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Shredded Cedar Bark: A Survey of Past Treatments

Sonia Kata[a] and Carole Dignard[b]

[a]Conservator, McCord Museum, 690 Sherbrooke Street West, Montreal, Quebec H3A 1E9, Canada; kata.sonia@gmail.com

[b]Senior Objects Conservator, Canadian Conservation Institute, 1030 Innes Road, Ottawa, Ontario K1B 4S7, Canada; carole.dignard@canada.ca

A survey of past treatments for shredded cedar bark was carried out on sixteen objects: two masks from the U'mista Cultural Centre and fourteen similar objects at the Canadian Museum of History (CMH), which had been assessed or treated by the CMH or the Canadian Conservation Institute (CCI) nearly 30 years ago. The objects were examined and evaluated with regard to cedar bark condition, appearance, pH and iron content. Treatments fell into four groups: 1) adhesive consolidation; 2) localized paper supports with adhesives; 3) localized thread wrappings, with or without adhesives; and 4) no treatment, sometimes coupled with a support. Parylene (poly-para-xylylenes) coating was also investigated as CCI carried out tests on cedar bark samples several years ago. Each treatment strategy had some benefits and drawbacks. Iron content was identified as an important factor in condition. A literature review on shredded cedar bark was also conducted to elucidate its properties, processing and conservation.

Cet article présente un réexamen de traitements (incluant le choix de non-intervention) pour l'écorce de cèdre déchiquetée qui ont été effectués il y a environ 30 ans au Musée canadien de l'histoire (MCH) ou à l'Institut canadien de conservation (ICC). Seize objets ayant ce type d'écorce comme élément décoratif ont été examinés : deux masques du centre culturel autochtone U'mista (U'mista Cultural Centre) et quatorze objets semblables de la collection du MCH. L'état de l'écorce, son aspect visuel, son pH et sa teneur en fer ont été évalués. Quatre types de traitements ont été recensés : 1) la consolidation avec adhésif; 2) l'application localisée de renforts en papier à l'aide d'adhésif; 3) l'application de fils de renforts, avec ou sans adhésif; et 4) la non-intervention, parfois avec installation sur un support. La consolidation au Parylène (ou poly-para-xylylènes) a également été évaluée parce que l'ICC avait traité des échantillons d'écorce de cèdre de cette façon il y a plusieurs années et les avait conservés en vue d'un tel réexamen. Chaque approche de traitement offrait des avantages et des inconvénients. La teneur en fer s'est avérée un indicateur important de l'état de l'écorce. L'article présente aussi une revue de la littérature portant sur l'écorce de cèdre déchiquetée et ciblant ses propriétés, les processus de fabrication et les interventions en conservation-restauration.

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INTRODUCTION

In 2014, two masks from the U'mista Cultural Centre (UCC) were sent to the Canadian Conservation Institute (CCI) for treatment following exposure to soot and water as a result of a fire in the building. Both masks were about 100 years old and had shredded cedar bark components in very fragile condition. The masks had been in the collection of the Canadian Museum of History (CMH) until their repatriation in 1979; in the late 1960s, both had been condition reported and one treated. Over the years, CCI has also examined or treated several similar objects of similar age decorated with shredded cedar bark from the CMH collection. It was therefore decided to re-examine these locally available CMH objects as a group along with the two UCC masks, so as to compare the current condition of their cedar bark and assess how their previous treatments have held up over the past 30–40 years. Records were consulted to review condition history as well as treatment decisions, methodology and outcomes relating in particular to strengthening, consolidating or otherwise protecting weak cedar bark. Previously Parylene-treated cedar bark test samples were also re-examined as part of this survey.

About Cedar Bark

Origin, Properties and Uses

Cedar bark is the processed secondary phloem of the western redcedar[1] *Thuja plicata*, or of the yellow cedar *Cupressus nootkatensis*.[2] Both species of tree share common characteristics and grow on the Pacific Northwest Coast of North America, where they are commonly referred to as cedar.[3] They are large, long-living, coniferous trees with straight grains and low-density, durable wood. Cedars have tremendous economic, cultural and spiritual importance in the lives of Northwest Coast Indigenous Peoples. Their bark provides strong, flexible and waterproof material used for many utilitarian items such as baskets, mats, hats, clothing, rope and cooking vessels. Ceremonial regalia worn during potlatch ceremonies are largely made of cedar: masks are carved from the wood and decorated with shredded bark fringes, while other items such as head and neck rings, wristlets and armbands are made entirely of shredded bark.[4]

Harvesting and Processing

Cedar bark is harvested by cutting and pulling strips from a living tree; this is only possible to do in the spring and summer months, when the sap is flowing.[5] An L-shaped cut is made in the bark at the base of the tree and the bark is pried up using a bone tool. The harvester, traditionally a woman, grips the bark and walks backwards away from the tree, stripping the bark from the tree as she goes (**Figure 1**). The strip is twisted to remove it from the tree. Bark strips can be a few inches to a foot wide and up to 40 feet in length. Once removed from the tree, the rough, fragmented outer bark and the green inner bark layers are removed by hand, so that only part of the inner bark remains. This product, wet with sap, is bundled up, air-dried and stored for a year before further processing. The bark thus collected is a hard material used to make boards or containers, or can be split along its width and

Figure 1. Harvesting cedar bark: (left) a strip of bark is pulled from the tree; (right) after removing the rough outer bark, the inner bark is rolled up for transport and storage. Photographs: © Museum of Archaeology & Ethnology, Simon Fraser University. Used with permission.

thickness to get long, flexible strands for making mats, basketry and other items. A tree is only harvested from once, and only a portion of bark is removed. This allows the tree to survive but leaves a "scar" – such trees are called "culturally modified trees" and are considered archaeological artifacts in their own right.[6,7]

Cedar bark can also be further processed to produce a soft, flexible material using a variety of different methods and implements, which vary by region and by end use of the bark. To produce *shredded* bark, the best raw material is thin bark (hence collected from a young tree) free of pitch (hence harvested at the right time). Bark from the redcedar is washed, completely dried, sometimes by passing over a fire, and then beaten with a blunt instrument made of wood, bone or stone against a hard wood or stone surface. Redcedar bark can also be worked wet but then does not shred well. Yellow cedar bark, which is a tougher material, must be soaked for several days and worked wet (this is sometimes referred to as plasticizing). *Soft-shredded* bark, that is, even softer, more absorbent bark used for clothing, bedding, towelling, padding and bandages, is produced by further ruffling or twisting the shredded strands, sometimes soaking the bark again in water, or applying oils. Wetting and twisting shredded strands by hand results in twisted strands, as the bark accepts shaping when wet and retains the form when dried.[8]

Cedar bark may be left its natural colour, or it can be dyed. Redcedar bark naturally has a light reddish-brown colour and yellow cedar is a light tan colour. A black or dark brown colour can be obtained by burying the bark in swamp mud. A red colour, often seen in ceremonial regalia, can be obtained by dyeing with alder tree (*Alnus rubra*) bark infusion.[9]

Structure and Chemistry

On a living tree, the vascular cambium, or growth layer, produces new xylem cells (wood) towards the inside of the tree, and new phloem cells towards the outside of the tree for food storage and transport. Bark is familiarly known as the outer layers covering the trunk, stems and roots of a tree, but technically, bark consists of all the layers outside of the vascular cambium. Typically this includes the phloem (or inner bark) located immediately adjacent to the vascular cambium, and the periderm (or outer bark, also referred to as "true bark" at maturity) which mainly consists of cork cells.[10] Redcedar and yellow cedar do not have this outer periderm layer – instead, the outer layer of a cedar is formed from old layers of modified secondary phloem cells.[11] These consist of three main cell types found in alternating layers (**Figure 2a** and **Figure 2b**):[12]

1. Fibres: These cells provide mechanical strength and structure of the phloem. Redcedar phloem fibres are quite distinctive in shape and order of layers: one layer of thick-walled, square-shaped fibres alternates with at least three layers of radially flattened, thin-walled rectangular fibres. Yellow cedar phloem fibres are mostly thin walled, radially flattened cells, with occasional larger cells distributed randomly.
2. Sieve cells: These are thin-walled cells with long slender shapes that transport materials, found on either side of fibre cells.
3. Parenchyma cells: These are thin-walled cells containing phenolic compounds that store nutrients (starch grains), found between sieve cells.

As the tree grows, the phloem layers move outward, and the older, outermost phloem cells undergo mechanical and chemical changes to form a protective outer skin. The fibre cells become increasingly lignified, sieve cells collapse, and parenchyma cells fill with tannins and phenolic compounds to make them resistant to decay.[12,13] In dead phloem, the thin-walled parenchyma and sieve cells fracture easily, causing layer separation or exfoliation[14] (**Figure 2c**).

Holocellulose (cellulose and hemicellulose) and lignins (cross-linked phenol polymers) are the major chemical components of the phloem cell walls. The cellulosic compounds are long-chain polymers that combine to make fibrils and fibres. The lignins act like cement by crosslinking the cellulosic compounds and other polysaccharides, imparting rigidity and stiffness to the cell walls.[15] Redcedar and yellow cedar phloem also contain biominerals such as calcium oxalate, which is produced when the cells are alive and may provide resistance to pests.[14,16,17] Thujaplicins, phytotoxic and antifungal compounds found in western redcedar heartwood, are not present in the bark itself.[18]

Conservation of Cedar Bark

Degradation

Condition issues commonly seen in cedar bark artifacts include brittleness, fragility, splitting, delamination, exfoliation and breakage. This degradation is inherent to the material as the cellular structure of cedar bark, with alternating thick and thin-walled cells, creates natural lines of weakness that easily separate (**Figure 2**). As a cedar tree grows and its girth increases, more and more pressure is exerted on the outer phloem. Changes occur to the outer bark cells: the thick-

