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Plump and Pliant: fluid retention in the preservation of cellulose-based bioart

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ABSTRACT

Intersecting spheres of heritage conservation and material creation, this research presents the results of collaboration between the Art Conservation Program at Queen's University and textile artist WhiteFeather Hunter at the Speculative Life BioLab, Concordia University. As a preliminary study, the goal was to create an immersion treatment for cellulosic biofilm to exist externally from containment while preserving life-like qualities of pliancy and fluid retention.

Immersion treatments were designed to reduce hygroscopicity and to minimize cellular-wall damage experienced by the biofilm during and after dehydration. Specific materials were tested for their physiochemical performances: collagen as plasticizers, polyols as consolidants, and either sugars or polyether compounds as preservatives. Procedural testing included sterilization and cyclic osmotic treatments (dehydration and immersion transfer of fluids via capillarity) applied to the biofilm test substrate: a yeast-derived, acetic acid bacterial cellulose. Technical analysis included ASTM cantilever bend tests to evaluate pliancy, mass/weight calculations to indicate fluid retention, and polarized light microscopy (PLM) of sample cross-sections to examine surface structure and cell integrity.

Successful results produced a new, treated bacterial cellulose that is water-resistant and exhibits an increase in flexibility and tensile strength. This cellulose, similar to latex in texture and tensile behavior, may offer applications within textile arts, art conservation, and biomedical fields.

Keywords: *bioart, fluid retention, cellulosic biofilm, bacterial cellulose, OT fluid transmission,*

BIOART AND THE QUESTION OF CONTAINMENT

The education of art conservation trains one to consider how objects can evade and cheat death – the task force deployed to extend and preserve. Yet what happens when conservation intersects with material that is orchestrated specifically to age and degrade? *Such as biomaterial*. With the exception of bioremediation, preservation tactics are designed to keep biological growth off of

the art object. This paper explores how to encourage bacterial growth upon art, because it *is* the art, and how we may preserve it with respect to both the gallery's and the artist's wishes.

Bioartists are often quick to differentiate their process as one that harnesses cellular activity in the production stages, whether or not at the time of display the artwork is still alive; therefore in order to be part of the bioart club, the artist must culture, foster, and manipulate living organisms explicitly to play a material role. This identity of bioart at the cellular level, as one grown of bacteria directs us swiftly to the question of open display: can biomaterial exist safely within the sterile conditions of the museum environment? The majority of bioart is a passive version of former germination and "active" stages of biological growth that are often captured via digital means; alternatively, the art is hermetically sealed. Artworks translated into digital form or held behind glass cages signal to the spectator that they are safe. What happens when that barrier is intentionally removed?

The example of Beatriz de Costa's: *Transgenic Bacteria Release Machine* (2001-2003) illustrates the anxiety of biologically-charged art. Displayed at the Museum of Natural History (London), the installation allowed the museumgoer to press a button that engaged a robotic arm to remove one of ten petri-dish lids, nine of which were innocuous, one dish contained the transgenic bacteria *E. coli.* Despite the fact that *E. coli* are incapable of assaulting the viewer in a leap from the petri dish, the threat of the material as potential biohazard is palpable. The museum environment is in fact more harmful for the bacteria – enough button pushing eventually kills the specimen. The installation hinges upon open containment; the performance is experienced not through just the eyes or ears but through skin, through respiration – one *becomes* the art medium (Mitchell 2010).

Yet performative art is notoriously hard to preserve. Anya Gallacio's use of rotting flowers in *Preserve "Beauty"* (1991-2003) or Jana Sterbak's use of oxidizing animal flesh in *Vanitas: Flesh Dress for an Albino Anorectic* (1987) embrace material degradation as an inherent aspect of the materials in their oeuvre. When intentional decay is part of the work's operatic flair, does preservation merit consideration?

DECAY V. PRESERVATION: PERFORMANCE AND RESISTING EMPHERALITY

Doris Salcedo, in collaboration with scientists, devised a treatment that rendered thousands of rose petals to be able to be stitched into a shroud, a textile that bends and folds to create *A Flor de Piel* (2011-2012). Natural roses rot or desiccate – so what magic is this? Salcedo's studio has shared her processing method with curators and conservation scientists in concern for the roses' ability to continue to perform as flexible fabric:

> The solution is a multistep process that involves treating the petals first with turpentine, followed by glycerin and collagen, followed by an immersion in Shellsol and pigment; then pressing them between sheets of Mylar with glycerin and pigment; then soaking and saturating them with pigmented wax; before finally flattening them in between high-density foam for a month. The petals are stitched together with waxed thread, and the juncture between the petal and thread is also waxed (Khandekar, 2016).

When *A Flor de Piel* passed through the Harvard Art Museums, conservation scientist Narayan Khandekar conducted a study on the preservation of the materiality of the work as textile, analyzing the petals' lifespans under the stress of intense environments to make the prediction that each petal, many of which have been already replaced, will eventually require a surrogate. Salcedo has granted permission to remanufacture petals, yet has also demanded that the piece should not lose function as textile (Khandekar 2016). As curator Mary Schneider Enriquez explains: "It is the impossibility of securing the presence of the absent body and the skin of petals in a lasting physical state that confounds the view, and defines the success of this work" (Mary Schneider Enriquez 2016). The rose petals embody the flesh of a victim's absent body, it is a shroud for mourning and as soon as it loses this functionality, it is doomed.

In a similar vein, Saskatchewan-based textile artist Astrid Lloyd constructed a skirt out of pomegranate peels for a performance piece *Mother* (2008, performances in Montreal, 2010-2013). Despite continuous treatments with vegetable glycerin, the biotextile object quickly showed signs of deterioration (e.g. imbibing ambient moisture and mold, crumbling, and resulting loss of material) to the level where it was deemed unsafe to exhibit outside of an enclosure. The piece is part of continuing performance series and therefore, in an effort to salvage a project that demanded over 1000 hours of production, Lloyd constructed an air-tight glass case to house the textile. In a personal conversation with the author, Lloyd expressed that

the encasement is an undesired barrier but a non-negotiable resolution in order salvage the piece as wearable and therefore performance-ready.

