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Dear Nanofabrication users,

It is with great pleasure that I have accepted to continue to operate as the Scientific Director of the Western Nanofabrication Facility with the goal to provide new technologies and maintain our existing ones at the best level to meet your fabrication and characterization needs. The last nanofab NSERC-RTI that was funded this year ($150k), concerns the acquisition of a new electron-beam deposition system providing the possibility to fabricate high quality thin films with low roughness. The new system has just been ordered and should be operational in the fall. This is the third RTI obtained since I have been the Facility Scientific Director. This is a critical instrument required by most users for the conception of their devices. In addition, together with Surface Science Western and the Tendetron accelerator facilities, we were also able to secure an Operation and Maintenance RTI grant ($150k) to support our combined facilities to maintain our state-of-the-art instrumentation. We have presently other grant applications under review for new instruments (Polymer imprint lithography) and upgrade of some instruments (CFI led by D.Shoesmith). If you have particular needs for instruments that could be operated and maintained by the Nanofab please contact me so that we can evaluate the best way to acquire them. The operation of this open-user facility that is operating since 2004 depends on your needs and your usage and must evolve accordingly. Finally, I would like to remind that the Western Nanofabrication Facility will continue to train your students and provide an exceptional added value to their Western graduate experience. Regarding the cost of research conducted in the Nanofabrication facility, it was pointed out in the recent survey that the incurred fees are a limiting factor. The activities conducted in the facility are research-oriented and necessitate the use of state-of-the-art instruments that are expensive to maintain. Nevertheless, some of your projects can be supported by NSERC-Engage grants, Mitacs, CMC, OCE providing a myriad of small and medium grants with fast turnover. I strongly encourage you to look at these options or ask me for more information. The nanofabrication team will always be keen to work with you and your HPQ for the conception, fabrication and characterization of challenging devices to the best our capacity.

Sincerely yours,

François Lagugné-Labarthet

Decellularized Adipose Tissue Biomaterials for Adipose Tissue Engineering

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Loss of subcutaneous adipose tissue (fat) due to aging, traumatic incident, or surgical procedure can result in the formation of an obvious deformation of the skin, known as a soft tissue defect. Current clinical strategies to treat these defects have had limited success, highlighting a need for an adipose tissue substitute that incorporates with the host tissues to fill the defect site and promote regeneration. Towards this goal, the Flynn lab focuses on the use of naturally-derived, extracellular matrix-based biomaterials for tissue-engineering applications. In the case of adipose regeneration, human adipose tissue (Figure 1A) is subjected to freeze-thaw cell lysis, enzymatic treatment, and the use of polar solvents to remove cellular components that could cause an immunogenic response in a process known as "decellularization". The resulting material is a purified extracellular matrix (ECM), termed decellularized adipose tissue (DAT) (Figure 1B) that has shown great promise as a biomaterial for the regeneration of adipose tissue.

More specifically, DAT in combination with adipose-derived stem/stromal cells (ASCs) has unique bioactivity and naturally induces the differentiation of seeded human ASCs towards the adipogenic lineage, as demonstrated by the upregulation of adipogenic genes and the production of the adipocyte-associated enzyme glycerol-3-phosphate dehydrogenase *in vitro* [1]. Further, DAT has been shown to stimulate the production of mature adipocytes (fat cells) when implanted subcutaneously in rats [2], demonstrating the naturally adipo-inductive capacity of this biomaterial. Further processing of the DAT can be applied to generate a range of different scaffolds with properties tuned for specific applications including injectable microcarriers [3], porous foams [4], and hydrogel-DAT composite materials [5].

Building on the tissue-specific approach of using purified ECM as a cell-instructive biomaterial for tissue-engineering applications, the Flynn lab is applying these techniques to a range of tissues including cartilage, skin, IVD, and bone.

