Measuring the Level of Polymeric MDI Vapors in the Workplace using GMD Systems MDI Monitors

Because of the ease of use, the reliability and the direct reading capabilities of the Scott Instruments Autostep Plus and RIS Monitors for airborne diphenylmethane 4,4'-diisocyanate (MDI), we are often asked if these instruments can be used to measure the airborne levels of polymeric MDI (PMDI). As with most issues, there is no simple answer to this question.

The Scott instruments for MDI monitoring include the Autostep Plus portable monitor, the RIS fixed site monitor and the Sure-Spot test kit for MDI. All three are based on Scott's proprietary paper tape technology that allows sensitive and selective measurement of almost any compound containing the isocyanate functional group. Both the Autostep Plus and RIS are electronic instruments that provide a near real-time indication of the airborne MDI concentration. The Sure-Spot kit relies on the operator to visually compare any color formed on the tape (after an air sample is taken) to a color wheel calibrated on various MDI concentrations.

All three systems are calibrated by Scotth on monomeric MDI aerosol. Because this material is of a known composition and purity, is relatively stable and is readily available from a number of sources, we feel that it is an ideal choice for calibrating instruments. GMD Systems put a great deal of effort in developing a test system that can generate stable test atmospheres of monomeric MDI aerosol, which approximate the aerosols formed in the workplace.

This is not the case for PMDI materials. PMDI's are mixtures that vary in composition between manufacturers and product grades. Since the paper-tape chemistry responds only to the isocyanate groups, characteristics such as the average molecular weight of the mixture and its molecular weight distribution are important in determining the response of the tape per milligram of the PMDI. Therefore, in order to have an accurate concentration calibration of a monitor for a PMDI, the monitor would have to be calibrated on the specific material and grade that is used in the intended workplace.

Another parameter that can influence the calibration of the monitor is the particle size distribution of the MDI or PMDI aerosol. As stated earlier, the MDI calibration system used by Scott has been developed to approximate the particle size range of the condensation aerosol expected in the actual use of MDI. In the case of PMDI, the actual use will determine the particle size distribution so it is difficult, if not impossible to reproduce the distribution in the calibration laboratory.

Because of this, Scott recommends that the Scott MDI Monitors should only be used as a rough indication of the PMDI airborne concentration. They should not be used when it is necessary to accurately quantitate the airborne concentration of PMDI materials. Scott stresses that this recommendation is not based on the ability of the monitors to detect PMDI materials but is based on the ability of the monitors to correlate a specific amount of stain to an airborne concentration of the PMDI material.

A look at the problem in detail

The importance the properties of the actual material being monitored becomes clear is we consider what is actually happening on the paper tape surface during measurement of MDI or PMDI. The paper tape is a flat surface having an excess of reagent capable of reacting with isocyanate groups to form a colored product. A sampling pump pulls air containing MDI from the atmosphere to be tested through an inlet tube and then through a piece of this tape. Isocyanate groups in the air sample come in contact with the tape, react with the tape reagents, and cause the color of the tape to change.

If the isocyanate is in the vapor form, it easily comes in contact with the tape as it is being pulled through by the pump, forming a color on the tape. As long as the concentration is not too high, essentially every isocyanate molecule reacts with the tape.

If the isocyanate is in an aerosol form, the situation is a little more complicated. Think of the aerosol as a ball, with isocyanate groups evenly distributed throughout its volume. The first step in the detection process is the "ball" striking the surface of the tape. If the "ball" is small enough and strikes the surface with enough momentum, it is smashed on the surface and all of the isocyanate groups will react with the tape. If the "ball" is large, or if it is moving slowly, it will not completely break up and only those isocyanate groups directly in contact with the tape will react. Those groups that cannot initially react with the tape eventually react with the ambient humidity to form non-colored products.

Therefore, what is really measured by the instrument is the number of isocyanate groups in contact with the surface of the tape during a defined sampling period. The instrument calibration is then the correlation of the weight of material giving rise to a measured stain under conditions of constant sampling flow rate and time. any factors that change the amount of stain per weight of test material will cause the instrument reading to be incorrect.

Scott Instruments MDI instruments are designed to accurately measure the concentration of monomeric MDI as produced in "normal" use. The inlet velocity is high enough so that the calibration MDI aerosol is effectively broken up and captured by the tape. The stains are correlated to the concentration of the generated, monomeric MDI aerosol. Larger aerosol particles may not be broken up completely and cause less stain per milligram. Polymers of MDI will have less isocyanate groups per weight of material and will also give less stain per milligram.

It is for these reasons that Scott can only recommend the use of its MDI monitors as screening tools and not as quantitative analyzers in applications involving PMDI materials.