Salcedo and Lloyd represent a clear desire to extend not only the lifetime of their ephemeral materials but also some degree of physical plasticity of biological origins. There exists a specific subset within bioart where performance relies upon preservation: that of textile bioart and the use of plant-based or bacterial biofilms employed as fabric. Therefore is it possible to free Lloyd's pomegranate-garment from its case? Can the toxic turpentine be removed from Salcedo's recipe?

PROJECT CREATION: GROW YOUR OWN CELLULOSE

When first approaching bioartists to discuss the conservation of biomaterials, I received some pushback, as it was voiced that bioart and preservation are not natural co-players; the cyclical processes of life and death are sometimes intrinsic to the performative aspect of working with biological materials. WhiteFeather Hunter, acting lab principle at the Speculative Life BioLab of the Milieux Institute for arts, culture and technology at Concordia University, Montreal argued that the artwork travels through life and death, it is created to perform and it necessarily decays.

Figure 1 (left): WhiteFeather Hunter and Théo Chauvirey, *Bucci*, 2017, bacterial cellulose and 3D-printed bioplastic; shirt, aged approx. two weeks; photo credit: WhiteFeather Hunter
Figure 2 (center): WhiteFeather Hunter and Théo Chauvirey, *Bucci*, 2017, bacterial cellulose and 3D-printed bioplastic; skirt, aged approx. two weeks; photo credit: WhiteFeather Hunter
Figure 3 (right): WhiteFeather Hunter and Théo Chauvirey, *Bucci*, 2017, bacterial cellulose and 3D-printed bioplastic; shirt, aged approx. six months; photo credit: WhiteFeather Hunter

However, Hunter's perspective on the interplay between conservation and bioart was open and evolving. In collaboration with Théo Chauvirey, Hunter fashioned a two-piece garment, *Bucci* (2017; **figures 1-3**) from bacterial cellulose biofilm – the same substance produced when fermenting kombucha tea. While the skirt of the ensemble was seemingly stable (**figure 2**), the shirt, thinner and processed differently, was actively falling apart (**figures 1, 3**). Fortunately the piece was exhibited immediately after creation, yet Hunter was increasingly keen on processing the material in order to extend the exhibition window.

Grown in a large vat, such as a kiddie pool in the case of *Bucci*, the cellulose body, scientifically termed a pellicle, is large enough to produce human-sized clothing (**figure 4**). Through a fermentation process that converts simple carbohydrates into acetic acid and CO_2 gas, the water-insoluble material grows from an active culture of yeast that colonizes in layers to create a cellulosic biofilm.

Figure 4 (left): *Gluconateobacter xylinus* bacterial cellulose grown in the Speculative Life Biolab for research project *Plump and Pliant*; source: RISE bacteria
Figure 5 (center): prepared bacterial cellulose samples for research project *Plump and Pliant*; source: RISE bacteria
Figure 6 (right): treated bacterial cellulose samples for research project *Plump and Pliant*

Bacterial cellulose differs from plant cellulose as it contains no hemicellulose or lignin (attractive sounding to conservation), and is characterized by a higher degree of crystalline, macromolecular structure as the cellulose groups in microfibril ribbons (Keshk 2008). This lends the biofilm impressive strength and flexibility. The pellicle when wet is firm and is incredibly flesh-like (**figure 5**). Upon drying, the biofilm retains a great deal of flexibility but loses up to

ninety-five percent of its fluid mass. The rate of which it crumbles over time varies according to processing, thickness, and environmental conditions. As soon as the dry material is exposed to a fluctuation of moisture, or lets say, skin contact, the biofilm's cellular structure, already weakened during dehydration, crumbles – making for a short time in the gallery and even shorter life-span on a human body.

Biofilm production has been popularized in the media as "vegan leather" or "kombucha leather." It is flexible, sustainable, biodegradable, and widely considered ethically responsible (i.e. no animal products). Susan Lee with her TEDtalk "Grow your own clothes" (2011) disseminated easily reproducible methods; however the hygroscopic properties that lead to the material deterioration are unresolved. The inherent vice of water-vulnerability is considered the leading obstacle for artists currently working with this material.

EXPERIMENTAL PROCESS: CORRALLING BACTERIA INTO COOPERATION

WhiteFeather Hunter and I designed a project in collaboration between the Queen's Art Conservation lab and Concordia's Speculative Life BioLab to see if our combined spheres and methodologies can defend bacterial cellulose. We outlined a common goal, to create an immersion treatment for bacterial cellulose that would allow the biofilm to exist externally from containment while preserving life-like qualities of pliancy and fluid retention through: 1. Retaining fluid, flexibility, and "life-like" texture 2. Reducing hygroscopic properties and 3. Installing anti-biodeteriogen properties.

Inspired by Doris Salcedo's process, our methods combine those used in the practice of conserving waterlogged, archeological organic material – bacterial cellulose behaves similarly to wet leather – along with cellular stabilization and dehydration methods used in the botanical and food industries. Sugars and polyols such as sucrose and mannitol are common preservatives used in the dehydration of fruits and vegetables; they also appear in conservation treatments as an alternative to Polyethylene glycol (PEG), the long-standing "darling" for consolidation treatment of wood and leather.

The pilot phase of this research tested ninety-nine samples of bacterial cellulose in twenty-one different combinations of immersion solutions (Table A). Experimental samples were compared with wet and dry specimen "controls" (i.e. no treatment or partial treatment). Casts of pure immersion mixtures were poured into petri dishes in order to compare and analyze the interaction of cellulose and immersion fluids with the performance of the isolated immersion fluid.

