Studies on the Polysaccharide JunFunori Used to Consolidate Matt Paint

Thomas Geiger and Françoise Michel

*Funori* is a polysaccharide extracted from the red alga *Gloiopeltis furcata*. This polysaccharide is generally known in conservation for its advantages as a product to consolidate matt paint. Because of variations in quality of the traditional *Funori*, the authors developed an extraction method and a purification procedure to obtain the pure polymer called *JunFunori*. The improved consolidant was tested in comparison with traditional aqueous consolidants such as gelatine, sturgeon glue, *Klucel E* (hydroxypropylcellulose) and *Methocel MC* (methylcellulose). The investigations showed that, in contrast to consolidation using *Klucel E* and *Methocel MC*, consolidation using *JunFunori* hardly changes the appearance of an unbound pigment layer consisting of a mixture of vine black and chalk on canvas. Accelerated ageing tests with simultaneous ultraviolet (UV) irradiation and variations in humidity, in combination with mechanical tests and Fourier transform infrared (FTIR) analysis, demonstrated that *JunFunori* shows good stability under these specific conditions. In viability tests *JunFunori* was as resistant to biological attack as the other consolidants tested. These results indicate that *JunFunori* demonstrates high potential as an alternative to traditional consolidants.

**INTRODUCTION**

Matt paints have been found at all periods and in all cultures. Prehistoric cave paintings or illuminated manuscripts, as well as chalk drawings by Joseph Beuys, are just some examples. Matt paint scatters the light from the rough surface, appearing matt and bright [1]. The reason for this is the high pigment volume concentration (PVC) of the paint [2]. Such paints often have poor cohesive and adhesive properties and are therefore not particularly stable against mechanical stress. Furthermore, the adhesive strength between the pigment particles decreases when the binder degrades with ageing. The paint starts to powder and chalk, or flaking of the paint layer occurs, and a conservation treatment is essential. The consolidation of matt paint is one of the most challenging aspects in conservation. It needs a consolidation system 'that minimizes changes in appearance, introduces the minimum quantity [of consolidant] necessary to achieve effective cohesion of the paint and adhesion of the paint layer to the substrate, and is compatible with the paint and support materials in the long term' [3]. Commonly used aqueous consolidants like gelatine, sturgeon glue and the cellulose ethers *Klucel E* and *Methocel MC* often produce undesired gloss, darkening, stains or tide lines and alter the aesthetic of the object.

A possible means of solving some of the consolidation problems with matt paint is through the use of the polysaccharide *JunFunori* extracted from the red alga *Gloiopeltis furcata*. This typically grows in the intertidal zones of the Pacific coast of Japan, Korea, South China and North America [4, 5]. Investigations of the structure of the polysaccharide from the *Gloiopeltis* family showed that the monomer units of the polymer are comparable to those of agar and carrageen [6—11]. One of the isolated regular repeating units was \( \rightarrow \)\( β\)-D-galactose-6-sulphate-(1→4)\( 3\),6-anhydro-L-galactose(1→\( \rightarrow \)), which is an ideal 6-sulphonated agarose.

In Japan, the red alga extract, historically called 'Funori', has been successfully used for many decades in paper conservation or to clean kimonos [12—14]. In the last 20 years, Funori has also become known to conservators outside Japan as a consolidant, suitable for matt paint especially, and for its cleaning properties [15—24]. Funori, like other natural products, is obtained from different places of cultivation and from varying treatment procedures undertaken by different producers, which means that Funori is often of variable quality. To minimize unwanted impurities and variations in the quality of the red alga, and to obtain the pure ('Jun') polysaccharide *JunFunori*, the authors developed an extraction method and a purification procedure. Before *JunFunori* was applied in a conservation treatment, its purity, usability and stability under the influence of ultraviolet (UV) radiation, humidity and biological attack were tested. This paper reports the results of consolidation tests, mechanical tests, accelerated ageing and Fourier transform infrared (FTIR)
analysis performed on JunFunori in comparison with other aqueous consolidants like gelatine, sturgeon glue, Klucel E and Methocel MC.

