Optimizing nanoparticle production with aerosol instruments for antibacterial and photocatalytic nanocoatings by Liquid Flame Spray

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Aim of this study is to evaluate antibacterial and photocatalytic activity of nanocoatings, made by Liquid Flame Spray (LFS) aerosol synthesis method (Tikkanen et al.). In LFS method, liquid precursor solution is injected into turbulent H_2/O_2-flame. Due to high temperature of the flame, precursor solution evaporates and generates solid nanoparticles via various aerosol processes. Produced nanoparticles are deposited onto substrate directly from the flame or indirectly, using specially designed deposition tube. In both deposition methods, substrate is covered with nanoparticles from the aerosol. However, when using metal nitrates as precursors, larger residual particles are often observed. To minimize the residual particle formation, process parameters and precursor solvents can be tuned. Process can be monitored in real-time with aerosol instruments, such as ELPI+ and DENSMO (Juuti et al.) and LFS parameters optimized accordingly.

Microscopic glass slides were chosen as substrate material, but other (even heat-sensitive) substrates can be used as well. LFS nanocoating has been previously applied also in roll-to-roll process (Haapanen et al.), which would be beneficial for developing cost-effective antibacterial and photocatalytic surfaces for various applications.

Liquid precursor solutions for TiO_2 and Ag nanoparticles were prepared by mixing titanium(IV) isopropoxide (TTIP) into 2-propanol and diluting $AgNO_3$ into deionized water and ethanol, respectively. Produced nanoparticles were analyzed in aerosol phase by SMPS, ELPI+ and DENSMO for process optimization. Deposited nanoparticles (primary particle size ~30 nm) were analyzed by TEM and SEM. Antibacterial activity was tested with Falcon tube method where o/n growth bacteria (E. coli / S. aureus) was diluted into phosphate buffer saline (PBS). Nanocoated samples were put into Falcon tube containing 1ml PBS and incubated at room temperature for 24 hours. Antibacterial tests were done for Ag and TiO_2 nanocoatings. Photocatalytic activity of the samples was tested by analyzing ability to decompose gaseous acetone in the closed chamber under UV light. Concentration of CO_2 increases in the chamber as acetone decomposes to CO_2 and H_2O via photocatalytis under UV exposure. CO_2 concentration change rate (ppm/min) was analyzed and compared between different TiO_2 coating thicknesses.

Results of the antibacterial and photocatalysis testing show a clear increase in activity as the amount of the nanocoating increases (Figure 1). Coating thickness increases as number of coating sweeps increase. LFS-made TiO_2 nanocoatings are considerably more effective photocatalytic coatings than commercially available Pilkington Activ glass. LFS-made Ag nanocoatings are highly antibacterial according to preliminary antibacterial tests. Further study will focus on combining antibacterial and photocatalytic properties to one nanocoating.

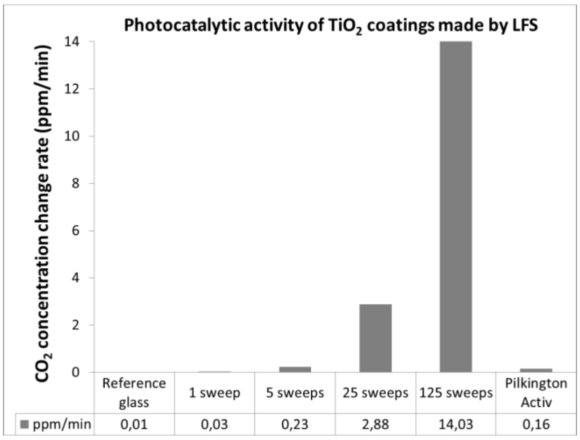

Figure 1: Photocatalytic activity of TiO_2 coatings with different thicknesses (number of sweeps). Higher value means better photocoatalytic activity.

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