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Mass Concentration, Particle Diffusion, and Solution Dosage

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Mass Concentration Analysis from Experimental Data

A direct comparison between the mass concentration experimentally measured to the number of particles measured is calculated to verify consistency. The mass concentration is given in $\frac{\mu g}{m^3}$ and the particle concentration is given in $\frac{particles}{cm^3}$. After one minute of operation the mass concentration is given as 489 $\frac{\mu g}{m^3}$ for 1-micron particles and the particle concentration is 925 $\frac{particles}{cm^3}$. The mass concentration is measured per m^3 of measured volume and the particle concentration is measured per cm^3 of measured volume. The mass concentration must be converted to $\frac{g}{cm^3}$:

$$\left(489\ \frac{\mu g}{m^3}\right)\left(\frac{10^{-6} g}{1\ \mu g}\right)\left(\frac{1\ m^3}{(100\ cm)^3}\right) = 4.89\ x\ 10^{-10}\ \frac{g}{cm^3}$$

The mass in the measured volume is $m = 4.89\ x\ 10^{-10}\ g$.

The total volume of the particles V_T is given by the measured mass concentration:

$$V_T = \frac{m}{\rho} = \frac{4.89\ x\ 10^{-10}\ g}{1\ \frac{g}{cm^3}} = 4.89\ x\ 10^{-10}\ cm^3$$

Where the density of the fluid in the particle is 1 $\frac{g}{cm^3}$. This is the volume required for the total number of particles measured. The volume per particle (V_p) is given by the measured value of the number of particles:

$$V_p = \frac{4.89\ x\ 10^{-10}\ cm^3}{925\ particles} = 5.286\ x\ 10^{-13}\ cm^3$$

For consistency, the diameter of the particles based on the number of particles measured and the required volume as defined from the mass concentration should give 1-micron.

The diameter of the particles calculated from the volume given by the mass concentration is:

$$d = \sqrt[3]{\frac{6}{\pi} V_p} = \sqrt[3]{\frac{6}{\pi}\ (5.286\ x\ 10^{-13}\ cm^3)} = 1\ x\ 10^{-6} m = 1\ \mu m$$

Which is the diameter of the counted particles.

Flow of Particle Droplets Exiting the Dry DeCon Defense Machine.

The diffusion of the particles is a combination of flow dynamics. Molecular diffusion is a minor contributing factor as the flow dynamics diffusion of the gas-like vapor and droplets exiting the machine plays a more dominant role. As the particle droplets exit the machine into the dry air, the droplets begin to evaporate and create a gas-like vapor which surrounds the air around the machine. As the relative humidity begins to rise, the droplets exiting the machine evaporate more slowly and the larger droplets evaporate into smaller droplets as they move away from the machine. The increasing droplet density around the machine causes the surrounding gas-like vapor and droplet particles to diffuse away from the machine. A mass transfer is carried by the volume flow rate of vapor and droplets produced by the flow created by the machine and directed through the cylinder and exiting the machine. This contributes to the localized particle density and localized pressure increase which produces additional diffusion and mass flow away from the machine and spreading the particle droplets and gas-like vapor throughout the space.

Hydrogen Peroxide Contained in 1-micron Diameter Droplets

A 7.5% Hydrogen Peroxide solution is used to create the droplets.

$$7.5\ g\ H_2O_2\ in\ 100\ mL\ H_2O = 75\ g\ H_2O_2\ in\ 1\ L\ H_2O$$

Molar Mass of H_2O_2 is equal to *34 g/mol*. The molarity of the 7.5% solution is:

$$\frac{75\ \frac{g}{L}}{34\ \frac{g}{mol}} = 2.206\ \frac{mol}{L} = 2.206\ M$$

The number of moles in a 1-micron droplet:

$$mols\ of\ H_2O_2 = \left(2.206\ \frac{mol}{L}\right)\left(\frac{\pi}{6}\ (10^{-6}m)^3\right)\left(\frac{L}{0.001\ m^3}\right) = 1.155\ x\ 10^{-15}\ mols$$

Number of H_2O_2 molecules in a 1-micron diameter droplet:

$$molecules_{H_2O_2} = (1.155\ x\ 10^{-15}\ mols)\left(6.022\ x\ 10^{23}\ \frac{molecules}{mol}\right) = 6.956\ x\ 10^{8}$$

Solution Dosage Delivered by Droplets

Mass concentration micrograms per m³ at Various Sizes							
	≤ 1µm	1 to 2.5 µ	2.5 to 4 µ	4 to 10 µ	Total	$HOCl$ @ $500ppm$	H_2O_2 @7.50%
Machine Powered						g/m^3 $HOCl$	g/m^3 H_2O_2
Fog Began	2.32	0.46	0.27	0.05	3.11		
5 min	3719.57	5740.25	4472.73	894.54	14827.10	0.01483	2.22406
10 min	7887.92	16701.79	13150.28	2630.05	40370.03	0.04037	6.05550
15 min	10107.03	24715.73	19532.94	3906.58	58262.29	0.05826	8.73934
20 min	11578.98	30372.36	24042.51	4808.49	70802.34	0.07080	10.62035
25 min	12646.63	34350.12	27212.14	5442.42	79651.32	0.07965	11.94770
30 min	13394.73	37325.33	29585.26	5917.04	86222.36	0.08622	12.93335

The chart above gives the measured mass concentration in $\frac{\mu g}{m^3}$ for each range of particle size and time of operation of the machine. Based on an operation time of 30 minutes and a 500 ppm HOCl solution, the dose delivered to the space is 0.08622 $\frac{g}{m^3}$. Based on an operation time of 30 minutes and a 7.5% H_2O_2 solution, the dose delivered to the space is 12.93335 $\frac{g}{m^3}$.