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Risk Assessment for Exposure to Respirable Dusts Generated from the Use of Chalks and Pastels

A concern has been raised that drawing with soft pastels will produce large quantities of respirable dust; that vacuuming dust produced during such activities will further entrain respirable dust in the air; and that exposure to this dust will present unacceptable hazards. In order to determine whether or not these concerns were valid, the following activities were undertaken:

- Chalks and soft pastels from 11 manufacturers were used to draw on artist's paper and the quantity of respirable dust produced was determined.
- Dust produced during drawing activities for 6 of these chalks and soft pastels was vacuumed with a non-HEPA vacuum cleaner and the quantity of respirable dust produced was determined.
- Measurements of respirable dust production during drawing activities were validated by measuring respirable dust levels generated during a 3 hour drawing class involving several students.
- An assessment of potential inhalation exposures for various pastel components was determined and compared to levels determined to be safe by California's OEHHA.

Respirable dust production

Dust generation activities were conducted in a 259 L. exposure chamber with respirable dust levels measured with a 10 mm nylon cyclone backed by a 2 μm pore-sized Teflon filter over a 10 minute sampling time. The cyclone collects respirable dust with a geometric median aerodynamic diameter of 4 μg. Total dust levels were measured simultaneously with an open-faced filter cassette loaded with a 5 μm PVC filter. Pumps were calibrated before and after each run using an SKC soap film flowmeter. Filters were weighted within ∀ 1.0 μg. Respirable dust levels using a characterized dust were within 6% of predicted values using this methodology. The exposure chamber was cleared with particle free air after each measurement. Activities were conducted in the chamber as described by product directions. Either respirable or total dust production could be measured with a sensitivity of 70-75 μg (3 times the standard deviation of a series of 6 blank runs). A bagless vacuum cleaner with a foam filter to protect its motor was used to attempt to re-entrain chalk and pastel dusts. The efficiency of the vacuum cleaner at collecting respirable dust was determined by vacuuming a dust with a known fraction of respirable dust. This unit was found to have a 33.1% efficiency. That is, it was transparent to 66.9% of the respirable dust that it vacuumed. Twelve 700 cm^2 sheets of artist drawing paper were completely filled during pastel and chalk dust production activities, each experiment lasting 30 minutes. All dust that could be knocked off of these sheets was collected, ranging from 0.80-3.20 gm for the pastels and 0.34-0.78 gm for the chalks. These dust samples were then vacuumed in their entirety and the vacuum left on for 1 minute prior to beginning dust measurements, a similar procedure that was used for determining filtration efficiency.

The total and respirable aerosol production was found to be as follows (mean ± standard deviation):

Activity	Respirable Dust (μg)	Total Dust (μg)
Drawing activities	364 ± 272	855 ± 590
Vacuuming	218 ± 212	

Respirable fraction is the percent of each product that is generated as respirable dust during dust generation experiments. The results of these analyses were as follows:

Activity	Respirable fraction (% ± sd)
Drawing activities	0.012 ± 0.009
Vacuuming	0.0040 ± 0.0033

In order to determine average respirable dust exposure, I assume that each activity occurs indoors in a poorly ventilated room (1 air change/hour) of average size (30 m^3). Exposure with each use can be determined using the dilutional ventilation equation:

$$\Pi_t = \Pi_i e^{-Qt/V}$$

Where: Π_t = concentration (mg/m^3) at time t
Π_i = initial concentration
Q = Ventilation rate (m^3/min)
V = room volume (m^3)

Assuming instantaneous dispersion of the respirable dust aerosol and solving this equation over 1 minute intervals, then the average concentration over 24 hours = $0.042\Pi_i$. After 8 hours, the concentration of dust is negligible, <0.01% of the initial concentration. Using this equation, the average exposure for activities would be:

Activity	Average Exposure over 24 hours ((:g/m^3)
Drawing	0.5
Vacuuming	0.3
Total average respirable dust exposure:	0.8

Dispersal confirmation study

A further experiment was done to test whether or not the assumption that particles are uniformly distributed at the time of production is conservative. A series of dusts were analyzed for particle size to develop a standard of high respirable particle size content for further investigations. Samples of each product were suspended and particles were fractionally separated using an Andreasen Sedimentation Pipette (Stopford, *Anal. Chim. Acta*, 286: 67-73, 1994). On repetitive testing of one sample, determinations of respirable fraction are repeatable with a standard deviation ∀ 1.0%. A kaolinite was chosen where 85% of the mass of the dust was in the respirable range.