EXPERIMENTAL

Extraction and purification of JunFunori
The red alga *Gloiopeitls furcata* (50 g) was washed twice with deionized water (1 L) with intensive stirring for 5 minutes. Deionized water at a pH of 6.5 and a conductivity of 4.5 µS·cm⁻¹ was used for extraction, purification and consolidation. During washing, the red alga swelled to a small degree. Conductivity, monitored using a conductivity meter (Conductivity Meter CDM83 from Radiometer Copenhagen) during the whole procedure, was found to be negligible at the end of the washing. Subsequently, the thalli of the red alga were filtered and finely chopped with a sharp knife to obtain a slimy mass. Extraction of the mass was performed with deionized water (6 L) with intensive stirring at 40°C for 3.5 hours. Meanwhile, the extract turned into a coloured, turbid, highly viscous solution. After extraction, charcoal (100 g) was added and the solution was stirred again at 40°C for 30 minutes. The solution was centrifuged at 5000 rpm for 30 minutes in order to remove all insoluble components. Subsequently, the warm solution was pressure-filtered through a fibreglass filter (mesh size <1 µm) at 8 bar. Evaporation of water from the purified extract at 60°C over two days led to the formation of a thin film of the polysaccharide, which was milled for later use.

Consolidation tests
Consolidation tests were performed with unbound pigment layers (a grey mixture of one part vine black and one part chalk) applied to canvas (linen with 16 threads per centimetre in warp and weft directions). Although several pigments and mixtures were tested, only results obtained for the mixture of vine black and chalk are presented here because changes in the appearance of this grey pigment mixture were the most easy to observe. The pigments were sieved and stirred in deionized water for several hours. Then they were filtered through a fine tissue and applied to canvas with a brush two or three times. The thickness of the pigment layers ranged between 50 and 130 µm. Next, each unbound pigment layer was consolidated with an aqueous solution of one of the consolidants. This was carried out by brushing the consolidant solution on to the pigment surface through a thin Japanese paper, which was removed when still wet. The Japanese paper protected the pigment surface from the mechanical action of the brush. JunFunori, gelatine, and sturgeon glue solutions were applied at 40°C. Methocel MC and Klucel E solutions were used at room temperature. The concentrations of the consolidants were chosen according to prior experience with these products. The solutions were applied three times in succession (Table 1). The consolidated pigment layers were dried at room temperature. The stability of the pigment layers was assessed by gently rubbing a finger over it; the consolidation was sufficient if pigments were not removed. If the pigment layers were not consolidated sufficiently after three treatments, the procedure was repeated. Changes in appearance such as stains and tide lines were visually assessed. In addition the changes in colour and gloss were measured with a CR-231 chroma meter (measurement area of 25 mm, illuminant D65) from Minolta (L*a*b* CIE 1976 system) and a micro-TRI-gloss meter from BYK-Gardner using 85° measurement geometry for matt specimens. Three colour and six gloss measurements were carried out on each sample (Table 2).

Accelerated ageing
Free-standing consolidant films were prepared by casting from their aqueous solutions. Round discs with diameters of 165 mm and thickness in the range 0.02-

| Table 1 | Concentrations of consolidant solutions |
0.08 mm were obtained as dried films. They were fixed in an aluminium frame covered with fibreglass foil in order to protect the films from direct metal contact.

Accelerated ageing was performed with a QUV Accelerated Weathering Tester (The Q-panel Company) light- and water-exposure apparatus. Humidity inside the machine was generated and controlled using an external humidity generator. In this case, special UVA lamps (Novamart AG UVA-351, irradiance 0.8 W·m\(^{-2}\) at 351 nm) were installed for simulations behind glass. For the ageing procedure, the aluminium frames with the film samples were installed in the specimen racks with the test surface facing the lamp. The programmed test conditions were 42°C at 32% RH and UV exposure duration of 1500 hours. The UV exposure period was interrupted twice for 45 minutes every 12 hours. This caused a drop in temperature to 32°C and an increase in relative humidity to 68%. After accelerated ageing the samples were visually assessed and cut into rectangular films for mechanical tests and FTIR analysis.

