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Source: *Objects Specialty Group Postprints, Volume Nineteen, 2012*
Pages: 109-127
Compilers: Mina Thompson, Emily Hamilton, and Kari Dodson

THE TREATMENT OF A MI'KMAQ BOX MADE OF BIRCHBARK, PORCUPINE QUILLS, AND IRON-DYED SPRUCE ROOT

CAROLE DIGNARD, AMANDA SALMON AND SEASON TSE

ABSTRACT

A 19th century Mi'kmaq birchbark box decorated with porcupine quills and spruce root from the McCord Museum in Montreal was treated at the Canadian Conservation Institute. The box's black spruce root was brittle and showed extensive losses, and the quilled birchbark lid cover was detached and curved. Dyes and mordants were analyzed: for the black spruce root, iron was confirmed using bathophenanthroline test strips as well as by atomic absorption spectroscopy. Iron and other metal ions are known to catalyze the oxidative degradation of cellulose. The birchbark lid cover required flattening while avoiding any compression of the quillwork decoration. This was accomplished by exposure to methanol vapors, followed by vacuum restraint pressure. The iron-dyed spruce root was chemically stabilized by applying calcium phytate / calcium carbonate solutions by brush. Problems included the swelling of the root during treatment due to absorption of water, and the migration of iron ions causing staining. The spruce root was physically repaired using toned Japanese paper facings or backings and Lascaux 498 HV acrylic dispersion. The quills' fading rates were measured using the micro-fading technique in order to provide specific display lighting recommendations.

1. INTRODUCTION

A 19th century Mi'kmaq birchbark box decorated with porcupine quillwork on its lid and spruce root whip-stitched on its walls was treated at the Canadian Conservation Institute (fig. 1a). This paper discusses the box's treatment, in particular the various analyses carried out, the stabilization treatment of the spruce root, and the cleaning and reshaping of the birchbark quill-worked cover.

2. DESCRIPTION

Owned by the McCord Museum in Montreal, the cylindrical box is made as an assembly of three birchbark outer rings, lashed to an inner birchbark cylinder, and pegged to a circular wooden board base. A fourth, mobile birchbark ring at the top of the stack is in fact the rim of the lid. Two of the birchbark rings are decorated with closely wrapped (whip-stitched) spruce root and with porcupine quill chevron decorations, while the bottom ring, and the third-ring-up-from-bottom, are decorated with black-dyed spruce root wrappings and quilled chevrons. The lid cover consists of a two layers of birchbark fixed together at cross-grain, decorated with porcupine quillwork. The brown-black spruce root wrappings were extensively deteriorated: they were almost totally missing, with only a few elements left on the two rings. These remaining strands of black spruce root were brittle, often split or precariously attached.

The lid cover, densely decorated with porcupine quillwork, was completely detached from its rim (the fourth, top ring). The cover was deformed, curving upwards approximately 2 cm high, and the deformation was such that it prevented it from fitting into the rim opening. It also had a small area of loss, and was quite dirty.

Fig. 1. Mi'kmaq box and lid, approximately 23 cm diameter, height 18 cm. McCord Museum of Canadian History, accession number UA35.1-2. (a) Left image shows before treatment. The quilled birchbark top was warped and detached from its rim (fourth birchbark ring, set on top of the three-ring box). There were extensive losses in the black spruce root wrappings, as compared to the red spruce root, largely intact. (b) Right images shows after treatment (© Government of Canada, CCI; photographs by Carl Bigras and Mylène Choquette)

3. QUILLWORKED BIRCHBARK LID COVER

3.1 CLEANING THE QUILLS

The first part of the treatment focused on the lid cover. The porcupine quills were in fairly good condition, although the dark brown quills were more damaged, with some fissures, surface delaminations, or losses. The colours were quite well preserved, with the blue and orange colours quite vivid.

The quills were cleaned using a soft brush and vacuum cleaner, followed with swabs moistened with saliva and rinsed with swabs moistened with distilled water. After cleaning, the presence of yellow-dyed quills became apparent (fig. 2).

