Nitrogen/Argon Gas Treatment Fact Sheet

Brief description of treatment

Nitrogen (N_2) and argon (Ar) gas used in controlled atmospheres are effective in causing insect death within 14-21 days if the oxygen levels are reduced to 0.1-0.3% (less then 1000ppm oxygen). Oxygen deprivation causes a disruption in the glucose production within insect bodies, dehydration, and weight loss, resulting in death of the insect. Rates of death vary with temperature, relative humidity, exposure time, and species type. Argon is a noble gas so individual atoms penetrate insect body walls up to 50% faster than the larger nitrogen gas molecule. Increasing the temperature helps reduce the exposure time for both gases because insect respiration is increased with higher temperature, causing rapid water loss and dehydration (Valentín 1993). Modified atmospheres using nitrogen and argon are usually continuous-flow systems with soft or hard walled, vapor impermeable chambers. The continuous flow of gas initially purges the chamber of oxygen, then maintains low oxygen levels to compensates for leaks.

What collections materials can be treated this way?

Almost all collections can be treated with nitrogen and argon. Exceptions include:

- Certain pigments. One study showed that minerals such as litharge (PbO), cinnabar (HgS), and sienna (mostly Fe_2O_3) undergo color change at these low oxygen levels (Arney, Jacobs, and Newman 1979), so care must be taken if this is a concern with artifacts or pigments.
- Wet artifacts. Wetness has the potential to reduce the effectiveness of treatment due to insect adaptation to use anaerobic respiration, although this is generally unlikely for the types of pests typically encountered for museum and library pests (Selwitz 1998).

General procedures

An anoxic atmosphere requires an enclosure, gas, and gas monitoring devices. Enclosures must be constructed of vapor impermeable materials such as steel or aluminized polyethylene and polypropylene films. Procedures vary by chamber type, but all include:

1. Loading the chamber so artifacts cannot crush each other, accidentally shift, or be crushed by the walls of a soft chamber.
2. Sealing the chamber (heat-seal for soft wall chambers, zipping shut for retrofitted fumigation soft wall chambers, and closing the door on a hard wall chamber ensuring the gasketing is in good alignment and condition).
3. Purging ambient air and oxygen from the chamber. Sometimes this is a two step procedure; first, introduction of nitrogen to push out the oxygen, followed by the secondary anoxia gas like argon or carbon dioxide. However, in larger chambers, this additional step has not proven to be necessary since many larger chambers have constant positive pressure to maintain low oxygen levels.
4. Monitoring and maintaining constant gas flow for the duration of the treatment, which depends on gas type and species of insect if known.
5. Evacuating the anoxic gas from the chamber and returning ambient air, while observing proper safety protocols to maintain safe levels for humans.
6. Examining artifacts followed by removal of dead insect debris by low suction HEPA vacuuming or tweezing.

Pros and Cons of this treatment

Pros

- Appropriate for a wide variety of collection materials.
- No chemical residue on artifacts.

- Argon gas has the additional benefit of preventing biodeterioration by microorganisms like fungi and bacteria (Valentín 1990).
- More time-efficient than treatment with carbon dioxide gas.
- Argon and nitrogen are not currently listed as a registered pesticide by the EPA, so users must follow state guidelines for the determinations and requirements for defining what gases are pesticides and if applicator licenses are necessary, based on the applicators residency and the entity which needs to perform the treatment. For the most up to date information, refer to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) on http://www.epa.gov/pesticides/regulating/index.htm

Cons
- Generally nitrogen and argon gases are more costly than carbon dioxide gas, depending on regional rates for gas acquisition.
- Nitrogen gas can in some cases contribute to growth of microorganisms which possess nitrogenase enzymes which help fix nitrogen as a fuel source, although more research in this area may clarify this potential issue.

Selected bibliography
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Materials, supplies, product manufacturers

Hard wall chambers

- Typically steel shell chambers or rooms hard-wired into building electrical and HVAC systems.
- Include a sealable door in which shelves or carts of infested materials can be inserted.

Soft-wall chambers:

- Can be made to any specific size or shape in-situ, which is helpful for odd-shaped or large objects. Constructed of a vapor impermeable film (also referred to as a barrier film) that is heat set together at the seams.
- Very large soft-walled chambers may have an internal frame support of lumber or PVC piping to prevent collapse on the artifact(s).
- Reusable soft wall chambers are usually chambers previously manufactured for chemical fumigation techniques that are no longer used or permitted by law (such as methylene bromide) and retrofitted for other gases like carbon dioxide, nitrogen, and argon.
- Barrier films for chambers: Aclar, Marvelseal, and Escal are available from many online vendors.
- Heat sealers for vapor barrier film:
- Search the web for “constant heat hand sealers,” there is a wide variety on the market such as the Futura Cello Model Sealer 6" long top and bottom heated hand sealer with 3 temp settings.
- Hot spatulas such as the The 21st Century Tacking Iron or the Coverite Trim Sealing Iron.

Suppliers of custom chambers

Soft-wall chambers

- Chambers built to custom size out of a vapor barrier film and internal support structure like wood or PVC pipe. Chambers accommodate nitrogen, carbon dioxide or argon. Gas supply is external.
    - Contact: Bill Louche, Art Care Int’l, tel: 845-457-8134, wlouche@aol.com
    - Michel Maheu, Maheu & Maheu Inc., Quebec, Canada. Tel: (418) 623-8000 # 228, maheu-maheu.com

Hard-wall chambers

- Chambers with steel outer shell custom built to size, usually for nitrogen or carbon dioxide. Chambers become a permanent fixture of the internal building and are hard-wired into existing systems. Doors can be secured.
    - Contact: Steve Colton, Fine Art Conservation, 13023 Arroyo St San Fernando, CA 91340. Tel: 818 426-5575.

- 6m^3 chamber is stainless steel, uses nitrogen, maintains 50% RH and 25ºC, has fixed and removable shelves, exterior monitoring gauges, purchase includes staff training, and collection treatment takes 1-3 weeks.
    - Contact: EXPM Desinfestacäo e Higienizacäo LDA, Ed. Copacabana, 32, 4ºB 2765-294 Estoril – Portugal, Tel: +351 21 466 19 10 geral@expm.com.pt http://www.expm.com.pt/en/

Mobile chambers

- Mobile self-contained 26’ trailer system. Has both generator systems and capacity for building power source connection. Includes electrical, T & RH control & loading ramp. Auto-injection and recycle of Argon gas. Maintains 0.1 – 0.5% O2 level. Has external monitoring panels. Chamber is 8’ x 8’ x 14.’ Trailer and trailer door can be secured.

- Contact: Lee Standard or Vanessa O’Neil Cedar Spring, Inc. 11 Wellesley, Irvice, CA 92612. Tel: 949-725-1775

Material Safety Data Sheets (MSDS)

Argon gas MSDS: http://www.iigas.com/argon_msds.htm (As seen on March 1, 2008).

Nitrogen gas MSDS: http://www.vngas.com/pdf/g7.pdf (As seen on March 1, 2008).