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PREVENTING AND REMOVING CONTAMINATION IN A NATURAL RADIOCARBON SAMPLE PREPARATION LABORATORY

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Abstract

The introduction of elevated ^{14}C contamination into a natural radiocarbon sample preparation laboratory can occur through many different pathways. The most difficult to control is the introduction of contaminated samples from outside labs. Laboratories can remain ^{14}C contaminated as a result of earlier tracer based research, even if "hot" work has not occurred in the laboratories in decades. Prior to accepting samples from outside collaborators, it is recommended that the collaborators test their labs for ^{14}C contamination. Any surface in a lab that has high use by multiple people has the potential to be contaminated. The standard procedure for determining whether a collaborator's lab is contaminated consists of swiping lab surfaces with small glass fiber filters wetted with alcohol and measuring them for ^{14}C content using AMS.

Volatile ^{14}C can be detected by using aerosol monitors consisting of fine soot that is depleted in ^{14}C. These monitors can be set out in the laboratory in question to check for volatile ^{14}C contamination.

In the event that a hot sample is introduced in the natural radiocarbon sample prep laboratory, all sample submission should be stopped until the lab is declared clean. Samples already being processed should be completed along with ^{14}C depleted material and measured by AMS. This will help determine if the contaminated samples have affected other samples in the laboratory.

After a contamination event, the laboratory and associated equipment requires cleaning or disposal. All surfaces and equipment should be wiped down with acetone or ethanol. All chemicals in use should be disposed of in the appropriate waste containers and those waste containers removed from the lab. Once the natural radiocarbon laboratory has been thoroughly "cleaned", several background samples consisting of ^{14}C depleted material should be processed through the lab and measured by AMS before unknown samples are processed again.

1. Introduction

One of the greatest challenges for a natural radiocarbon sample preparation laboratory is the introduction of ^{14}C contamination. Contamination can be spread from collaborators' samples, equipment, and personnel. Once a laboratory is contaminated controlling the contamination is not a trivial matter. Elevated ^{14}C contamination is not recognized until both samples and supplies have been compromised. Prior to recognition, exchange of equipment and access of personnel will allow the contamination to spread and potentially affect other samples, laboratories, and research within the facility.

Contamination can cost the laboratory personnel and collaborators a great deal of time, funding, stress, and in severe cases, lost research. We address these issues and discuss the measures adopted at our sample preparation laboratory to prevent and remove ^{14}C contamination.

2. The workspace

The history of isotope research conducted within a building is pivotal. Elevated ^{14}C from earlier radiocarbon tracer based research can be detected in background samples decades later. If radiocarbon is currently being used within the building, both pedestrian traffic and airflow can potentially contaminate the laboratory**.** It is essential that the laboratory not be a shared facility, or at the very least, no common areas are using radiocarbon**.** Ventilation systems within such a facility should be segregated as well and foot traffic adjacent to the laboratory should be restricted. Controlling access to the workspace itself is vital. Persons from hot labs should not enter the natural labs and vice versa. Non-essential personnel are deterred by installing locks and mounting signs restricting entrance to the lab. Any maintenance work should be scheduled in advance. Maintenance personnel should be aware of the potential for contamination from outside sources. Any maintenance work should be performed in the natural laboratory before the workers move on to areas where radiocarbon is being used. The laboratory should have its own janitorial supplies

3. Swipes

Laboratory contamination can be determined in the laboratory by taking "swipes". A small glass fiber filter (e.g., Whatman GF/A 21-24mm) is wetted with isopropyl alcohol and wiped across the surface in question [1]. The swipe will pick up

organic and inorganic material. A blank filter should be included in any set of swipes. The swipes should be individually packaged and sent to a bio-AMS sample preparation laboratory for conversion to graphite and measured for ^{14}C content using AMS [2].

Surfaces routinely touched by multiple users, such as door knobs, light switches, drawer handles, telephone receivers, computer keyboards, faucet handles, lab stools, armrests, balances, apparatus controls, centrifuges, sonicators, and work bench tops should be swiped. The introduction of used equipment into the laboratory is not recommended. Should it be necessary, the equipment should be swiped, and the swipes measured prior to the introduction of the used equipment into the building. Swipes of material sampled from sample collection equipment can also be taken if there is any question concerning ^{14}C contamination.