TABLE A: Sample Treatments

Immersion Treatment	Immersion Components	Number of Samples Treated	Immersion Period	Sterilization methods	Dehydration methods
Collagen-based	Collagen in DI	2	20 minutes	75°C bath for 20 min.	Air dried
	Collagen and glycerol in DI	4	20 minutes	75°C bath for 20 min.	Air dried
	Collagen II in DI	6	20 minutes	75°C bath for 20 min.	Air dried
	Collagen II and glycerol in DI	4	20 minutes	75°C bath for 20 min.	Air dried
Consolidant-based: sugars	Sucrose (20% and 40%) in DI	4	6 weeks for each concentration	90°C bath for 20 min.	Air dried and oven dried (37°C)
	Mannitol (20% and 40%) in DI	4		90°C bath for 20 min.	Air dried
Consolidant-based: PEGs	PEG 400 (20% and 40%) in DI	4	6 weeks for each concentration	90°C bath for 20 min.	Air dried and oven dried (37°C)
Consolidant-based: cellulose ether	Methocellulose (1.5% and 0.5% concentrations) in DI	8	6 weeks for each concentration	90°C bath for 20 min.	Air dried
Combination	PEG 400 (20% and 40%) and sucrose (2% and 4%)	4	6 weeks for each concentration	90°C bath for 20 min.	Air dried and oven dried (27°C)
	PEG 400 (20% and 40%) and mannitol (2% and 4%)	4	6 weeks for each concentration	90°C bath for 20 min.	Air dried
	PEG 400 (20%), collagen, and glycerol	12	6 weeks for the PEG and 20 minutes in combination	90°C bath for 20 min.	Air dried and oven dried (37°C)
Solvents: acetone	Collagen in DI	4	20 minutes	75°C bath for 20 min.	Air dried
	Collagen and glycerol in DI	4	20 minutes	75°C bath for 20 min.	Air dried
Solvents: mineral spirits; mineral oil	Wet cellulose; active and inactive	12	6 weeks (8 samples); 12 weeks (4 samples		Air dried
Preservatives: wax	Acetone treated cellulose	6	5 to 10 second dips		Air dried
	Collagen-treated cellulose	8		75°C bath for 20 min.	Air dried
Preservatives: borax	Consolidant-based: sugars	10	15 minutes; 10% borax in DI	90°C bath for 20 min.	Air dried and oven dried (37°C)
	Consolidant-based: PEGs	3		90°C bath for 20 min.	Air dried and oven dried (37°C)
	Consolidant based: cellulose ethers	3		90°C bath for 20 min.	Air dried
	Combination treatments	6		75°C bath for 20 min.	Air dried and oven dried (37°C)

The bacterial cellulose samples used in this research derived from one, large pellicle grown in the Speculative Life BioLab from an active culture of *Gluconateobacter xylinus* yeasts (RISE brand), nourished with white table sugar and kept at approximately a pH of 4 at all times. A gestation period of six weeks produced a range of thickness from 0.5-1 cm. The cellulose pellicle

was cut into samples measuring approximately 5 x 5 cm in width by height; circular specimens were cut to a diameter of 5 cm. Wet cellulose samples were rinsed with tap water to remove strands of yeast and kept dormant in refrigeration until required for testing. Samples that were air-dehydrated at 20°C were left upon a polyethylene tarpaulin coated with petroleum jelly for three weeks and then stored between wax paper sheets prior to immersion treatments.

Wet, untreated samples of bacterial-cellulose pellicle were exposed to a series of sterilization, immersion, and dehydration treatments.[1] Immersion treatments relied upon heating the solution to achieve higher penetration and saturation of the immersion fluid into the cellulose, or longer dwell times of the cellulose in immersion fluids at room temperature. Each immersion solution was tailored to target properties of plasticity, consolidation, preservation, or a combination of each. Dehydration was performed by air-drying or in artificial aging ovens. Some samples are treated first with solvents such as acetone, followed by immersion in baths carrying a solution built with 3 main components: a plasticizer, a consolidant, and a preservative – all designed to protect the cellular structure during dehydration and impart resilience to rewetting.

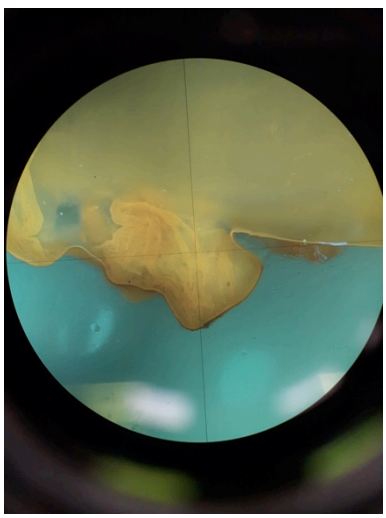
A few limitations warrant mention as the materials selected for the project necessarily complied with the following in mind: the intention to open source these methods to practicing bioartists mandated materials be accessible and health-conscience. This stipulation excluded considerations of powerful fixatives and stabilizers such as turpentine, formaldehyde, or dimethylsulfoxide, expensive sugars such as trehalose, or crosslinking agents such as genipin. Additionally, the Speculative Life BioLab at present does not have access to a vacuum-freeze dryer (the preferred method of dehydration for organic material) and according to biolevel safety codes, biologically active testing material necessarily remained within the lab.