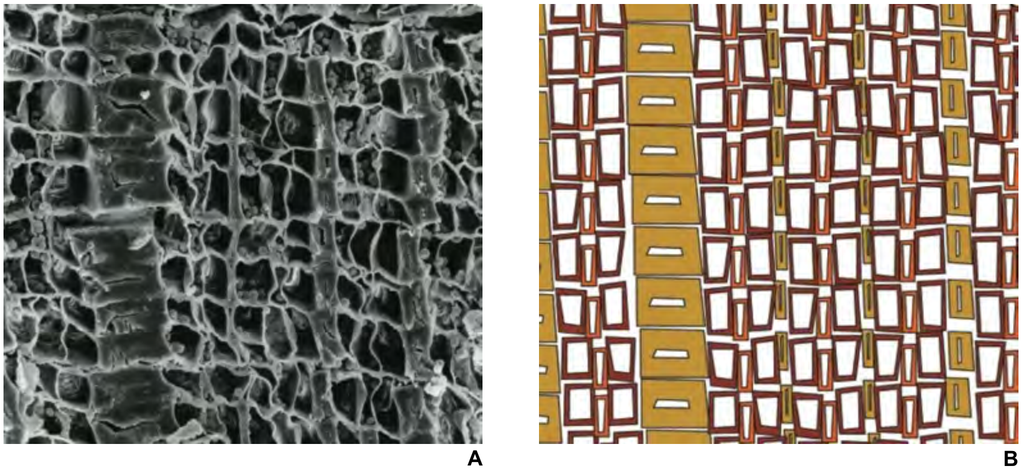
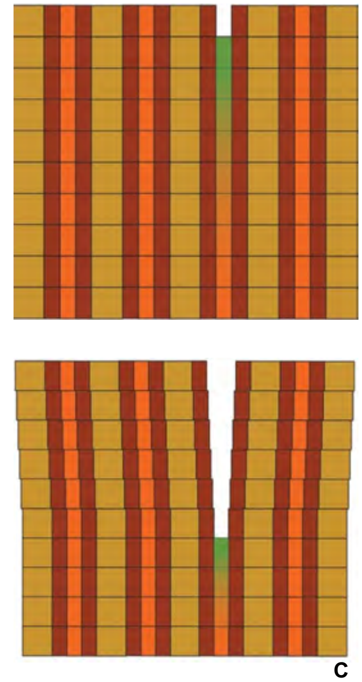



Figure 2. (a) Transverse cross-section of Western redcedar secondary phloem (electron micrograph, 480X magnification). Image: © Arlene Bramhall, courtesy Mary-Lou Florian. (b) Line drawing of (a) to illustrate the 3 types of cells within the structure: yellow = fibre cells; red = sieve cells; orange = parenchyma cells. (c) Once a fracture initiates at the thin-walled cells (top), it tends to propagate along the axial plane (bottom). Images: © Peter McElhinney.

walled fibre cells become increasingly lignified and tougher, while the thin-walled sieve and parenchyma cells are compressed and crushed, no longer functioning to transport nutrients. The phenolic compounds that accumulate in some of the parenchyma cells help them resist compression. These changes and subsequent compression can lead to fractures along the thin-walled cells, which propagate along lines of weaker cells.[13] The outer, old phloem easily fragments, allowing the tree to expand. This inherent quality is exploited during the harvesting and processing of cedar bark into strips and fibres, but can continue and lead to physical damage in artifacts. The processing of bark by soaking, heating and beating does not destroy the cells of the phloem, but reduces their structural integrity and encourages the separation of layers. Yellow cedar bark phloem often separates completely into individual cells.[19]

Another inherent vice from the conservation perspective is the presence of calcium oxalate crystals (**Figure 3**) that accumulate in the radial and tangential cell walls of phloem tissue.[17] In living tissue the calcium oxalate crystals are embedded in a pectin gel matrix, but in harvested bark the pectin gel matrix dries out and the remaining crystals can abrade the phloem internally, initiating fractures that then propagate along the cell wall structure.[13] Humidification of the phloem prior to manipulation may reduce this abrasion by partially humidifying the dried-out pectin.[13]

Dyeing can contribute to chemical degradation. The swamp mud used to dye bark brown contains iron, which catalyzes oxidation reactions in cellulose, causing chain scission that weakens the bark. A high iron content has been associated with severe weakening of spruce root, also a lignin-rich cellulosic material;[20] the same mechanism also causes the degradation of paper with iron gall ink[21,22] and of black-dyed “New Zealand flax”/ harakeke (*Phormium tenax*).[23] High acid content (low pH), which catalyses the hydrolytic breakdown of cellulose, also favours the formation of water soluble iron(II) ions that catalyses oxidative degradation.[23]

Cedar bark is most susceptible to damage by physical forces and water. Physical stresses, including weight if the cedar bark is hanging, can cause rupture of fragile layers at the cellular level, leading to delamination, breaks or losses. Exposure to water followed by drying or exposure to large relative humidity fluctuations causes differential swelling and shrinkage between cells, which may also lead to physical damage.[24] Because the phenolic compounds and biominerals in living cedar bark provide resistance to deterioration by UV or to biological attack by fungus and insects, such deterioration is less prevalent.[13,25]

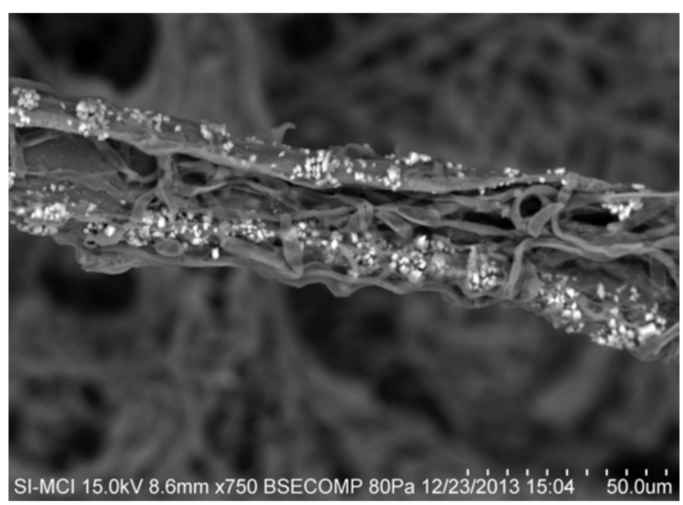


Figure 3. SEM microphotograph of calcium oxalate crystals attached to a phloem cell wall (scale = 50 microns). Image: © Nicole C. Little, Museum Conservation Institute, Smithsonian Institution.

Conservation

The published conservation literature offered few accounts of treatments for shredded cedar bark, focusing mainly on non-shredded cedar bark. Archaeological cedar bark (for example, woven mats, basketry, clothing and rope) is often discussed: it is generally found waterlogged and is commonly impregnated with polyethylene glycol (PEG) or other consolidants similarly used on waterlogged wood to prevent the collapse of its cellular structure upon drying.[26-28] Otherwise, most published sources focus on the treatment of flat, smooth cedar bark strips used for mats or basketry, which typically involves mending breaks with adhered paper backings.[29,30] Such treatments are not specifically designed for, or necessarily applicable to, shredded bark, which has distinct properties and problems.

Remedial treatments for shredded cedar bark aim to add a material or support to counter brittleness and impart strength and flexibility. This is difficult to achieve with bundles of thin, irregular, twisted and fraying strands of bark that usually must remain loose and hanging, sustaining their own weight. Ideally, treatments should add sufficient strength while not altering the feel, drape, appearance, sheen or colour of the bark. Further challenges include that plant materials are sensitive to water (which causes swelling and shrinking, potentially causing further disruption) and to many solvents (which can leach compounds). Such treatments fall into two groups: (1) adhesive consolidation or (2) application of a localized support with or without adhesive. The only reference to remedial treatment of shredded cedar bark found in published literature – a 1978 article on the conservation of a raven mask with fragile bark – discussed adhesive consolidation, though only as a treatment proposal (the treatment had not yet been completed at time of publication). The proposal was to separate the bark layers and laminate them with an adhesive backing inserted between the layers, then to consolidate the surface of the bark where needed with an adhesive.[31] In the end though, the cedar bark was left untreated.[32] Due to the bark's brittle condition and shedding, a consolidation treatment was later reconsidered, since the mask was planned for display in 2017.[32]

Another treatment option for degraded shredded cedar bark is replacement of severely damaged elements, as was carried out on a raven mask treated for the 2006–07 exhibition *Listening to Our Ancestors: The Art of Native Life Among the North Pacific Coast* at the National Museum of the American Indian (NMAI).[33] Kwakwa̱ka̱'wakw curators felt that, in its original context, the mask would not have been presented in such a poor condition. In a collaboration between conservators, curators and artists, the degraded cedar bark fringes were documented, removed and replaced with new material. This approach respected the intended function of the mask and treated it as part of a living culture. Clavir differentiates such an approach as "caring for objects," whereas traditional museums "preserve objects."[34] Consultation and collaboration with the originating community is essential in this process. In a similar vein, another possible treatment option could be the temporary addition of new cedar bark, or of other material (such as dyed raffia), to replace or supplement lost bark while the object is on display; the aim would be to restore to some extent the object's original appearance without permanently changing the object or risking damage with a more interventive treatment.

The concept of minimal intervention is a prevalent current approach: the decision is made to not treat degraded shredded cedar bark, accepting some amount of losses and saving detached pieces in polyethylene bags.[35] In these cases, shedding is deemed acceptable given that its occurrence was acceptable by the original owners during use, and given the invasiveness and potential drawbacks of alternative treatments. Minimal intervention shifts the focus to preventive conservation, following guidelines for plant-based materials, especially in minimizing handling and physical disturbances that provoke losses.

Ethical Issues

Cedar bark on Kwakwa̱ka̱'wakw objects has a tremendous significance:

> Today, the ˜se…a, (Red Cedar Bark Ceremony) and the T‡a'sa̱la or Peace Dance take place in one full day from late morning to late evening ceremony. The most important is the ˜se…a, and is considered a sacred ceremony. Red cedar bark on a mask or costume identifies the ˜se…a.
>
> The ˜se…a, a series of staged dramatic performances, describes the experience of our ancestors. The stories […] are expressed in dance and are the proudest possessions of the Kwakwa̱ka̱'wakw.[36]

Contrary to past museum practices, which often did not integrate Indigenous perspectives into decision-making processes relating to Indigenous tangible cultural heritage, it is now recognized as fundamentally important that the cultural and spiritual aspects of objects be understood or respected by custodians through consultations with source communities. Consultations are required if the physical preservation of materials may be in conflict with the original intention, usage and history of the object it is part of. As mentioned with the example of the NMAI raven mask, the cedar bark elements on ceremonial regalia were often refurbished when the object was in use in its original context. As well, shredded cedar bark strands on masks were meant to be soft, draped elements that cover and move with a dancer's body. Consolidation of fragile bark should avoid stiffening, as well as darkening or gloss. Minimal intervention is an important ethical concept guiding decisions, and no treatment may be the best choice in many cases. Actions such as consolidation with adhesives are in practice non-reversible, so the benefits must be weighed against the risks of such treatments.

