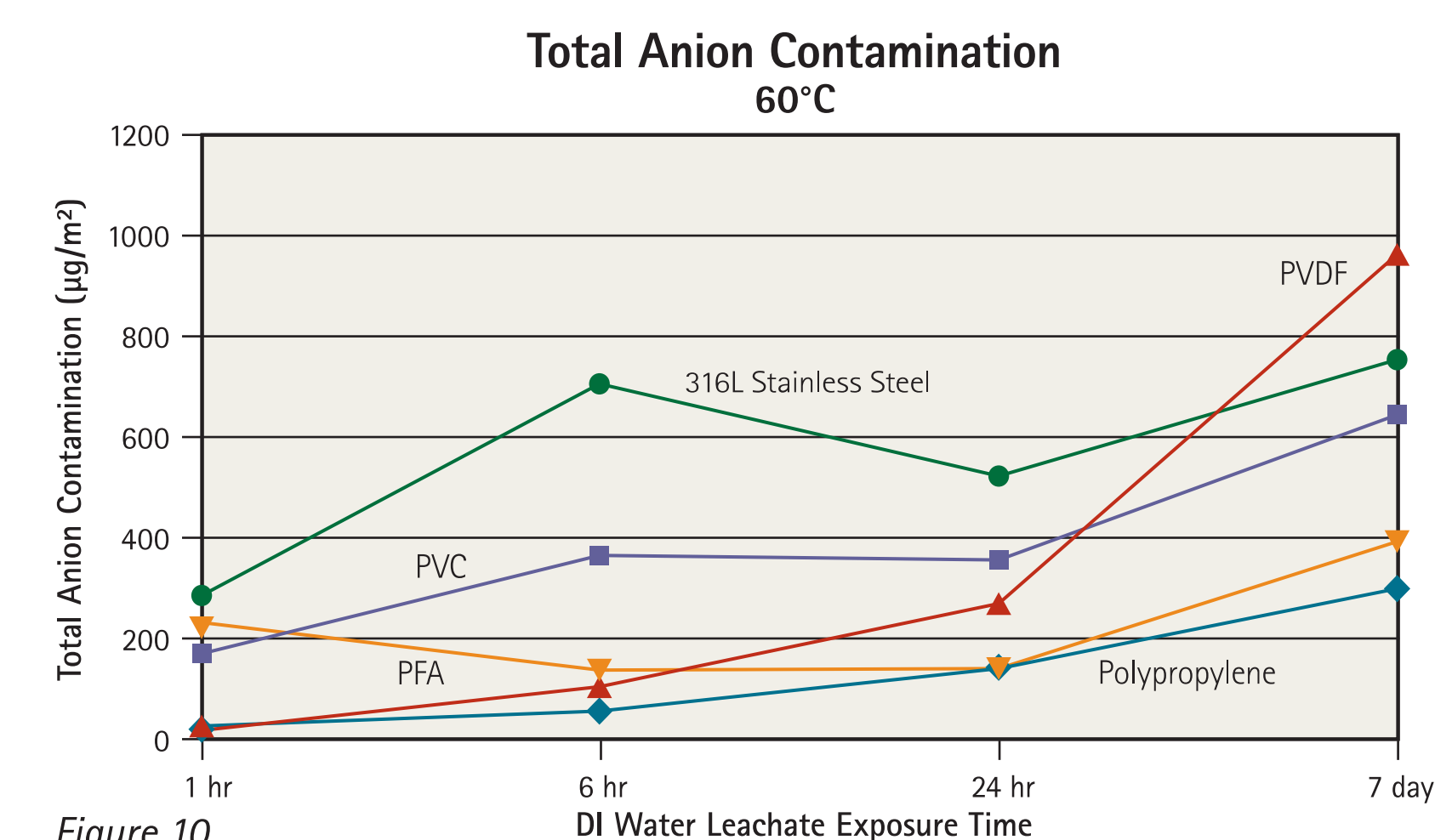


Figure 10

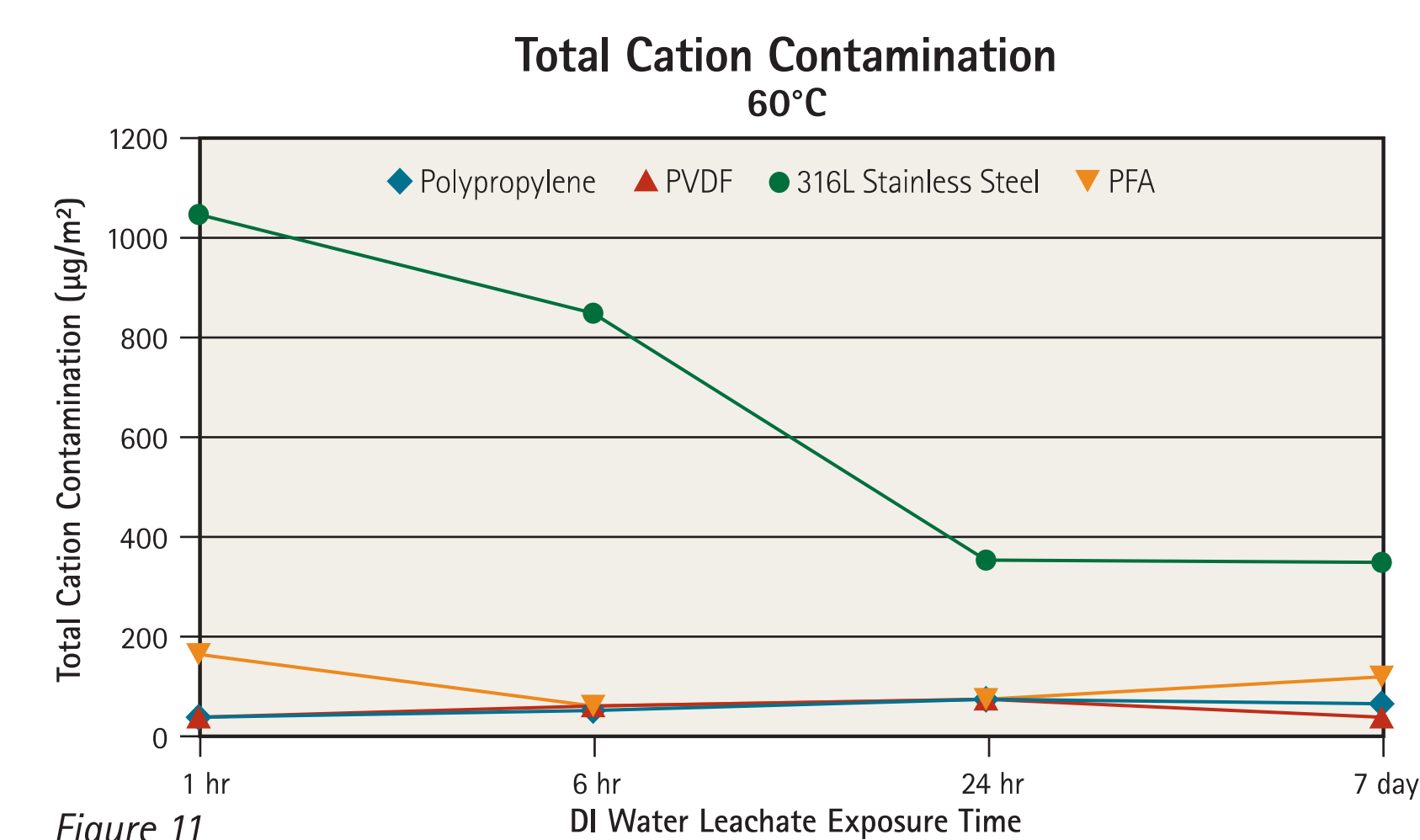


Figure 11

Conclusion

It has been proven that metal impurities can degrade the performance of photovoltaic solar cells by reducing the minority carrier lifetime. These impurities can be present in the silicon source stock or they can be introduced during the cell processing steps through the chemical or gas delivery systems. Though the chemicals used in processing the cell may initially start out as high purity, the data in this test clearly show that the materials in contact with process fluids can alter the purity of the process chemistries.

The amount of metal poisoning as well as the specific metal elements introduced into the process media is dependent upon the type of material in contact with the fluid, the type of chemical being transported, the temperature of the process fluid as well as the duration of contact. The test data shows that PFA contributes the least amount of metal contaminants to the fluid media while 316 stainless steel along with PVC contribute the greatest amount of metal contaminants. The data also shows that PFA has very low levels of anion and cation contamination.

This data also shows the significance that temperature plays in expediting the leaching process for each material. All materials tested show an increase in the total amount of metal contaminants leached from them at 60°C. PFA had the least overall increase in total metal contaminants from room temp to 60°C followed closely by PVDF and PP. Both PVC and 316L stainless steel had a very large increase in total metals extracted far exceeding the amounts shown by PFA, PVDF and PP.

This information is valuable in reducing the amount of residual metal and ionic contamination introduced during the pre-diffusion texture, etch and clean steps as well as the post-diffusion phosphosilicate glass (PSG) etch and clean steps. By using fluid handling products made with high-purity PFA wetted surfaces the amount of metal and ionic contamination is minimized on a photovoltaic cell, which can in turn improve a cell's efficiency as well as improve production yield.

Future Work

- Metal and ionic contamination in other chemistries such as hydrochloric acid, phosphorus oxychloride or potassium hydroxide
- Metal and ionic contamination of multiple grades of the same polymer