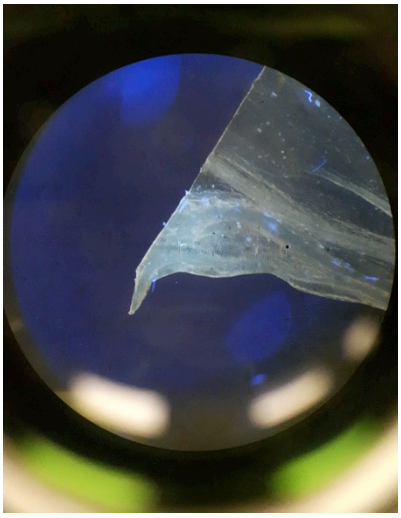
The technical analysis used to map our pilot results included ASTM cantilever bend tests to evaluate preserved or improved textile pliancy, mass/weight calculations to indicate fluid retention, and PLM-UV microscopy to monitor adjustments in surface morphology.[2] It was

[1] For the purposes of this study, the term “active” denotes unsterilized, biologically or bacterially-charged specimens (i.e. alive or dormant), whereas “inactive” denotes specimens sterilized of bacterial growth; “wet” denotes untreated, hydrated specimens, whereas “dry” denotes dehydrated (via oven or air dried) specimens.

[2] Observation and image captures completed using an Olympus BX53 microscope and Olympus DP73 camera (CellSens software) with a U-FUW Ultraviolet excitation filter: BP 340-390 nm; emission filter: LP 430 nm.

challenging to discern distinct cellular wall structure and collapse (electron microscopy techniques such as ESEM may be useful in future studies), yet optical microscopy proved useful for monitoring changes in texture, layering structure, and topical morphology; cracking and degradation properties were observable in edge grains and thinner cross sections (**figures 7, 8, 9**). Optical microscopy was also useful in verifying if sterilization had gone awry; bacterial activity showed in beaded strains under UV radiation (**figure 13**).





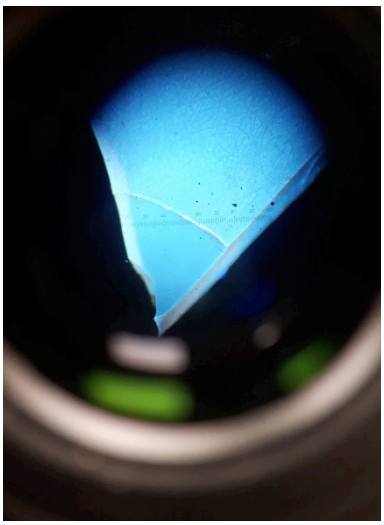


Figure 7 (left): amorphous texture of untreated cellulose; biologically active and wet; image captured through microscope eyepiece (30 mm diameter) and polarized light
Figure 8 (center): semi-crystalline texture of cellulose treated with PEG and sucrose; biologically active and wet; image captured through microscope eyepiece (30 mm diameter) and UV fluorescence
Figure 9 (right): rubbery texture of cellulose treated with collagen; biologically inactive and oven-dried; image captured through microscope eyepiece (30 mm diameter) and UV fluorescence

PROJECT RESULTS AND DEVELOPMENTS

All of the treatments altered the cellulose to some degree, challenging the goal of retaining life-like verisimilitude. Yet most alterations, including color, texture, and dimensional shrinkage (depth-wise, to a certain degree) were anticipated and deemed acceptable to WhiteFeather Hunter and other consulted artists within the Speculative Life BioLab. As long as the biofilm "read" as biomaterial and the resistance to degradation was lengthened, the resulting, treated cellulose was deemed an aesthetic and display-worthy success.

Of the ninety-nine cellulose samples tested, ten immersion solutions were deemed successful in some capacity. "Success" was determined by maintained properties of fluid retention, aesthetic

qualities, and flexibility or by enhanced properties of the same; samples that proved more resilient to foreign bacterial or fungal contamination were also deemed more successful. Controls of untreated wet and dry samples, as well as samples that were simply sterilized, provided a point of contrast to those treated with tailored immersion solutions (**figures 10-13**).