SURVEY OF PREVIOUS TREATMENTS

Description of Objects Surveyed

The sixteen objects surveyed are described in **Table I**. All were treated or assessed for treatment between 1966 and 1989. Two masks are from the U'mista Cultural Centre (identified with "UCC" accession numbers), and the remaining objects are from the Canadian Museum of History (CMH). All are approximately 100 or more years old, with two previously confirmed to be redcedar. Ten of the objects are identified or listed as being of Nootka origin, three Kwakwa̱ka̱’wakw, one Tsimshian, one Bella Coola and one “Northwest Coast.” Of these objects, nine are wood dance masks with shredded cedar bark “hair,” usually attached by string to the crown or back of the mask, with freely hanging strands. Two are headdresses made mostly or entirely of shredded cedar bark. The remaining objects have varied forms. The Merganser Canoe is a large wood framed structure in the shape of a bird, covered with painted cloth, with shredded cedar bark strands hanging at the crown and throat. The Dragonfly Screen consists of large painted wooden planks with a raven-like beak protruding outwards, from which hang cedar bark strands. The Harpoon Point Cover is made of a folded piece of cedar bark with ends split into strips. The Jacket is made of shredded cedar bark warp “yarns” fairly tightly woven at 1/4 inch (6 mm) intervals between a twined cord weft, possibly nettle fibre. The cedar bark warp sections appear to have been beaten to separate them into fine fibres, with no twist, giving them the appearance of thick yarns.

Methodology and Criteria for Assessment

Treatment dossiers were consulted to determine the before-treatment condition of the cedar bark, the treatment method and the immediate after-treatment condition. Dossiers, staff and museum catalogues provided the objects’ dates of creation or collection, exhibition histories and known storage relocations. Exhibition catalogues and museum records also provided exhibition dates and photographs of the objects over time, providing information on condition. The objects were re-examined in situ at the Canadian Museum of History, during which post-treatment condition observations were made by the authors. Eleven objects could be examined up close; the rest were on display and could only be seen in their display cases. A visual and tactile assessment was conducted using the following parameters:

- appearance: colour, gloss, presence of adhesive residues, visual obtrusiveness of the repairs;
- physical properties: fragility, strength, brittleness, flexibility, ability to withstand flexing without damage (subjectively assessed, as no scientific testing method could be applied);
- losses: amount of cedar bark present compared to archival photographs (including catalogue photographs and treatment photo-documentation); noticeable fine shedding or losses (such as presence of debris on mounts).

Bark colour was assessed using Munsell Soil Colour Charts,[37] as colour may provide insights into condition. When it appeared dyed, the bark was tested for iron and for pH. The presence of iron(II) ions was qualitatively confirmed using bathophenanthroline test strips developed for identifying iron-gall ink in documents,[22] following the procedure and using the CCI iron(II) ion test strip colour chart.[38] In a minor modification of the method, 0.1 M (1.8%) sodium dithionite solution was used instead of ascorbic acid to determine the presence of iron(III) ions.[39] The pH of samples was taken by placing a fragment of the bark onto ColorpHast pH strips (2.5–4.5 and 4.0–7.0 ranges) and moistening with reverse osmosis water. Bark from a few objects was further tested using cold extraction pH method (TAPPI standard T509 om-02 or ASTM D778–97 (Cold)) for paper, modified for small sample size.[40,41]

Results and Discussion

Colour, Iron Content, pH

As seen in **Table I**, the colour of the cedar bark for the majority of objects was brown or reddish brown, probably the bark’s natural colour. The two Kwakwa̱ka̱’wakw raven masks had cedar bark strands of two distinctive colours, a “natural” brown and a deeper reddish-brown, and another object had cedar bark that was obviously dyed a vivid red; they were likely dyed with alder bark extract. Four other objects had cedar bark dyed a dark brown colour. The museum documentation for one of these indicated the bark was “dyed with swamp mud,” a method reported in the literature.[9]

The condition of selected bark samples, their colour, iron content and pH readings are presented in **Table II**. Wording for colour follows Munsell Soil Color Chart names.[37] All dark brown samples of cedar bark tested positive for the presence of iron(II). These bark samples were also in poor condition, consistent with degradation symptoms for iron(II) catalyzed oxidation. In the case of the two cedar bark samples that were clearly red, the red colour bled and stained the iron test strip paper, yielding inconclusive results. Since red-coloured bark is likely dyed with alder extract (not an iron-based dye) and these barks were in fair condition (and did not show deterioration like the iron-dyed barks), we assumed these bark samples did not contain iron. The natural-coloured brown cedar bark and the alder-dyed cedar bark lab samples also tested negative for iron.

Extraction pH values are more accurate than values produced by pH strips, but extraction could not be used for all samples. In comparing both methods, the pH strips gave reasonable estimates, the difference between them and the more precise extraction method being less than half a pH unit.[41] The pH of the 100-year-old dark brown cedar bark samples taken from objects ranged from 3.6–4.59 (based on extraction values when possible). The dark brown bark samples from Wolf Mask VII-F-379ab and Wolf Mask VII-F-665 were the most severely degraded and also had high iron content and low pHs, respectively at 3.6 and 3.9–4.2. The two other dark cedar bark samples tested (from the Ba̱k̓wa̱s mask and a lab sample) were brittle and fragile but had higher pHs in the range of 4.2 to 4.5 – similar to the pH of the cedar bark samples that did not contain iron. Deteriorated cedar bark samples that had no iron(II) (the form of iron that degrades cellulose) – two samples from the Hamsiwe’ mask and two from “old” lab samples – had pHs ranging from 3.48 to 4.59. The newest natural brown sample tested, collected in the spring 2012 from northern Vancouver Island, had a pH of 4.4.

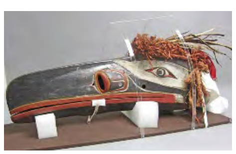
Altogether, the cedar bark samples were all acidic, yet the lowest pH values did not always correlate with the most degraded barks. A dark brown colour and high iron(II) content were the clearest indicators of poor condition. The pH value alone may not be indicative of condition; iron content and physical properties should also be considered.

Table I. Results of the survey of past treatments on shredded cedar bark.

Object (**Name**, **accession number**, *provenance*, *date*)	Munsell Colour & Code	Cedar Bark Description & Before Treatment Condition	Treatment (by CCI, or *by CMH)	After Treatment Condition	Post-treatment Condition & Observations	Summary: Appear-ance	Summary: Phys. Props.	Summary: Losses
1. Adhesive consolidation								
Wolf Mask, VII-F-665 *Nootka, collected 1900* 	Very dark brown 7.5YR 2.5/2	1955: *Long (18" approx.) cedar bark hair lashed to an interior strut – "swamp mud-coloured" according to [collector Lord] Bossom catalogue.* 1958: *Exhibited in Ottawa.* 1985: *Cedar bark weak and damaged. Cedar bark mane is fairly fragile as it is dry and brittle.* (**Figure 5a**)	1985: *Consolidated cedar bark hair – sprayed ends with 2% PVB [polyvinyl butyral] in ethanol, and brushed on 2% PVB in areas nearest mask. Made protective mount for cedar bark.* [Mask sits on padded mount, cedar bark wrapped in paper.] (**Figure 5b**)	1985: *The cedar bark mane is fragile and should be handled with care.*	2015: Very brittle and stiff. Large and small breaks, losses, and powdering. Lots of shedding, possibly exacerbated by abrasion from slightly stiff paper wrapping. (**Figures 5c and 5d**) **Iron (II) = 25 ppm range; pH 3.9-4.2**	Fair	Poor	Major
Head Mask for Wolf Dance, VII-F-379ab *Nootka, collected 1913-14* 	Dark brown 7.5YR 3/2, 2.5/2	Cedar bark tufts tied with string hang across back. 1965: *Exhibited in Berkeley, California.* 1985: *Cedar bark weak, broken. Dusty, split, shredded.* (**Figure 6a**)	1985: *Consolidated (ends only, approx. 2") with 2% Klucel G (hydroxypropyl cellulose)* [solvent not specified]. (**Figure 6b**) [Supplemented with paper backings, see below.]	1985: *Keep mask on Ethafoam support to prevent breakage of cedar bark.*	2015: Cedar bark brittle and fragile. Breaks and many lost fragments, but no fine shedding. (**Figure 6c**) **Iron (II) = 25-50+ ppm range; pH 3.6**	Good	Poor	Minor ~5%
Bak'was Mask, VII-E-588/ UCC-80.01.013 *Kwakwaka'wakw, before 1921* 	Dark reddish brown 5YR 3/2	1963-64, 1965: Photographs show long strands of cedar bark "hair" all over back of head. 1965: *Exhibited in Berkeley, California.* 1966: *Cedar bark hair desiccated.*	1966*: *Cedar bark hair sprayed with P.V.A.* [polyvinyl acetate, solvent and concentration not specified]. 1983: CCI Mobile Lab: no treatment of shredded cedar bark, but surface cleaning and humidification of other elements.	1967: *Exhibited in Vancouver.* 1968: Exact replica made showing cedar bark now tied in a bundle within fabric. Major losses occurred, possibly linked to travel.	1969-71: *Exhibited in Paris, France and Ottawa. No change in condition.* 1979: *"…Red fabric to which is tied… a bundle of shredded cedar bark"*; photo shows cedar bark similar to 2015 appearance but with longer strands. 1980: *Returned to U'mista Cultural Centre, put on permanent exhibit.* 1998: *Exhibited in Vancouver.* Condition appears unchanged in photograph. 2011: *Exhibited in Dresden, Germany. Condition: unchanged.* 2015: Cedar bark is brittle, snaps and breaks off in small pieces. **Iron (II) = 10 ppm range; pH 4.4-4.5**	Good	Fair	Major
Head Mask, VII-F-380 *Nootka, collected 1913-14* 	Dark brown	Cedar bark strips suspended at lower rear, top ends attached on lower rear strut. 1967: *Shredded bark … very weak.*	1967*: *Shredded bark consolidated with 5% PVA* [polyvinyl acetate] *spray* [solvent not specified].		1985: *Cedar bark very dry and brittle. Cedar bark stiff and shiny from previous consolidant.* [Re-treated, see below.]	Fair	Poor	?
		1985: *Cedar bark stiff and shiny from previous consolidant. Bark strips are very dry and brittle. Loose pieces rested at the bottom of the box it was transported in. Desiccated and brittle.*	1985: *Methylcellulose 0.5% in 40:60 ethanol and water was applied as a consolidant, the water relaxing the fibres…. Support of Corex cut to support the fall [bark].* [Supplemented with paper backings, see below.]	1985: *Restrict movement of the mask - otherwise pieces of the bark could come off.*	1994: *Cedar bark is very dark and brittle … has completely disintegrated – only individual pieces left laying on bottom of … mount.* 1996: Photographs show bark losses. 2015: On display – could not fully assess. Some bark losses at fringe ends. Corex support removed for display.	Fair	Poor	Major ~15%
Shaman's Headdress, VII-F-220 *Nootka, 1885-1901* [Cannot reproduce photograph]	Yellow-ish red 5YR 4/6	Cedar bark coiled around wood peg at top of head. 1985: *Cedar bark is fraying and fragile. Handle by mount only.*	1985: *Re-arranged bark, consolidated with 2.5% methylcellulose in water.*	1985: *Cedar bark is very fragile.... Handle by mount only....for exhibition, a special mount … required.*	2015: Cedar bark slightly hard and stiff. Some strands are glued together. Visible excess adhesive. Small breaks and minor shedding.	Poor	Poor	Minor

Sources: *object's dated documentation files* (quoted or paraphrased); or authors' observations. Photographs: © Government of Canada, Canadian Conservation Institute.
Phys. Props. = physical properties (strength and flexibility); ppm = parts per million; ETOH = ethanol; ? = unable to assess.