**Mechanical tests**

The tensile strength and the elongation at rupture of the consolidants were measured with a Zwick Z010 (10 kN) machine. All experiments were carried out using rectangular films (100 x 15 x 0.02-0.08 mm) following the test procedure indicated in the EN ISO 527 standard. A pull rate of 5 mm per minute was used at 23°C and 50% RH. Samples of the consolidants were tested before and after accelerated ageing.

**Infrared analysis**

Infrared spectra were measured using a FTIR spectrometer Vectra 22 (Bruker) equipped with a single reflection ATR system (Golden Gate Sepcnc, 2000-300 cm\(^{-1}\), 64 scans, 4 cm\(^{-1}\) resolution). Small film pieces from the consolidants were prepared before and after accelerated ageing.

**Viability test**

0.1 mL of a 0.75% (w/w) consolidant solution was applied to sand-blasted microscope slides and substrates of plaster, wood and canvas. The samples were dried for two weeks at 23°C and 50% RH. The dried samples were inoculated with a carbon-free spore suspension, which included the fungi *Aspergillus niger*, *Penicillium funiculosum*, *Paecilomyces variotii*, *Gliocladium virens* and *Chaetomium globosum*. The viability tests were carried out either at 24°C and 85% RH or at 24°C and >95% RH for eight weeks. The fungal growth was visually assessed.

**RESULTS AND DISCUSSION**

<table>
<thead>
<tr>
<th>Consolidant</th>
<th>JunFunori</th>
<th>Gelatine</th>
<th>Sturgeon glue</th>
<th>Klucel E</th>
<th>Methocel MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration in water % (w/w)</td>
<td>0.3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0.5</td>
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Table 2  **Gloss and colour measurement of consolidated pigment**

<table>
<thead>
<tr>
<th></th>
<th>Gloss G</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>ΔL*</th>
<th>Δa*</th>
<th>Δb*</th>
<th>ΔE*</th>
<th>αΔE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconsolided sample</td>
<td>0.6</td>
<td>39.96</td>
<td>-0.35</td>
<td>-1.54</td>
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<td></td>
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<tr>
<td>Clucel E</td>
<td>-0.1</td>
<td>-2.24</td>
<td>0.03</td>
<td>0.61</td>
<td>2.36</td>
<td>1.64</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Methocel MC</td>
<td>-2.12</td>
<td>0.14</td>
<td>0.30</td>
<td>2.15</td>
<td>0.45</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Gelatine</td>
<td>0.0</td>
<td>-1.27</td>
<td>0.10</td>
<td>0.58</td>
<td>1.40</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sturgeon glue</td>
<td>0.0</td>
<td>-0.40</td>
<td>0.07</td>
<td>0.43</td>
<td>0.61</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JunFunori</td>
<td>0.2</td>
<td>-1.07</td>
<td>0.07</td>
<td>0.04</td>
<td>1.07</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

† Total colour difference
Extraction and purification of JunFunori from the red alga Gloiopeltis furcata

The objectives that were set for the JunFunori production were to deal only with the natural red alga *Gloiopeltis furcata* and to use as little 'chemistry' as possible for any extraction and purification. JunFunori usable for consolidation should be a salt-free, colourless, odourless substance after successful purification.

The main salts found in extracts of the red alga were sodium chloride, potassium chloride and calcium carbonate. Three different methods to remove the salts from the red alga and its extract (dialysis, ion exchange and washing) were tested. Dialysis proved too time consuming and was therefore not applicable for larger aqueous extract volumes. Ion exchange columns were unusable because of the high viscosity of the red alga extract and the sensitivity of the polysaccharide to exchanged ions. Often degradation occurred during the ion exchange process. Finally, a simple washing procedure of the red alga thalli with deionized water was found to be successful and sufficient. The final conductivity of the extract (157 µS·cm⁻¹, 0.1% (w/w) solution) was even lower than the conductivity of tap water (288 µS·cm⁻¹). The salinity was low enough to prevent salt formation on consolidated matt paint.

