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THE EVALUATION OF SOME CONSOLIDATION AGENTS APPLIED IN THE CONSERVATION OF GRAPHICAL DOCUMENTS

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Abstract

Specific features of some exudate gums from species *Prunus*, and of some cellulose ethers, traditionally used to consolidate graphic documents on paper support are analyzed. Structural characteristics of polymers are related to the adhesive properties and physico-mechanical behaviour of consolidated papers. Results allow to the optimization of the consolidation technology and establishing of properly areas of utilization.

Keywords: Prunus domestica gum, Prunus avium gum, adhesives, carboxymethylcellulose, methylcellulose

1. Introduction

The restoration issue has a great importance for conservation of cultural heritage on paper base. An important step in the process of restoration–conservation of books and documents represents the consolidation operation, resticking and reassembly of elements constituting the artefact.

Since its appearance, cellulose ethers, especially water soluble ones, had a special interest, despite incomplete information concerning their stability over time [1], being frequently used as adhesives, consolidants, protective coating and fixatives, alone or mixed with starch paste [2-5].

In past times, because of remarkable adhesive properties, the vegetable gums were used in the manufacture of ink, of some paper materials or in manuscripts ornamentation [6]. The vegetable gums are gluey exudates, secreted as a result of pathogenic action, by the attack of microorganisms, from injuries of trees or can be extracted from wood by boiling in water [7].

The term gum generally defines hydrophilic and hydrophobic molecules with high molecular weight possessing colloidal properties. The exudate gum from some species of *Prunus* has been widely used in Europe in the 19th century. The gum from *Prunus cerasus* is often mentioned, but gums resulted from almond tree, plum tree, apple tree and pear tree have similar properties. They are

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partially soluble in water, often forming gels, and can be used as additions in tempera painting [8].

The consolidation agents used in restoration-conservation of graphic documents based on natural polymers and their derivates are classified according to the origin and nature of the obtaining chemical reactions [9] (Figure 1).

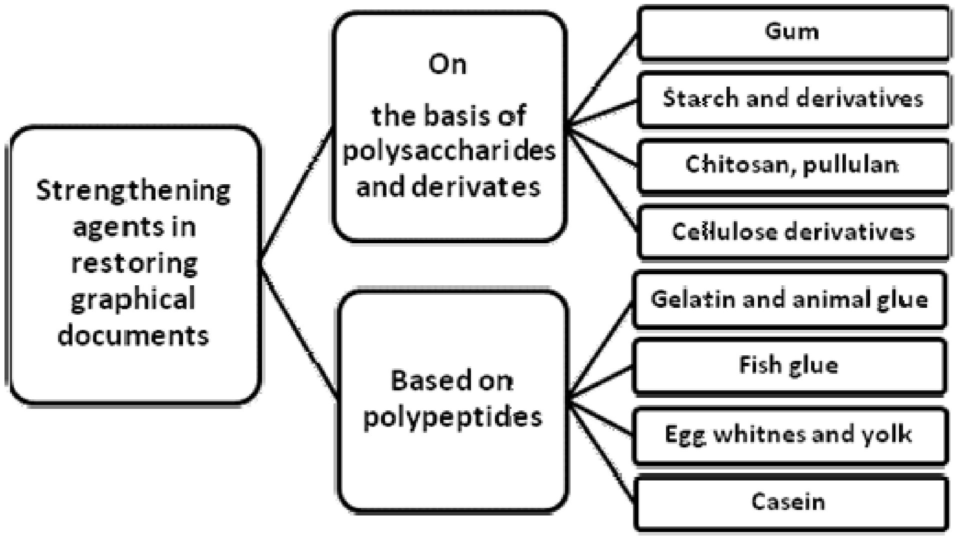

Figure 1. Classification scheme of main natural polymers and their derivatives with applications in restoration-conservation of graphic documents.

The adhesives based on natural products have been used since ancient times for a large variety of supports: wood, stone or metal [10]. Adhesives are products able to maintain together two components by surface bonds [11].