Table I. Results of the survey of past treatments on shredded cedar bark (cont'd).

Object (**Name, accession number**, *provenance, date*)	Munsell Colour & Code	Cedar Bark Description & Before Treatment Condition	Treatment (by CCI, or *by CMH)	After Treatment Condition	Post-treatment Condition & Observations	Summary: Appear -ance	Summary: Phys. Props.	Summary: Losses
1. Adhesive consolidation (cont'd)								
Wolf Mask, VII-F-407a *Nootka, collected 1913-14* 	Yellow-ish red 5YR 4/6	Shredded cedar bark mane at top rear, folded over to hang down. 1927: *Exhibited in Ottawa.* 1985: *Cedar bark is dirty, split and delaminating.* (**Figure 9a**) *Cedar bark strands missing from top sides and front.*	1985: *Sprayed underside of bark with 1.25% Ethulose 400 (ethyl hydroxyethyl cellulose) in 2/3 water/ethanol. Sprayed with ETOH to relax and give a more natural drape.* (**Figure 9b**)	1985: *Handle with care – cedar bark is very fragile.*	1996: *Weak, friable, embrittled.* 2015: Cedar bark is stiff, not very flexible, but strong. Virtually no losses or shedding. Excellent appearance, no adhesive residue. (**Figure 9c**)	Good	Fair	None
Wolf Mask, VII-F-459 *Nootka, collected 1914* 	Natural	Shredded cedar bark strips extend from top of mask all down rear. 1976: *Cedar bark mane is very brittle: object sheds fragments of cedar bark whenever it is handled.*	1976: *Cedar bark sections were detached, washed in Fisher Methyl hydrate (denatured ETOH), then consolidated with 10% Rhoplex AC-33* [acrylic dispersion] *in ETOH. Analysis by M.L. Florian confirms bark is Thuja plicata (redcedar).*	1976: *Resulted in no darkening, but considerable stiffening and strengthening of the previously very weak fibres.*	1985: *Cedar bark mane is fairly hard and stiff. Use normal care in handling.* [No further treatment was proposed.] 2015: On display – could not fully assess. Most cedar bark appears present (similar to 1985 photograph).	Good ?	?	Minor
2. Localized Paper Backings								
Head Mask for Wolf Dance, VII-F-379ab *Nootka, collected 1913-14* 	Dark brown 7.5YR 3/2, 2.5/2	Tufts of cedar bark tied with string hang across back. 1965: *Exhibited in Berkeley, California.* 1985: *Cedar bark weak, broken. Dusty, split, shredded.*	1985: *Repaired broken pieces with Jade 403* [polyvinyl acetate – ethylene copolymer dispersion] *and cockerall handmade paper.* (**Figure 10a**) [Supplemented with adhesive consolidant, see above.]	1985: *Keep mask on Ethafoam support to prevent breakage of cedar bark.*	2015: Cedar bark is brittle and fragile; many breaks and lost fragments, but no fine shedding. Paper backings apparent on back of bark strands, but not visible from the front. Backings are well adhered and support the strands. **Iron (II) = 25-50+ ppm range; pH 3.6**	Fair	Poor	Minor ~5%
Head Mask, VII-F-380 *Nootka, collected 1913-14* 	Dark brown	Cedar bark strips attached in bundles on mask's lower rear and hanging. 1985: *Cedar bark stiff and shiny from previous consolidant. Bark strips are very dry and brittle. Loose pieces rested at the bottom of the box it was transported in. Desiccated and brittle.*	1985: [After consolidation, see above.] *Where necessary, backings of Japanese tissue of a medium weight handmade paper were applied… Initially MC* [methyl cellulose] *2% was used as the adhesive but it proved too weak. Wheat starch paste 7% provided a better bond. A support of Corex cut to support the fall.*	1985: *Restrict movement of the mask – otherwise pieces of the bark could come off.*	1994: CCI re-examination: *Cedar bark is very dark and brittle. Cedar bark fall has completely disintegrated – only individual pieces left laying on bottom of … mount.… Parylene coating next time.* 2015: On display – could not fully assess. Some losses of bark at fringe ends. Corex support removed for display.	?	?	Major ~15%
Bird (Raven) Mask, VII-E-5 *Kwakwaka'wakw, 1890-1904* 	Red & natural 2.5 YR 4/6 · 7.5 YR 5/6	Shredded cedar bark on crown with a few hanging strands. 1932: *Exhibited in Toronto.* 1955: *Exhibited in Winnipeg.* 1960: *Exhibited in Montreal and Stratford.* 1961: *Exhibited in Ottawa.* 1975-81: *Exhibited in Ottawa.* 1978: *Cedar bark dry.* 1981: *Cedar bark extremely dry and brittle.* 1988: *The cedar bark fibres are extremely dry and brittle and there is considerable loss.*	1975: *Cedar bark was untangled; no other treatment.* 1988: *Backed cedar bark strips with ink-toned Japanese paper adhered with 5% wheat starch paste.* (**Figure 10b**) [Also applied cotton thread wrappings, see below.]	1988: *A few more bits of cedar bark have come off* [during manipulations while making mount]. *Cedar bark should not be touched or moved.*	2015: Backings support flat broken strands. Backings are subtle and well attached. Minor shedding and losses elsewhere overall.	Good	Fair	Minor

Sources: *object's dated documentation files* (quoted or paraphrased); or authors' observations. Photographs: © Government of Canada, Canadian Conservation Institute.
Phys. Props. = physical properties (strength and flexibility); ppm = parts per million; ETOH = ethanol; ? = unable to assess.

Table I. Results of the survey of past treatments on shredded cedar bark (cont'd).

Object (**Name, accession number**, *provenance, date*)	Munsell Colour & Code	Cedar Bark Description & Before Treatment Condition	Treatment (by CCI, or *by CMH)	After Treatment Condition	Post-treatment Condition & Observations	Summary: Appear-ance	Summary: Phys. Props.	Summary: Losses
2. Localized Paper Backings (cont'd)								
Face Mask, VII-F-1 *Nootka, collected 1910* 	Yellow-ish red 5YR 4/6	Cedar bark hair nailed on top of head and gathered with string. 1985: *Cedar bark hair is delaminating and fraying – overall very fragile. Bark hair missing from top front.*	1985: *Backed three large pieces of cedar bark with Japanese tissue and 10% EHEC* [ethyl hydroxyethyl cellulose]*/25% PVA [polyvinyl acetate] in ethanol.* [Also wrapped with hair silk, see below.]		2015: Cedar bark is friable and brittle, but flexible. Small losses and shedding overall. Paper backings are small and offer minimal support, but are well attached.	Good	Fair	Minor
Harpoon Point Cover, VII-F-28b *Nootka, collected 1910* 	Natural	Single piece of cedar bark folded in half, ends are split into strips. 1984: *Poor condition, [bark] cover split and cracked.* 1985: *Poor – bark has split and is delaminating.*	1985: *Steamed open… breaks lined up - repaired with handmade cockerall paper. Adhered with 15% P.V.A.* [polyvinyl acetate] *AYAA and 15% EHEC (ethyl hydroxyethyl cellulose in ethanol)* [sic]. *Clamped until dry. Bark steamed to close. Polyethylene wedge cut to fit inside sheath.*		2015: On display – could not fully assess. Paper appears to be well attached and supporting the cedar bark. No losses are noticeable. Cannot tell if foam support is still inside.	Good	?	None
3a. Wrappings with Adhesive								
Bird (Raven) Mask,VII-E-5 *Kwakwaka'wakw, 1890-1904* 	Red & natural 2.5 YR 4/6 · 7.5 YR 5/6	Shredded cedar bark on crown with a few hanging strands. 1932: *Exhibited in Toronto.* 1955: *Exhibited in Winnipeg.* 1960: *Exhibited in Montreal and Stratford.* 1961: *Exhibited in Ottawa.* 1975-81: *Exhibited in Ottawa.* 1978: *Cedar bark dry.* 1981: *Cedar bark extremely dry and brittle.* 1988: *Cedar bark extremely dry and brittle…. considerable loss.*	1989: *Consolidation of cedar bark by adhering cotton threads along the edges of small thin fibre bundles; in some areas the threads were wrapped around these bundles; other fibre strips were backed with dyed (Pelican drawing ink) Japanese paper, adhesive: wheat starch paste 5%.* (**Figure 10c**)	1989: *A few more bits of cedar bark have come off [during manipulations while making mount]. Cedar bark should not be touched or moved.*	2015: Cedar bark is slightly brittle, fragile, and friable, but still flexible and in fair condition. Bark strands treated with thread are stable and threads are well attached. Minor shedding and losses elsewhere. Threads are visible up close but less noticeable from afar.	Fair	Fair	Minor
3b. Wrappings, No Adhesive								
Wolf Mask, VII-F-667 *Nootka, collected c. 1900* 	Dark red (dyed) 10R 3/6	1955: *Red dyed shredded cedar bark knotted through some of holes at back. [Collector] Bossom catalogue notes "originally there were bunches of natural and dyed bark."* 1958: *Exhibited in Ottawa.* 1985: *Cedar bark split and delaminating. Cedar bark fraying.* (**Figure 11a**)	1985: Cedar bark wrapped with hair silk thread in a matching colour, stitching thread through groups of fibres rather than wrapping the braid overall. (**Figure 11c**)	1985: *Handle with care. Keep covered in storage.*	2015: Only red-dyed bark is discernible. Cedar bark strand hanging at one end is in good condition. Braids are supported by thread. Minor shedding. (**Figure 11b**) **Reddish cedar bark tested for iron but results inconclusive (dye interference); likely negative.**	Good	Good	Minor
Face Mask, VII-F-1 *Nootka, collected 1910* 	Yellow-ish red 5YR 4/6	Cedar bark hair nailed on top of head and gathered with string. 1985: *Cedar bark hair is delaminating and fraying – overall very fragile. Bark hair missing from top front.*	1985: *Consolidated cedar bark using hair silk* [wrapped overall with dyed hair silk thread].		2015: Cedar bark in good to fair condition (friable and brittle but flexible) and physically supported by thread wrappings. Small losses and shedding overall.	Good	Fair	Minor

Sources: *object's dated documentation files* (quoted or paraphrased); or authors' observations. Photographs: © Government of Canada, Canadian Conservation Institute.
Phys. Props. = physical properties (strength and flexibility); ppm = parts per million; ETOH = ethanol; ? = unable to assess.