Several methods exist to eliminate impurities that are responsible for colour or odour from solutions. They can be removed via adsorption, chemical reactions or compensation. Typically, silica gel, bleach earth or charcoal is used to adsorb such contaminants but in this case only the treatment with charcoal was successful. Bleach earth destroyed the polysaccharide because of its high pH and silica gel did not adsorb enough colouring substances. Treatment of the alga with oxidizing or reducing chemicals resulted in degradation of the polysaccharide.

Optimal extraction was achieved if the thalli of *Gloiopeltis furcata* were finely chopped. Milling or homogenizing, or using higher extraction temperatures or more alga resulted in extracting a large amount of gelling compounds from the red alga. This resulted in highly viscous solutions that could not be purified enough and were unusable for consolidation.

Finally, water was removed in order to obtain the polysaccharide JunFunori. To evaporate the laboratory scale quantity of water, an air-circulated drying oven was used in this case. Large plates of JunFunori were obtained, which were milled to a colourless powder and stored in a dry place for several months.

Consolidation test on unbound pigment layers

Unbound pigment samples that were prepared as described earlier were used as indicators of the quality of the consolidation. Solutions of all the consolidants were applied in order to fix the unbound pigments (Figure 1). The gloss measurements show that the values of gloss are so low that variations from unconsolidated to consolidated paint layers can be characterized as insignificant for all consolidants (Table 2). Consolidation with JunFunori led to a minor darkening of the grey layer, similar to the result obtained with sturgeon glue. Hardly any tide lines appeared after application and drying. The appearance of the paint layer was only moderately changed by JunFunori. Sturgeon glue gave comparable

![Figure 1](image)

**Figure 1** Grey pigment layers on canvas, untreated (upper part) and consolidated (lower part) with, from left to right, JunFunori (*from Gloiopeltis furcata*), gelatine, sturgeon glue, Klucel F and Methocel MC.
results. Sturgeon glue and gelatine showed good penetration and the best adhesive strength of all the consolidants. However, the pigment layer consolidated with gelatine showed tide lines (observable in the middle part of the sample, Figure 1). Pigment layers consolidated with sturgeon glue showed a significantly lower tendency to form tide lines than those consolidated with gelatine. In comparison with JunFunori, the appearance of the pigment layers was slightly more affected by gelatine and sturgeon glue.

The appearance of the pigment layer was changed significantly using Klucel E. The sample darkened intensively and tide lines appeared. The adhesive strength of Klucel E was the lowest of all the consolidants. Methocel MC gave slightly better results in terms of optical changes and much better results in terms of adhesive strength than Klucel E.

Based on these results JunFunori and sturgeon glues can be recommended as good consolidants for matt paints.

Ageing of the consolidants

Ageing conditions were chosen in order to simulate an indoor environment. UV exposure was simulated with UVA lamps (irradiance 0.8 W·m$^{-2}$ at 351 nm) and the humidity and temperature were varied from 32% to 68% RH and from 42 to 32°C. After accelerated ageing the samples were visually assessed and gloss and colour measurements were made (Table 3). Before ageing, JunFunori films appeared slightly turbid and nearly colourless. After UV exposure they were bleached (Figure 2, right sample). Fresh samples of gelatine and sturgeon glue were both slightly yellow and bright. The sturgeon glue film showed insignificant optical changes after exposure (Figure 4, right film). In contrast, gelatine lost some of its brightness and, although the integrity of the film did not seem to have been affected (Figure 3), small cracks occurred on the edges of the aged gelatine film while cutting smaller samples for mechanical tests, which was not the case with the aged sturgeon glue samples. Klucel E and Methocel MC were the most affected by the accelerated ageing. Fresh Klucel E formed milky, slightly turbid free-standing films and after half the exposure time the appearance of the samples drastically changed to glassy and shiny. Additionally, the films contracted and tore (Figure 5, right film). Before ageing, films of Methocel MC were slightly turbid, colourless and a little shiny. After ageing they turned to cloudy, bright and brittle films (Figure 6, right film).

