

# NANORESTORE PAPER®

## Technical Sheet

### OVERVIEW

Nanorestore Paper® dispersions are used for the pH control and deacidification of cellulose-based artifacts. The use of nanoparticles grants good penetration into the porous substrate, quick neutralization of the pH and the formation of an alkaline buffer. These systems represent an alternative to methods that use micron-sized particles and precursors of hydroxides (or carbonates). The use of organic solvents makes Nanorestore Paper formulations® compatible with water-sensitive substrates.

### AVAILABLE FORMULATIONS

**Nanorestore Paper® Ethanol 3:** Calcium hydroxide nanoparticles dispersed in ethanol at a concentration of 3 g/L. These particles are specifically designed for pH control and deacidification purposes.

**Nanorestore Paper® Ethanol 5:** Calcium hydroxide nanoparticles dispersed in ethanol at a concentration of 5 g/L. These particles are specifically designed for pH control and deacidification purposes.

**Nanorestore Paper® Propanol 3:** Calcium hydroxide nanoparticles dispersed in 2-propanol at a concentration of 3 g/L. These particles are specifically designed for pH control and deacidification purposes.

**Nanorestore Paper® Propanol 5:** Calcium hydroxide nanoparticles dispersed in 2-propanol at a concentration of 5 g/L. These particles are specifically designed for pH control and deacidification purposes.

**Nanorestore Paper® Test Kit:** This kit includes 100 ml of Nanorestore Paper® Ethanol 3 and Nanorestore Paper® Propanol 3. It could be used for preliminary tests, in order to choose the best formulation for your specific need.

### WHEN ARE THEY USED?

Acidity affects several types of artworks, leading to their weakening. For instance, cellulose-based artifacts, such as paper, wood and canvas exhibit loss of mechanical properties due to acid hydrolysis of cellulose. It is therefore necessary to counteract acidity through the neutralization of the pH and the application of an alkaline buffer on the endangered material. Nanorestore Paper® dispersions are specifically designed for the pH control and deacidification of these artifacts.

#### OK to be used for

- Deacidification and pH control of blank paper
- Deacidification and pH control of printed books
- Deacidification and pH control of iron and metal gall ink manuscripts
- Deacidification and pH control of wooden artifacts
- Deacidification and pH control of canvas, i.e., backside of easel paintings

□ *For different applications, it is advised to contact us for assistance. We will be glad to help you in finding the best solution for your conservative need.*

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## HOW DO THEY WORK?

Calcium hydroxide nanoparticles of Nanorestore Paper® formulations adhere to the cellulose fibers, and rapidly neutralize acidity on site. The excess of particles reacts with CO<sub>2</sub> in the atmosphere, turning into carbonate, granting protection against reoccurring acidity.

## HOW ARE THEY USED?

### General features

Nanorestore Paper® formulations are specifically designed for the pH control and deacidification of cellulose-based artifacts. Calcium hydroxide nanoparticles are used to raise the artifacts pH around neutrality (7.0-8.0). Neutrality prevents the degradation of cellulose due to acid-catalyzed hydrolysis and also hampers metal-catalyzed oxidation.

### Storage

Nanorestore Paper® dispersions are shipped in HPDE bottles, which should be kept firmly closed to prevent the contact between calcium hydroxide nanoparticles and air, to avoid the clustering of particles and their carbonation. The contact between nanoparticles dispersions and humidity has to be avoided too. Water doesn't affect the effectiveness of Nanorestore Paper®, but it may cause changes in nanoparticles size. Bigger particles than the ones originally present may result in white haze on the treated surfaces, which has to be promptly removed. Nanorestore Paper® formulations contains no additives and are formulated to prevent sedimentation. Even though, after long storage, it is recommended to shake energetically the dispersion before use.

### Safety

Nanorestore Paper® dispersions should be handled with care, following the same standard operating procedure recommended for ethanol and 2-propanol. Therefore, the formulations must be used in the presence of good air ventilation, and should be handled wearing goggles and gloves. Nanorestore Paper® dispersions cannot be used in presence of open flames, sparks, and hot surfaces.

### Preliminary tests

Before the application, pH measurements on the substrate should be carried out (**Fig. 1.2**). Depending on the type of artifacts, measured can be carried out by cold extraction (TAPPI T 509 Om-2, ASTM D778-97 2002) or on the surface (TAPPI T529 Om-88). A deacidification treatment is needed when the measured pH is lower than 5.5. Before the application of Nanorestore Paper® dispersions, the compatibility between the artifacts and the chosen system should be checked (**Fig. 1.1**). Solvents included in the Nanorestore Paper® formulations are suited for most of the interventions performed in restoration.

### Dilution (optional)

Nanorestore Paper® dispersions are available at a concentration of 3 g/L or 5 g/L. It is worth noting that for standard applications, a concentration of 2.5-3 g/L is advisable. In the case of low porous substrate, white hazes can be seen on treated surface. To avoid the formation of these hazes, each Nanorestore Paper® dispersion can be diluted to the appropriate concentration by using the corresponding pure and anhydrous solvent (it is important that the chosen solvent does not contain water).