To assess the adhesive properties of cellulosic ethers and vegetable gum, initially are studied the capacity of adhesive to bond similar specimens. For adhesion surface and constant amount of adhesive it was pursued the adhesion strength till the specimen will break.

In the following we examine some rheological behaviour of paper consolidated with exudates gums and cellulose ethers.

2. Experimental

2.1. Materials

Support materials:

- Unsized linters paper with a basis weight of 40 g/m^2;
- Drawing paper with a basis weight of 200 g/m^2.

Adhesives – consolidation agents:

- Carboxymethylcellulose (CMC)
- Methylcellulose (MC)
- Exudate gum from *Prunus domestica* (P)
- Purified exudate gum from *Prunus domestica* (PMm)
- Exudate gum from *Prunus avium* (C)
- Purified exudate gum from *Prunus avium* (CMm)

Exudate gums from *Prunus domestica* species (plum tree) and *Prunus avium* species (cherry tree) were collected as exudates from trees coming from a private orchard in the south-eastern region of Husi, Vaslui department (Romania). After collection, gums were dried at room temperature and grinded. Dissolution and purification of gums was performed according to the next scheme (Figure 2).

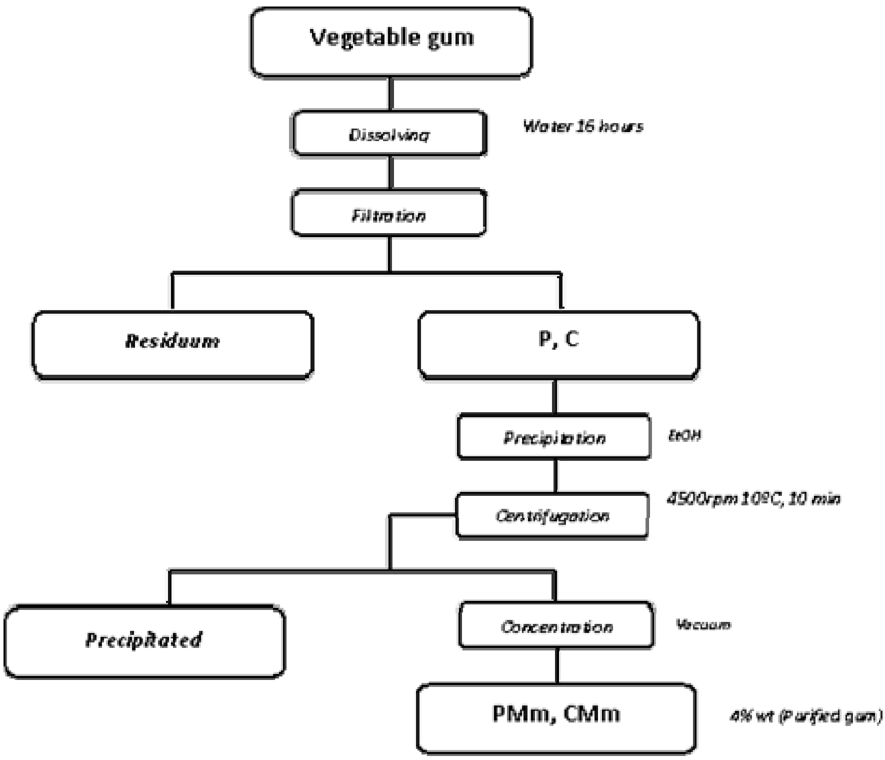

Figure 2. Scheme for obtaining and purifying vegetable gums.

2.2. Methods

Samples of drawing paper with a basis weight of 200 g/m^2 and dimensions L = 80 mm, l = 20 mm were used to determine the adhesive properties of cellulose ethers and vegetable gums. The surface area of gluing was $S_{gluing} = 400$ mm^2 (see Figure 3).

