Molecular (Gas & Odour) Filtration with IQAir® Systems

Awareness of the ever increasing influence of molecular (gaseous) contamination on indoor air quality (and subsequently its influence on the health and well-being of the inhabitants) has prompted the development of several special IQAir® systems that focus on the filtration of chemicals/gases and odours (IQAir® GC and GCX Series).

Outdoor Sources

Outdoor pollution sources include vehicle exhaust fumes, combustion by-products from industrial processes as well as chemicals used in agricultural pesticides and fertilisers.

Combustion products contain irritants such as nitrogen dioxide (NO_2) sulfur dioxide (SO_2) as well as formaldehyde (HCHO). Engine exhaust fumes from cars and especially from diesel vehicles and jet engines produce many volatile organic compounds (VOCs) which can be odorous even at very low levels. Ozone (O_3) is a common outdoor pollutant that varies with weather but can reach problematic levels during various seasons. Even buildings in rural areas near farms or factories can see elevated levels of ammonia (NH_3), hydrogen sulfide (H_2S), and hydrogen chloride (HCl). These and many other outdoor pollutant sources add to the chemical environment inside a building. These odorous and corrosive pollutants can pose a significant problem not only in critical environments such as semiconductor clean rooms, hospitals and museums, but also in domestic and commercial indoor environments.

Indoor Sources

Indoor sources of molecular contamination can be equally concerning. Human metabolic by-products include hydrogen sulfide, ammonia and carbon dioxide. Electronic equipment generated ozone as well as fugitive chemicals from housekeeping activities can rival or exceed pollutants from outdoor sources. Even internally generated VOCs from the off gassing of synthetic materials used in construction contribute to Indoor Air Quality (IAQ) problems. Unlike outdoor levels of chemical pollution, which are highly variable, inside levels tend to maintain at a more steady state and are cumulative in nature.

Nature of Gases

Not unlike particles, molecules do have size. However, while particle levels are measured in intuitive units (numbers per unit volume), molecule levels are measured in concentration units such as parts per billion (ppb) or parts per million (ppm). Molecule size is measured in Angströms (1/10,000,000,000 of a meter). They are in general 1,000 to 10,000 times smaller than a fine dust particle and so pass through the finest particle filters. Being of this extremely small size and weight, they pose different challenges for collection and removal than do particles. To evaluate many of the new technologies being introduced for gas-phase filtration, it is important to understand the behaviour of molecular contaminants and the principle of gas-phase filtration.

Particle contaminants move through the air in air currents. Molecules in contrast move by diffusion. If a chemical contaminant were introduced to one side of a large room with no air movement, it would simply be a matter of time before the chemical would be detected uniformly through the room. The molecules would diffuse through the room from an area of high concentration to areas of lower concentration until we had a homogenous concentration throughout. The speed and force with which the contaminant travels is called diffusion gradient.

Filtration of Gases

Two main processes are used in IQAir® gas-phase air filtration systems. One is a reversible physical process known as *adsorption* condensation used in the IQAir® *VOC* model. The other involves an irreversible chemical reaction known as *chemisorption used in the* IQAir® *ChemiSorber* model. Other IQAir® models combine these two processes in a media blend to achieve a wider filtration spectrum (e.g. IQAir® *MultiGas*™). For the removal of specific gases and odours the activated carbon media can be impregnated. For example, for the filtration of ammonia (NH_3) and amines the IQAir® *AM* gas-phase media contains an acid impregnant.

Adsorption

Adsorption is a surface phenomenon. A vapour or gas will diffuse onto the surface of a sorbent such as activated carbon. Secondary diffusion can take place to move the pollutant further into the sorbent particle's centre, fully utilising all external and internal surface area. Concentrations are typically low and so is the diffusion gradient. With a low diffusion gradient we will not take advantage of secondary diffusion and the tremendous surface area available within a carbon particle. *Adsorption condensation* in low-level gas-phase filtration is therefore an outside surface phenomenon. Sorbent particle size, not mass, is the key to good filter design. This understanding has been the driving force behind many of the IQAir® gas-phase filter products.