3.2 MICROFADE TESTING

Microfade Testing (MFT) on these quills was carried out at the CCI (Bannerman 2009). MFT is a technique developed in the mid-1990s by Paul Whitmore (Whitmore et al. 1999; Whitmore 2002) for identifying colorants that are at high risk of light damage. Object-specific light sensitivity data is difficult to obtain using conventional methods; MFT is unique in being able to 'predict' light sensitivities of colorants through direct testing on the object. It involves directing a tiny, high intensity light beam on the test area, and recording the colour change during a series of brief, but intense, light exposures (typically 5-7Mlux for 10 minutes). The light spot is approximately 0.3 mm in diameter.

The results are then compared to ISO Blue Wool Standards'[1] fading rates. Blue Wool 1 (BW1) is extremely light sensitive, while BW 8, the upper end of the scale, has very low sensitivity to light. For this Mi'kmaq box, the orange, blue and yellow-dyed quills changed colour at a rate equivalent to a value between BW3 and 4. BW4, exposed to 50 lux, 8 hours a day, and 6 days a week, will show a perceptible colour change in 100 years. Knowing that the

Fig. 2. Detail of porcupine quillwork on the lid cover during cleaning: the left proper section is cleaned, the right proper section is not cleaned. Yellow quills are noticeable in the far left proper triangular decorations, along with blue, orange and brown, as well as in the bottom semi-circular decoration, while white quills are present in the centre "double Y" area (© Government of Canada, CCI; photographs by Carl Bigras and Mylène Choquette).

quills have a similar fading rate provides the museum with an estimate of the light dosage these quills can take, and enables it to make accurate risk assessments for this piece when choosing its display light level and duration of exposures. MFT revealed that the brown quills will fade at a slower rate, between BW4 and 5.

3.3 RESHAPING AND REPAIRING THE BIRCHBARK COVER

3.3.1 Background and Testing

The next part of the treatment focused on reshaping the lid cover. Birchbark exposed to methanol vapours becomes soft and pliable enough to allow reshaping through the application of weights, pressure or clamping, without splitting or cracking (Gilbert 1986). Past experience at CCI has shown that pressure should be maintained for several days to 'coax' the birchbark into its new form and to deter rebound, or 'plastic memory', after treatment. For this Mi'kmaq box, the presence of the dense quillwork pattern on the lid cover posed a challenge: how to apply pressure without crushing the rounded, delicate porcupine quills covering the entire surface? Porcupine quills are made of a sturdy but pliable keratinous skin and a spongy medulla interior. During quillworking, the quills are usually moistened (usually with saliva) and then pinched through holes in the bark; this flattens the quills to a certain extent but some roundness or volume remains. Applying pressure risks damaging or crushing the quills.

Table 1. Vacuum pressure tests on new quillworked birchbark samples

Sample	Vacuum pressure (in. Hg)	Duration of pressure (days)	Results	
			Quills	Birchbark
A	25	1.5	Some quills were flattened	Flat, no rebound
B2	15	2	Quills undamaged	Bark stayed essentially flat, with small amount of rebound
C	12	3	Quills undamaged	Bark stayed essentially flat, with small amount of rebound
B1	10	1	Quills undamaged	Bark rebounded to original curvature within a few days
D (control)	0	0	Quills undamaged	Bark curved

Vacuum clamping, a technique commonly used in boat and furniture-making, and in conservation for applications such as veneer repair (Kolbach 1998), is a means of applying an even amount of pressure over the whole surface and has the advantage of being able to conform to any shape and curvature. Vacuum clamping offered a controllable means of applying uniform pressure over this 22 cm diameter bowed surface. To test the technique for use on the Mi'kmaq box, mock-ups were made using new pieces of birchbark of similar thickness (approximately 1/16 to 1/8 in.) and curvature to the box's lid cover, on which new porcupine quills were applied in the traditional manner. Tests were carried out by varying the vacuum pressure and lengths of exposure to pressure. The results were assessed in terms of whether the quills were flattened or damaged, and whether the birchbark remained flattened with little post-treatment rebound (table 1 and fig. 3).

The results were as follows: with a vacuum pressure of 25 inches of mercury (in. Hg) (equivalent to 12.5 p.s.i.), some of the porcupine quills were flattened or their surface cracked. On the lower end, a vacuum pressure of 10 in. Hg applied was insufficient in preventing almost full rebound within a few days (test B1). In these tests, 12 in. Hg during 3 days was the lowest pressure that worked successfully for both the quills and the birchbark (sample C). It was therefore decided to use this pressure.