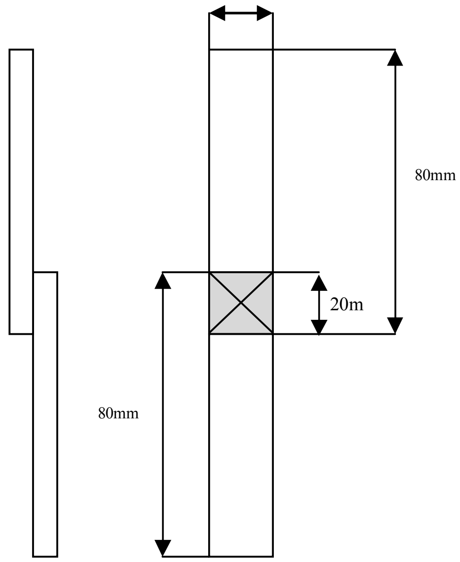

Figure 3. Working scheme for determining the adhesion resistance.

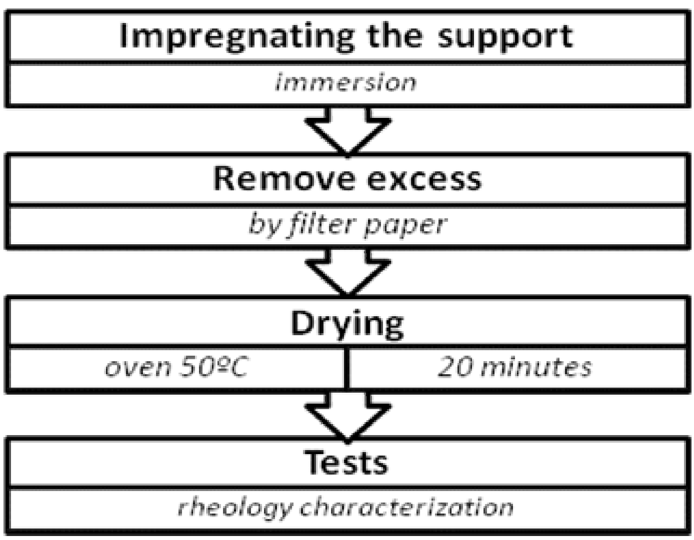

Figure 4. Working scheme for paper consolidation

The bonding was achieved between two specimens with adhesive solution (1% concentration) on the surface of 400 mm^2. After the adhesive applying, the samples were pressed under constant weight of 500 g in order to achieve adhesion on the mentioned surface and were dried in a drying oven with air ventilation at 50ºC for 20 minutes. The specimens were subjected to tensile request using the Instron device which registers the adhesive strength, according to ISO 1924-2/1995.

In the second part of the study, linters paper (40g/m^2) was treated by impregnation with adhesive/consolidation agents according to Figure 4. The concentration of adhesive solutions was 1% and the adhesive amount, after impregnation, deposited on paper was of 11 g/m^2. After oven drying at a temperature of 50°C, the conditioned paper samples were subjected to tensile test in order to establish some rheological characteristics of the treated paper.

3. Results and discussion

3.1. Determination of adhesive properties

The adhesive capacity of the consolidation agent provides the required properties to consolidate paper (resistance, flexibility, aesthetics valences).

The adhesion strength of purified (PMm, CMm) and unpurified (P, C) vegetable gums was compared with adhesion strength developed by cellulose ethers (CMC, MC). The results are presented in Table 1 and Figures 5-7.

Table 1. The adhesion strength values of vegetable gums and cellulose ethers.

Adhesive amount (g/m^2)	**Shearing stress (MPa)**					
	P	**C**	**PMm**	**CMm**	**CMC**	**MC**
0.25	13	13	13	18	81	114
0.50	26	28	61	89	115	132*
0.75	63	69	132*	132*	132*	-
1.00	88	94	-	-	-	-
1.50	115	121	-	-	-	-
2.00	132*	132*	-	-	-	-

Observation: The paper breaking occurs at 132 MPa.