Table I. Results of the survey of past treatments on shredded cedar bark (cont'd).

Object (**Name**, **accession number**, *provenance*, *date*)	Munsell Colour & Code	Cedar Bark Description & Before Treatment Condition	Treatment (by CCI, or *by CMH)	After Treatment Condition	Post-treatment Condition & Observations	Summary: Appear-ance	Summary: Phys. Props.	Summary: Losses
3b. Wrappings, No Adhesive (cont'd)								
Cedar Bark Headdress, VII-F-118, *Nootka, 1889* 	Yellow-red & brown 7.5YR & 5YR 4/6	Shredded cedar bark bundle twisted with ends joined to form a circle, secured with cotton. 1973: *Brittle.* *1985: Cedar bark is frayed, split and delaminating. Very fragile.* (**Figure 12a**)	1985: *Consolidated cedar bark using hair silk – bound cedar bark with hair silk* [wrapped overall with dyed hair silk thread]. (**Figure 12c**)	1985: *Headdress very fragile – not to travel, not advisable to display.*	2015: Cedar bark in good condition and supported by thread. Minor shedding. Fair appearance – thread wrapping is visible up close, but less noticeable from afar. (**Figure 12b**)	Fair	Good	Minor
Merganser Canoe, VII-D-205 *Bella Coola, c. 1910, collected 1921* 	Natural	Cedar bark fringes hanging at crown and throat. 1981: *Cedar bark is dry and brittle.* 1986: *Loose and friable cedar bark mane. Bark very fragile.*	1987: *Locks of "hair" [cedar bark] bound with hair silk – great deal of loose cedar bark coming off during this process.* Loose lock re-attached with braided silk.	1987: *Handle cedar bark with great care.*	2015: Object on display – could not be fully assessed. All cedar bark appears present. Hair silk repairs not visible.	Good	?	Minor
			2011-12?: Photographed. Possibly when a bundle of cedar bark is encased in silk crepeline.		2015: Crepeline encasement is visible, even at low light.	Poor	?	Minor
4. No treatment								
Cedar Bark Jacket, VII-X-58b *Northwest Coast, collected 1899* 	Brown 7.5YR 5/6	Strips of cedar bark bound by twined cord. 1973: *Overall condition: Fair.* 1986: *Sleeves flattened […] back in good condition.*	1986: *No treatment.*		2015: Cedar bark in very good condition (possibly yellow cedar?). Bark is strong and supple, with virtually no breakage or shredding, even though it is stained and torn in some areas.	Good	Good	None
Dragonfly Screen, VII-C-1130 *Tsimshian, c. 1850, collected 1924* 	Natural or red-brown?	Cedar bark strips suspended from bottom of beak, knotted through holes at beak base. 1924: *Beak added last time it was used, about 30 years ago…. Under beak was suspended swans-down with red cedar bark.* 1927?: *Exhibited in Ottawa.* 1968: *Exhibited in Ottawa.* 1969-70: *Exhibited in Paris, France and Ottawa;* exhibition photograph shows strands of cedar bark hanging. 1970-71: *Exhibited in Ottawa.*	1983: *No treatment.*	1983: *All cedar bark hangings cut off at knots.* [After treatment photos show that cedar bark hangings are missing, only ends remain, tied to beak.]	2015: On display – could not fully assess. Cedar bark appears similar to 1983 after treatment photos – only the ends of cedar bark hangings present in the 1969-70 catalogue photograph remain affixed to the beak.	Good	?	Major
Hamsiwe' Mask, VII-E-617/UCC-80.01.001 *Kwakwaka'wakw, before 1921* 	Brown & reddish brown 2.5 YR 4/4 / 7.5 YR 4/4	Long cedar bark strands suspended at back and bottom of head (from crown, sides and jaw). 1927-28: *Exhibited in Ottawa, Toronto, and Montreal.* 1965: *Exhibited in Berkeley, California.* 1967: *All cedar bark shredding are secure.* 1967: *Exhibited in Vancouver.*	1967: *No treatment.* 1979: *No treatment.*	1979: *The cedar bark is, of course, fragile. The fringes are crushed and many of the long strands are lost.*	1980: *Returned to U'mista Cultural Centre, put on permanent exhibit.* 2011: *Exhibited in Dresden, Germany: Large loss of cedar bark material [during travel]. Cedar bark is very brittle. Every movement leads to loss of material.* 2015: Cedar bark extremely fragile. Comparison with older photographs shows losses from hanging strands. **Brown cedar bark: negative for iron; pH 4.13. Reddish-brown cedar bark: iron test inconclusive; pH 4.59.**	Good	Fair	Major

Sources: *object's dated documentation files* (quoted or paraphrased); or authors' observations. Photographs: © Government of Canada, Canadian Conservation Institute.
Phys. Props. = physical properties (strength and flexibility); ppm = parts per million; ETOH = ethanol; ? = unable to assess.

Table II. Objects, condition, colour, iron content and pH of selected samples of cedar bark.

Samples and Condition	Munsell Soil Chart Code and Colour	Iron(II)	Iron(II+III)	pH (ColorpHast)	pH (extraction)
Head Mask for Wolf Dance VII-F-379ab: Cedar bark brittle, fragile, pieces break off, many breaks, breaks with gentle handling, small 1–10 mm fragments shed, many larger fragments lost.	7.5YR 3/2, 2.5/2 Dark brown	25–50+ ppm	25–50+ ppm	3.6	–
Wolf Mask VII-F-665: "Swamp mud-dyed" cedar bark, very brittle and stiff, large and small breaks, losses, powdering, lots of shedding.	7.5YR 2.5/2 Very dark brown	25 ppm	25 ppm	3.9–4.2	–
Bak'was Mask VII-E-588/UCC-80.01.013: Cedar bark very fragile, broken into small to medium length fragments.	5YR 3/2 Dark reddish brown	10 ppm	10 ppm	4.4–4.5	4.51
Lab sample: "Old" black dyed cedar bark, very fragile.	Dark brown	~10 ppm	~25 ppm	4.2	–
Wolf Mask VII-F-667: Cedar bark not very brittle, but lots of splitting and breaks, small fragments ~1–10 mm in size litter the mount.	10R 3/6 Dark red	Inconclusive‡	Inconclusive‡	*	–
Hamsiwe' Mask VII-E-617/UCC-80.01.001: Cedar bark in poor condition overall.	2.5 YR 4/4 Reddish-brown	Inconclusive‡	Inconclusive‡	*	4.59
	7.5 YR 4/4 Natural brown	Negative	Negative	4.4–4.5	4.13
Lab sample A: "Old" soft shredded cedar bark, fragile.	Natural brown	Negative	1 ppm	3.9	3.67
Lab sample B: "Old" soft shredded cedar bark, fragile.	Natural brown	Negative	1 ppm	3.9	3.48
Lab sample: "New" (25 year old) unprocessed cedar bark, in good/fair condition.	Natural brown	Negative	Negative	3.9–4.0	–
Lab sample: Cedar bark collected in spring 2004 (Haida Gwaii).	Natural brown	Negative	–	3.9	
Lab sample: Cedar bark collected in spring 2012 (Vancouver Island).	Natural brown	Negative	–	4.4	–

‡Dye stained bathophenanthroline paper red; possibly dyed with alder for red colour.
*Anomalous reading (running dye interfered with pH strip color reading).

Exhibition History and Relocations

As expected within a museum setting, the objects have moved or travelled as part of ongoing museum activities. **Table I** provides the dates and locations where each object travelled on loan for exhibitions. Besides exhibition travel, the CMH objects were transported locally to the CCI facilities in the 1970s and 1980s for treatment. After treatment, they were moved from CCI back to local storage facilities, and later moved to the newly built (and current) museum storage facilities which opened in 1989, with some objects most likely moved to a temporary storage facility prior to that move.[42] In addition to the exhibitions listed in **Table I**, the two U'mista Cultural Centre masks surveyed were condition reported or treated at the CMH facilities, which probably also required local transportation to and from the museum's conservation laboratories, and they travelled to Alert Bay, B.C. in 1979–80 when they were repatriated to the community, and to CCI for treatment in 2014.

Treatment Evaluations

The types of treatments used on the shredded cedar bark fell into four groups: consolidation with dilute adhesives; localized paper backings; localized wrappings, with or without adhesive; and no treatment. The results are summarized in **Table I** and discussed below. Note that all relevant information regarding the cedar bark was transcribed from previous documentation, and some information on materials may be missing because it was not included in the original treatment reports.

1. Adhesive Consolidation

Seven objects surveyed had received six different adhesive treatments, each with different parameters (spray or brush application, solvents, concentration):

- 0.5% methylcellulose in 40/60 ethanol/water (applied over a previous 5% polyvinyl acetate consolidation treatment) (product not specified);
- 2.5% methylcellulose in water (product not specified);

- 1.25% Ethulose 400 (ethyl hydroxyethyl cellulose) in 2/3 water/ethanol, sprayed on;
- 2% Klucel G (hydroxypropyl cellulose) applied by brush (solvent not specified);
- 2% polyvinyl butyral in ethanol, sprayed on loose ends and brushed on areas nearest to wood (product not specified);
- 5% polyvinyl acetate, sprayed on (product and solvent not specified);
- polyvinyl acetate, sprayed on (product, concentration and solvent not specified);
- 10% Rhoplex AC33 (methyl methacrylate, ethylacrylate and ethyl methacrylate) in ethanol.

Treatment proposals also included carboxymethyl cellulose (CMC) and Calaton (soluble nylon) as possible testing options, but these materials were not used in any of the actual treatments.

In most cases, the visual appearance of adhesive-treated cedar bark was good: the adhesive did not seem to darken the surface and was not visually perceptible. Two exceptions were: the object treated with 2.5% methylcellulose (Shaman's Headdress VII-F-220) where small clumps of shiny adhesive buildup were visible, and Head Mask VII-F-380 which photo-documentation shows as dark and shiny (as discussed below).

Dark brown cedar bark was present on four objects that had been adhesive-treated.