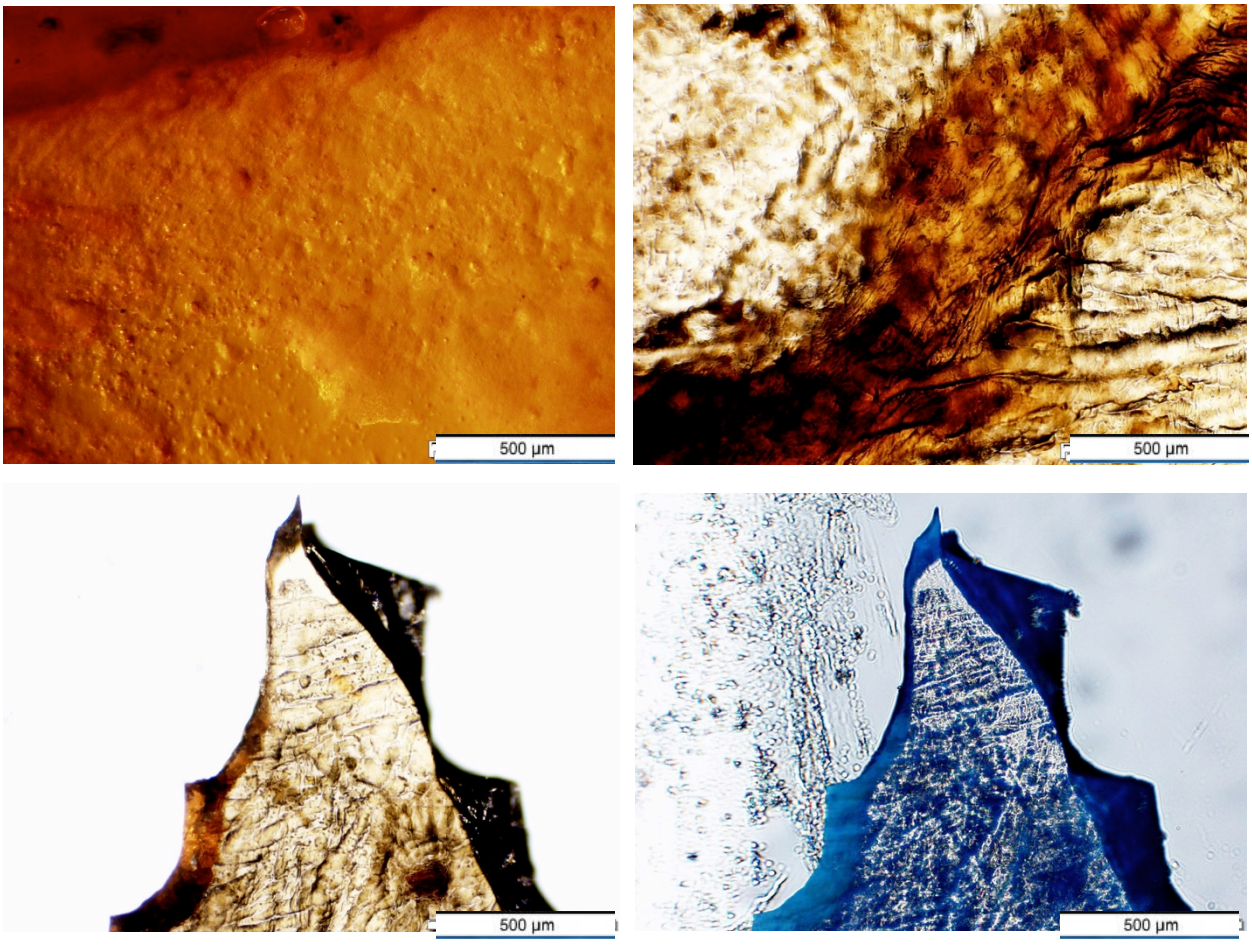


Figure 10 (top left): Micro-capture: wet, active, untreated cellulose, control sample; reflected light, 200x
Figure 11 (top right): Micro-capture: dry, active, untreated cellulose, control sample; reflected and transmitted light, 200x
Figure 12, 13 (bottom left and right): Micro-capture: dry, inactive (sterilized), no further treatment; reflected and transmitted light and UV-wide fluorescence (bacterial strains visible), 200x

RESULTS: RETAINING FLUID, FLEXIBILITY, AND "LIFE-LIKE" TEXTURE

Immersion treatments that combined components from the most successful collagen treatments with the most successful consolidation treatments produced life-like, firm and yet pliant textures, while retaining the softer natural hues of pinks and tans of wet, untreated bacterial cellulose;

these were samples treated with PEG, collagen, and glycerol (**figures 16, 17, 21**). Viewed under microscope, thick cross-sections of these samples demonstrate retention of the dimpled and smooth topography exhibited in untreated, wet cellulose (**compare figures 10 and 16**).

Combination treatments that included an acetone pre-immersion treatment with collagen/glycerol mixtures also preserved a surface morphology similar to untreated cellulose (**figures 14, 15, 18**); these samples also displayed an enhanced strength, as collagen fibres can be observed connecting interlayers of cellulose (**figure 14**). The step of immersion in acetone during the preparation of the cellulose (before immersion in the collagen/humectant/preservative solutions) requires further testing in order to further test the preservative effect of the acetone.