As can be seen in Figure 5, no significant differences are registered for the investigated gum for the developed adhesion strength. The shearing strength of adhesive exceeds the tensile strength of paper irrespective of the type of exudate gums when the amount of adhesive is of 2 g/m^2.

Purified vegetable gums showed an adhesive capacity higher with 50% when compared with the unpurified ones. Furthermore, the purified exudate gum from *Prunus avium* (cherry tree) behaves better than that from *Prunus domestica*.

The adhesion strength induced by cellulose ethers, especially MC, is superior to the vegetable gums. The behaviour can be explained by the significant differences of molecular weights of polymers. A complete justification for this comportment of the analyzed adhesives needs further investigations.

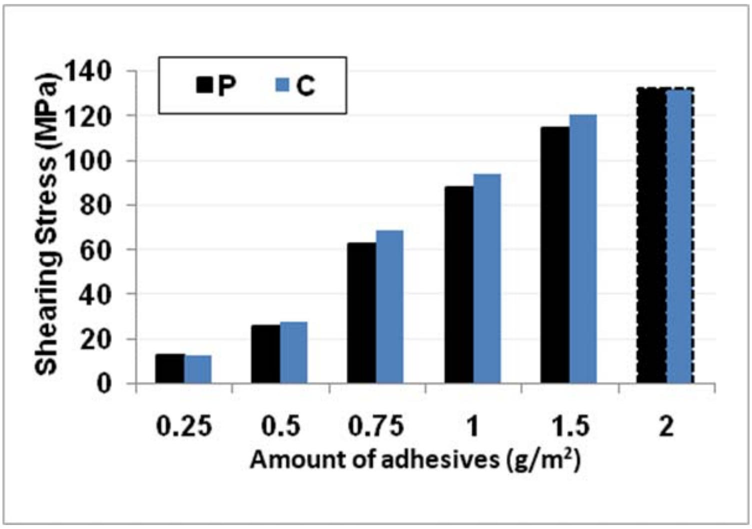

Figure 5. Adhesion strength developed by unpurified vegetable gums (P, C) as a function of the amount of added adhesive.

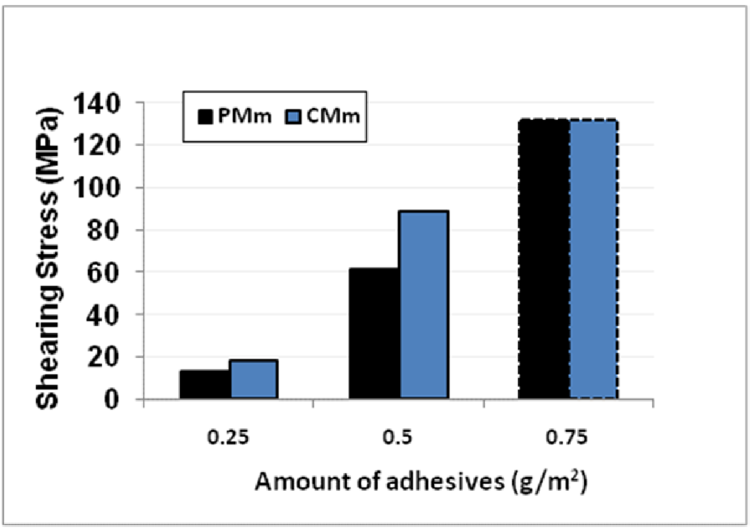

Figure 6. Adhesion strength of purified vegetable gums (PMm,CMm) vs. addition of adhesive.