To validate this determination, the kaolinite sample was then suspended in a 259 L. exposure chamber with respirable dust levels measured with a 10 mm nylon cyclone backed by a 5 μm pore-sized PVC filter over a 10 minute sampling time with calibrations as described above. Respirable dust levels using this characterized dust were within 6% of predicted values using this methodology.

Samples of this kaolinite dust were then suspended during trial activities in an unventilated 11120 m^3 room. Sampling was done in the operator's breathing zone 18 in. from the activity using the same equipment and calibration techniques as for the exposure chamber experiments. Sampling occurred for 10 min during and after dust generation activities. Clouds of suspended dust were observed to pass through the breathing zone area in 12-18 seconds after being generated. Dust was generated during the following activities:

#1. 52 mg suspended within 1 min, all dust seen to pass in a cloud pass the breathing zone monitor.
#2. 71 mg suspended during 6.5 min of activity, most dust seen to go through breathing zone.
#3. 70 mg suspended during 6.5 min of activity, dust seen to go through breathing zone only part of time.
#4. 68 mg suspended during 6.5 min of activity, no generated dust clouds observed.

The following exposure levels for respirable dust were found during each of these activities. Based on the amount of respirable dust suspended, the dispersion volume equivalent to the measured dust level was calculated as shown in the following table:

Activity	Measured respirable dust level (mg/m^3)	Theoretic volume if equally dispersed (m^3)
#1	0.410	127
#2	0.279	255
#3	0.249	283
#4	ND	4

It would appear that respirable dust stays in the breathing zone only a brief period of time before beginning to diffuse throughout a room. The assumption that dust is dispersed immediately to a volume of 30 m^3 would result in calculated exposures ranging from 1.7-2.4 mg/m^3. Thus the assumption that any generated dust is dispersed throughout a poorly ventilated 30 m^3 room at the time it is generated is a conservative presumption.

Industrial hygiene exposure assessment

To further assess potential exposures associated with the use of dust drawing materials, actual respirable dust exposures were measured in a drawing class at UNC Greensboro. Respirable dust measurements were taken in the breathing zone of 5 students during 155 minutes of drawing activities. Pumps were stopped during breaks. Air samples were drawn through a 10 mm nylon cyclone backed by a 5 μm pore-sized PVC filter. Samples were analyzed gravimetrically using a method based on NIOSH methods 0500 and 0600. No respirable dust could be detected with detection limits ranging from 180-201 $\mu g/m^3$.

Risk assessment

The Office of Environmental Health Hazard Assessment (OEHHA) safe harbor levels presume that there will be a lifetime (70 years) of exposure. The number of years pastel artists draw, however, averages less than 70 years. In order to determine the average number of years artists use pastels, a survey was made of a population representative of the US population who also declare themselves as artists. In 1991 NFO Research conducted a national survey of artists. This survey was made by polling a 20,000 households representative of the US population. Nine percent of these households contained artists. A representative sample of 385 of these artists were asked detailed questions concerning their art work. 70% of those surveyed responded. The results are considered representative of the population of the United States with a precision of ± 5.9% at a 95% confidence interval. In this survey, the respondents were asked specifically how many years they had used each type of art work. Pastel-using artists drew with pastels for an average of 18 years. When interested in lifetime exposures, the lifetime exposure to pastel dust would average $18/70 \times 0.8\ \mu g/m^3 = 0.2\ \mu g/m^3$.