3.3.2 Treatment

The warped lid cover was placed in a double polyethylene bag and exposed to methanol vapours for 48 hours to let the birchbark soften. Once it was sufficiently pliable, it was prepared for flattening in the following manner: the birchbark lid cover was covered with a thin Mylar, padded between two layers of cross-linked polyethylene foam (Volara) and placed onto a plywood base, and then the whole was bagged in polyethylene and sealed with heavy-duty tape. Vacuum pressure of 12 in. Hg was applied for 55 hours (fig. 4). After this, the lid cover was taken out of the bag and left to re-acclimatize. Overall, we were satisfied

Fig. 3. (Left) Vacuum pressure tests on new quilled birchbark samples. Parameters applied to samples (from top to bottom) D, C, B2 and A are identified in table 3. Sample B1 is not shown. (Right): Detail, Sample A, showing crushing, especially quill at far right (© Government of Canada, CCI; photographs by Carl Bigras and Mylène Choquette).

with the results: the quills had remained rounded and intact, although, under microscopic examination it was possible to detect that a few isolated quills had become slightly flattened or had developed tiny cracks (fig. 5).

Birchbark has an elastic memory and some degree of rebound is to be expected after a couple of days; in this case, the lid cover ended up bowing upwards 0.7 cm after treatment. Compared to the initial bowing of 2.0 cm high before treatment, this result was deemed acceptable and no further flattening was attempted, as the cover was now sufficiently flat to

Fig. 4. Softening and reshaping of the birchbark lid cover. (Left): Lid cover bagged in polyethylene, with cotton waddings imbibed with methanol. The cover was further sealed in a second polyethylene bag. (Right): Lid cover sandwiched in-between cross-linked polyethylene foam, undergoing vacuum pressure flattening. The round cover's outline can be seen in the foam. At the right is the vacuum suction port with mesh used as a breather layer (© Government of Canada, CCI; photographs by Amanda Salmon).

Fig. 5. Detail of quillwork (left) before reshaping the birchbark base, and (right) after reshaping using vacuum pressure (there was no colour change to the dyed quills – the colours do not exactly match in these photographs because the shots were taken with different cameras and settings) (© Government of Canada, CCI; photographs by Carl Bigras and Mylène Choquette).

fit into the rim ring and span the area within it. The lid was inserted within the lid rim (fig. 6) and secured with five toned, feathered Japanese paper (Kozo) hinges, adhered with Lascaux 498 HV acrylic dispersion. The 5 cm area of loss on one side of the perimeter was filled using layers of toned Japanese paper, with interstices filled with a paste of toned cellulose powder and methylcellulose. Inpainting was carried out with acrylic paints.

4. SPRUCE ROOT

4.1 BACKGROUND, ANALYSES AND TESTS

4.1.1 Analysis of Dyes and Mordants

The third part of the treatment focused on the spruce root. It was obvious that the black colour was causing degradation, as compared to the largely intact red spruce root. Iron is a well-known culprit: Fe (II) ions can catalyze the oxidative degradation of cellulose and other organic materials. The authors had previously observed this type of degradation with a black-dyed furskin (Dignard and Gordon 1999). Other common examples include iron gall ink corrosion of paper documents (Banik 1997, 1998) and the degradation of black-dyed ‘New Zealand flax’ i.e. *Phormium tenax* or harakeke (Daniels 1999a; More et al. 2003). Hofenk de Graaff (2004, 321) has pointed out differences between the condition of iron gall ink documents and iron-dyed

Fig. 6. (Above left) Lid cover placed into the rim ring remains slightly bowed. (Above, right) Lid cover secured with paper hinges applied on the inside surface. (Below) Detail of paper pulp fill (© Government of Canada, CCI; photographs by Carl Bigras and Mylène Choquette).

fibres: in the dyeing process using iron salts, excess acids would usually have been rinsed out after the insoluble black colour is formed, therefore iron-dyed fibres are more likely to suffer mainly from iron-catalysed oxidative degradation, initiated by small amounts of remaining ironII compounds, and not from acid hydrolysis due to excess acids. It is possible though that the iron tannate dye complex may deteriorate over time, producing tannic acid and iron ions as decomposition products, which could cause both hydrolysis and oxidation.

