Savillex Technical Note

Design Features of the HPX Series Inert Hotplate

Summary

Design features incorporated into the HPX Series inert hotplates give unmatched temperature uniformity across the heating surface, providing greater control over sample digestion and evaporation. Incorporating more cartridge heaters than are typically used in inert hotplates reduces temperature variability across the heating surface. In addition, the use of premium, ISO-molded, low porosity graphite gives superior thermal conductivity and also allows for a high integrity PFA coating which protects the heating block, prevents corrosion and contamination, and extends operating life.

Savillex HPX-200 and HPX-100 Hotplate

Temperature Uniformity

In trace metals analysis, consistency in sample treatment during sample preparation is critical to data quality. During heating or evaporation, all samples must be exposed to uniform heating as far as possible, to prevent analytical bias due to incomplete digestion and variability in matrix removal or retention of volatile analytes. The key to optimum temperature uniformity across the surface of a heated graphite block used in an inert hotplate is the number of cartridge heaters used (cartridge heater density). The HPX-100 (heated working surface 292 mm x 212 mm) features three cartridge heaters while the HPX-200 (heated working surface 415 mm x 212 mm) features four cartridge heaters – hotplates of this size normally use two cartridge heaters. Increasing cartridge heater density has a direct impact on the temperature uniformity across the surface and shortens the time to reach the set temperature after start up. In addition, the use of premium, ISO-molded, low porosity graphite for the heating surface gives a much smoother surface than extruded graphite which is used in other inert hotplates. ISO-molded graphite, although more expensive, is pressure formed from very fine particles (approximately 50x smaller) than used in extruded graphite, which gives it better thermal conductivity and allows it to be machined to give a much smoother surface.

The temperature specification of the HPX Series is +/- 2°C at 150°C. For best performance in actual use, the temperature specification should be achieved across the entire surface of the hotplate, to ensure consistent heating from sample to sample. To confirm that higher cartridge heater density and the use of ISO-molded graphite reduces temperature variation across the surface, an IR sensing camera was used to measure temperature uniformity of an HPX-100 and compare it to a competitive hotplate of a similar size. A FLIR E60 thermal imaging camera was used. Both hotplates were set to 150°C using the hotplate controller and allowed to reach set temperature. The thermal images obtained are shown in figures 1 and 2. Surface temperature is represented in colors with the key shown on the right side of the image.

The color scale ranges from 100°C to 160°C. The HPX-100 thermal image is shown in figure 1. As can be seen, the surface temperature is very uniform, with only very slight cooling at the corners of the hotplate (orange areas). The cool edges (shown in purple) on each side are the PTFE side guards. In the case of the competitive hotplate (figure 2), the temperature uniformity varies, with the hottest area in the center clearly visible. In fact it can be clearly seen that this hotplate has two cartridge heaters as evidenced by localized hotspots showing their position on this thermal image. The hotplate did not have side guards fitted which is why the edges of the hotplate appear slightly different to the HPX-100.