Adsorption condensation takes place when molecules of a pollutant diffuse onto the surface of a sorbent. The sorbent surface represents an area of relatively lower concentration of pollutant. The unique properties of the chemical will determine its behaviour and the effectiveness of the adsorption process. A chemical's boiling point, vapour pressure, and reactivity all play a role.

In general, materials having a boiling point in excess of 100ºC (212°F) lend themselves to adsorption condensation quite readily. The chemical will exist in a vapour but readily convert to its liquid phase when diffused onto a sorbent's surface. These materials will exist as a liquid at room temperatures. Adsorption condensation is a reversible process and pollutants of different molecular weights will compete for the same space on the sorbent surface. Temperature as well as moisture will also affect the adsorption process. Moisture competes for space on a sorbent surface making an adsorption-based filter less effective on a humid day.

Chemisorption

Chemicals or compounds that are highly reactive with low molecular weights and low boiling points exist in a gas state at room temperature. Pollutants of this nature may diffuse onto the surface of a sorbent, but will not convert to a liquid state and will quickly off-gas or be displaced by other molecules. To capture these pollutants, a process called chemisorption is used. In this process, a chemical reagent is added to the sorbent. The target pollutant reacts with the reagent on the sorbent surface, forming a by-product. To be effective, this by-product must be highly stable.

For example, if we wished to remove a chemical with a very low boiling point such as hydrochloric acid, we might take a carbon sorbent and impregnate it with potassium iodide. The resulting chemical reaction on the surface of the sorbent would yield potassium chloride, which is a salt. Salts are highly stable, and unlike hydrochloric acid, can be handled and disposed of safely. Unlike adsorption condensation, chemisorption is enhanced and in fact needs moisture for a reaction to take place. Many pollutants of concern in indoor air quality are of low molecular weights and require filtration products that utilise this chemisorptive process. Generally, if you want to remove a pollutant that is a base in nature ($pH > 7$), the reagent would be an acid. Likewise, if your pollutant were an acid, a reagent in the base family would likely be selected. Chemisorption is a non-reversible process. Filters using this principle can not be regenerated.

New Products

Gas-phase filters based on adsorption condensation or chemisorption have been around for decades. These filter media are typically designed to offer proper surface area and residence time of the pollutant in the media bed. The largest drawback to these products was their physical size and weight, as well as the dust created during servicing. For that reason, IQAir® gas-phase filtration systems use smaller geometry activated carbon media filled into disposable gas cartridges. This media offers more outside surface area vs. mass and the cartridges enable a quick and clean replacement of the filters. With demand for performance in gas-phase filtration, several IQAir® systems offer reagent treated sorbent as well as standard activated carbon. While carbon impregnated polyester media which many manufacturers are using has the same basic component (i.e. activated carbon) their performance and life span is vastly inferior. That is mainly due to the very small amount of carbon that is used in these filters. Often the media surface area of these filters represents only a fraction of the surface area offered by IQAir® gas-phase filters.

Testing Gas-Phase Filters

Testing gas-phase filters and interpreting the results has always been difficult. Most filters used in non-industrial applications see only low level concentrations. Any test using high concentrations of a challenge chemical will not accurately characterise the remaining surface area available for collection of low level contaminants. All sorbent-based filters have a decreasing efficiency curve with service life. Knowing what a threshold efficiency level should be in a particular application is difficult. Certainly, someone wanting to reduce annoying odours in an office building will have different parameters than a laboratory wishing to reduce human exposure to chemicals or a museum seeking to protect artwork.

Conclusion

Increased awareness of indoor air quality has fostered many new filtration technologies. IQAir® offers gas-phase filtration systems with greatly enhanced performance for both particulate and gas-phase filtration. As for other filtration systems, looks and marketing claims can be deceiving, and many new technologies may even challenge one's sense of logic. The common characteristic of many of these new products is lower removal efficiencies and higher life cycle cost. At IQAir® we believe that IAQ problems can only be solved effectively by applying the most suitable filtration technology for the problem at hand.

Please refer to the "*IQAir® Model Selection Chart for Gaseous Contaminant Control*" to find the most suitable IQAir® system for your particular application.

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