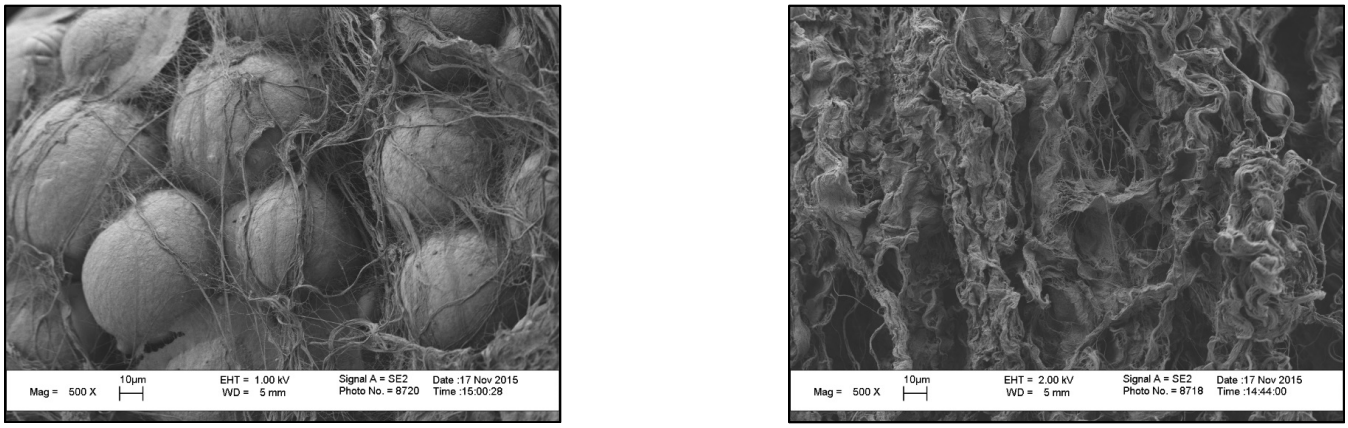

Figure 1: A) Scanning electron microscope (SEM) image of human adipose tissue showing the interaction between adipocytes and the extracellular matrix. B) SEM image of the purified extracellular matrix (ECM) biomaterial, decellularized adipose tissue (DAT), confirming removal of cells with macroscopic preservation of the 3-D architecture of the collagen-rich ECM.

[1] L.E. Flynn, Biomaterials. 31 (2010) 4715–24.
[2] T.T.Y. Han, S. Toutounji, B.G. Amsden, L.E. Flynn, Biomaterials. 72 (2015) 125–137.
[3] C. Yu, A. Kornmuller, C. Brown, T. Hoare, L.E. Flynn, Biomaterials. 120 (2017) 66–80.
[4] C. Yu, J. Bianco, C. Brown, L. Fuetterer, J.F. Watkins, A. Samani, L.E. Flynn, Biomaterials. 34 (2013) 3290-3302.
[5] C.F.C. Brown, J. Yan, T.T.Y. Han, D.M. Marecak, B.G. Amsden, L.E. Flynn, Biomed. Mater. 10 (2015).

Re-Imaging 19th Century Photographs: A Nanotechnology Investigation.

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Daguerre's (1787-1851) creation of the first photographic image, the daguerreotype, gained instant popularity across Europe and North America upon its invention in 1839. Due to their extreme fragility, the preservation of the daguerreotype continues to challenge scientists and conservators alike, because its chemical and physical properties are still not fully understood. By exposing a light sensitive silver coated copper plate to the scene of interest, an image with spectacular resolution and clarity was produced; for the first time, images of everyday life could be accurately preserved. Unlike the predominantly uniform methodology of the contemporary photographic process, chemical individuality is a distinctive feature to the daguerreotype. To date, synchrotron X-ray fluorescence (XRF), conducted at the Canadian Light Source, and scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS), performed at the Western Nanofabrication Facility, has been used to analyze daguerreotypes from the National Gallery of Canada Study Collection (Figure 1). This has provided never-before-seen elemental images of treated and un-treated historic plates while permitting non-contact, non-invasive, and non-destructive examination of these historical images.

