Personal exposure measurement during dental nanocomposite grinding

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During routine dental work such as the removal, polishing and shaping of composites, a high concentration of respirable particles (< 4 μm) can enter the breathing zone of staff and patients. Detailed characterization of aerosol particles has shown that a high percentage of these airborne particles belong to the nanoparticles (< 100 nm), which are easily inhaled and can penetrate deeply into the lungs. There are two approaches to determining particle concentrations in the workplace, personal or static/area monitoring. Personal sampling seems to be a more accurate way to obtain information about the individual exposure of each worker, since it takes into account the influence of all phenomena that take place in the breathing zone of the worker.

The purpose of this study was to measure the personal exposure of each participant of the study and to compare the results with those of static monitoring. Personal nanoparticle samplers (PENS), which can simultaneously detect both nanoparticles ($PM_{0.1}$) and respirable particles (PM_4), were used to determine personal exposure (Tsai et al., 2012). Area monitoring included measurement of mass concentrations using the Berner Low Pressure Impactor (BLPI 25/0.018 /2, Hauke GmbH, Gmunden, Austria) and the Low Volume Sampler (LVS, Sven Leckel Ingenieurbüro GmbH, Germany). The number concentrations and their size distributions were measured with the Scanning Mobility Particle Sizer (SMPS 3936, TSI Inc., USA) and the Aerodynamic Particle Sizer (APS 3321, TSI Inc., USA). Measurements with all of the above-mentioned instruments were performed in four shifts with six participants per shift. Each participant milled for 10 minutes and then remained in the room until the group finished the session, so the total exposure lasted about 70 minutes. Due to the high content of filler nanoparticles, the nanocomposite Filtek Ultimate (body A2, 3M ESPE, USA) was selected for these measurements.

Comparison of the ratio of nanoparticle to respirable mass concentrations of PENS samplers (PENS-$PM_{0.1}$/PENS-PM_4) and BLPI (BLPI-$PM_{0.1}$/BLPI-$PM_{3.5}$) showed that we were not able to prevent particle bounce in the PENS samplers, significantly overestimating the PENS-$PM_{0.1}$ concentration. This was also confirmed by comparing the ratios of the PENS samplers (PENS-$PM_{0.1}$/ PENS-PM_4) and the SMPS/APS system (SMPS_APS-$PM_{0.1}$/SMPS_APS-PM_4). To correct the nanoparticle concentrations from the personal measurements, we used the ratio from the SMPS/APS system, which is more accurate. The values of the corrected nanoparticle mass concentrations (PENS-$PM_{0.1}$_corr.), respirable particle concentrations (PENS-PM_4), and the amount of ground material for each participant during the first shift are shown in Table 1.

Table 1. Personal exposure, shift 1. Respirable fraction, nanoparticles and total amount of mass removed by grinding.

Shift.Person	PENS-PM_4 ($\mu g/m^3$)	PENS- $PM_{0.1}$_corr. ($\mu g/m^3$)	Removed by grinding (g)
1.1	419.2	3.5	0.876
1.2	369.3	3.0	0.922
1.3	1097.4	9.0	0.890
1.4	334.8	2.8	0.795
1.5	388.8	3.2	1.401
1.6	312.3	2.6	0.920

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References:

Tsai, Ch.J., Liu, Ch.N., Hung, S.M., Chen, S.Ch., Uang S.N., Cheng, Y.S., Zhou, Y. (2012) Environ. Sci. Tech. 46 (8), 4546-4552.

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