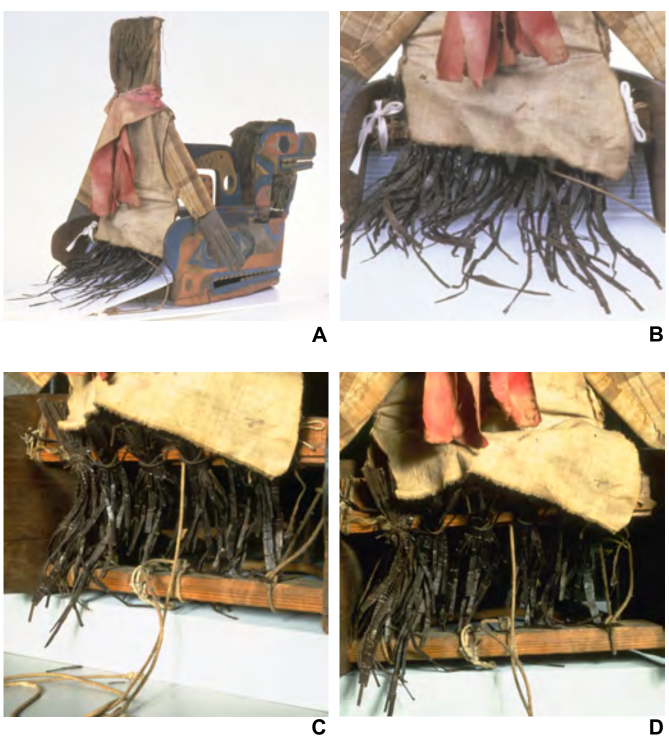


Figure 4. Head Mask VII-F-380, rear view. (a) and (b) 1985, after treatment. Photographs: © Government of Canada, Canadian Conservation Institute. (c) and (d) 1996 photo-documentation, showing shortened strands. Photographs: © Canadian Museum of History.

Head Mask VII-F-380: the mask could not be closely examined because it was on display, but from visitors' distance, the cedar bark fall or mane appeared similar in quantity and length to its 1996 museum documentation photographs,[43] and noticeably shorter than how it was after its 1985 CCI treatment (**Figure 4**). Loss of the cedar bark was also documented in 1994 during a previous survey of past CCI treatments.[44] The cedar bark had been first consolidated in 1967 with 5% PVA "spray." When assessed in 1985 prior to its CCI treatment, the conservator described it as stiff and shiny from previous consolidation treatment, unstable, very dry and brittle. As the object was planned for permanent display in the Grand Hall, its 1985 consolidation using 0.5% methylcellulose in 40:60 ethanol:water (combined with some Japanese paper backings, see below) was an attempt to strengthen what was already extremely weak, yet the after treatment recommendations appear to concede the treatment's limited success, noting: "Restrict movement of the mask – otherwise pieces of the bark could come off."

Wolf Mask VII-F-665: its cedar bark treated with 2% polyvinyl butyral was currently in the worst condition, being very brittle and stiff, and prone to losses and disintegration (**Figure 5**), although at least most of the long cedar bark fringes had been well protected and remained intact.

Figure 5. Wolf Mask VII-F-665, rear view: (a) 1985 before treatment; (b) 1985 after treatment, after consolidation with 2% PVB in ethanol; (c) condition in 2015; (d) 2015 detail, showing extensive shedding and splintering of iron-dyed dark brown cedar bark. Photographs: © Government of Canada, Canadian Conservation Institute.

Head Mask VII-F-379ab: its cedar bark treated with 5% Klucel G was also in poor condition, although slightly better than the one described above (**Figure 6**); in particular, it was more robust and not as prone to fine surface shedding, although some larger losses occurred, evidenced by a petri dish of collected broken and detached bark pieces (**Figure 6c**).

Bak̓was Mask VII-E-588: the shredded cedar bark was consolidated with polyvinyl acetate "spray" in 1966; since then, it was evaluated and exhibited many times without further treatment. In 1964 prior to treatment, the mask had long, voluminous strands of shredded cedar bark along the top and back head (**Figure 7a**).[45] In 1968 when an exact replica was made[46] (which was examined during this survey), the cedar bark consisted of only short strands wrapped in a bundle of red cloth at the top of the mask which looks very similar to the current appearance of the mask (**Figure 8**). Losses of the cedar bark likely occurred during a loan for a 1965 exhibition,[47] and would be consistent with the perceived need for the 1966 treatment. Currently the short bark strands are relatively strong but brittle and if bent would snap into small pieces, but they are relatively well protected from physical damage by being wrapped in cloth. Photo-documentation showed little change in amount of cedar bark between 1968 and 2014 (1979–80,[48] 1983,[49] 1998,[50] 2011[51]), although the cedar bark strands are possibly slightly shorter now (**Figure 8**) than in 1979–80 (**Figure 7b**).

The before treatment condition of the iron-dyed shredded bark in these four cases had been described as extremely brittle, hence the decision to consolidate. Currently for all, the cedar bark remained brittle and was very fragile, easily snapping and breaking with manipulations, so it appears that the four treatments did not have long-term strengthening effects on the iron-dyed bark.

The cedar bark of the three other objects treated with adhesives was natural in colour (not dyed with iron) and was in better condition overall.

Shaman's Headdress VII-F-220: the cedar bark was treated with methylcellulose and was in fair condition; it was still somewhat fragile and showed minor shedding, but no major losses.

Wolf Mask VII-F-407a: its cedar bark, which was consolidated with Ethulose 400, was in best condition, showing virtually no shedding or losses (**Figure 9**), though it was noticeably stiffer than all other cedar bark samples. The low concentration of the adhesive solution plus the use of an ethanol/water solvent mixture may have improved wetting and penetration of the consolidant[52,53] and thus may have contributed to the relative success of this treatment.

Wolf Mask VII-F-459: the mask was on display and could not be fully assessed, but the cedar bark, treated with Rhoplex, did not show major losses.

2. Localized Paper Backings

Five treatments – Head Mask VII-F-379ab, Head Mask VII-F-380, Bird Mask VII-E-5, Face Mask VII-F-1 and Harpoon Point Cover VII-F-28b – consisted of localized applications of paper backings. The method was the same for all objects, with toned paper backings adhered to the back of broken bark strands. Various adhesives were used:

- Jade 403 (vinyl acetate – ethylene copolymer dispersion) in water (concentration not specified);
- Wheat starch paste in water (7% or 5%);
- Ethyl hydroxyethyl cellulose/polyvinyl acetate in ethanol (10% EHEC added to a 25% PVA [probably AYAA] solution in ethanol, or 15% EHEC added to a 15% PVA AYAA solution in ethanol).[54]

For Head Mask VII-F-380, paper backings were initially tested with 2% methylcellulose, but this adhesive was found to be too weak; instead, 7% wheat starch paste proved successful.

Paper backings were difficult to detect and hence it was not possible to carry out a full survey and assessment; usually only 2 to 4 examples could be found on an object. Based on those that were discerned, this treatment strategy appeared successful in mending broken flat cedar bark strands. Results were good in all cases, whether the bark was iron-dyed or not (**Figures 10a** and **10b**). The paper was toned and visually subtle, applied to the back of strands. All adhesives used held securely without peeling.

3. Localized Thread Wrappings

3a. Cotton Thread with Wheat Starch Paste

In one treatment, Bird Mask VII-E-5, selected hanging, twisted strands of cedar bark were wrapped with cotton thread coated with 5% wheat starch paste. This offered support along the strands and kept delaminating strand fibres together (**Figure 10c**). The treatment was visually subtle and the adhesive held well. Small detached pieces were also successfully reattached using the adhesive-coated thread as a splint.

3b. Silk Wrapping/Encasement

Four treatments – Wolf Mask VII-F-667, Face Mask VII-F-1, Cedar Bark Headdress VII-F-118 and Merganser Canoe VII-D-205 – made use of silk thread, where large coiled structures of cedar bark (such as braids) were wrapped overall with hair silk thread (**Figures 11** and **12**). In all cases the wrappings successfully held together loose cedar bark fibres and offered overall physical support, preventing the loss of large strands, but not eliminating fine shedding. The silk thread is soft, springy, does not compress the bark and is visually very subtle from afar. This approach was the least invasive of the treatments in that it is completely reversible and allows for re-treatment, though the manipulations needed to carry out the treatment may cause minor losses and shedding.

The Merganser Canoe VII-D-205 treatment also used silk crepeline as a stitched sandwich support or encasement for a fragile area of cedar bark. This probably was successful physically as a support (a tactile assessment was not possible as the object was on display) but was visually obtrusive.

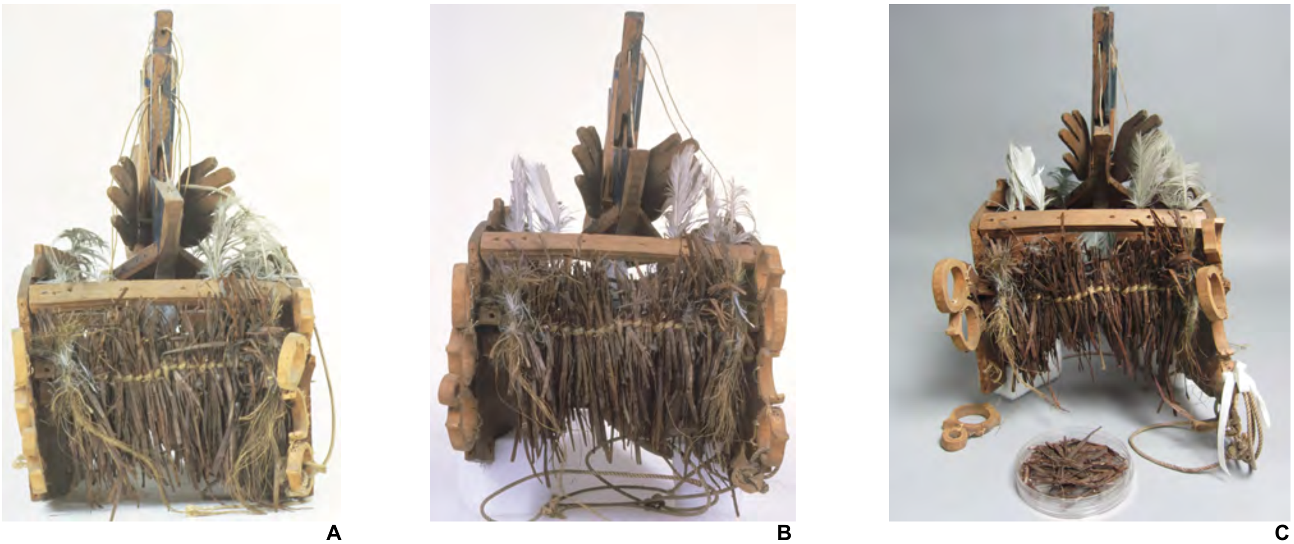


Figure 6. Head Mask VII-F-379ab, rear view showing dark brown cedar bark fringes: (a) 1985 before treatment; (b) 1985 after treatment, after consolidation with 2% Klucel G; (c) condition in 2015. Photographs: © Government of Canada, Canadian Conservation Institute.