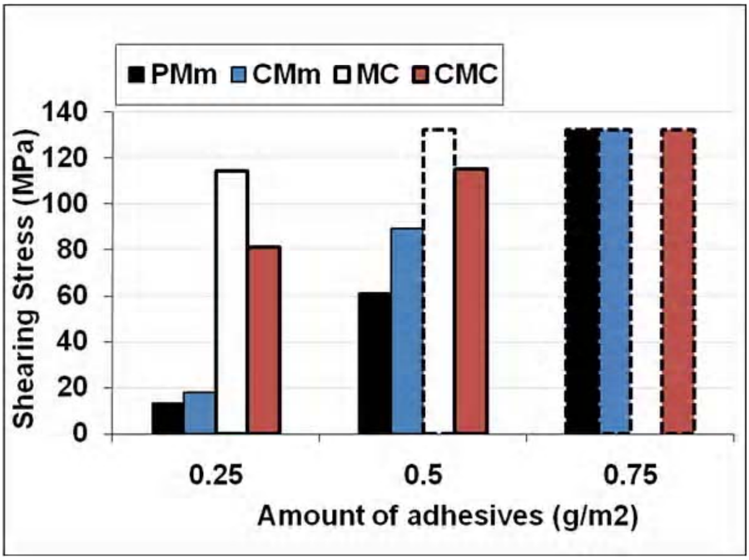

Figure 7. Adhesion strength developed by purified vegetable gums (PMm,CMm) and cellulose ethers (CMC, MC) depending on the addition of adhesive.

3.2. Rheological characterization of consolidated paper

The rheological characteristics of consolidated paper were expressed by: breaking length (km), elongation (%), modulus of elasticity (MPa), and tensile energy absorption (J/m^2) (Figures 8-11).

For the same amount of adhesive per unit area of paper, breaking length increases in the order: raw vegetable gums, cellulose ethers. Purified gums give strength characteristics located at CMC level.

Breaking length increases when the paper is strengthened, with no significant differences between agents used in consolidation.

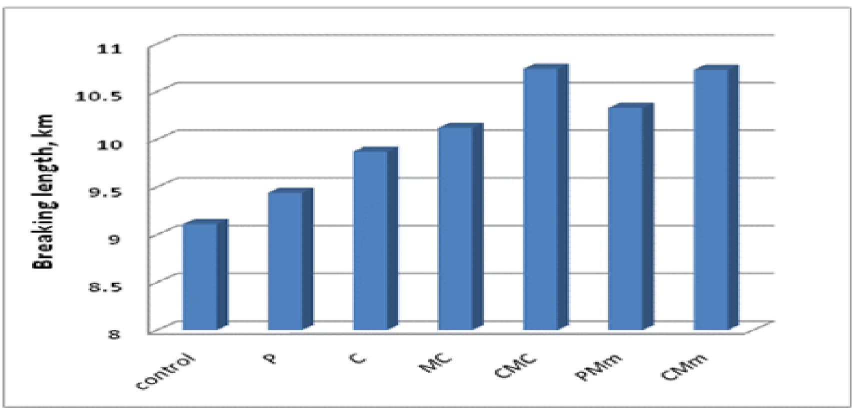

Figure 8. Breaking length of the samples impregnated with different adhesive type.

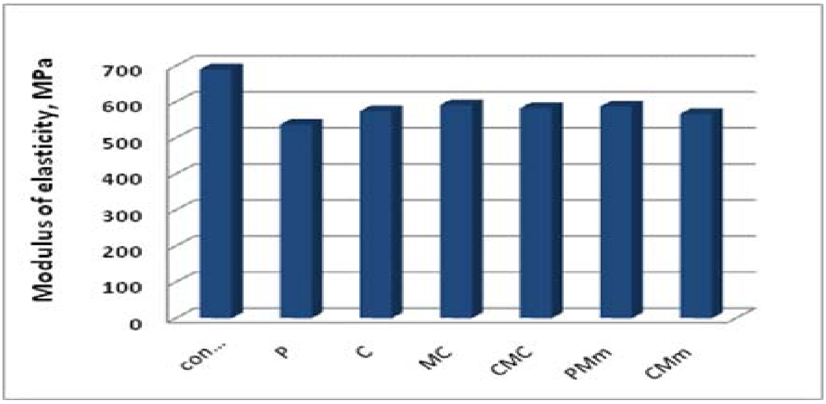

Figure 9. Effect of adhesive type on the modulus of elasticity of impregnated samples.

