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Remove of silver tarnish films by using atmospheric-pressure plasma jets

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Silver was and still is a highly valued metal because of its lustrous surface and its excellent workability. Unfortunately atmospheric gases like hydrogen sulfide and carbonyl sulfide react with surfaces made of silver, thereby generating a dark tarnish film. The main product of silver tarnishing is silver sulfide, which leads to an unsightly change of the silver object's surface. To remove the tarnish film abrasive silver polish consisting of calcium carbonate and distilled water is used in restorer practice. However, due to the abrasive effect a measurable amount of silver is removed with every polish procedure, which leads to a loss of invaluable cultural heritage. This is a major problem especially with silver-plated or fragile artifacts. In the most recent thirty years scientists have investigated low pressure plasma processes as a non-destructive alternative cleaning method. A more competitive and handier alternative is surface reduction with atmospheric-pressure plasma. By using plasma jet that operates with nitrogen and 3.3% hydrogen the tarnished surface can be cleaned within a few seconds depending of the degree of contamination. The silver sulfide is reduced to hydrogen sulfide and pure silver and the blackening disappears. The effects of plasma treatment have been evaluated through the investigation of different silver alloys before and after treatment, by means of different analytical techniques like SEM-EDX, XPS and measurements of reflection by using the Ulbricht sphere. The atmospheric-pressure plasma method has been compared with different silver cleaning methods, like low-pressure treatment, polishing with Paris white and electrochemical cleaning. The advantages of this process are its non-abrasive mode of operation and, in comparison to low-pressure systems, the possibility of local treatment. Furthermore restorers get a novel possibility for treatment of fragile objects and textile artifacts which cannot be cleaned mechanically or wet chemically.

Keywords

cultural heritage
atmospheric-pressure plasma jet
silver sulfide reduction