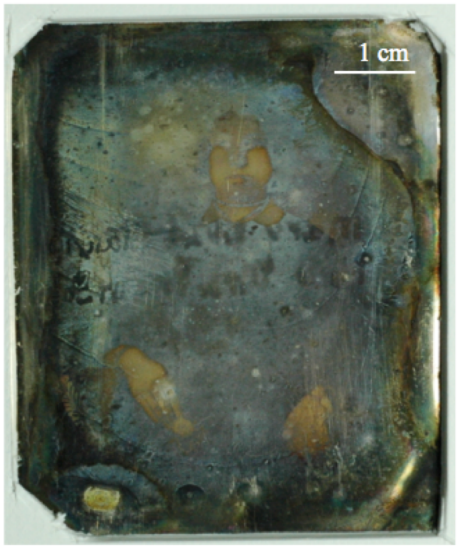

Figure 1: 19th century daguerreotype from the National Gallery of Canada Study Collection.

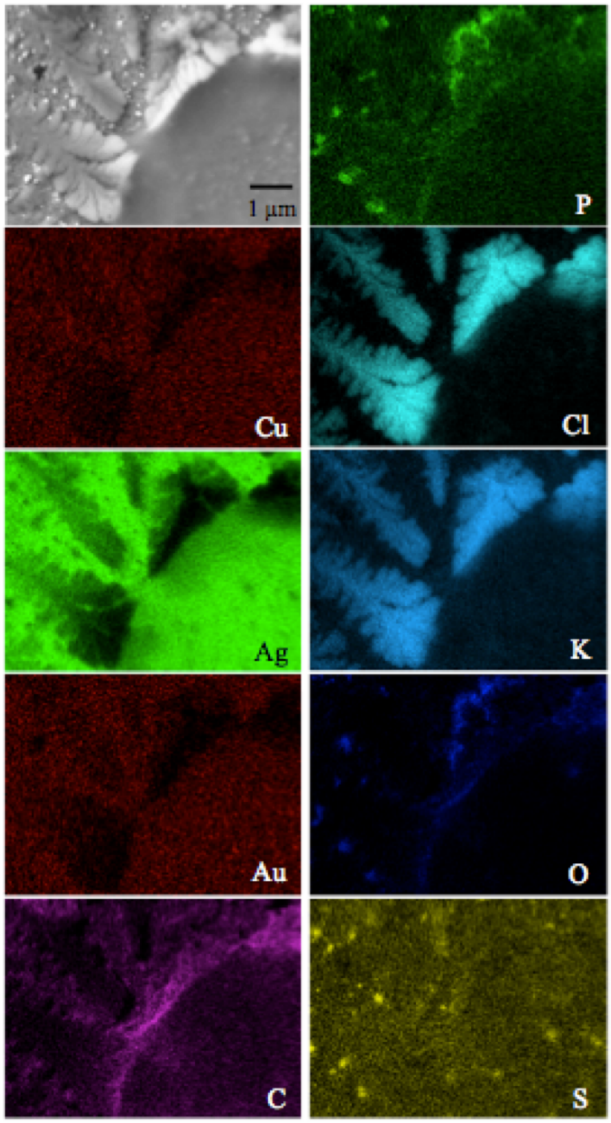

Figure 2: Electron microscope image and EDX maps of a tarnish spot on a NGC Study Collection daguerreotype plate. Recorded elements include: P, Cu, Cl, Ag, K, Au, O, C, and S.

Figure 2 shows a petal-like tarnished area on a daguerreotype. These petals are rich of K and Cl with C enrichment along the base and P present in hot spots along the edges of the petal features. Oxygen is observed to be associated with the P, suggesting the presence of a phosphate. The source of K on the surface may arise from the deterioration of the cover glass under which the daguerreotype was enclosed.[i,ii] Dendrite-like structures containing K and P have been previously observed with SEM. This is a result of cover glass deterioration that was originally placed over the daguerreotype to protect the image from corrosion.[iii] Furthermore, the presence of Cl on the daguerreian surface has been attributed to glass deterioration.[iv] A second possibility for Cl may be as a residual from the gilding or photosensitising process. However, as the daguerreotype was received without its original cover, the origin of K remains unknown.

