



Sample Evaporation in Hot GC Injectors



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Is sample evaporation in a hot GC injector something you have to think about? Injector temperatures seem to guarantee almost instant evaporation of solutions in volatile solvents. However; appearances are deceptive. Not even vaporization of the solvent is ensured, and as long as not all of the solvent is evaporated, sample components cannot evaporate. Sample liquid "raining" onto (or rather by) the column entrance is not wanted.

THE LIEDENFROST PHENOMENON

The problem of solvent evaporation has to do with the short time available for sample evaporation inside the injector and the Leidenfrost phenomenon. Have you ever seen what happens to a droplet of water falling onto a hot electric cooking plate? Was there the sharp hiss and the water was vaporized? No! The droplet became flat as a small disk and hovered a fraction of a millimeter above the plate. It may have moved nervously, jumping around the hot griddle. Evaporation took many seconds. If this experiment was repeated with a drop of edible oil, you'd observe a totally different behavior: the oil dropped onto the plate, adhered to it, and evaporated more rapidly than the water -although (or rather

because!) the boiling point is much higher.

According to the "Leidenfrost phenomenon", liquids cannot touch a surface with a temperature above their boiling point because evaporation forms a cushion of vapor preventing contact. The higher the surface's temperature is above the boiling point of the liquid, the more rapid evaporation occurs. But, since more vapor is formed, the liquid is repelled further above the surface.

boiling liquids may evaporate slower than higher boiling ones.

TIME AVAILABLE FOR EVAPORATION

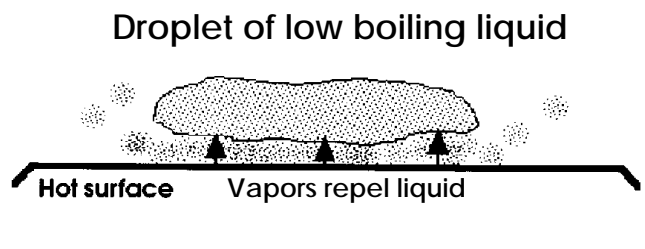
The time required for evaporating the sample (first of all the solvent) is determined by the transfer of the heat consumed. For 2ul of hexane, it was calculated as several hundred milliseconds', while 2 ul of water require several seconds. Is this time available? It depends on how the sample liquid moves through the injector.

achieve. If the injector liner is empty and the sample continues to travel at this speed, the column is reached in far less than 0.1-3 m/s-which is 100-10,000 times less than needed for sample evaporation. To achieve full vaporization, the sample liquid must be slowed or stopped above the column entrance.

NEBULISATION OF THE SAMPLE LIQUID

If samples are injected by a technique involving a hot syringe needle, partial evaporation inside the needle often nebulizes them. The resulting fine droplets are rapidly slowed to the gas velocity and reach the column after several hundred milliseconds only (depending on the gas flow rate). Visual experiments have confirmed that most organic solvents are nebulized when injected by the hot needle

Figure1. The Leidenfrost phenomenon: a cushion of vapor repels liquids from surfaces the temperature of which is above their boiling point.



The solvent vapors separating the sample liquid from the hot surface of the injector liner have two important effects. First, they render the liquid highly mobile-it glides away from hot surfaces. Secondly, they insulate the liquid from the hot surface. Since heat transfer is the time-determining step of evaporation, low

During manual injection, the plunger is depressed at a speed of around 1-2 m/s. However, as the liquid enters the narrower needle, it is accelerated to 15-30 m/s (some 50-100 km/h) and leaves the needle at this same speed at least. Fast autosamplers cause it to exit at speeds even far above those fast cars can

Figure2: Sample evaporation involving nebulisation at the needle exit.

