Multifunctional Hydrogels for the Cleaning of Paper Samples

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Abstract

The characterization and application of rheoreversible, hydrophilic and biocompatible gels based on poly(ethylene oxide) or poly(ethylene oxide)-poly(propylene oxide)- poly(ethylene oxide) and α-cyclodextrin are presented. These gels have been used to clean several paper samples. The advantage of using rheoreversible gels resides in the easiness of removing completely it, avoiding an invasive gel remotion and liquid treatment, procedures that can induce damages on paper, a fragile material. FTIR spectroscopy, SEM, HPLC and pH investigations and chemometric analysis show that these gels by themselves were able to remove patina from paper.

Introduction

Paper is probably one of the most difficult media to be restored, due to its inherent fragility, its degradation processes and the numerous materials present in it; therefore a cleaning treatment may cause irreversible damage. One of the commonly methods used for paper cleaning is the application of solvents (organic or not) that may cause swelling and dissolution of some components, and is harmful for operators [1].

An innovative methodology to overcome these problems is the application of cleaning agents entrapped in gel matrices. However, the removal of the gel residuals often requires the use of abrasive mechanical action or solvents and not removing such residuals could promote the growth of microbials, resulting in damage for books and documents. An approach to minimize removal problems could be the use of a rheoreversible gel whose sol-gel transition is highly sensitive to external, mechanical or physicochemical stimulus [2].

In this paper we report the results obtained by using two rheoreversible hydrogels as cleaning agents for paper materials. These gels are made up of polyethylene oxides (PEO) or poly(ethylene oxide)-poly(propylene oxide)-poly(ethylene oxide) (PLU) and α-cyclodextrin (α-CD)[3]. The compatibility of the gels with papers and their efficiency in removing patina from new and aged paper samples were tested.

Materials & Methods

We have prepared two kind of gels that differ in the polymer used (PEO MW=100000 in the first, PLU in the second), and in the cavitand/polymer ratio, modifying slightly a procedure reported elsewhere [3,4]. Not aged commercial filter paper (soiled with linseed oil or not) has been used as model sample to test the compatibility and removability of our systems. To acquire the long term effect of hydrogel treatment, the cleaned papers were artificially aged in an oven at 90°C (RH= 25%) for 10 days .The hydrogels were also used to clean real samples (RS) that are papers sheets part of the printed volume "*Theatrum Veritatis and Justitiae*" Venezia, (1735).

Every hydrogel was applied on paper samples with a spatula and left to act for fixed time (15, 30 or 45 minutes); then, it was removed with a soft brush.

The results of our proofs were analyzed by using m-FTIR ATR, NIR, SEM, pH and HPLC measurements. NIR data have been coupled to chemometric analysis. Here we present some of our results.

Results

m-FTIR ATR and NIR spectra performed on paper samples before and after gel application are comparable (see in Fig.1 m-FTIR spectra of RS sample), indicating that no gel residues are present after cleaning processes. These results are confirmed by HPLC measurements performed on aqueous extracts of samples, as in the chromatograms no peaks attributable to gels are present (data not shown). HPLC and pH measurements on RS samples cleaned with gels indicate that gels are able to remove the acidic components due to paper aging, as can de deduced from the attenuation of some chromatographic peaks and the pH increasing from 7.8 to values close to the optimal one for cellulosic material (8.9). IR measurements performed on filter paper soiled with an hydrophobic contaminants (linseed oil) and cleaned with gels, show that the gels are able to clean oil from paper as IR peaks due to oil are absent in treated samples spectra. PCA analysis performed on NIR data rationalizes this result (Fig.2 and 3). This analysis is clearly able to highlight the sample containing linseed oil (point G), and, consequently, the ability of our hydrogels to remove it. In particular, paper samples soiled with oil and then treated with PLU or PEO hydrogels for oil removal (H,I respectively) fall in a region of the PC plot very close to the untreated paper samples (A). Spectroscopic experiments and PCA analysis performed on artificially aged samples indicate that treatment with gels does not induce long-term damages on paper.

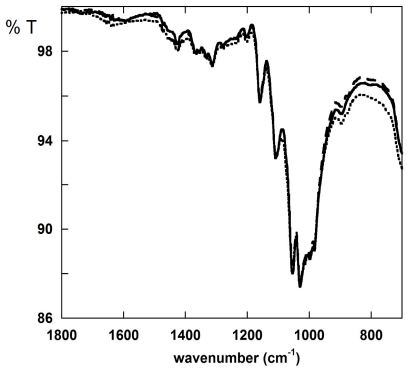

Fig.1 m-FTIR spectra of RS samples. Dotted line: no treated paper; continuous and dashed lines: paper cleaned using PLU or PEO gel.

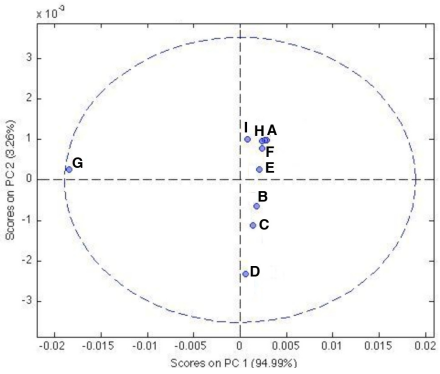

Fig.2. Projection of filter paper samples onto the space spanned by the first two principal components: (A) untreated; (B-D) treated with PEO gel for 15, 30, 45 minutes; (E-F) treated with PLU gel for 15 and 45 minutes; (G) loaded with linseed oil; (H-I) loaded with linseed oil and treated with PEO or PLU gel.

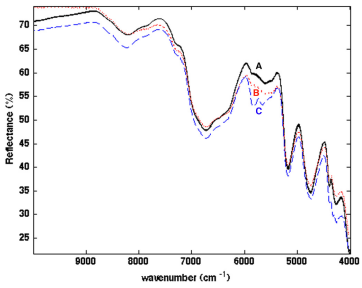

Fig. 3. NIR spectra of (A): B-D and H samples; (B): A, E, F and I samples; (C): G samples (see Fig. 2).

Conclusions

These reported results indicate that the presented systems represent a promising method to clean paper artworks, as they are more efficient of the alternative procedures, easy-to-prepare, relatively cheap and safety.

References

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