Radiopaque flame-made Ta$_2$O$_5$/SiO$_2$ nanoparticles with controlled refractive index and transparency

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Mixed Ta$_2$O$_5$-containing SiO$_2$ powders with high specific surface area, controlled refractive index, transparency and crystallinity were prepared by flame spray pyrolysis as fillers for dental composites. The production rate ranged from 6.7 – 100 g/h in a lab scale reactor. The effect of the Ta-precursor, the solvent, the total metal concentration and the Ta-content were studied by nitrogen adsorption, x-ray diffraction, light microscopy, HRTEM, DIFTS analysis, as well as the composite transparency within a polymer matrix of dimethylacrylate for dental restoration applications. Filler properties such as transparency, crystallinity and Ta-dispersion in the SiO$_2$ matrix altered the composite performance. Ta$_2$O$_5$ crystallites and a low Ta-dispersion within the SiO$_2$ matrix decreased the filler and composite transparency. Powders with identical specific surface area, refractive index and Ta$_2$O$_5$-loading (24 wt%) showed a wide range of composite transparencies from 33 – 78 % depending on filler properties. Fillers with an amorphous structure, a high Ta-dispersion and a matching refractive index with the polymer matrix showed the highest composite transparency of 86 % for a 16.5 wt% filler loading including 35 wt% Ta$_2$O$_5$ giving an optimal radiopacity.