NOTES ON THE PRESERVATION OF THE NEW WAVE OF MODELING MATERIALS USED IN CONTEMPORARY ART

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Beyond the extreme increase of art materials offered on the market, contemporary artists continue to push the limits of art creation, the concept and artistic intention overcoming traditional media and techniques in a process that can be seen as a quest towards new forms of artistic expression. In this context, modeling materials as those used in industrial 3D printing can be easily found among the choices of modern artists, the objects generated by this new entry level technology receiving their artistic values by projecting them within a dedicated art environment – museum, galley, exhibition. In this preliminary study we discuss the color stability of this new class of modeling materials under controlled accelerated ageing and integrate the obtained data onto the implications surrounding the preservation of these unconventional works of art.

Keywords: contemporary art, preservation, 3D printing, composite materials, accelerated ageing, materials stability, optical properties

1 Introduction

Due to its ability to print complex 3D objects, relatively fast and using various types of prime materials, 3D printing technology has received an increased attention in recent years as a promising method towards a broad area of applications, from industrial concept modeling and functional design analysis, to space engineering [1] or biomimetic microstructures [2]. The technique uses digital designed data (generated either by computer aided design software, or by digitizing the shape of existing objects via 3D scanning) for producing accurate 3D physical models typically in a powder-base process, or other processes that may vary in the way the layers are deposited and in the range of materials that can be used. Despite the chosen manufacturing technique though, the generation of 3D models always involves a few fundamental steps [3] as image acquisition, image post-processing and 3D printing. With recent developments in the field and increasing availability towards cutting-edge technologies, a wider range of applications than those originally designed were attained in the last years, leading to an interdisciplinary research and nonetheless to creative synergies [4]. Under these perspectives the artistic potential of the application soon emerged across the fields of experimental design, art installation, sculpture or architecture, as new

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ways of space construction, perception and projection were within reach. Moreover, the technique can be seen as an inspiring tool not only for 3D modeling for exhibition, but also as part of an innovative form of documentation of artifacts or even archaeological sites [5] that may open up in the future new possibilities for hybrid forms of conservation practices. With the entrance of this unconventional class of modeling materials into the art world some considerations on issues regarding the preservation of these artifacts have to be made, as little or no information exists about the behavior, ageing characteristics or the ways these materials may respond under specific stress conditions or certain restoration treatments. In addition, under the lines of contemporary art, the wide range of materials and techniques that can be encountered within the artworks [6] which often appear with complex stratigraphic distribution or various embedded structures, are situations that rise significant difficulties in the context of scientific analysis and proper ways of preserving the object without affecting its initial expression.

2 Materials and methods

2.1 Sample design

For the evaluation and ageing characteristics of these new-entry-level materials, high performance composite materials as well as a series of infiltrants widely used for 3D printed models were chosen. Samples were first generated as a 3D digital model [Fig. 1] with the use of specialized software and then submitted for 3D printing. A layer grown technique [7] was used for constructing the samples - a series of parallelepipeds on a general block, with the thickness of a layer of 0.1 mm and with a speed of 2-4 layers per minute. As regard the color information, this is added only on the surface of the printed object, the top layers, using a tricolor (cyan, magenta and yellow) printing cartridge. For this reason the samples were printed as a series of true colors and also as true RGB. Two more series were printed, one which remained uncolored and the second one, printed with a gray tone similar to a discolored white surface after infiltration. Depending on the final application and desired features of the 3D models the surface of the pieces is post-processed via different types of infiltration that fills the microscopic pockets of the model and gives specific characteristics. Typically, the infiltrants based on resins can improve the mechanical properties of the models, while the acrylate ones can enhance color saturation, situation useful for surfaces with high resolution photo texture. For the present study, three different types of infiltrants were used: one based on cyanoacrylate, another one based on epoxy resin and a third one, very volatile, with acetone as the main constituent. Two series of samples remained uninfiltrated, as references.

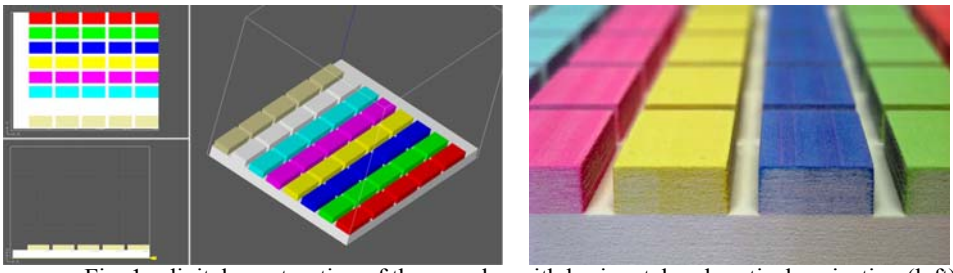

Fig. 1 - digital construction of the samples with horizontal and vertical projection (left); detail on one of the sample block; it can be seen how only the top layers of the printed objects are colored (image on the right)

2.2 Ageing tests

The photo-ageing behavior of selected materials was tested under controlled UV exposure via compact fluorescent lamps with wavelength radiation covering the complete UV region of the spectrum. Samples were photo-aged for 200 hours which would correspond up to a maximum exposure dose of about 0.21 kJ/cm2. In the context of acceleration rate and correlation with real-time scenarios, under UV-A irradiation sources the intensities can be balanced with the radiation dose gained during a year in a typical controlled museum environment based on an average exposure of 2950 hours at 150 lux of near-UV intensities [8]. The shorter wavelengths of the UV region even if usually filtered were considered for interest as they can still be found in more stressful environments or certain improper displays conditions frequently encountered when dealing with contemporary art exhibitions. On another approach, exposures bellow 301 nm were thought to offer a better understanding of the influence of specific wavelengths on the mechanism and type of degradation [9]. In terms of induced thermal and moisture oxidative deterioration, a sub-set of samples were stressed for a period of 30 days in a dedicated climate chamber under a microclimate dynamics of severe temperature (T) and relative humidity variations (RH) at each 24hours: T between 10° and 65°C, RH from 40% to 65%.