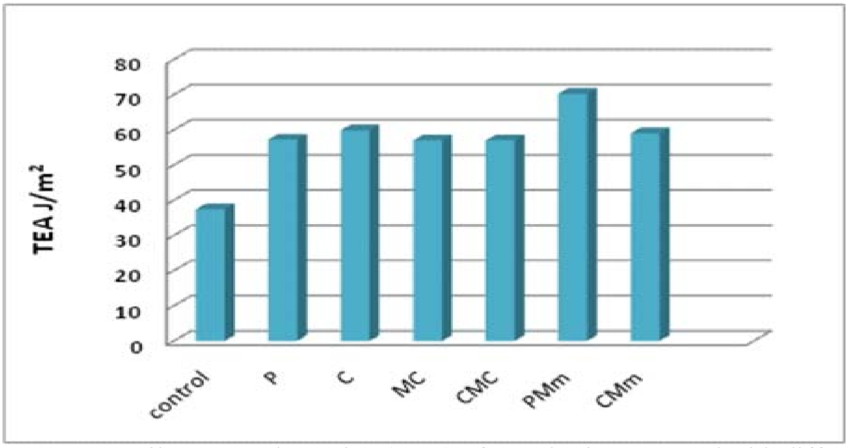

Figure 10. Tensile energy absorption (TEA) of samples impregnated with different adhesives/consolidants.

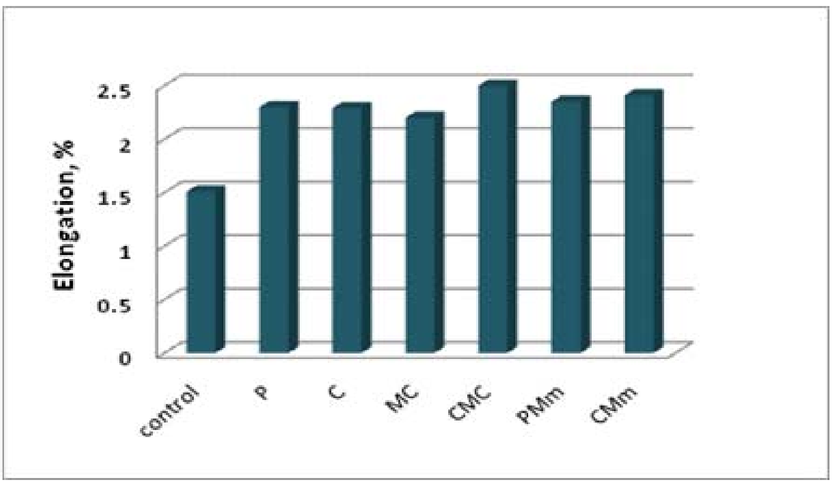

Figure11. Elongation at failure of sample impregnated with different adhesives/consolidants.

The obtained values for modulus of elasticity are probably imposed by the structural features acquired by strengthening support.

Mechanical work at break presents significant increases and closed values for supports treated with gums (CMC and MC). Purified vegetable gums give higher values for these rheological characteristics.

4. Conclusions

1. The adhesive properties were rated for some vegetable gums, used for the consolidation of graphic documents in the processing of metalo-gallic inks and for pigments fixing until the 20th century. They were compared with adhesion resistance conferred by the main cellulose ethers involved in the restoration-conservation of books and documents on paper support.

2. The adhesion resistance is higher in CMC and MC case, as a consequence of their structural features.

3. The rheological characteristics established for paper support: breaking length, elongation, modulus of elasticity and tensile energy absorption distinguish the specific features of the analyzed adhesives.

4. Tensile energy absorption is a characteristic that indicates with more sensitivity the effects of additives on consolidated paper.

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