<table>
<thead>
<tr>
<th>Table 3 Gloss and colour measurement of unaged and aged consolidant films</th>
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<tbody>
<tr>
<td><strong>Gloss</strong></td>
</tr>
<tr>
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</tr>
<tr>
<td><strong>Consolidant</strong></td>
</tr>
<tr>
<td>Klucel E</td>
</tr>
<tr>
<td>Methocel MC</td>
</tr>
<tr>
<td>Sturgeon glue</td>
</tr>
<tr>
<td>Gelatine</td>
</tr>
<tr>
<td>JunFunori</td>
</tr>
</tbody>
</table>

† Total colour difference

Figure 2 JunFunori film before (left) and after (right) accelerated ageing under UV.
The visual assessment indicated that accelerated ageing noticeably changed the properties of all the consolidants except sturgeon glue and gelatine. Methocel MC and Klucel E were seriously altered. Transferring these results to the consolidation of matt paint, it seems that one should be careful when deciding whether to use Klucel E or Methocel MC. Matt paint consolidated with these two consolidants may show earlier degradation than matt paint consolidated with Jun-Funori, sturgeon glue or gelatine.

**Tensile properties of the consolidants**

Sometimes consolidants, originally showing small elongations when under stress, become hard and brittle materials after ageing, and break if forces increase. This mechanical behaviour can pose problems for consolidated matt paints. If the paint layer expands or shrinks because of changes in temperature and/or humidity, consolidants could cause damage. The tensile test curves, where stress ($\sigma$) is plotted as a function of strain ($\varepsilon$), allow the mechanical properties of the consolidants before and after accelerated ageing to be assessed.

The unaged consolidants showed the following tensile properties in general. Jun-Funori and gelatine were both hard and brittle, but Jun-Funori could withstand higher levels of strain without breaking. Sturgeon glue broke abruptly at the same strain level as gelatine but was softer than Jun-Funori and gelatine. At low strain Methocel MC behaved like sturgeon glue but was more elastic. Although its breaking point appeared at the same level of stress, higher strain was achieved. Klucel E was
Figure 7  Stress-strain curves of the unaged consolidants.

the softest material and was stretchable at low stress over a long range. Its breaking point was between five to ten times lower than that of the other four consolidants (Figure 7).

The tensile behaviour of the consolidants can be explained by their molecular structure. Gelatine and sturgeon glue are polypeptides and JunFunori is a polysaccharide. Both polymer types are hard and brittle crystalline materials because their polymer chains are not flexible and are cross-linked via hydrogen bonds. In contrast, Klucel E and Methocel MC are modified polysaccharides that are not very crystalline and cross-linked. Therefore, they are softer and more stretchable materials.

The mechanical properties of the consolidants were investigated before and after accelerated ageing by testing six to eight samples of each consolidant. The curves obtained are shown in Figures 8-11. JunFunori, gelatine and sturgeon glue hardly showed any change in their mechanical properties after ageing (Figures 8—10). The observable variance of the curves depended on the slight inhomogeneity of the samples. Films of JunFunori were found to be slightly more plastic after ageing. This could be due to the plasticizing effect of water absorbed during the accelerated ageing process, as JunFunori is hygroscopic. Gelatine broke at a slightly lower level of elongation and sturgeon glue became slightly more rigid.

Figure 8  Stress-strain curves of JunFunori.
Figure 9  Stress-strain curves of gelatine
Significant changes in tensile properties were observable for Methocel MC and Klucel E after ageing. Aged samples were in such a bad condition that it was hardly possible to elongate samples of Methocel MC (Figure 11) and impossible to prepare any sample for tensile tests from aged Klucel E films. Aged Methocel MC films became extremely rigid and broke at very low strain (about 0.4% at 0.5 N·mm⁻²). Obviously, UV radiation and variations in humidity and temperature led to a degradation of Methocel MC and Klucel E. FTIR investigations gave further insights into the degradation mechanism of Methocel MC and Klucel E, which will be described in the next section.