Analysis of the dye compounds (Poulin 2012) using Gas Chromatography – Mass Spectrometry (GCMS) found that red brazilwood dye and sumac tannins were present in both the red and the black spruce root, but in different proportions: the black spruce root had much more sumac, and less brazilwood. As well, tartaric acid was identified in the red root, suggesting an alum mordant because this produces a light colour with sumac. For the black spruce root, an iron mordant, which was already suspected because of the obvious degradation, was deduced since iron produces very dark colours with sumac tannins.

Analysis by Atomic Absorption Spectroscopy (Caduceon 2011) was carried out to determine elemental (metal) contents: the black spruce root contained iron in the range of 4 to 6 thousand ppm – 25 times more than in the red spruce root; while the red spruce root contained high amounts of aluminum (three times more than the black and five times more than new undyed root), which also suggests an alum mordant for the red spruce root (table 2).

The presence of ironII ions was also qualitatively confirmed in situ using bathophenanthroline test strips developed for iron-gall ink assessments (Neevel and Reissland 2005). These work by simply wetting the non-bleeding test strips and applying them to the object for thirty seconds. A pink stain indicates the presence of free ironII ions, which are the form of iron that catalyzes oxidation. IronIII ions do not catalyze oxidation and will not give a positive result with water. However, the test can be modified with ascorbic acid to detect ironIII as well. It

Table 2. Identification of dyes and mordants in the red and black spruce root

Sample	Dye components and method of analysis		
	Gas chromatography – mass spectrometry (GC-MS)	Atomic absorption spectroscopy (ppm)	
		Iron	Aluminum
red spruce root	– Brazilwood dye (relatively high)	180	630
	– Unidentified dye compound from sumac (relatively low)		
	– Tannins (gallic acid and ellagic acid)		
	– Tartaric acid		
black spruce root	– Unidentified dye compound from sumac (relatively high)	4220–5850	120–240
	– Brazilwood dye (relatively low)		
	– Tannins (gallic acid and ellagic acid)		
new (2011) spruce root, undyed	(not tested)	0–30	30–110

is useful to identify the presence of ironIII because these ions can reduce to ironII in appropriate conditions (Neevel and Reissland 2005).

The *Iron-II ion Test Strip Colour Chart* was developed at CCI (Tse and Vuori 2005) as a qualitative tool to assess and record these results: Levels 1 and 10 are considered positive with low quantity of free ironII ions, while levels 25 to 50+ are considered medium to high. A dark pink result, as shown in figure 7a, indicates a high concentration of free ironII ions, which means high risk of iron-catalyzed oxidation. This test strip colour chart is not intended to be used quantitatively; it is rather a practical colour code that can be used to compare test results relative to another. For this Mi'kmaq box, the test strips indicated a dark pink colour for the black spruce root, and did not show any colour for the red spruce root (fig. 7b).

4.1.2 pH Measurements

If iron is present, acidic pHs favor the corrosive ironII ionic state. New non-dyed spruce root was measured as having a pH in the range of 4-4.5. The pH of the black spruce root was compared to that of the red spruce root, so as to determine if pH was a contributing factor in its degradation. The pH tests were carried out using three methods (table 3). Measurements with pH meters followed the *TAPPI standard T509 om-02* (or *ASTM D778-97 (Cold), Vol. 15.09*) for the pH of paper extracts, a cold extraction method modified for small sample size (Tse 2007). Three detached red spruce root elements and three detached black ones were immersed in deionized water. A sample weight-to-water ratio of 1 mg per 70 microlitres of water was used, with an extraction time of 1 hour.

The pH of the deionized water was 5.9. The results in table 3 show some variability but overall were fairly consistent independent of the method used. The black spruce root's pH