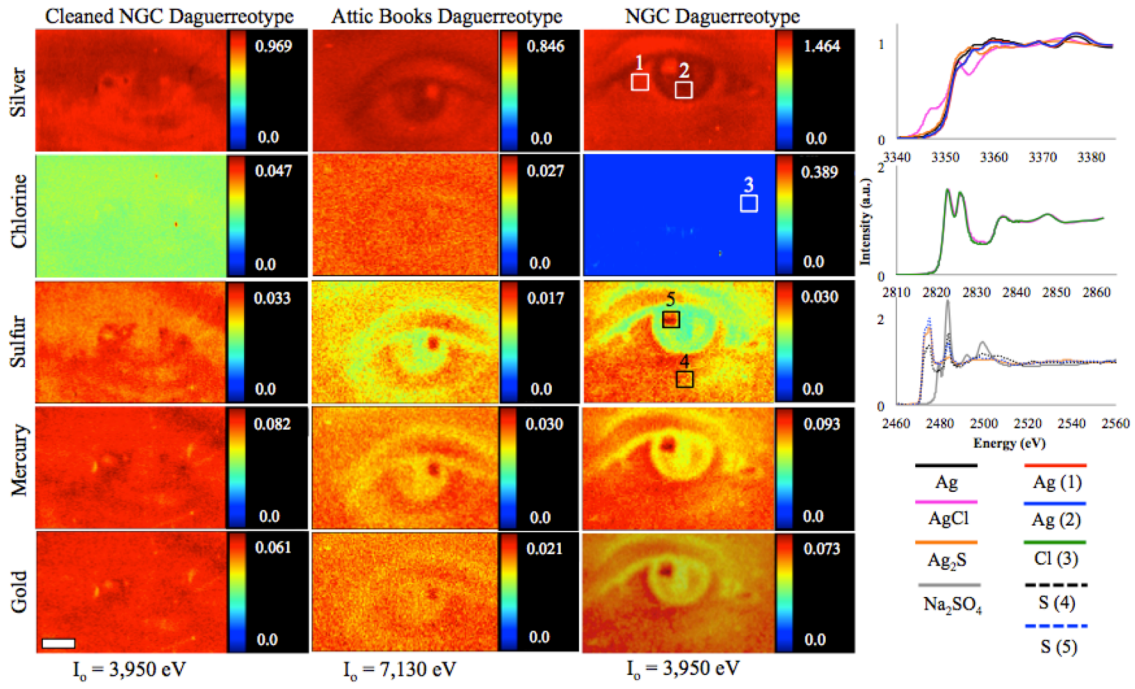

Figure 3: Synchrotron XRF 2D images of three daguerreotypes collected at the SXRMB Microprobe of the Canadian Light Source. Excitation energy indicated below each row of XRF images; pixel size 10 microns. Image bar equates 300 microns. Elements of interest: silver, chlorine, sulfur, mercury, and gold. XANES spectroscopy spectra for silver, chlorine, and sulfur are included (top right).

In Figure 3, 2D X-ray fluorescence (XRF) maps reveal the distribution of elements on the surface. Portrait details otherwise unobservable by the eye due to fogging (as seen in the camera image in Figure 1) are revealed. Furthermore, the deposition of sulfur follows the distribution of silver-mercury image particles on the surface. Conversely, chlorine follows a more uniform distribution. Some distinction is seen in the Attic Books daguerreotype but inversely follows the distribution of image particles. The X-ray absorption near edge structure (XANES) analysis for chlorine (spot 3) confirms that chlorine is in the form of silver chloride. XANES collected from spot 4 and spot 5 on the sulfur XRF map indicates the presence of silver sulfide and sulfate.

i L. Robinet, C. Pulham, C. Hall, K. Eremin, S. Fearn, Understanding glass deterioration in museum collections through SIMS analysis, *MRS online proceeding library archive*, 852, 2011, DOI: 10.1557/PROC-852-OO8.8.

ii B. Wagner, A. Nowak, E. Bulska, J. Kunicki-Goldfiner, O. Schalm, K. Janssens, Complementary analysis of historical glass by scanning electron microscopy with energy dispersive X-ray spectroscopy and laser ablation inductively coupled plasma mass spectrometry, Microchim. Acta., 162, (2008), 415-424, DOI 10.1007/s00604-007-0835-7.

iii S.M. Barger, Characterization of corrosion products on old protective glass, especially daguerreotype cover glasses, J. Mat. Sci. 24 (1989) 1343-1356.

iv A. Swan, C.E., Fiori, K.F.J. Heinrich, Daguerreotypes: A study of the plates and the process, Scan. Electron Micros. 1, 411–424, (1979).