In general, it is not possible to predict exactly the lifetime of consolidated matt paints based on these investigations. The simultaneous exposure of the samples to changes in relative humidity and to light were an attempt to simulate real conditions, with the aim of ranking the adhesives aged under similar conditions [25]. Methocel MC and Klucel E did degrade considerably and sooner than the other three consolidants, and damage to matt paints consolidated using these two products would probably occur earlier. However, it is not possible to conclude whether degradation of the consolidants is caused by changes in relative humidity or by exposure to UV, or due to both factors.

**Infrared analysis**

Infrared analysis is a quick way of getting basic information about chemical changes of the consolidants before and after accelerated ageing. Therefore, FTIR spectra of the consolidants were recorded before and after accelerated ageing. Absorption bands in the fingerprint region (2000-3000 cm⁻¹), shown in Figures 12-16, were directly compared.

The spectra of JunFunori, gelatine and sturgeon glue (Figures 12—14) showed no significant changes, indicating that no molecular changes occurred during accelerated ageing.

The IR spectra of Klucel E and Methocel MC were significantly modified after accelerated ageing (Figures 15 and 16). In both cases one additional absorption band was observed (at 1722 cm⁻¹ for Klucel E and at 1732 cm⁻¹ for Methocel MC). Comparisons with spectra from IR data banks and investigations by Feller and Wilt [26] indicate that the new absorption bands are characteristic of carbonyl groups generated by the degradation of cellulose ethers. Obviously, oxygen from the atmosphere attacks the alkylxoy side groups of the cellulose ether leading to the formation of peroxides. Subsequently, the side chains degrade, forming carbonyl groups, and finally the cellulose main chains degrade (thermo-oxidative degradation).
The results from the IR investigations are in agreement with the tensile tests and the visual assessment after accelerated ageing.

**Viability tests**
All consolidants are potential carbon feed sources for micro-organisms such as bacteria, fungi or algae. Therefore, consolidated matt paint could be damaged through biological attack (bacterial, fungal or algal growth) under
certain climatic conditions such as high humidity. The aim of the viability tests was to show under what conditions the susceptibility is high. The consolidants applied on glass and incubated by exposure to 85% RH and 24°C for a period of eight weeks were not covered with micro-organisms. In contrast, after the same period micro-organisms significantly covered the consolidants kept at >95% RH and 24°C. Since a cotton control sample gave the same results under these conditions, the consolidants on glass could not be considered as a real culture medium. Micro-organisms need a balanced feed source containing carbon and nitrogen. A high fungus attack was observable for all consolidants applied on plaster, wood and canvas at 85% RH and 24°C. Consequently, only combinations of consolidant, substrate, pigment, binder and dust can be an ideal culture medium for micro-organisms if the humidity is high enough. Under such conditions fungus growth will occur on JunFunori as well as on all other consolidants tested.

CONCLUSIONS
Investigations on new consolidants for matt paint are important in order to assess their usability. JunFunori was tested for this application in comparison with traditionally used gelatine, sturgeon glue, Methocel MC and Klucel E. The polysaccharide JunFunori was extracted from the red alga Gloiopeletis furcata. Because of variations in the quality of this seaweed and of the traditional Japanese adhesive Funori produced from it, an extraction method and a purifying procedure were developed to obtain the pure polysaccharide.

Consolidation tests simulated on a grey pigment layer consisting of vine black and chalk showed that JunFunori hardly changed the appearance of this layer in contrast to Klucel E and Methocel
MC. Klucel E, in particular, produced tide lines and significant darkening of the pigment layers after consolidation. Accelerated ageing demonstrated that JunFunori free-standing films showed good stability when exposed to UV radiation and variations of humidity and temperature, as did films of gelatine and sturgeon glue. Under the same conditions Methocel MC and Klucel E were seriously degraded. Tensile tests of unaged and aged films and FTIR investigations of all consolidants confirmed these observations. IR spectra indicated that Methocel MC and Klucel E degraded because of thermo-oxidation. Viability tests showed that JunFunori showed no higher or lower viability against biological attack than the other consolidants. These investigations show that JunFunori demonstrates high potential as an alternative to traditional consolidants used for consolidation of matt paints.

