The Dielectric Barrier Discharge Detector

Principles of the Dielectric Barrier Discharge:

Advanced Industrial Chemistry (A.I.C.) detectors are based on the use of a dielectric barrier discharge (D.B.D.). A D.B.D. is a plasma discharge that is obtained using a high voltage alternating current applied to a dielectric material like glass or pyrex. The application of high voltage to a gas results in a breakdown in the gas and, subsequently, a discharge from one electrode to the other. However, the presence of the dielectric barrier behaves as a capacitor in the localized region of the discharge. This limits the amount of current that can be funneled into any one discharge and, as a result, each discharge is self terminating. This means that the discharge puts a substantial amount of energy into each discrete discharge to create highly excited state molecules and atoms such as helium and argon. The resulting plasma is essentially continuous and, to the eye, it appears as a continuous glow.

The physical characteristics of the D.B.D. give it a number of features that make it advantageous as a GC detector. Since each discharge is self terminating and non-thermal, electrode wear is significantly reduced. This eliminates the need to operate the system with any sort of cycle time that may be necessary to cool electrodes in more traditional, arc-type, discharge systems. Furthermore, since the system is non-thermal, it is possible to use pure reaction gases, such as argon, instead of blends which may be needed to keep the electrodes cool. It is also not necessary to provide any other cooling to the plasma source other than an air flow across the outer, high voltage electrode. Because the system uses the dielectric barrier to limit each discharge, the power supply can be extremely simple. Rather than designing a pulsing circuit, a simple high voltage alternating current power source is sufficient. These power sources can be readily obtained from the commercial market in reliable and compact packages. In addition, since the energy is put into creating excited states and not into heating the gas, it is possible to run these power sources at relatively low power consumption (on the order of 10 - 20 watts.)

Dielectric barrier discharges are also able to operate at elevated pressures. Due to the nature of the discharge, the D.B.D. is actually more effective at a slight positive pressure. This positive pressure is currently obtained through the use of a fixed restriction, a piece of tubing with a narrow inner diameter. The ability to operate in this manner means that no vacuum pumping systems are required for operation. Furthermore, it means that the detector can easily be used in series with another detector with the effluent from the D.B.D. being fed into a second detector or to an analyte trap.

Finally, due to the large number of discrete discharges present and the high rate that discharges are created, the plasma becomes a very stable and virtually continuous light source. As such, it is an excellent photoionization source for use as a GC detector.

Design/Construction of the the Dielectric Barrier Discharge Detector:

The detector is designed with a reverse flow configuration. Reaction gas comes in from the top, the carrier from the bottom and the combined flows exhaust out a side port of the detector body. This design results from a number of considerations. The reverse flow configuration results in generally less quenching for the plasma cell system. It also nearly eliminates the possibility of the analytes of interest making it to the plasma cell itself which yields an added measure of reliability and safety. It also results in less opportunity for the electrodes to become contaminated by the analytes which leads to longer electrode lifetimes.

Once the analytes in the carrier are commingled with the reaction gas, the analytes are ionized. The electrons formed in the ionization process are pushed or pulled, depending on the electrometer being used, to the collector electrode. The collector electrode is attached to the GC electrometer where the current generated in the detector is converted to an output voltage.

The detector has been designed for easy maintenance, repair or replacement of all of the parts within the detector in the field. Access to these components is simply a matter of removing or loosening Swagelok (TM) fittings with a spanner. Any of the components could then be changed out, the system re-assembled, and, depending on the mode of operation, be ready to run within 30 minutes to 12 hours

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