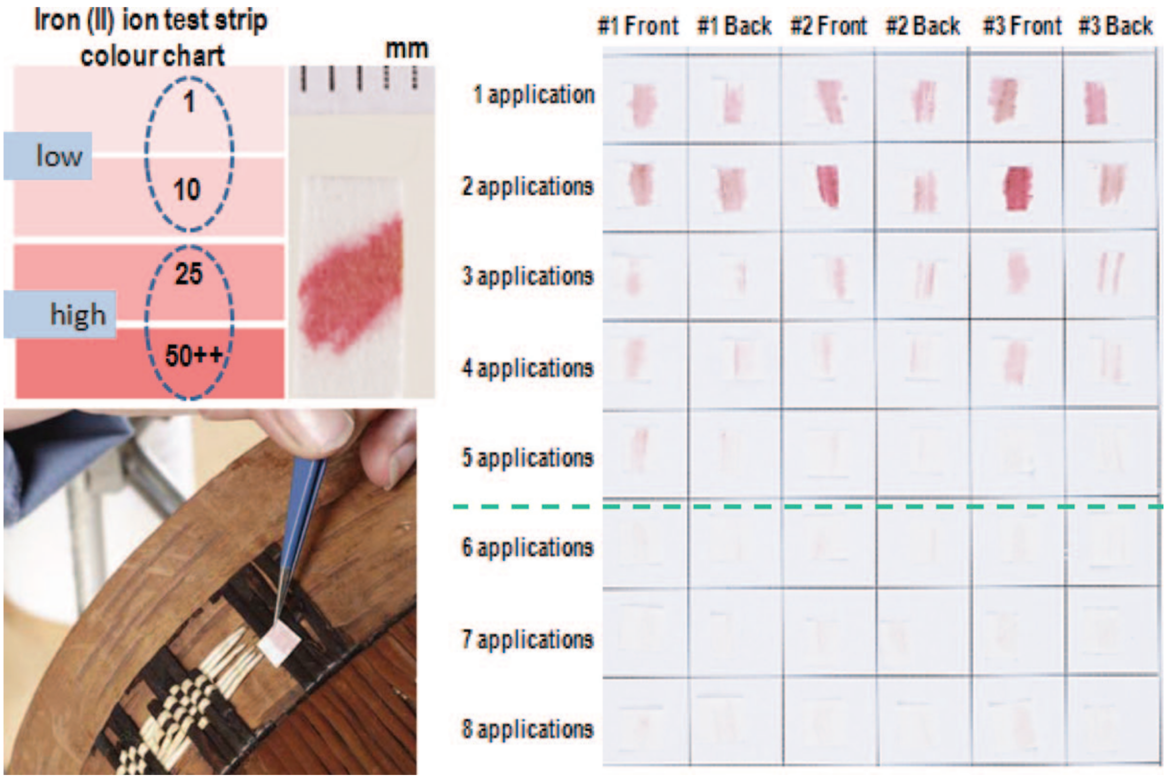

Fig. 7. (a) (Above, left) The *Iron-II ion Test Strip Colour Chart*, and beside it, an example of a positive result using the bathophenanthroline test strip: the intense pink indicates a relatively high ironII content. (b) (Bottom, left) Detail while testing iron content on the black spruce root on the Mi'kmaq box using the bathophenanthroline test strip. (c) (Right) Measuring the quantity of ironII in three detached samples of black-dyed spruce root (Samples #1, 2 and 3, each front and back) after each application of a saturated solution of aqueous calcium phytate (see section 3.2.1). The amount of free ironII became stable after five applications (© Government of Canada, CCI; photographs by Carl Bigras and Mylène Choquette).

Table 3. pH tests of spruce root samples (BT) using three different pH measuring devices

	Weight (mg)	Volume of water (mL)	pH		
			IQ 240 pH meter	Horiba twin pH meter	ColorpHast strips
Black spruce root					
Sample 1	14	1	3.56	3.39	3.6–3.9
Sample 2	13.8	1	3.49	3.35	3.6–3.9
Sample 3	14.3	1	3.62	3.34	3.6–3.9
Red spruce root					
Sample 4	16.6	1.2	3.52	3.1	3.6–3.9
Sample 5	14.5	1	3.45	3.34	3.9
Sample 6	14.5	1	3.29	3.16	3.6

was comparable to that of the red spruce root, both in the range of 3.5. As a comparison, old twined spruce root basketry fibres of Tlingit origin, which were not dyed but were fragile and fragmentary, had a pH of 3.6 (Clavir 1976). Old black-dyed samples of *Phormium tenax* were found to range in pH from 3.5 to 4.3, while modern samples ranged from 4.4 to 6.9 (Daniels 1999a). For this Mi'kmaq box, because both the red and the black spruce root essentially have the same pH level, it was concluded that the root acidity on its own is not the cause of the embrittlement of the black spruce root. However, a lower pH range contributes to degradation because it favors the formation of free iron ions which can then catalyse oxidative degradation (Daniels 1999a).