### Choosing the right amount of dispersion to be used

The calculation of the precise amount of nanoparticles needed to deacidify a substrate is not feasible in many practical cases, because several parameters, including starting pH, paper grammage, and substrate porosity, should be considered. Please, note that an excess of particles has positive effects, because it grants the formation of an alkaline buffer on the treated surface. The suggested values reported below are based on real case studies, but it should be noted that the amounts needed may vary from case to case.

**Example 1:** 1L of Nanorestore Paper® dispersion at 3g/L can be used for the neutralization of 24 m<sup>2</sup> of paper having a starting pH of 5 and a grammage of 80 g/m<sup>2</sup>.

**Example 2:** 1L of Nanorestore Paper® dispersion at 3g/L can be used for the neutralization of 16 m<sup>2</sup> of paper having a starting pH of 4 and a grammage of 100 g/m<sup>2</sup>.

*For different application, do not hesitate to contact us for assistance. We will be glad to help you in choosing the right amount of dispersion needed for your specific case.*

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### Application

Nanorestore Paper® dispersions are typically applied either by brushing, by spraying over the artifact's surface, or by immersion of the artifact into the dispersion (**Fig. 1.3**). If possible, both sides of the object should be treated, in order to grant a homogenous distribution of nanoparticles within the substrate. It has been reported that nebulization and spraying of dispersion can be used to avoid the solubilization of modern inks that are usually sensitive to alcohols. In general, it is advisable to saturate the substrate with nanoparticles dispersion, wait for the evaporation of the solvent and then apply again the treatment until the given volume of dispersion is applied.

### After the application

After the application of Nanorestore Paper® dispersions, it is advisable to keep treated artifacts at about 60% RH and room temperature for 10-15 days, in order to favor the conversion of calcium hydroxide to carbonate (**Fig. 1.4**), and then check the pH (**Fig. 1.5**). If the pH is lower than 7, it is recommended to apply again the dispersion until neutrality is reached. If the formation of an alkaline reserve is desired, higher amount of Nanorestore Paper® should be applied after neutralization. The following values are based on real case studies, but it should be noted that the amounts needed may vary from case to case.

Example 1: for paper having a starting pH of 5 and a grammage of 80 g/m<sup>2</sup>, the formation of a 1-2% alkaline reserve requires the application of another 200mL at 3g/L concentration per square meter (100mL front, 100mL backside).

Example 2: for paper having a starting pH of 4 and a grammage of 100 g/m<sup>2</sup>, the formation of a 1-2% alkaline reserve requires the application of another 200mL at 3g/L concentration per square meter (100mL front, 100mL backside).

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## APPLICATION GUIDELINES AT A GLANCE

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**Goggles** Yes

**Gloves** Yes

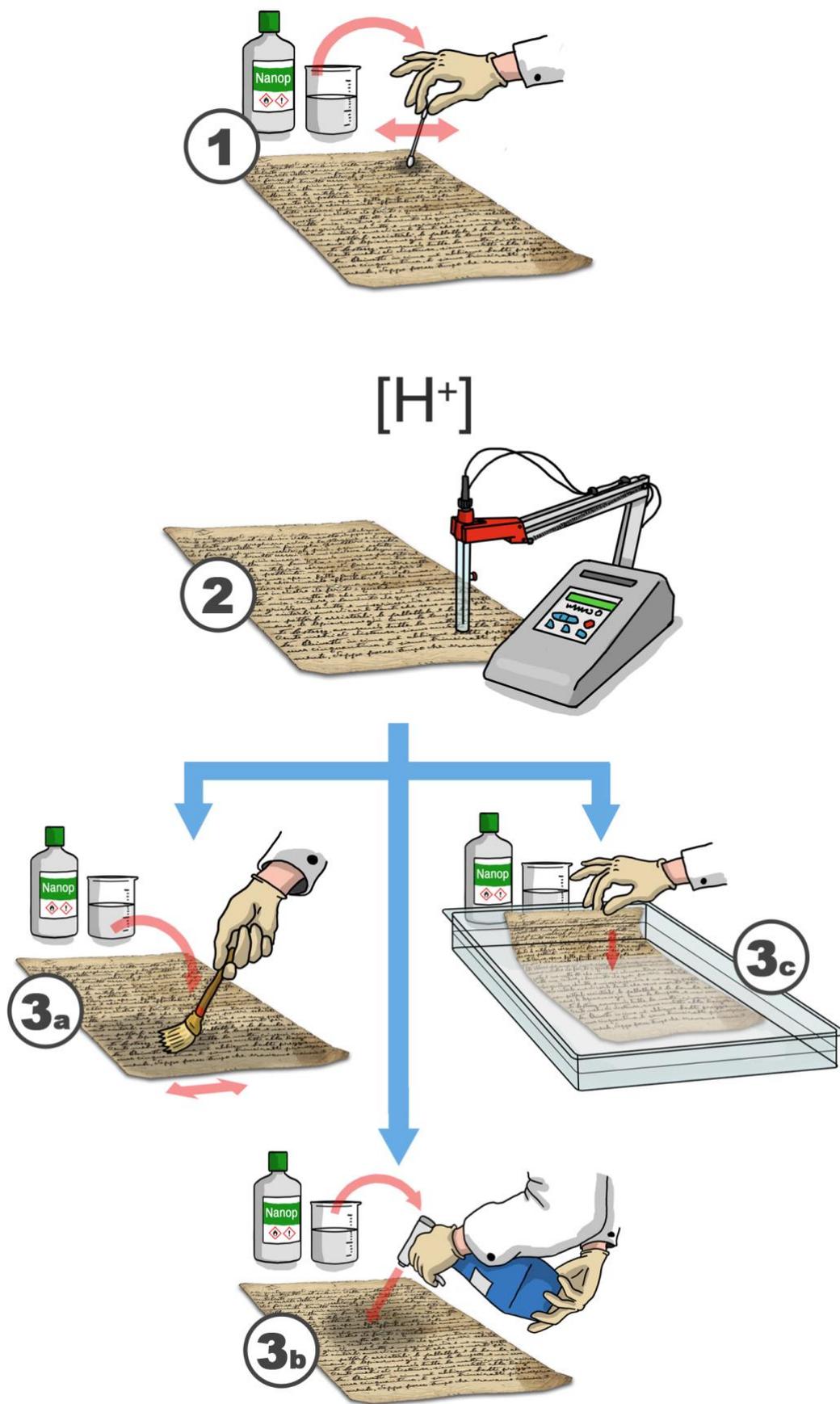
**Ventilated hood or environment** Recommended

