Preservation of Cultural Heritage by Radioanalytical Techniques

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Abstract

Ancient raw materials are degraded and finally destroyed, mainly by humidity taking up dissolved salts from soil, which are deposited on walls surface breaking plasters and material structure as time goes by. This process is added to environment humidity and temperature changes, but in any case is proportional to porosity materials. This is why, such materials as limestone, sand stone and volcanic stones are most difficult to preserve that feldspar or marble, for example. One easy way to measure the relative porosity of any stuff used in the past as raw material, is to cut samples in the shape of small prisms, to weigh each and to place their basis on a layer about 3 mm deep of a Na-22 (0.01 microcuries/ml)radioactive solution during 5 minutes. Once dry out and conditioned in test tubes or small plastic bags, annihilation gamma rays are detected in a low background, well type 3x3" NaI(Tl) scintillation detector, during suitable time to accumulate as much counts as possible. Counts per time unit (seconds or minutes) and per weight (grams of stuff) are a relative measurement of the material porosity, which is always proportional to its absorbing power. So, when other pieces of same stuff are cut in similar way and put in contact with a warm solution (60º-80ºC) of French gelatin (5%), plus potassium sorbate (2.5%) and sodium benzoate (2.5%), warm solution tends to occupy the small air volumes of pores and channels quicker that if it were cold water. About 3 hours later, at room temperature, when the material looks little thicker and brilliant, it is added a concentrate solution (38%) of formaldehyde, about 10-15% of volume of gelatin employed, in order to get tougher and almost quite insoluble in water gelatin, as well as quite unsuitable to create some organic cultures in it, since potassium sorbate and sodium benzoate are used as food conservatives, and formaldehyde is used to preserve corpses. When these pieces are treated with the radioactive solution, in the same way that previous ones, detection counts per time and weight units are reduced dramatically by factors at inverse proportion than those obtained with no gelatin. Also, it is a reversible process; since it is possible to dissolve the gelatin just by washing with warm water (60º-80ºC) while it resists perfectly washing with cold water (20º-30ºC). Based on these laboratory results some pre-hispanic pieces have been treated in Mexico quite successfully, with no problem at all during 3-8 years. This paper presents these results and proposes to perform the procedure in some other mankind's prides such as Haga Sophia, Xian's warriors, Mithraeum in Sutri, Italy, Borobudur in Java island, Indonesia, Sukhothai, Thailand, Ajanta Caves and Maluti Temple in India, and many others all over the world.

Introduction

Ancient raw materials are destroyed by many internal and external agents, but humidity seems to be the strongest one, either in the environment, or even worst coming up from underground by capillarity. In this way, materials capillarity is associated to lower density and weight, but also with larger capacity to absorb humidity, which creates necessary conditions for growing crops on the surface as well as sediments of dissolved salts coming up from soil. On the other hand, any change in the structure of ancient raw materials is against the principles of preservation, even when time and humidity produce first a visible damage on the surface and then a loss of cohesion inside the materials, which finishes breaking them after some years. So, the idea of stuffing materials porosity with some kind of solid, insoluble matter in water, in order to reduce capillarity and humidity absorption, seems to be useless because it is impossible to do it in the whole bulk of material and it would change the nature and aspect of the treated wall or monument. However, we have used a polymer whose properties of transparence, quick formation from aqueous solution and compatibility with organic food preservers such as sodium benzoate, potassium sorbate and formaldehyde seems to be an ideal agent for ancient raw materials preservation, not only for dramatically reducing humidity absorption in direct proportion to capillarity, but to compact and to stick loose material in a practically unnoticeable way.

Experimental

When samples of raw materials such as bricks, quarry stones, adobe or any other material not as tough and dense as marble or granite, are cut in the approximate shape of a prism and placed one side on water, they get completely wet in a matter of few minutes, according their porosity. One very easy way to measure the relative capillarity of each material by comparing to others is to use a $^{22}NaSO_4$ radioactive solution (0.01μCi/ml) and conditioned the over night dry samples in either test tubes or polyethylene bags, in order to be detected in a well type, NaI(Tl) 3x3" scintillation detector. Counts per unit time and weight should be a relative measurement of porosity for several material samples in contact with radioactive solution, during same time and absorption conditions. When similar samples are placed in contact with a warm solution of French gelatin (60-80^{0}C, 5%), added with soluble in water food preservatives such as sodium benzoate (2.5%) and potassium sorbate (2.5%) during few minutes, gelatin begins to solidify after 3-4 hours, and then samples are sprayed with formaldehyde solution (35-38%) to form a tougher gelatin over night. When treated samples are tested for capillarity in the same way that those with no treatment, counts per second and gram are dramatically reduced in direct proportion to original absorption capacity, while their look remains almost the same, except for a light shine on them.