4.1.3 Stabilization: Research and Preliminary Tests

In the iron gall ink literature, Dr. Neevel published a landmark study (1995) on a calcium phytate treatment that sequesters ironII ions and stabilizes corroding iron gall ink. Since then, variants of this method or methods using other chelating agents and antioxidants have been studied, including work done at CCI (Neevel 2002; Kolar et al. 2005; Kolar and Strlic 2006; Kolar et al. 2008; Tse, Guild et al. 2012; Tse, Trojan-Bedynski et al. 2012). Still, as stated on *The Iron Gall Ink Website*: 'All studies agree that the calcium-phytate / calcium-bicarbonate method is an effective aqueous method to prolong the life-time of ink corroded objects with minimal side effects' (Reissland et al. 2007). The method typically involves immersing the iron gall ink document in water to remove, as much as possible, free, water-soluble ironII ions. This is followed by immersion in a calcium phytate solution, where the calcium ions are exchanged for any free remaining ironII ions, forming a complex between ironII ions and phytates (*myo*-inositol hexaphosphate) which prevent the catalytic degradation of cellulose. The ink's black colour is, by and large, not affected. Deacidification in a calcium bicarbonate solution follows the calcium phytate treatment to neutralize the acids in the ink. A possible result is the formation of ironIII phytates as loose, white deposits on the surface after treatment, which are usually easily brushed off.

In the case of this Mi'kmaq box, it was not possible to immerse the black spruce root in a phytate solution to wash out the free iron ions, given the intimate assembly of the three birchbark rings with spruce root wrapped tightly around each ring. It was decided to test whether successive applications by brush of the calcium phytate and calcium bicarbonate solutions would have any benefit on the black spruce root having had no prior washing. The solutions were prepared following the *The Iron Gall Ink Website* instructions (Reissland et al. 2007). As a test, the solutions were applied on the front and back sides of three detached pieces of black spruce root, and after each application, the spruce roots were left to air-dry, then tested for the presence of ironII using the bathophenanthroline indicator strips. Results are shown in figure 7c. Up to eight applications of the phytate/bicarbonate solutions were applied. The bathophenanthroline strips indicated that the amount of free ironII decreased progressively with up to five applications, and that there was no significant difference after further applications. It was decided that the successive applications of calcium phytate / calcium bicarbonate solutions were at least partially successful in sequestering some of the ironII, and that this treatment would benefit the degraded, brittle black spruce root.

There have been a few investigations on similar chemical stabilization methods for iron-dyed basketry or vegetable fibres. Daniels (1999b) studied various stabilisation treatments for black-dyed *Phormium tenax* ('New Zealand flax') and found magnesium bicarbonate, with or without phytate, was the most effective. Cull (2007) applied phytate / magnesium bicarbonate solutions to help stabilize Maori black-dyed *Phormium tenax*. Smith et al. (2005) studied treatment solutions to chemically stabilize Maori iron-dyed *Phormium tenax* and found that a post-dye treatment with tannins extracted of the bark of the native *hinau* tree *Elaeocarpus dentatas* Vahl, was effective at sequestering ironII (ferric) ions; and that the treatment had the added benefits of enhancing the fibres' coloration and of not introducing any foreign materials, since the *hinau* extract is part of the traditional dyeing process. Wilson et al. (2011) published preliminary findings on the efficiency of various non-aqueous stabilisation solutions (sequestering agents or anti-oxidants) for black-dyed fibres, and are pursuing this research.

4.2 TREATMENT

4.2.1 Chemical Stabilization

Based on the previous tests, the black spruce root on the Mi'kmaq box was treated with five successive applications, by brush (fig. 8a), of calcium phytate (1%) and calcium bicarbonate solutions. The pH of the spruce root after treatment was in the range of 6.0. No white deposits were formed on the surface that would have required removal.