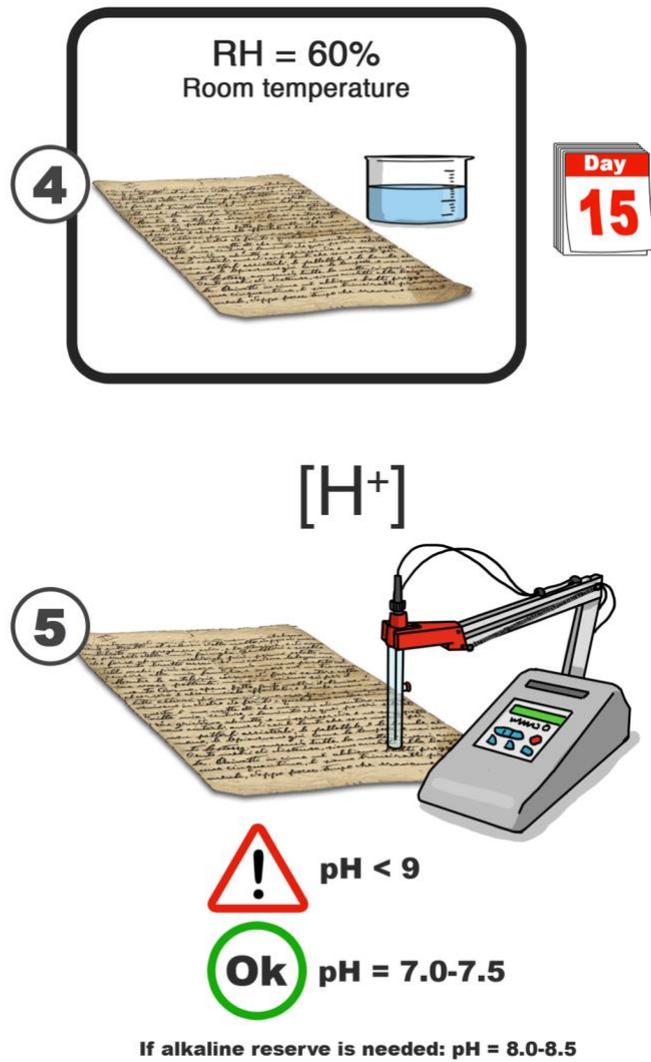
**Starting pH** Typically, deacidification is needed if pH is lower than 5.5

**Recommended final pH** For standard application, pH should be around neutrality (7.0-8.0)

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FIGURES





**Figure 1.** Application of Nanorestore Paper®.

- (1) The compatibility between the artifact and the chosen system should be checked.
- (2) Before the application, a pH measurement on the substrate should be carried out.
- (3) Nanorestore Paper® is applied either by brushing (a), by spraying (b), or by immersion of the artifact into the dispersion (c).
- (4) After the application, it is advisable to keep treated artifacts at about 60% RH and room temperature for 10-15 days, in order to favor the conversion of calcium hydroxide to carbonate.
- (5) Check pH of the treated artifact.

## REFERENCES

Further information can be found in the following textbooks:

1. Piero Baglioni and David Chelazzi. *Nanoscience for the Conservation of Works of Art*. Royal Society of Chemistry, 2013.
2. Piero Baglioni, David Chelazzi and Rodorico Giorgi. *Nanotechnologies in the Conservation of Cultural Heritage: A Compendium of Materials and Techniques*. Springer, 2014.

For technical questions:

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