USEPA (Exposure Factors Handbook, 1997), finds that the average inhalation rate for women is 11.3 m^3/24 hours and for men 15.2 m^3/24 hours. Using the latter figure, the average daily inhalation dose of respirable dust for pastel artists would be 3 μg/day.

U. Heinrich (OSHA Cadmium Rule Making Hearings, Exhibit 142) noted that the carcinogenicity of cadmium depends on the amount of cadmium ion (the carcinogenic species) that is available to the lung. The bioavailability of cadmium in cadmium pigments is, however, considerably less than for soluble cadmium species: 1% of cadmium cleared from the lung after dosing with cadmium sulfide deposits in kidneys vs 35% of the cleared dose of cadmium chloride (H.J. Klimisch and C. Gembardt, OSHA Cadmium Rule Making Hearings, Exhibit 142). Cadmium sulfide has similar solubility in a lung interstitial fluid surrogate (Stopford and Turner, unpublished data): it is reasonable to use the cadmium sulfide bioavailability test results in addressing long-term lung risks from exposure to other cadmium pigments.

California’s Office of Environmental Health Hazard Assessment (OEHHA) has developed safe harbor levels for a number of toxicants, some of which might be found in pastels. If exposure is less than these levels, then labeling under Proposition 65 is not required. Examples of such safe harbor levels are as follows:

Potential pigment components	
cadmium	0.05 μg/day
D&C Red 9	100 μg/day

Potential contaminants	
hexavalent chromium	0.001 μg/day
Hexachlorobenzene	0.4 μg/day
3,3’-dichlorobenene	0.6 μg/day
respirable quartz	0.54 μg/m^3

Although D&C Red 9 (Colour Index Pigment Red 53:1) is no longer used in artist’s pastels, it can be used as representative of chronic toxicological concerns for pigments where cancer testing has not been done.

When determining the contribution of a specific pigment or component contaminant to the respirable dust generated from using pastels, the percentage of this dust that may be composed of the chemical of concern will depend on how frequently the colors containing the chemical are used. For more expensive pigments, such as cadmiums, unit sales of art materials containing these pigments is less than for art materials not containing these pigments. A conservative use correction is to assume that the color of interest will be used proportional to the number of colors in the line. This approach is that used by the Consumer Product Safety Commission for making color-specific use adjustments.

The amount and type of pigments in pastels is known and measurements of pigment or pastel component contaminants, when such contaminants may be present, is required. Levels found in 12 pastel lines were determined and were found to range as follows. Levels were corrected for the number of colors containing the chemical vs the number of colors in the product line. No correction was made for either pigment loading or respirable quartz levels, the latter being present in all colors, when it was identified.

Component of interest	Range (%)
pigment	4.8-44.4%
cadmium	0-2.7%
hexavalent chromium	0-<0.10 ppm
Hexchlorobenzene	0-0.083 ppm
3,3’-dichlorobenene	0-<0.06 ppm
respirable quartz	0.0029-0.43%

Only 2 of the 1159 pastel colors evaluated contained cadmium pigments. All of the pastels contained binders that would be expected to suppress respirable dust formation.

Since D&C Red No. 9 was not identified in any of the surveyed pastel lines, pigment loading was used as a surrogate.

If a pastel artist used the pastel line with the highest level of each of the noted chemicals, then exposures would be less than the OEHHA safe harbor levels in each instance. The fraction of the OEHHA safe harbor exposure level for each of these chemicals would be as follows:

Component of interest	Fraction of Safe Harbor Level (range)
pigment	0.001-0.013
cadmium	0-0.05
hexavalent chromium	0-0.0003
Hexachlorobenzene	0-0.0000005
3,3'-dichlorobenene	0-0.0000005
respirable quartz	0.00001-0.0016

Although pastel dusts may contain components that can increase risk of chronic health effects at high exposure levels, exposures to pastel dusts are low. The risk of any adverse effect is correspondingly low as well. No special precautions are necessary to prevent excessive exposure to such dusts, either during use or cleanup.

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