The treatment was not without its set of problems. Firstly, because spruce root absorbs water and swells, broken elements would spring outwards during treatment (fig. 8b). Upon drying the root would usually go back down to its original position. When necessary, it was remoistened and pressed back down with light weights. Another problem was the risk of iron ion migration and staining, as shown in figures 8c and 8d. It is important to avoid the migration of iron ions, as these ions may then catalyze the degradation of these new areas (in this case, the red spruce root). The application of calcium phytate solutions by brush was carried out with the box on its side so as to avoid having gravity lead any excess solution towards the red root (fig. 8a). Unfortunately migration and staining occurred, probably when the Mi'kmaq box was removed from its support too soon after the application of solutions. The aqueous phytate and bicarbonate solutions need to be applied in sufficient quantity to achieve their purposes, yet avoiding excess to avoid migration. IronII ions are quite soluble in water, and remain invisible – a solution containing free iron ions is not colored (no black color). In this case the iron reacted with tannins in the red spruce root, resulting in a stain. Adjacent areas should be protected against migration of iron ions and potential staining with a barrier layer (e.g. Parafilm, cyclododecane, etc). Where staining occurred on the red spruce root, localized, controlled rinsing was carried out to remove the free ironII ions, followed by poulticing using Gellan gum (Iannuccelli and Sotgiu 2010) to reduce staining (fig. 8e). The removal of iron ions was monitored using the bathophenanthroline strips described above.

4.2.2 Physical Stabilization and Photodocumentation

Since chemical stabilization does not enhance physical strength, physical stabilization was needed to prevent further losses in loose, cracked or fragmented spruce root elements, both black and red. Kozo Japanese paper with feathered tips was cut to approximately 2–3 mm (1/8 in.), i.e. the width of the spruce root strands, and adhered in situ where required. After considering various options for the adhesive, in particular the use of gelatine which can provide some degree of protection against ironII migration (Kolbe 2004), Lascaux 498 HV acrylic dispersion was selected because of its good removability with acetone, and because it would not swell or dissolve in water after drying, thus repairs would not be weakened should future applications of calcium phytate solutions be needed. Its working properties were also appreciated, i.e. its thick texture, quick tack, and ease of clean-up with moist swabs.

Fig. 8. Top to bottom, left to right: (a) Application of the phytate and bicarbonate solutions by brush on the black spruce root, while the box is set sideways. The milky phytate solution can be seen in the beaker. (b) Swelling of the spruce root during treatment, while wet. (c) Before and (d) after staining of the red spruce root below the black spruce root; (e) AT of the same area after poulticing to reduce the stain (© Government of Canada, CCI).

Fig. 9. (a) (Left) After physical stabilization, side view; (b) (Right) Same, infrared photodocumentation, which easily documents the repairs: on the red spruce root, the repairs appear a darker grey; on the black spruce root, they appear totally black (© Government of Canada, CCI; photographs by Carl Bigras and Mylène Choquette).

Because access to the back of the spruce root was difficult due to the tight weave of the spruce root decoration against the birchbark rings, paper was applied as a backing in only approximately 20% of the repairs, using fine tools, tweezers and a lot of patience. In the remaining cases, the Japanese paper was applied as a facing, bridging two broken areas of the spruce root, or reinforcing cracks. Light finger pressure was used to achieve contact and bonding in most cases. Some broken spruce root strands were bridged with Japanese paper fills. The Japanese paper was first dyed with Pelikan acrylic inks to achieve a base colour for the repairs, and later inpainted with Liquitex (acrylic) or Golden (PVA) dispersion paints to match the surrounding spruce root colour.

Consolidation is also a possible treatment option for brittle fibres, for example brittle Maori black-dyed *Phormium tenax* fibres were successfully strengthened with alginate solutions; the alginate also reacted with acids produced during ageing of the fibres (Te Kanawa et al. 2008). In the case of this Mi'kmaq box, facings and backings provided sufficient strength since the spruce root wrappings were essentially fixed against a rigid birchbark support and so were not expected to be exposed to flexing, contrary to other situations, e.g. a flexible textile, or a loosely-woven basket.

Infrared photodocumentation is a useful way to document the location of repairs: on the red spruce root, the repairs appear a darker grey; on the black spruce root, they appear totally black (fig. 9). Figure 1b shows the Mi'kmaq box after treatment.