Results

The above results at laboratory level encouraged the use of this procedure at real scale, but with rather small pieces, considering that antiques preservation is a longtime matter, since just time can test the efficiency of any proposed preservation method. However, small antique pieces made out in Mexico with a variety of materials showing a certain absorption capacity or capillarity, have been treated with no visible deterioration effects after 8 years, even when some of them have remained outdoors or in rather poor reservation conditions (1,2,3). As an extreme example we can consider the image of Guadaloupe Virgin, painted on a wall at the beginning of 19th century. The wall is in a corridor with no doors ay both extremes, and presented thick sediments of dissolved salts coming from under ground. Also, a broken pipe line provoked even more humidity and painted plaster pieces fell down to soil. It was necessary to stick first the loose material on the wall by using gelatin plus preservatives as described, and then to cut out the image to be translated and repaired in the workshop, and once the entire wall was treated, to relocate the religious painting on site (Figs. 1, 2, 3), where it has remained with no further damage during 4 years.

Conclusion

In spite of scarce number and small size of treated pieces, as well as short time span, the proposed treatment has not failed till now in any of the tested materials. On the contrary, they look in good condition, with no humidity and no salts deposit on the surface. The only inconvenience found has been some small flakes of old gelatin, easily eliminated either by the use or tweezers or tissue paper soaked up in warm water. Nevertheless, additional good conditions of gelatin treatment are as follows: it can be repeated as many times as needed when time goes by, but also it can be eliminated with warm water (60-80^{0}C) and extracted with tissue paper, if it does not work either to avoid humidity or as binding agent for some particular material, case not found at present. Therefore, it seems that from the surface to some depth in front of raw materials, gelatin forms a thin, soft, elastic layer, insoluble in cold water, but soluble in warm water, whose food preservatives and formaldehyde added protect it both against humidity and any sort of biological cultures. So, there are in the world a great number of ancient monuments, whose preservation seems to need every available mean, in spite of authorities reluctance, and it seems also worthwhile to try out the technique described in this paper. Few examples of this sort are:

Figure 1

Figure 2

Figure 3

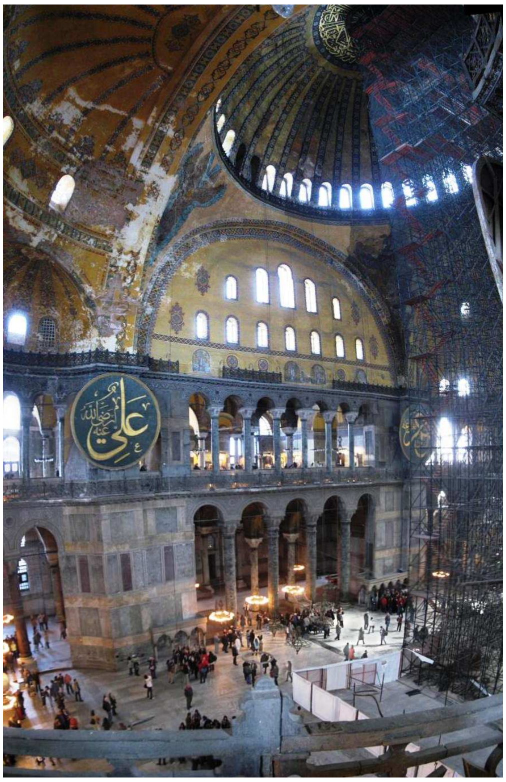

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

Figure 1.- Image of Guadaloupe Virgin, painted on wall plaster in Mexico, at beginning of 19^{th} century, before treatment.

Figure 2.- Same image during treatment, ready to be translated to workshop.

Figure 3.- Same image at present, 4 years after treatment.

Figure 4.- Haga Sophia, Turkey, arc below the roof, attacked by internal humidity.

Figure 5.- Xian's warrior, China, under preservation treatment.

Figure 6.- Painting of Mithraeum, Sutri, Italy, attacked by both, internal and environmental humidity.

Figure 7.- Temple of Borobudur, in Java Island, Indonesia, 9^{th} century

Figure 8.- Sukothai Kingdom, in Thai.

Figure 9.- Ajanta Caves, India, 6^{th} century

Figure 10.- Maluti Temple, India, with organic cultures on the roofs.

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