HEPA Is Not Enough

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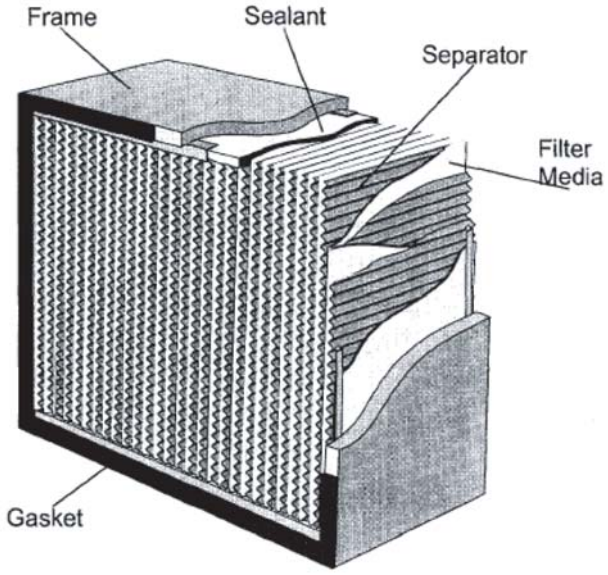
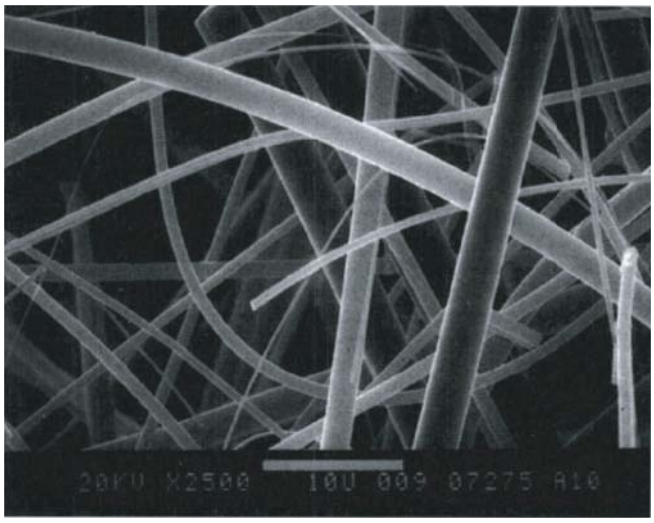
Most embryologists are familiar with the HEPA (High Efficiency Particulate Air) filters used in laminar flow hoods and, in some cases, in central air supply systems (Figure 1). Interestingly, HEPA filters do not resemble a sieve, but rather are a mat of bound fiberglass fibers, with approximately 10-micron spaces between the fibers (Figure 2). Particles in the air stream adhere to, or become imbedded in, the fibers, and HEPA filters will trap almost all particles greater than 0.3 microns in diameter. This is sufficient to remove airborne particles, fungi, mold spores, and bacteria, and therefore HEPA filters can significantly reduce microbial contamination. However, HEPA filtration is not enough, and will never be enough, for the stringent air quality requirements of human ART.

Figure 1. Deep-pleated high efficiency filter with separators. (Klocke and Whyte 2002)



Molecules of embryotoxic compounds are 100 to 1000 times smaller that the effective pore size of a HEPA filter. Volatile organic compounds (VOCs) such as benzene, formaldehyde, acetaldehyde, acetonitrile have been found in laboratory air (Hall *et al.* 1998), and they are not trapped by a HEPA filter. To trap or destroy these materials requires a smaller trap, such as is provided by activated charcoal. The spaces between the carbon particles contain a cloud of delocalized electrons that acts as an electronic glue (van der Walls forces), to bind chemical contaminants onto the carbon. Compounds

Figure 2. Photomicrograph of high efficiency filter medium. (Klocke and Whyte 2002)



such as alcohols and ketones are not easily removed by carbon, but they can be oxidized, and thereby detoxified, by potassium permanganate. Again, this is a chemical reaction happening at a scale of a thousand times smaller than the particles trapped by a HEPA filter. The essential point is having an effective removal device that fits the scale of the particle or chemical molecule.