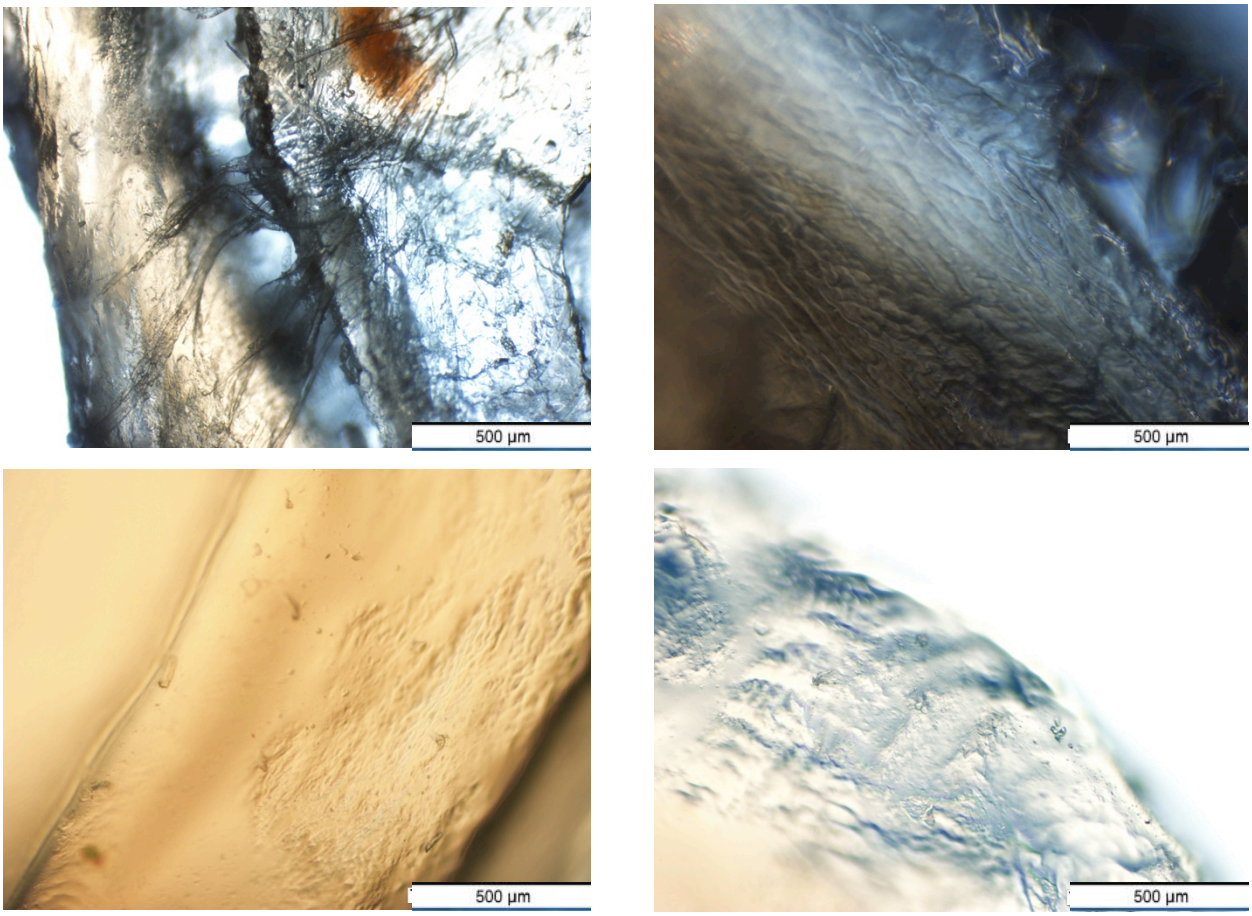


Figure 14 (top left): Micro-capture: cellulose treated with acetone, collagen, glycerol; sterilized and air-dried; reflected and transmitted light, 200x
Figure 15 (top right): Micro-capture: cellulose treated with acetone, collagen, glycerol; sterilized, air-dried; reflected light, 200x
Figure 16 (bottom left): Micro-capture: cellulose treated with PEG 400, collagen and glycerol, sterilized and oven-dried; reflected and transmitted light, 200x
Figure 17 (bottom right): Micro-capture: cellulose treated with PEG 400, collagen, glycerol; sterilized and oven-dried; UV-wide fluorescence, 200x

Overall, treatments with collagen and glycerol produced a strength and flexibility similar to wearable latex. Immersion treatments with low-molecular PEG 400 produced a semi-firm, gelled texture that is most suggestive of a life-like "plumpness" to the original wet biofilm. The combination of PEG, collagen, and glycerol has produced a phenomenal biofilm; while again not a mimetic copy of the fresh, wet bacterial cellulose, this new treated biofilm is strongly water-resistant and has a non-greasy, plump and pliable surface texture that is closest produced to untreated bacterial cellulose. (e.g. **figures 16, 17, 21**).

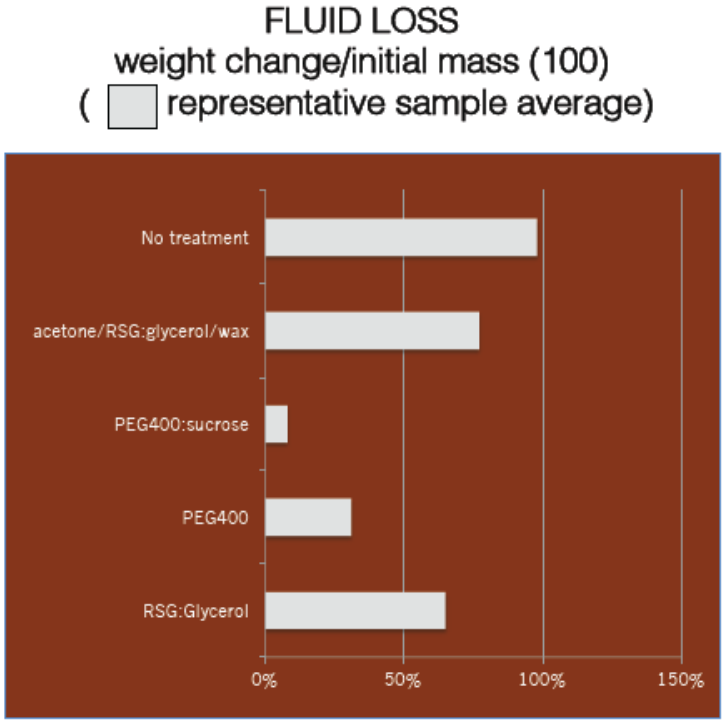


TABLE B:
Condensed representation of treatment fluid loss

vertical axes = samples treatment
horizontal axes = percentage of fluid lost

The majority of treated samples lost significant amounts of fluid during dehydration. Solutions that produced secondary cellulosic growth (i.e. treatments with sugars, metho-cellulose, and some PEG treatments) gained weight during the immersion treatment but subsequently also lost significant fluids during dehydration. The wet, untreated bacterial cellulose on average experienced up to 97% fluid loss during dehydration; in comparison, combination treatments involving solvent immersion and collagen/glycerol immersion produced the least amount of fluid loss, as seen in **Table B.**

RESULTS: REDUCING HYGROSCOPIC PROPERTIES

Cellulose treated with the combination of solvents, collagen/glycerol, PEG or wax proved the most successful during rewetting immersion tests. “Winning” prototypes are currently under further examination for response to ambient moisture and artificial aging – after the ultimate test against rewetting (i.e. plunging them straight into a water bath), they are now being exposed to more subtle and sophisticated strategies of increased RH levels and temperatures (37°C to simulate body temperature) in light of its application as wearable textile.

In order to test performance of the treated cellulose upon human skin (i.e. performance as a wearable textile) one of the samples from the combined collagen and glycerol mixture was cut in half (measuring 2 x 4 cm each) and worn taped to human skin (i.e. each researchers’ skin) for 24 hours to test reactivity to moisture and acid/salt fluctuations of a human body. Although the samples softened slightly under the conditions of body temperature warmth, they showed no visible signs of deterioration or wear. As samples treated with this immersion solution performed second to the PEG, collagen, glycerol treatments in terms of durability and rewetting, it may be assumed the latter may outperform the samples’ successful body-wear endurance in future tests.