5. CONCLUSION

The treatment of this quilled birchbark box with iron-dyed-spruce root decorations was quite a challenging one. Vacuum pressure was successful in reshaping the birchbark cover, although microscopic examination revealed that a few isolated quills were slightly affected. This method may not be suitable for degraded quills, or for quillwork designs retaining higher relief or topographies. The calcium phytate / calcium bicarbonate treatment of the iron-dyed black spruce root will help to chemically stabilize the remaining black spruce root and prevent further embrittlement and losses. However, if this treatment were to be repeated, further measures would be taken to prevent staining, for example, by physically protecting adjacent areas using temporary barrier layers such as moldable Parafilm wax film, silicone gasketing film or cyclododecane.

ACKNOWLEDGEMENTS

The following colleagues are warmly thanked for their help, advice or contribution to this project: Judith Bannerman, Carl Bigras, Mylène Choquette, Marion Cinqualbre, Patricia Dunnett, Alison Fleming, Sherry Guild, Emily Higginson, Elisabeth Joy, Anne MacKay, Caroline Marchand, Janet Mason, Joanna McMann, Jennifer Poulin and Jan Vuori.

NOTE

1. Blue Wool Standards are a set of eight different dyed fabrics that fade after exposure to a known light dose. The dyes are chosen such that each reference takes about two to three times longer to begin fading as the next lower reference in the scale (Michalski 2011).

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SOURCES OF MATERIALS

Colour charts for Fe(II) test strips
Canadian Conservation Institute
(Attention: Season Tse)
1030 Innes Road
Ottawa, Canada K1A OM5
Telephone: 613-998-3721
Fax: 613-998-4721

Bathophenanthroline indicator strips and instruction manual (Product Code 539-3000)
Preservation Equipment Ltd
Vinces Road, Diss,
Norfolk IP22 4HQ, U.K.
Telephone: +44 (0)1379 647400
Fax: +44 (0) 1379 650582
www.preservationequipment.com/

Calcium phytate (phytic acid, calcium carbonate), Calcium bicarbonate (use calcium carbonate and carbonate with a soda siphon or seltzer bottle)
Sigma-Aldrich Ltd.
Customer Support
PO Box 14508
St. Louis, MO 63178, USA
Telephone: 800-325-3010
Fax: 800-325-5052
www.sigmaaldrich.com/customer-service.html

Soda siphons and seltzer bottles (Kitchen devices for making sparkling water)
The Prairie Moon Company
311 W Monroe St
Highland, IL 62249-1326
Telephone: 866-331-0767 or 618-651-9939
Fax: 618-654-7768
Email: service@prairiemoon.biz
www.prairiemoon.biz

Horiba TwinpH Compact pH Meter model #B-213:
Osprey Scientific Inc
105 Avenue Northwest
Edmonton, AB T5S 2T4, Canada
Telephone: 780-487-4334
www.ospreyscientific.com/

IQ240 pH Meter Microprobe with ISFET (non-glass) sensor:
RL Instruments
9 Main Street, Suite 2E
PO Box 423
Manchaug, MA 01526, USA
Telephone: 508-476-1935
Fax: 508-476-1927
www.rlinstruments.com

Methanol, EMD ColorpHast pH strips: (pH 4.0–7.0 and 2.5–4.5)
Fisher Scientific Company
112 Colonnade Road
Ottawa, ON, Canada K2E 7L6
Telephone: 800-234-7437
Fax: 800-463-2996
www.fishersci.ca/default.aspx

Japanese 'Kozo' paper
The Japanese Paper Place
77 Brock Avenue
Toronto, ON Canada M6K 2L3
Telephone: 416-538-9669
Fax: 416-538-0563
Email: washi@japanesepaperplace.com
www.japanesepaperplace.com/general/contact_us.htm

Cellulose powder; Gellan gum; Mylar (Melinex) polyester film, Golden PVA Conservation Paints; Lascaux acrylic adhesive 498HV; Volara cross-linked polyethylene foam
Talas
330 Morgan Ave
Brooklyn NY 11211
Telephone: 212-219-0770
Fax: 212-219-0735
www.talasonline.com/

Polyethylene sheet, tape
Local hardware store

Liquitex acrylic paints, Pelikan inks
Local art supplier

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This article was presented at the Objects Specialty Group or in the joint Research and Technical Studies/OSG Sessions at the 2012 AIC Annual Meeting in Albuquerque. The papers presented in this publication have been edited for clarity and content but have not undergone a formal process of peer review.