ACKNOWLEDGEMENTS
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MATERIALS
JunFunori: Empa, Laboratory for Functional Polymers, Überlandstrasse 129, 8600 Dübendorf, Switzerland, (email: junfunori@empa.ch)
Gelatine (food grade): Merck, VWR International AG, Rüchligstrasse 20, 8953 Dietikon, Switzerland.
Klucel E (hydroxypropylcellulose with low viscosity, 2% Brook-field viscosity: 7 mPa-s) from Aqualon: Alois Diethelm AG, Las-caux Farbenfabrik, Zürichstrasse 42, 8306 Brüttisellen, Switzerland.
Methocel MC (Methocel A, Dow Chemical, methylcellulose with low viscosity, 3280 mPa-s) and charcoal: Aldrich, Fluka Chemie GmbH, PO Box 260, 9471 Buchs, Switzerland.
Sturgeon glue: Andrei Andrée, Ak. Artzimovicha St. 16-378, 117437 Moscow, Russia.
Chalk and vine black: Kremer Pigmente, Farbmühle, 88317 Aichstetten/Algäu, Germany.
Fibreglass filters: Schleicher & Schüll AG, Lörracherstrasse 50, 4125 Riehen, Switzerland.

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AUTHORS
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Résumé — Le funori est un polysaccharide extrait de l'algue rouge Gloiopeltis furcata de plus en plus utilisé par les restaurateurs d'œuvres d'art pour la conservation des peintures mates. Du fait de la variation en qualité du funori, les auteurs ont mis au point une méthode d'extraction et un processus de purification pour obtenir un matériau de consolidation dénommé JunFunori. Ce produit purifié a été testé et comparé à d'autres agents de consolidation aqueux (la gelatine, la colle d'esturgeon, le Klucel E (hydroxypropylcellulose) et le Methocel MC (methylcellulose)). Contrairement au Klucel E et au Methocel MC, le JunFunori ne modifie guère l'aspect de peintures pulvérulentes faites d'un mélange de noir de vigne et de craie après consolidation. Des essais de vieillissement accéléré avec exposition aux ultraviolets et variation d'humidité relative, combinés avec des tests mécaniques et l'analyse par spectroscopie infrarouge, ont montré que les films de JunFunori présentent une bonne stabilité dans ces conditions particulières. Les résultats de tests microbiologiques révèlent que la sensibilité du JunFunori aux microorganismes est comparable à celle des autres produits de consolidation. Ces résultats démontrent que le JunFunori constitue une alternative aux matériaux de consolidation usuels.


Resumen — El Funori es un polisacárido extraído del alga roja Gloiopeltis furcata. Este polisacárido es conocido en el mundo de la conservación por sus ventajas como producto para consolidar pinturas mates. Debido a las variaciones en la calidad del alga, los autores desarrollaron un sistema de extracción y de purificación para obtener el polímero puro llamado JunFunori. El consolidante mejorado fue probado en comparación con consolidantes acuosos tradicionales como la gelatina, la cola de esturión, el Klucel E (hidroxipropilcelulosa) y el
Methocel MC (metilcelulosa) has investigaciones mostraron que la consolidación usando JunFunori muy difícilmente cambia la apariencia mate de una capa de pintura sin aglutinante sobre lienzo compuesta de negro de vid y calcita, al contrario que la consolidación usando Klucel E y Methocel MC. Las pruebas de envejecimiento artificial, con influencia simultanea de radiación ultravioleta (UV) y variaciones de humedad, en combinación a test mecánicos y a análisis de infrarrojos por transformada de Fourier, demostraron que el JunFunori tiene una buena estabilidad en estas condiciones específicas. En las pruebas de potencialidad de uso a las que fue sometido el JunFunori se mostró tan resistente al ataque biológico como los otros consolidantes probados. Todos estos resultados indican que el JunFunori presenta un buen potencial como alternativa a los consolidantes tradicionales.