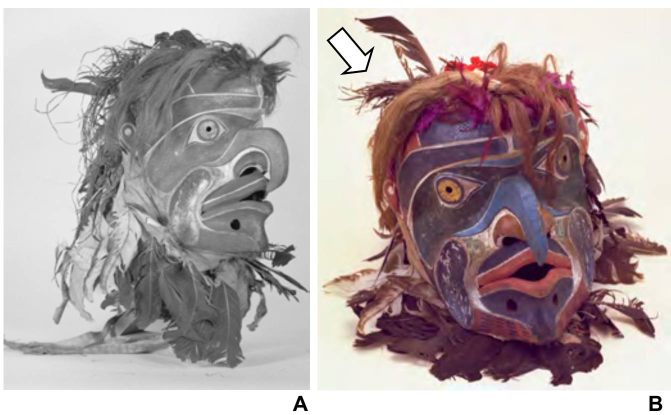


Figure 7. Ba̱ḵ’wa̱s mask: (a) photograph taken *circa* February 7, 1964; (b) in 1980 prior to repatriation to U’mista Cultural Centre. Arrow points at the cedar bark bundle at top back of head. The mask’s 1968 replica currently at the CMH is identical to this appearance. Photographs: © Canadian Museum of History.

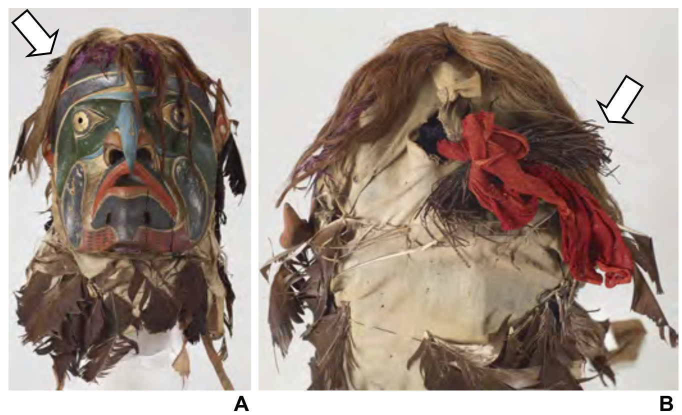
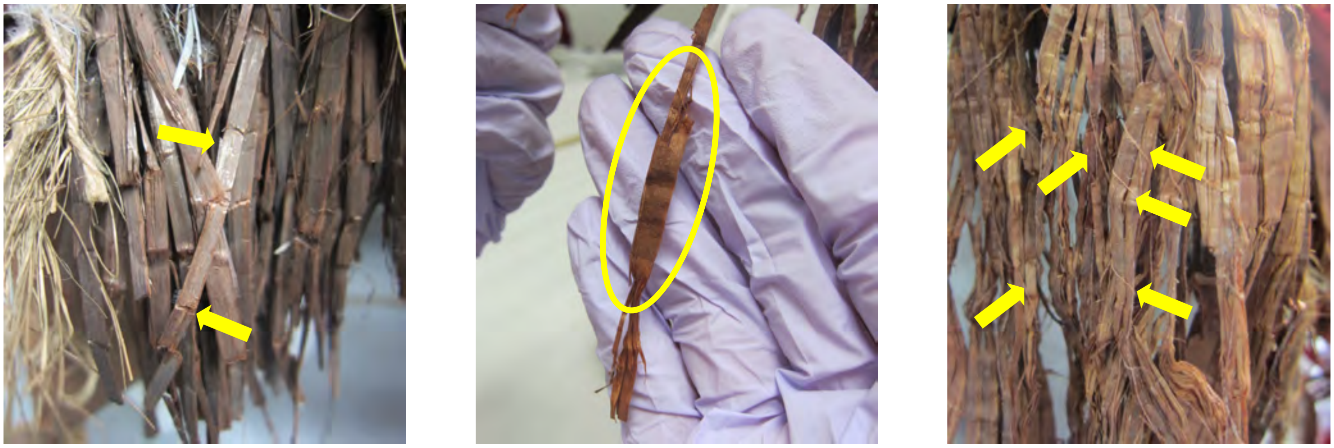


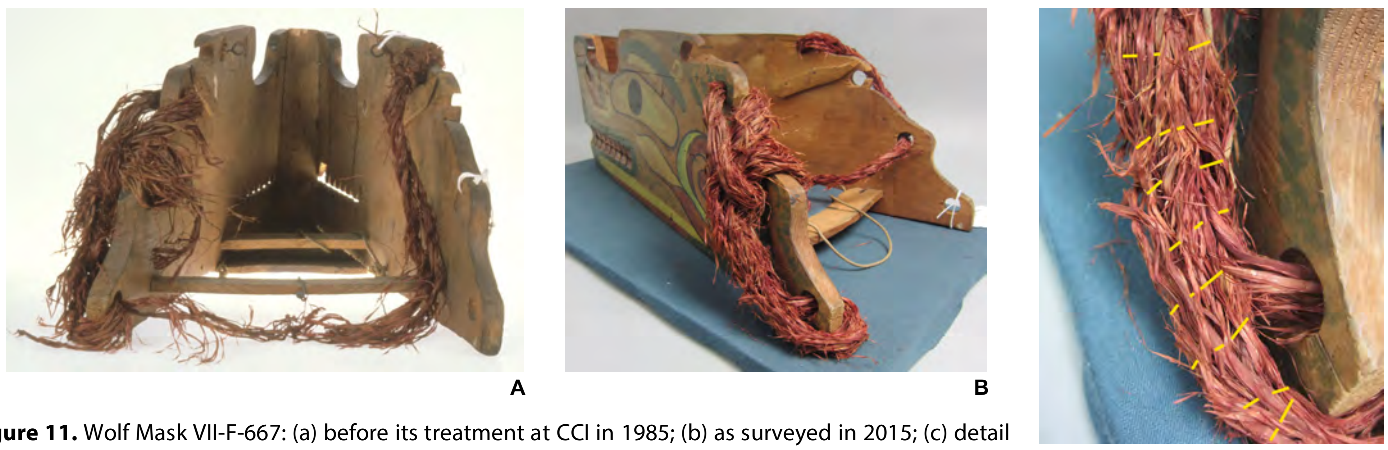
Figure 8. Ba̱ḵ’wa̱s mask in 2014 at CCI: (a) frontal view; (b) back top view. Arrows point to the cedar bark bundle. Cedar bark strands from front view appear similar, or possibly slightly shorter, than in 1980 (Figure 7b). Photographs: © Government of Canada, Canadian Conservation Institute.

Figure 9. Wolf Mask VII-F-407a, rear view showing cedar bark fringes: (a) 1985 before treatment; (b) 1985 after treatment, after spraying underside of bark with 1.25% Ethulose 400 in 2/3 water/ethanol; (c) condition in 2015. Photographs: © Government of Canada, Canadian Conservation Institute.



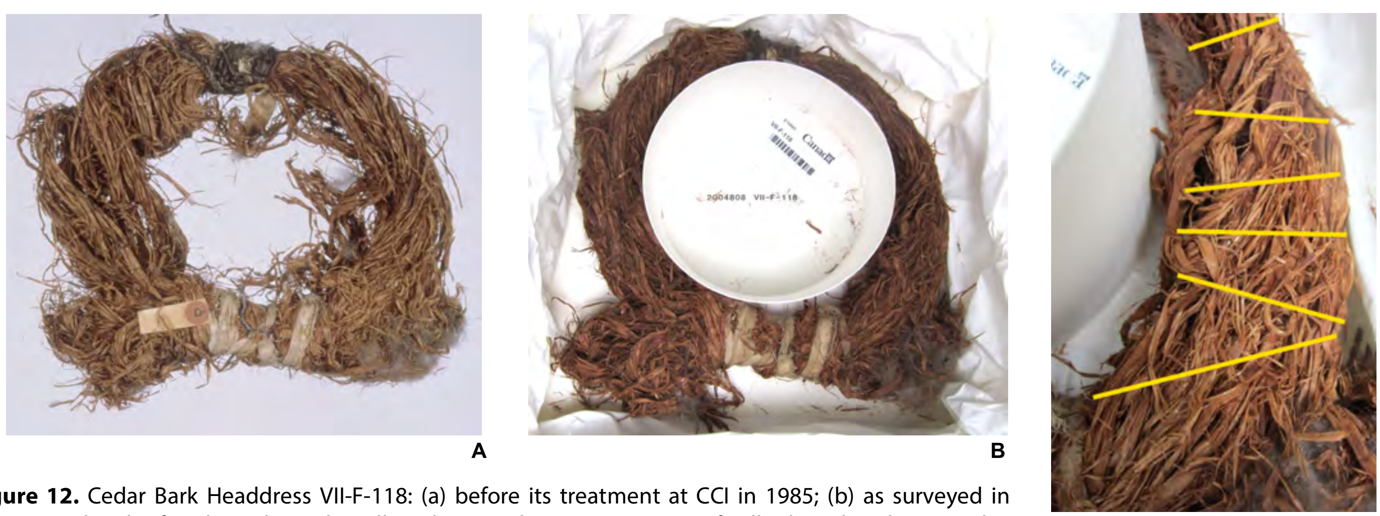
A B C

Figure 10. (a) Detail of Head Mask VII-F-379ab: arrows indicate edge of paper backings on iron-dyed cedar bark strand, adhered with Jade 403 (bark was first consolidated with 2% Klucel G). (b) Detail of Bird Mask VII-E-5: oval indicates toned paper backing on bark strand, adhered with 5% wheat starch paste. (c) Detail of Bird Mask VII-E-5: arrows indicate cotton threads wrapped around a bark strands, adhered with 5% wheat starch paste. Photographs: © Government of Canada, Canadian Conservation Institute.



A B C

Figure 11. Wolf Mask VII-F-667: (a) before its treatment at CCI in 1985; (b) as surveyed in 2015; (c) detail of right side with yellow lines indicating position of silk threads. Photographs: © Government of Canada, Canadian Conservation Institute.



A B C

Figure 12. Cedar Bark Headdress VII-F-118: (a) before its treatment at CCI in 1985; (b) as surveyed in 2015; (c) detail of right side with yellow lines indicating position of silk threads. Photographs: © Government of Canada, Canadian Conservation Institute.

4. No Treatment

Three objects examined within this survey had been previously assessed by conservators, and the decision made was not to treat the shredded cedar bark. The objects were provided with a handling platform, a box or a protective support cover for some physical protection and support, though these were removed when objects were put on display. Object condition varied.