Petroleum Coke KOH Activation for Removal of Organics from Oil Sands Process-Affected Water

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Each year, several million tonnes of oil sands process-affected water (OSPW) are being produced during the extraction of bitumen in Alberta, Canada [1]. There are different kinds of organic compounds in OSPW, such as poly aromatic hydrocarbons (PAHs) and naphthenic acids (NAs) which are toxic and need to be removed [2]. In this research, a Box-Behnken design was employed to find the optimum condition on KOH activation of petroleum coke (PC) to produce activated PC (APC) as an adsorbent for OSPW treatment. The SEM images of raw PC and APC prepared at three different activation conditions are shown in Figure 1.

The results illustrate that the surface area could be increased from a value less than 15 m^2/g for the raw PC to more than 1700 m^2/g for the APC prepared at the optimum condition to achieve the best NA adsorption capacity. The produced highly porous APC adsorbents also showed superb performance in adsorptive removal of total organic carbon TOC (including NAs and PAHs, etc.) from OSPW. Furthermore, the elemental analysis of the prepared APC illustrated that sulfur and metals such as V, Cr, Co, Fe, Al, V, Cr, Mn and Mg originally present in the raw PC can be significantly reduced during the KOH activation process, and the leaching of metals from the APC is negligible when using it as adsorbent for OSPW treatment.

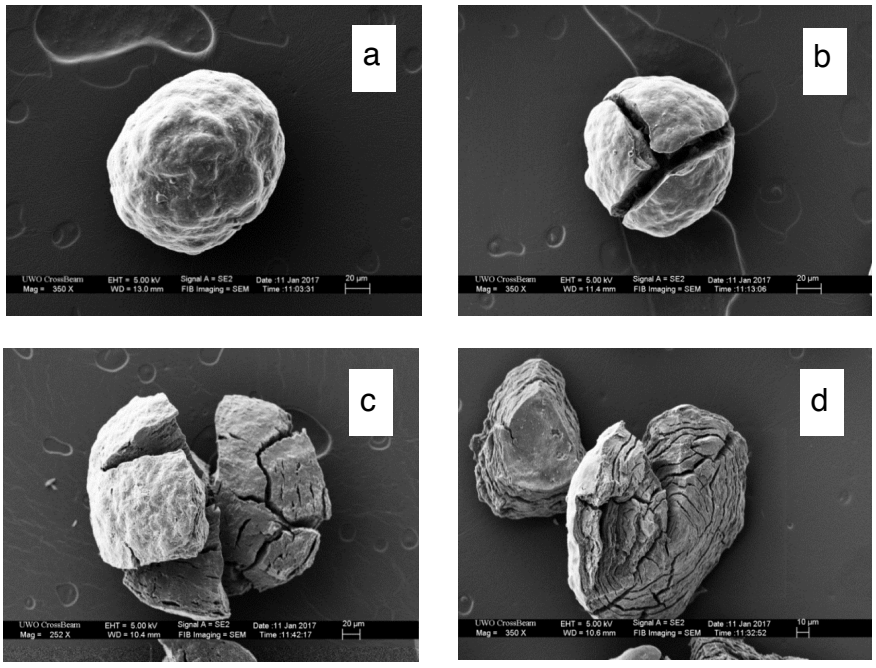

Figure 1: The SEM images of a) raw PC, b) APC prepared at KOH/coke mass ratio of 2, 3h activation time, and 650 °C activation temperature, c) APC prepared at KOH/coke ratio of 2, 2h and 750 °C, d) APC prepared at KOH/coke ratio of 3, 3h, and 750 °C.

1. McQueen, A. D. *et al.* A risk-based approach for identifying constituents of concern in oil sands process-affected water from the Athabasca Oil Sands region. *Chemosphere* **173,** 340–350 (2017).

2. Scarlett, A. G. *et al.* Acute toxicity of aromatic and non-aromatic fractions of naphthenic acids extracted from oil sands process-affected water to larval zebrafish. *Chemosphere* **93,** 415–20 (2013).