RESULTS: INSTALLING ANTI-BIODETERIOGEN PROPERTIES

The choice to not “deactivate” all of specimen samples redirected our study. For example, Hunter discovered a series of unfortunate colonoscopy cases in the 1980s involving mannitol and increased hydrogen production, bacterial produced methane, and explosive consequences in the bowel (La Brooy 1981). It was decided not to use biologically “active” cellulose with the mannitol. Sterilized cellulose treated with mannitol produced supersaturated solutions that encased the cellulose in sharp crystals (e.g. **figure 20**). These samples and those treated with simple sucrose demonstrated repeated contamination foreign bacteria and fungus; despite borax treatments, they were discarded as biohazard waste after repeated attacks.

Bacterially active samples mixed with sugars and methocellulose produced layering effects of different colours and transparencies between separate celluloses – a biofilm within a biofilm

(**figure 19**). These thriving communities were potently acidic and hungry, even eating through and fusing together with wax paper, forming curiosities versus success stories.

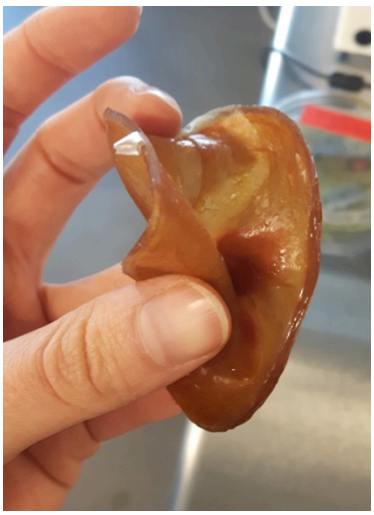
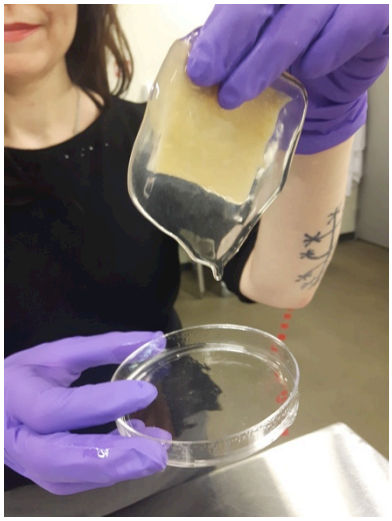



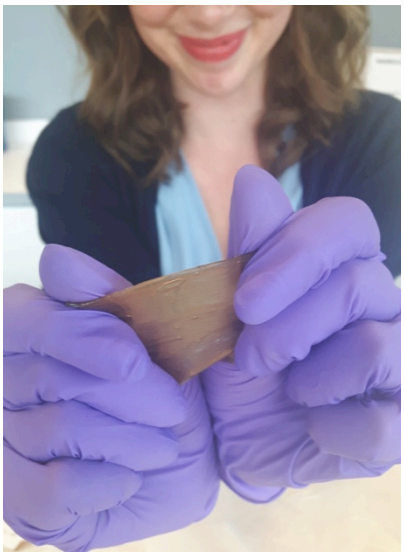

Figure 18 (bottom left): cellulose treated with collagen and glycerol, sterilized and oven-dried.
Figure 19 (center): cellulose treated with methocellulose (1.5%) exhibiting secondary cellulose growth; wet, biologically "active"
Figure 20 (bottom right): cellulose treated with mannitol (20%, 40% concentrations) exhibiting super-saturation and crystals

We discovered that the bacterial cellulose that remained biologically "active" proved more resistant to foreign attack; "sterilized" samples were often infected with foreign bacterial strains (**figure 13**). The *Gluconateobacter xylinus* bacteria of the cellulose will continuously create an acidic surface environment of around pH 4 – too acidic for most common strains of contaminants. We therefore questioned our approach: is leaving the cellulose "active" a viable option? Probably, in terms of the safety of other art objects – recalling the *E. coli* example of *Transgenic Bacteria Release Machine*, these bacterial strains will not jump and exchange hosts. However the acidic effects upon anything placed in contact with the material must be considered. Furthermore, if the cellulose is allowed to remain acidic, the life span of the material is once again unavoidably shortened as the cellulose eats away at itself. These are considerations that demand further research and testing.

RESULTS: POTENTIAL APPLICATIONS

In terms of the treated cellulose stemming from our research, local scientists have inquired regarding its potential applications in internal tissue repair and other practicing artists have requested use of our biomaterial for their own traveling exhibitions.

Further extensions of the project may include mapping a model for designing research between bioart production and art conservation, collaborating at the type of material conception versus strictly material preservation. Establishing common goals and allowing for the flexibility to emphasize specific parameters and controls, while eliminating or relegating other goals is a crucial requirement for framing successful, applicable results for practicing artists. Furthermore, it is recommended that studies such as these encompass an attention to ethical considerations; bioart is by nature an artistic practice loaded with choices of life and death. While most artists and conservators may be comfortable with the utilization of live cells cultured for bacterial cellulose production, others may contest, for example, cellulose treated with animal-sourced collagen (Lapworth 2015) (Vaage 2016).