3 Results and discussions

The artificially induced ageing effects of the UV exposure and microclimate test were quantified by colorimetric measurements expressed within the CIELAB color scale. A portable spectrophotometer was used to monitor the colorimetric parameters of each sample prior to exposure and periodically during the experiment. For each reading, the lightness – L*, the red/green – a* and yellow/blue - b* coordinates were registered under the standard illuminant D65 using the 10° supplementary standard observer. Further, the delta values

associated and the overall color difference – ΔE* were calculated in order to evaluate the color changes between samples and associated references. Resulted data [Fig. 2] highlights an extremely high-sensitivity within all tested samples, the general color variation exceeding in a proportion of 98.8% of the cases the threshold value of 1.5 reported [10] to correspond to a color change that is visually perceptible. In terms of the applied infiltration products we can hardly distinguish any differences upon light-ageing, on all treated surfaces significant shifts of the L*a*b* coordinates being recorded, with average ΔE* values ranging between 20 and 40. A different response to the above mentioned fading tendency was measured for the series of samples in yellow ink under epoxy resin and cyanoacrylate where much lower ΔE* values are registered while for the uncolored surfaces infiltrated with epoxy resin and acetone base infiltrant no significant variations were recorded under near UV (for cyanoacrylate a yellowing effect was observed). An unexpected increase of the optical properties can be noticed in the case of the untreated samples, as the values of the general color variation are generally lower (ΔE* below 15) at least in the first hours of exposure under near UV. Overall, the extent degree of the color changes can be associated with each ink's sensitivity to light, the influence of wavelength specificity and its effect on the extent of degradation pointing to a maximum activity bellow 315 nm. An exact evaluation of material response to the applied UV-accelerated ageing regimes is difficult though to take into account as for certain situations - like for example the samples infiltrated with cyanoacrylate, discolorations on the same order of magnitude are recorded under all types of UV-light sources. In this last case, the very small variations of the L*a*b* values with the exposure time stresses the fugitive characteristic of these materials, a maximum rate of discoloration being reached from the first stages of irradiation. On regard the microclimate test, the general response points to a relatively good color stability, except the bunch of samples that suffered post-processing treatments with cyanoacrylate and acetone where variations of the colorimetric parameters were measured (average ΔE* value around 10).

At this point of the study, based on the accepted standards of intended use and photochemical stability for materials in conservation [11], investigation of the color output stability with ageing points towards unstable or fugitive Class C materials, considered to be those that would suffer severe degradations in less than 20 years of normal usage in a museum. Still, a direct quantitative evaluation of the induced effects can't yet be done at moment as the colorimetric results shown here are based on narrow spot measurements only, and therefore they should rather be taken as an indicator of color variations patterns that may appear in time.

Fig. 2 – variation of the overall color difference (ΔE*) with exposure time and UV irradiation source on selected test blocks: REF – control samples, CYA – cyanoacrylate, EPX – epoxy resin and ACE – acetone infiltrant block samples; 1 to 8 color set: red, green, blue, yellow, magenta, cyan, uncolored, grey

On a related background, previous research in the field of color 3D printing technologies [12], that have to be taken into consideration in the context of color stability and surface appearance, have shown that color differences can be due not only to the various finishing agents used in post-processing, but also to the position and orientation of the surfaces that directly affects color accuracy and consistency. Starting from this data, a clear understanding of materials characteristics, sensitivity and response to the various aspects that may be encountered during and/or later on manufacturing has to be developed in order to have the possibilities of preserving and maintaining these novel applications within the art and art design area.

4 Conclusions

Despite originally used for rapid prototyping, 3D printing technologies are becoming increasingly exploited among contemporary artists as innovative ways of expression and geometrical representations are possible to achieve. Out beyond the technique's capabilities relies a series of limitations at material level though that induce a certain degree of uncertainty on regard the possible ways of preserving these artifacts in time without a significant loss of their initial plastic expression. The technical evaluation presented here shows an extremely high photosensitivity within all sets of color test blocks that further can be correlated with a high photochemical activity that ultimately may affect the mechanical properties of the substrate. In terms of color stability, care must be considered in post-processing infiltration and/or the various finishing options, as the visually results obtained immediately upon manufacture are not always the best options on the long term, where - as in the case of cyanoacrylate, severe yellowing were recorded under light ageing regimes. Nevertheless, it should not be forgotten that this class of modeling materials are not dedicated to the art market - but rather range at the frontier line, and therefore the restorer may have to confront the transitory nature of these artifacts and adapt the need of innervations and conservation practices.

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