4. Aerosol monitors

Aerosol monitors consisting of sorbant carbon (e.g., fullerene soot such as Alfa Aesar product#40971) with high surface area and depleted ^{14}C ratios may be used to detect airborne contamination. The soot is mixed with iron powder and packed directly into AMS sample holders, loosely wrapped in aluminum foil to protect against the introduction of particles, and left in the laboratory for 1 to 2 weeks. Volatile organic compounds meander through the aluminum foil and are absorbed on the soot. Samples are analyzed for ^{14}C using AMS [1]. Any levels above background identify contamination.

5. Preventative measures within the sample preparation laboratory

Measures can be taken within the sample preparation laboratory to prevent the introduction and later spread of contamination. Workstation design can greatly influence

laboratory cleanliness. Adhesive peel-away sticky mats should be placed at each doorway to make personnel aware of the potential for contaminants dispersed via "foot traffic." Within the lab, counter tops and workbenches should be covered in aluminum foil and re-foiled routinely in order to provide for clean sample processing areas. This practice also keeps the original underlying surface free of contamination. Using disposable glass/plastic ware (pipets, bottles, etc) is necessary to maintain a clean lab. Equipment such as vacuum ovens, centrifuges, refrigerators, and freezers are often extremely susceptible to contamination. Developing routines such as keeping accurate records of a sample's movement throughout the laboratory can help locate areas that have been contaminated and proves beneficial to preventing further contamination. Maintaining logbooks for all sample processes and equipment documents the path of a sample. This information functions as a vital tool for potentially identifying the source of contamination. Logbooks also help determine what equipment requires cleaning or disposal and which samples may be compromised after a contamination event. For this reason, long term sample archiving within the proximity of the lab is not recommended. Separate, designated, clean storage areas for samples are recommended.

6. Responding to a contamination event

The initial response to a contamination event is to control the spread of the contaminant. This is largely done by suspending all sample processing and limiting laboratory access to mandatory personnel. The next step is to begin cleaning. Dispose of all replaceable suspect supplies (i.e. bottles, tubes, surface covers). Dispose of all laboratory chemicals used in the processing and pretreating of the suspect samples that were opened. Thoroughly clean all laboratory surfaces, (e.g., tables, floors, light

switches, door handles, telephones, computer keyboards, and other items handled or accessed by multiple personnel). Recommended cleaning agents are detergent, bleach, and ethanol. It is also important to clean and track down equipment exchanged with other laboratories or offices.

Graphitization rigs, vacuum manifolds and other equipment used to process samples will require dismantling and cleaning. Reduction rigs made of stainless steel, or glass need to be disassembled, washed in detergent, washed in a solvent if possible, rinsed with deionized water several times and dried in a convection oven.

Vacuum driers also require cleaning. All parts need to be wiped down with acetone and or ethanol. Dispose of and replace all plastic tubes, gaskets, bearings and vacuum pump oil. Thaw the cold traps, remove the chemicals and clean the basin with acetone and/or ethanol.

All tools and containers that come into contact with the samples should be properly disposed of or cleaned. Glassware should be cleaned with acetone and then baked at the highest possible temperature. Tools used for loading samples should be cleaned in a manner similar to the manifold and graphitization rig parts. Clean heating blocks with acetone, it may be necessary to bead blast the surface of the blocks. Bake or dispose of sample catalysts and other additives (i.e. CuO, Ag).

7. Successful cleaning

One method for determining if the cleaning was successful is to run background samples consisting of ^{14}C free material through the different stages of sample preparation. Background samples work the best if they have a large surface area and are highly absorbent: some possible background materials include; old wood, coal and petroleum

products. It is important to test as comprehensibly as possible. Samples should pass through all sample handling equipment (Centrifuges, ovens, heating blocks, weighing tables, scales and vacuum manifolds). Limit the exposure of individual background samples so that suspect samples can be tracked to a single piece of equipment. Continue to clean and run background samples until the laboratory is free of contamination. Other laboratories or offices that exchange materials or equipment with the contaminated laboratory may also need to be tested with swipes and aerosol monitors.

8. Conclusions

^{14}C contamination is in most cases is inevitable; but with these procedures, if executed properly, can control the spread and restore the laboratory. The procedures discussed within this paper cover a number of different aspects dealing with the prevention and cleanup of contamination but are not all encompassing. The extrapolation of the procedures discussed can address issues from different laboratory arrangements and procedures. It is crucial that laboratory personnel and collaborators understand the threat of ^{14}C contamination. Collaborators who submit samples are responsible for ensuring that their samples are uncontaminated and laboratory personnel are responsible for ensuring that the natural radiocarbon sample preparation laboratory remains sterile.

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