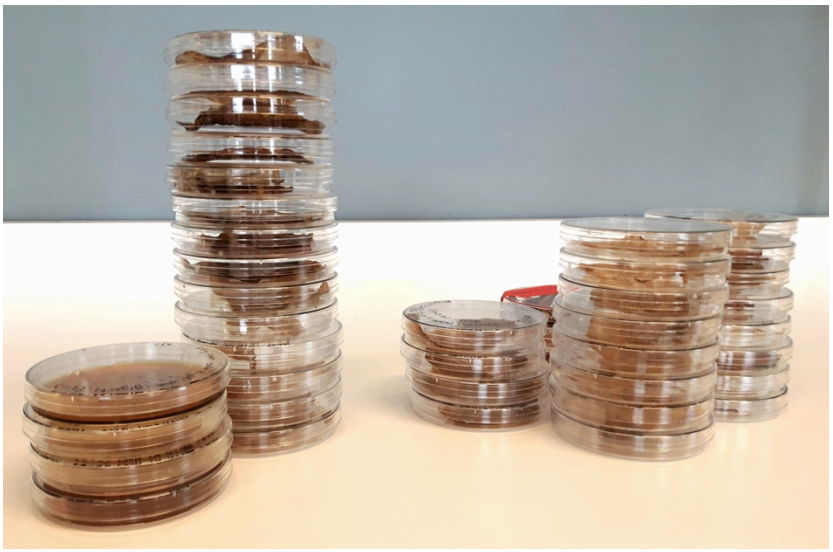


Figure 21 (left): demonstration by hand of the tensile strength of cellulose treated with PEG, collagen, and glycerol, sterilized and oven-dried
Figure 22 (right): selection of cellulose samples and cast immersion fluids for research project *Plump and Pliant*

Cellulosic biofilms and bio-produced gels already enjoy a pervasive popularity in art and heritage conservation. Conservation scientists, using dehydrated bacterial cellulose as an alternative lining material to Japanese paper, have proposed bacterial cellulose may be superior to Japanese paper in the repair of substrates of higher gloss such of coated paper, tracing paper, parchment, or vellum (Santos et al. 2015, 2016). The potential of bacterial cellulose films to serve as strength-reinforcing repair material for hygroscopic leathers, parchments, and textiles holds exciting promise. Submitting the treated samples to artificial aging or isotherm testing may develop the research further and confirm positive results in respect to reduced hygroscopicity or anti-biodeteriogen

performance. Additionally, access to a vacuum freeze dryer could produce superior results. The potential applications for bacterial cellulose treated with the successful immersion methods of this research warrant further study. In the meantime, practicing bioartists are excited to push the exhibition limits of this new, latex-like, "plump and pliant" bacterial cellulose.

A NOTE ON ETHICS AND BIOART: SACRIFICIAL BACTERIA

It is important to consider the question of ethics in any bioart discussion, since within the field of conservation when it is said that an artwork can't be "saved", this most often does not mean in a literal sense. The bioartist group known as the Tissue Culture and Art Project ends the exhibition of performance pieces such as *Victimless Leather* (2004) with a "killing ritual" of cellulose and tissue that rips apart the illusion that their art objects are in a sense "play" and by forcing the audience to reconcile that living organisms are in view. Paola Antonelli, who curated the piece at MoMA in 2008, lamented:

> [It] started growing, growing, growing until it became too big. And [the artists] were back in Australia, so I had to make the decision to kill it. And you know what? I felt I could not make that decision. I've always been pro-choice and all of a sudden I'm here not sleeping at night about killing a coat. That thing was never alive before it was grown. (Lapworth 2015)

When asked for her opinion, WhiteFeather Hunter said she's as comfortable with the "killing ritual" as she is with washing her hands, meaning this is the same level of destruction – what she is not comfortable with is calling it the substance vegan (an opinion I insist upon as well). Awareness of material processing is ever more nuanced as we move towards sustainable, environmentally conscience products. Are we comfortable growing and killing a colony of bacteria to make a kombucha-leather handbag? Are we more comfortable if the dead colony is repairing a historical artifact?

The entanglement of bioart & ethics is sure to develop as the genre grows and innovates. We will see more and more biomaterial under our purview as conservators – working alongside an artist at the creation point offers invaluable lessons in negotiating a common ground, one that includes preservation by embracing a bit of the unorthodox.

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WORKS CITED:

Keshk, Sherif M. A. S. 2008. "Homogenous Reactions of Cellulose from Different Natural Sources." *Carbohydrate Polymers* 74 (4): 942–45.

Khandekar, Narayan. 2016. "Inherent Vice and the Ship of Theseus." In *Doris Salcedo: The Materiality of Mourning [Exposición]*. 2016. New Haven: Yale University Press (2) 141-152.

La Brooy, Susan J., Fendick Avgerinos, C.B. Williams, and J.J Misiewicz. 1981. "Potentially Explosive Colonic Concentrations of Hydrogen after Bowel Preparation with Mannitol." *The Lancet*, no. 317 (8221) (March): 634–36.

Lapworth A. 2015. "Habit, art, and the plasticity of the subject: the ontogenetic shock of the bioart encounter". *Cultural Geographies.* 22 (1): 85-102.

Lee, Susan "Grow your own clothes". TED2011. https://www.ted.com/talks/suzanne_lee_grow_your_own_clothes

Lloyd, Astrid, and Courtney Books. October 30, 2017. Textiles and Bioart: on the topic of pomegranate preservation. Personal conversation; phone call from Kingston, ON to Regina, SK.

Mitchell, Robert E. 2010. *Bioart and the Vitality of Media*. Washington: University of Washington Press.

Santos, Sara M., José M. Carbajo, Nuria Gómez, Ester Quintana, Miguel Ladero, Arsenio Sánchez, Gary Chinga-Carrasco, and Juan C. Villar. 2016a. "Use of Bacterial Cellulose

in Degraded Paper Restoration. Part I: Application on Model Papers." *Journal of Materials Science* 51 (3): 1541–52. https://doi.org/10.1007/s10853-015-9476-0.

———. 2016b. "Use of Bacterial Cellulose in Degraded Paper Restoration. Part II: Application on Real Samples." *Journal of Materials Science* 51 (3): 1553–61.

Schneider Enriquez, Mary. 2016. "Organic and Ephemeral: Salcedo's Recent Material Challenges." In *Doris Salcedo: The Materiality of Mourning [Exposición]*. 2016. New Haven: Yale University Press (1) 119-139.

Vaage N.S. 2016. "What Ethics for Bioart?" *NanoEthics.* 10 (1): 87-104.