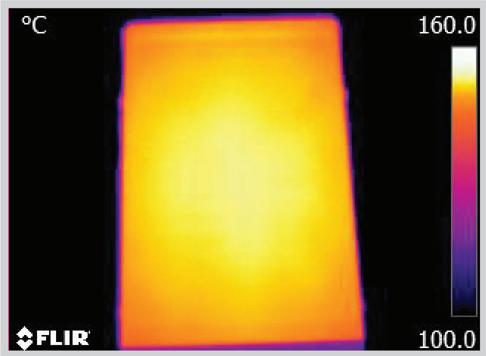

Figure 1.
Thermal Image of Savillex HPX-100 Hotplate

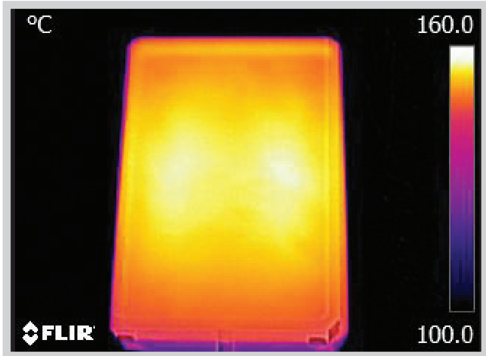

Figure 2.
Thermal Image of a Competitive Hotplate

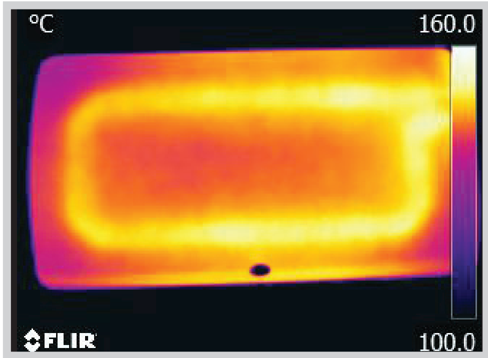

Figure 3.
Thermal Image of a Domestic Griddle

Table 1 (below) shows the data obtained from the thermal images. All data is in °C and each measurement is the average of a 2 in diameter circle. Measurements were taken in seven rows of five, starting at top left in the images and finishing at bottom right. It can be expected therefore, that positions 1-5 and 31-35 would be the coolest. Although both hotplates were set to 150°C, the thermal imaging camera reads slightly higher, as can be seen from the average measurements. The most accurate method of measuring surface temperature is to use a thermocouple. A thermal imaging camera was used here because these devices are most useful to show variations in temperature since hundreds of points are measured across the hotplate surface. The measured temperatures of the HPX-100 range from 149.6°C to 153.6°C, which is 4°C or +/-2°C. The competitive hotplate ranged from 149.2°C to 156°C which is 6.8°C or +/-3.4°C. Clearly the addition of a third cartridge heater and the use of ISO-molded graphite reduces temperature variability across the heating surface of the HPX-100.

Position	HPX-100	Competitor	Position	HPX-100	Competitor
1	149.9	150.9	19	153.4	156.0
2	151.0	152.0	20	152.5	155.8
3	151.4	151.9	21	151.8	154.1
4	151.1	151.5	22	152.8	155.2
5	149.9	150.6	23	153.4	154.7
6	151.2	153.4	24	153.1	155.2
7	152.2	154.5	25	152.2	154.8
8	152.7	154.0	26	150.9	152.2
9	152.2	154.2	27	152.0	153.3
10	151.2	153.5	28	152.6	152.9
11	152.0	155.0	29	152.5	153.0
12	153.1	156.0	30	151.7	152.9
13	153.5	155.4	31	149.6	149.2
14	153.1	156.0	32	150.7	150.1
15	152.2	155.3	33	151.3	150.1
16	152.2	155.1	34	151.1	150.2
17	153.2	156.1	35	150.2	149.8
18	153.6	155.5	Average	151.9	153.4

Table 1.
Temperature measurements taken from thermal images. All data in °C.

In some countries, geochemistry labs use low cost domestic griddles as an alternative to commercial lab grade inert hotplates. These griddles are PTFE coated aluminum and feature a single loop shaped heating element. For comparison, a domestic griddle was set to 150°C and a thermal image taken (figure 3). The looped heating element is clearly visible and temperature variation across the surface is large. The measured temperature range was 27.5°C at 150°C, or +/-13.8°C. Surface temperature varied by 20°C within 2-3 in across the surface at certain points. Clearly a griddle designed for cooking will not give reproducible heating for digestion and evaporation in an analytical lab.

Further Benefits of ISO-Molded Low Porosity Graphite

ISO-molded graphite was chosen for the HPX Series for its superior thermal conductivity, but also to enable the application of a high integrity inert PFA coating. The extruded graphite used in other inert hotplates has fissures and pores in it which makes it very difficult to effectively apply a PFA coating to the surface. In the case of very deep pores, the PFA may not reach the bottom of the pore, leaving a gap or break in the coating. Acid spills can then work between the graphite and the coating, causing the coating around the pore to separate over time. Contamination will also be trapped in this area. In contrast, ISO-molded graphite has a much more dense structure and can be machined more precisely, creating a very smooth surface which is ideal for coating. Figure 4 shows a competitive hotplate with a 7 mL Savillex PFA vial shown for scale. Deep fissures and pores can be seen. In the bottom of the largest pores, it could be observed that the PFA coating did not reach the bottom of the pore, leaving an incomplete seal. Figure 5 shows the surface of an HPX hotplate with the same 7 mL Savillex PFA vial. The much smoother surface of the coated hotplate is clearly evident.

Figure 4.
Competitive Hotplate Image Showing Deep Pores in the Surface

Figure 5.
HPX Hotplate Image Showing Smooth Surface

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