The possible significance of air quality on IVF was raised by Cohen *et al*. (1997) who observed decreases in in-vitro embryo development and pregnancy rates associated with the move of an IVF lab from suburban Naples, Italy to the downtown area in 1992, and associated with construction around another IVF lab in New Jersey in 1995. Some environmental effects from other events involving construction in neighbouring spaces and the use

of toxic materials in lab spaces preceeded these periods. They consequently measured significant concentrations of VOCs in the laboratory air, and in the compressed CO_2 used for the incubators. Based on these observations, they designed the Coda® incubator units for use inside the incubators, in-line Coda® filters for the CO2 supply, and larger Coda® towers to filter the laboratory air, all of which contain HEPA filters, activated charcoal and potassium permanganate.

A number of studies have shown improved pregnancy rates with the use of Coda® air filtration in human IVF labs (Racowsky *et al*. 1999, Figure 3; Mayer *et al*. 1999, Figure 4) and cattle IVF (Merton *et al*. 2007, Figure 5). It is important to note, however, that it is not realistic to expect the use of Coda units to improve in-vitro development and/or pregnancy rates in every case. A difference in clinical outcome is only likely if there is an ongoing problem with air quality, or if a there is a dramatic decrease in air quality, from nearby construction,

Figure 3. The effect of Coda® incubator units and towers in a human IVF laboratory on pregnancy and abortion rates. (Racowsky *et al*. 1999)

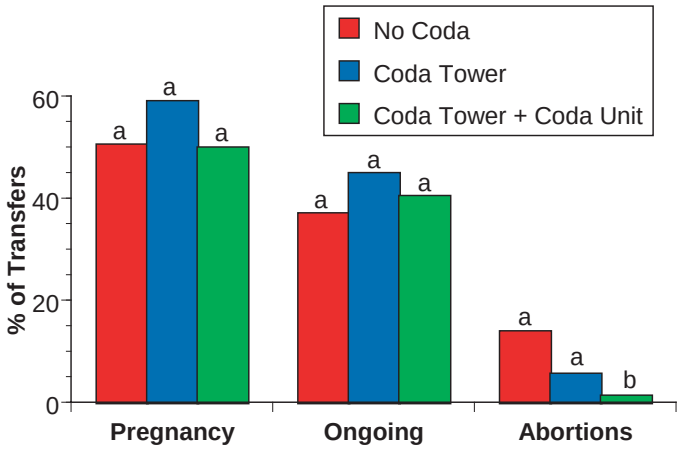


Figure 4. The effect of Coda® incubator units in a human IVF laboratory on pregnancy rates (Mayer *et al.* 1999).

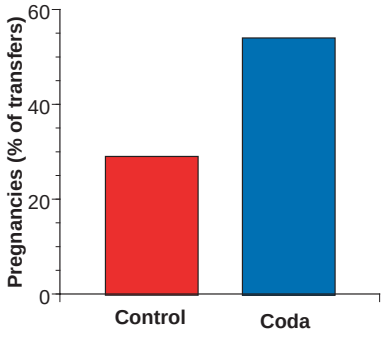
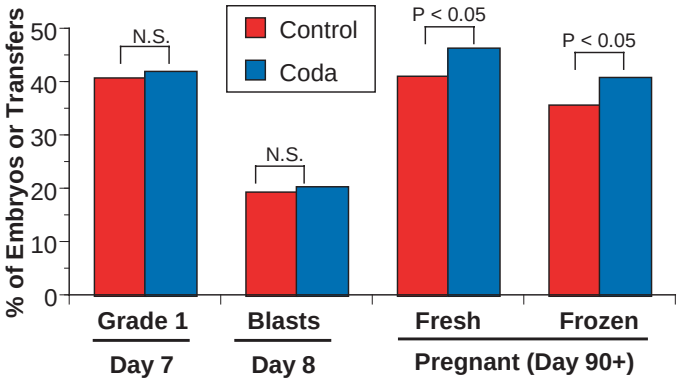


Figure 5. The effect of Coda® incubator units in a bovine IVF laboratory on embryo development and pregnancy rates (Merton *et al*. 2007)



for example, during the study period. Such environmental crises can and do occur, but they are often intermittent and rarely predictable.

In conclusion, HEPA air filtration is highly effective for the reduction of particulates and bacteria, but cannot reduce the concentrations of embryotoxic VOCs in the ART laboratory. Coda® filters contain activated charcoal and potassium permanganate and can significantly reduce VOCs. Coda® units should be considered as common-sense safety devices. That is, they should always be in place, in order to deal with unforeseeable changes in air quality.

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