Cedar Bark Jacket VII-X-58b, made of woven, shredded cedar bark, was in very good condition. The bark was still strong, flexible, and not brittle or friable. Fur elements had been eaten by moths but the cedar bark was untouched. The construction of this piece helps to explain its good condition: the tightly woven cedar bark warp has crossing weft strands that support the bark and prevent unravelling, so even though the bark fibres are separated, the overall structure is maintained. This object was believed to be made of yellow cedar as opposed to redcedar, because the colour was brown rather than reddish, and soft-shredded yellow cedar is most often used for clothing because it is the softer, more pliable material.[7,55]

The Dragonfly Screen VII-C-1130 had a short cedar bark fringe hanging from a raven's beak. As the object was currently on exhibit it was not possible to assess the cedar bark condition. However, a photograph shows that in early 1969[56] this piece had some long cedar bark strands hanging from the beak, which were missing at the time of the 1983 CCI treatment assessment; losses are possibly linked to subsequent exhibits (1969–70, 1970–71). The question remains whether an earlier treatment would have helped prevent these losses.

The Hamsiwe' Mask VII-E-617 was assessed by CMH staff both in 1967 and 1979 and it was decided not to treat the cedar bark. An archival photograph from 1922[57] shows a large amount of cedar bark fringe, and later photo-documentation (1927,[58] 1972,[59] 1979–80,[60] c. 2003,[61] 2011[62]) show some progressive losses. Substantial losses occurred when travelling on a loan in 2011,[63] and photo-documentation before and after this loan verifies that losses occurred. At CCI in 2014 the shredded cedar bark was extremely fragile, with exfoliating fibres, and ongoing small and large losses. The bark also appeared darker and duller in colour compared to photographs before the UCC fire event.

REVIEW OF PARYLENE-TREATED CEDAR BARK SAMPLES

In 1989, CCI carried out tests to consolidate old, disintegrating shredded cedar bark with Parylene C as part of a larger research project.[64] A hand-sized bundle of loose, shredded cedar bark and several samples of flat cedar bark strips (such as would be used for basketry) were coated with Parylene C at two different thicknesses. Parylene (poly-para-xylylene) is a hydrocarbon polymer that can form extremely thin (on the order of microns), even and colourless coatings on surfaces. Parylene N is purely hydrocarbon and used when significant penetration is required, whereas Parylene C has a mono-substituted chlorine group attached to the aromatic ring and is used for surface consolidation.[64,65] An object to be coated is placed inside a deposition chamber and brought under vacuum; solid Parylene is pyrolyzed and then polymerizes upon the object's surface.

Initial 1989 results were reported as being successful: a 2 micron layer of Parylene C gave "good consolidation of individual fibres," although a 4 micron layer "caused the bark strands to mat together."[64] These samples were re-examined in 2015 after 25 years of dark storage sealed in polyethylene plastic bags. The bark had remained in good condition and successfully consolidated. Visually, the samples had a very good appearance, with a few samples looking slightly silvery after treatment, but otherwise had no indication of a coating. Delaminating and exfoliating surfaces were held together to prevent further losses. When handled, the shredded cedar bark was noticeably strengthened and showed virtually no shedding or loss, and overall the bark remained flexible. All of the thick, straight strands of bark were robust and did not shed with manipulation, though they were not very flexible and risked snapping when bent (though this can be true of untreated bark as well).

DISCUSSION

Survey of Past Treatments

Past conservation treatments for cedar bark are difficult to assess. Since artifacts are unique, it is hard to compare the condition of materials and results of treatments. Without having evaluated the artifact before treatment, and without having a "control" against which to compare, the successes or failures of a conservation treatment remain subjective. All of the condition assessments relied on qualitative assessments, as unfortunately standardized scientific tests to quantify such properties are not always available or feasible to carry out on artifacts. For example, fold endurance or flex tests that require applying stresses until rupture occurs are too destructive to be applied repeatedly to strands from actual objects (but perhaps micro-tests could be developed and used).

Some treatment reports were vague and justifications were not provided. Reports did not systematically note the exact location and number of repairs, making them difficult to find on the object (namely, paper backings). Examination of objects under a UV lamp did not show any noticeable fluorescence of adhesives. Wording such as "wrapped with hair silk" was imprecise and did not describe how the treatment was carried out (i.e., how was the thread secured). Test samples documenting the treatment method kept in the object dossier or diagrams illustrating the treatment or treated areas would have been useful. Current documentation tools (easier in-lab photography during treatment) and practices (integrating annotated digital images within treatment reports; treatment proposals that include justification and objectives of treatment as required by the 2000 *Code of Ethics*[66]) are much improved in this regard.

Many reports lacked specific details about adhesive treatments, which made it difficult to understand why some outcomes were non-optimal, or how such treatments could be improved. The solvent, concentration and application method (spray or brush) were not always mentioned, yet these parameters have a large impact on the outcome of consolidation.

The five earliest treatments or treatment assessments, dated 1966, 1967 (two), 1976 and 1979, involved three adhesive consolidation treatments and two decisions for no treatment (twice for the same object twelve years apart). The thirteen other conservation treatments, carried out between 1983–88, were more diversified, making use not only of adhesive consolidation (five) but also of Japanese paper backings (five) or of thread wrappings (five), sometimes in combination (four), besides the two decisions for no treatment.

Parylene

Parylene's ability to delicately and evenly coat irregular surfaces is undoubtedly a reason why it successfully consolidated fragile and disintegrating shredded cedar bark. Despite these good results, other factors in the use of Parylene raise serious concerns – beyond the questions of whether to add extraneous material to an artefact, or whether the treatment is reversible (most consolidation treatments are not). Its stability is questionable: Parylene was originally believed to have a long lifespan;[64] however, further research estimated its lifespan at 11–15 years rather than decades, and less than three if exposed to light. The polymer rapidly degrades under UV radiation causing oxidation, yellowing and breakdown; its use with antioxidants is now recommended.[65,67] Parylene use would require re-treatment when it eventually breaks down and becomes ineffective as a consolidant (although the CCI samples still appeared to be in good condition after dark storage in sealed bags for 25 years). Additionally, the Parylene application process may adversely affect organic materials: when the material is brought under vacuum its equilibrium moisture content decreases and bound water is permanently lost.[68] Presumably, this would embrittle organic materials and cause physical changes. There are also very real practical limitations in using Parylene for cedar bark on artifacts, as the bark would need to fit inside the deposition chamber and may need to be removed from the object – an ethically questionable operation since its removal and replacement afterwards in exactly the same location would be difficult even with excellent photo-documentation, and the necessary manipulations would pose serious risk of losses in the process.

CONCLUSIONS

Conducting a treatment survey on shredded cedar bark was useful in many respects. It provided insights into the material and presented concrete examples of different treatment strategies and their failures or successes after 30–40 years of museum use. Strengths and weaknesses in conservation documentation were also highlighted.

One trend emerged: the extreme brittleness and fragility of dark brown cedar bark that tested positive for iron. The bark's severe degradation (loss of strength, shedding to powder) is typical of iron-catalyzed oxidation of cellulose. Previous consolidation treatments to strengthen this type of bark were not very effective. Physical supports and protective shields to minimize disturbances provided benefits in some instances, while in others, exhibition-related travel, storage relocations and manipulations proved to create high risks for further losses. More work is required to find effective strategies for preservation of such iron-dyed materials. For example, antioxidants, iron chelation, or deacidification treatments (as carried out for paper with iron gall ink) could potentially benefit this material, but may not be applicable to cedar bark, as it usually cannot be immersed in water and treated the way paper can. Cool or cold storage and low-oxygen environments may be options to slow iron-induced degradation reactions. Iron-dyed bark should be provided with extra physical protection and care during manipulation as it is especially fragile and will continue to weaken due to the iron's catalytic action. Dark brown to black coloured bark should be tested using bathophenanthroline strips to confirm the presence of iron. Properly identifying iron in cedar bark – a material highly sensitive to physical damage – could be integrated into a risk management approach and decision tree for collections.

The survey also presented some diverse, although limited treatment options, which sometimes can be combined in a complementary manner. Most adhesive treatments, of the seven surveyed, only consolidated the surface of the cedar bark to prevent minor shedding. Flat, cohesive strands of cedar bark, like those in basketry, can be successfully mended with lightweight paper backings adhered with adhesives such as wheat starch paste. Shredded and twisted cedar bark strands can be wrapped with silk or cotton threads, with or without adhesives, for physical support of exfoliating and delaminating strands. Coiled and braided forms of cedar bark can be wrapped overall with thread alone for gentle support. These non-consolidation methods offer some physical support in localized areas, are easily removed and minimally interventive, but do have limitations: they are time consuming and likely not practical to carry out on every strand of cedar bark on an object that may need support. Also they do not prevent shedding or add internal cohesive strength (as overall adhesive consolidation aims to do).

More research and testing is needed to find the best means of achieving increased penetration and overall strengthening of cedar bark during consolidation – especially for iron-dyed bark – should this treatment option be acceptable and warranted. Parylene coating appeared successful in stopping nearly all shedding and breakage; however, its serious drawbacks include limited stability and the fact that it would require removing the cedar bark from the rest of the object to carry out the treatment in a vacuum chamber, which also risks further desiccating the cedar bark in the process.

Shredded cedar bark is an inherently fragile material prone to fragmentation and delamination due to its chemistry, structure and processing. As the condition and exhibition histories of objects showed, travel, collection moves and other major movement and manipulations pose a very high risk for damage and losses to shredded cedar bark. Decision to loan such objects must be weighed against high potential for damage and loss of bark. Treatment methods reviewed in this survey had limited success in strengthening the material, eliminating losses, and generally improving the condition of cedar bark, though some treatments were able to reduce losses and offer external physical support to help withstand mild stresses that may occur even with careful manipulation. As such, preventive conservation should be emphasized as the first strategy for the preservation of shredded cedar bark.

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MATERIALS

Iron gall ink test paper (bathophenanthroline indicator strips) and instruction manual (product code 539-3000): Preservation Equipment Ltd, Vinces Road, Diss, Norfolk IP22 4HQ, UK; Tel.: +44 (0)1379 647400; Website: <www.preservationequipment.com>

Iron(II) test strip colour chart: Canadian Conservation Institute, 1030 Innes Road, Ottawa, Ontario K1A OM5, Canada; Tel.: 613-998-3721; contact: crystal.maitland@canada.ca

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66 See Article 14 “Treatment Proposal,” in: *Code of Ethics and Guidance for Practice of the Canadian Association for Conservation of Cultural Property and of the Canadian Association of Professional Conservators*, 3rd edition (Ottawa: CAC and CAPC, 2000), p. 7, as compared to the corresponding article in earlier versions of this *Code*, Article 11 (1986) or Article 13 (1989).

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68 Florian, Mary-Lou E., “Parameters of the parylene conformal deposition treatment and their effects on ethnographic materials,” in: *Objects Specialty Group Postprints*, Richmond, VA, 29 May–3 June 1990 (Washington, DC: American Institute for Conservation of Historic and Artistic Works, 1990), p. 48, <http://resources.conservation-us.org/osg-postprints/postprints/1990-2/florian/>. Accessed March 2017.