Analysis of SiO_2 and $BaSO_4$ leachates from dental composites by thermal lens spectrometry

Korte D[(1)]*, Jereb V[(2)]*, Franko M[(1)]

(1) University of Nova Gorica, Laboratory for environmental and life sciences, 5000 Nova Gorica, Slovenia
(2) Polident d.o.o., 5293 Volčja Draga, Slovenia

* Corresponding authors' email: Dorota.Korte@ung.si, Vesna.Jereb@polident.si

Nowadays ceramics and resin-based dental composites containing micro (MPs) and nanoparticles (NPs) are used for restoring dental caries or other defects instead of conventional alloys due to the improved mechanical properties (strength, toughness, surface hardness, durability) of the whole matrix. This is of high importance especially in the case of large area restorations [1, 2]. Furthermore, resin-based dental composites are the most popular restorative materials and are mainly composed of a resin polymeric matrix, inorganic filler particles and silane coupling agents [3]. In the present study, the inorganic filler in the resin-based composite is microsized SiO_2 with traces of nanosized SiO_2. Additionally, the resin-based material contains small amounts (a few tenths of a percent) of nanosized $BaSO_4$ used as a functional additive during production. Incorporation of these two components in dental materials introduces the oral route of exposure for these NMs. Their absorption in the gastrointestinal tract may be high due to their small particle size causing histopathological changes in liver and kidneys or alterations in blood parameters [4]. Furthermore, oral uptake of SiO_2 and $BaSO_4$ NPs from dental materials is likely to occur at low doses over long periods of time leading to their accumulation in body tissues [5]. Thus, monitoring of their leachates requires highly sensitive detection techniques.

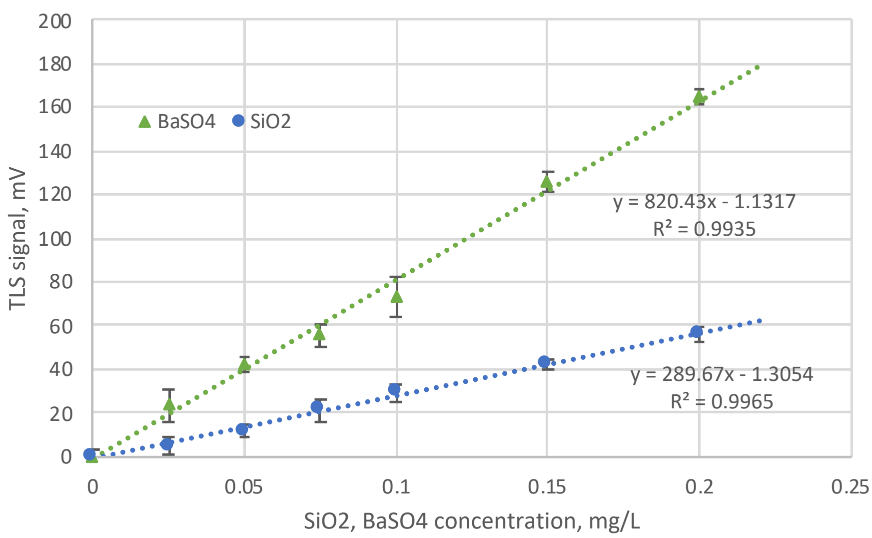

Fig. 1. Calibration curves used in the study for SiO_2 and $BaSO_4$ determination.

In the present study, thermal lens spectrometry (TLS) is applied for the determination of the amount of SiO_2 and $BaSO_4$ NPs released from artificial teeth under chewing simulation. TLS is based on probing the temperature rise in illuminated samples that induce related changes in their properties (refractive index, density etc.), which are a result of non-radiative relaxation of the energy absorbed from an excitation laser beam [6]. SiO_2 and $BaSO_4$ determination was performed by the use of the calibration curve presented in Fig. 1.

The obtained LOD for SiO_2 and $BaSO_4$ determination was 30 and 10 ppb, respectively, whereas RSDs were between 1-5% indicating the high sensitivity and good reproducibility of the method.

Table 1. Values of SiO_2 and $BaSO_4$ leachates from resin-based dental composite obtained in the study.

Sample no.	SiO_2/ppb	$BaSO_4$/ppb
D1	31	ND*
L1	28	ND
D2	36	9
L2	33	7

*not detected

It was found that the release of SiO_2 from the designed resin-based composites is at the level of LOD of the detection method, whereas $BaSO_4$ under LOD. It can be also stated that the designed resin-based composites that contain SiO_2 MPs and NPs are promising dental materials with improved mechanical properties such as enhanced hardness and scratch resistance, since they do not release SiO_2 or $BaSO_4$ NPs from artificial teeth under long term chewing simulation. Thus, such materials seem to be an excellent choice as dental resins especially in cases of large area restoration where the mechanical stresses under use are of large value.

References

[1] Y. Liu, Y. Sun, F. Zeng, X. Weili, Y. Liu, L. Geng, Effect of nano SiO_2 particles on the morphology and mechanical properties of POSS nanocomposite dental resins, J. Nanopart. Res. 16 (2014) 2736-2744. https://doi.org/10.1007/s11051-014-2736-0.

[2] L.H. Prentice, M.J. Tyas, M.F. Burrow, The effect of ytterbium fluoride and barium sulphate nanoparticles on the reactivity and strength of a glass-ionomer cement. Dent. Mater. 232(8) (2006) 746-751. https://doi.org/10.1016/j.dental.2005.11.001.

[3] Advanced dental biomaterials, Elsevier (2019) edited by Z. Khurshid, S. Najeeb, M. Sohail, Zafar, F. Sefat

[4] A.T. Florence, Nanoparticle uptake by the oral route: fulfilling its potential? Drug Discov. Today: Technol. 2 (2005) 75–81. https://doi.org/10.1016/j.ddtec.2005.05.019.

[5] S. Dekkers, H. Bouwmeester, P.M.J. Bos, R.J.B. Peters, A. Rietveld, A. Oomen, Knowledge gaps in risk assessment of nano- silica in food: evaluation of the dissolution and toxicity of different forms of silica. Nanotoxicol. 7(4) (2013) 367–377. https://doi.org/10.3109/17435390.2012.662250.

[6] D. Korte, A. Grahovac, A. Jerkič, O. Vajdle, J. Anojčić, V. Guzsvány, B. Budič, M. Franko, Speciation and determination of ionic and trace-level colloidal silver in selected personal care products by thermal lens spectrometry. Pharm. Anal. acta. 9 (2018) 1-10. http://doi.org/10.4172/2153-2435.1000573.