

A LOW TECH METHOD FOR INSECT ERADICATION USING AGELESS™

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INTRODUCTION

This paper will review the use of low oxygen or anoxia treatments using the oxygen scavenger Ageless™ to eradicate insect infestations in organic objects such as furniture, wooden sculpture and panel paintings. Insect damage to wooden objects is caused by several wood boring species which lay their eggs on unfinished areas of wooden objects. During the life cycle of the insect, the larval stage bores into the wood, forming tunnels or channels and the adults emerge through the characteristic round flight holes. This excavation of the wood undermines the structural stability of the wood and ultimately the object. The wood-boring insects which commonly attack wood objects in North America and Europe include: common furniture beetle (*Anobium punctatum*); death watch beetle (*Xestobium rufovillosum*); powder post beetles (*Lyctus* spp.); house longhorn beetle (*Hylotrupes bajulus*) and termites (*Cryptermes* spp.)

Traditionally insect infestations in objects have been treated with a wide range of toxic gases and chemicals to eradicate the infestation. Materials which have been recommended and used in the past include toxic gases such as Vikane, ethylene oxide and methyl bromide, all of which are still in use, and applied chemicals such as chloro-naphthalene, mercuric chloride, Xylamon CombiClear (Bayer) and arsenic salts (1-3). All of these materials are highly toxic and increased environmental and health concerns (4-7) over the use of these toxic fumigants has resulted in the restriction or banning of many of these traditional treatments. There is also concern that the use of these materials can cause chemical change and damage to artifacts such as discoloration of surfaces and corrosion of metal components (8). The residual effects of these chemicals may well still have health implications and there is some doubt as to the effectiveness of some of these chemical treatments (9). The use of toxic gases also requires the transportation of objects to pest eradication facilities which increases the risk of physical damage to objects and the cost of transportation and art handling must be added to the fumigation expense.

THEORY OF MODIFIED ATMOSPHERES

These concerns have encouraged research into viable non-toxic alternative systems for pest eradication in objects which will kill all life stages of the insects which infest wooden objects. The idea to use low oxygen atmospheres to control and eliminate pest infestations was based on research from the agricultural stored products industry, which has used modified atmospheres to control insect pests in stored grains and food for several years (10). However their aim was control (90-95% mortality rate) rather than total eradication and the insect species studied were not directly relevant for art object collections. Inspired by this work, several different studies were performed during the late 1980s and early 1990s which determined the oxygen concentration and duration needed to kill all life stages of the insects studied (11-15). A very comprehensive study of ten insect pests commonly found in museums was sponsored by the Getty Conservation Institute (GCI) and was performed by Rust et al. at the University of California, Riverside. This study determined the mortality rates of all life stages of the insects studied at 55% RH and 25.5° C in a nitrogen atmosphere having less than 0.1% oxygen (14). The time required for 100% kill varied from three hours for the adult firebrat to 192 hours for the eggs of the cigarette beetle. This study only included one wood borer, the western drywood termite (*Incisitermes minor*). Other studies have examined the mortality of some of the major wood boring insects such as furniture beetle (*Anobium punctatum*), powderpost beetles (*Lyctid brunneum*), and the house longhorn beetle (*Hylotrupes bajulus*) at

0.1% oxygen (16). This research showed that the wood boring insects are the most resistant to low oxygen atmospheres and required longer times of exposure to low oxygen concentrations to achieve 100% mortality. Further studies looked at the effect of temperature and relative humidity on the mortality rate. No significant impact was made by varying the RH but temperature has a significant effect. Temperatures below 20° C drastically reduced the mortality rate. (16)

ENCAPSULATION AND PLASTIC FILMS

The basic requirements for low oxygen fumigation are to encapsulate the object to be treated and to reduce the oxygen concentration within this enclosure to 0.1% or less. The simplest method of encapsulating an object for low oxygen atmosphere fumigation is to use plastic film which is heat sealed to form a bag or pouch to enclose the object to be treated. However, the oxygen permeability of different plastic films varies considerably and it is critical to select a plastic film which has the lowest possible oxygen permeability. (17) This is important as it will make it easier to maintain the low oxygen concentration within the bag for the duration of the treatment. There are several composite plastic films available which have low oxygen permeabilities or transmission rates and

are suitable for this application. In addition to having a low oxygen permeability, the films must also have a polyethylene inner layer which will allow it to be heat sealed together to form a bag. Films which we have used include Marvelseal 360, which has an aluminium coating and has an oxygen transmission of 0.01 cc/m²/day, and Filmpak 1193, which is transparent and has a transmission rate of 0.1 cc/m²/day.

REDUCTION OF OXYGEN LEVEL

After the object is encapsulated in its bag, it is necessary to reduce the oxygen concentration to less than 0.1%. Air is composed of approximately 20.9% oxygen with the remaining volume being made up of nitrogen and other gases. The procedure for producing and maintaining the low oxygen atmosphere within the bag is to either continuously purge the bag with an inert gas or to use an oxygen scavenger. The first method uses nitrogen or argon gas to flush out the oxygen contained within the encapsulating bag (18-21). The oxygen concentration is thus reduced by half with each exchange of the bag's volume. By this method eight volume exchanges will reduce the oxygen concentration to below 0.1%. However, a fair amount of equipment is required for this method, such as gas tanks, regulator valve and a humidification system



Figure 1. Loose packets of Ageless™ and oxygen indicator tablets.

(as the nitrogen gas contains no water). In addition, considerable time is required to monitor the bag during the flushing process and to maintain a slow flow of nitrogen to keep the oxygen concentration below 0.1%.

The second method uses the same encapsulating bag system but uses an oxygen scavenger (Ageless™) to reduce the oxygen concentration. Ageless™ (22-26) is manufactured by the Mitsubishi Gas Corporation and is made to be packed with certain foods to prevent them from oxidizing. Ageless™ is described by Mitsubishi as a mixture of finely divided iron and potassium chloride and is marketed in several different compositions which are used for a range of applications. Ageless-Z or ZPT™, which is formulated to react rapidly and thoroughly with oxygen at a relative humidity of 50% can be used with art objects (23). The active ingredients are contained inside small flat paper packets and are designated as Z-100, Z-1000, etc., to indicate the milliliters of oxygen which a single packet can scavenge. In most situations we have used Ageless™ Z-2000, which will scavenge two liters of oxygen, as this minimizes the number of packets which need to be placed inside the bag. Initially, the finely divided iron in the sachet is in its elemental state and as it is exposed to oxygen it oxidizes with the formation of iron oxides. As this reaction of Ageless™ with oxygen is exothermic, the Ageless™ packets can become fairly hot. It is therefore important that when the packets are placed in the encapsulating bag they are not placed on the surface of the object being treated.

Initially it was thought that using Ageless™ would only be applicable for small volume bags. However treatments were performed on two large objects: a contemporary wooden sculpture and an upright piano which required bags whose volume were 1,700 liters and 2,300 liters respectively. The oxygen concentration of both of these treatments was monitored with a Teledyne oxygen monitor and showed that the oxygen concentration took approximately three days to fall down to 0.1%. This time is accounted for by the rate of absorption of the oxygen by the Ageless™ packets but also that it takes approximately 2–3 days for all of the oxygen

contained within the wood to diffuse out and be scavenged.

DETAILED DESCRIPTION OF HOW TREATMENT IS PERFORMED

The two components necessary for a successful anoxia treatment are Ageless™ packets and a barrier film. The packets of Ageless™ come sealed in an airtight wrapper that should not be opened until you are ready to begin the treatment. Once the packets are exposed to air (fig.1) they will begin to absorb oxygen. You will notice the two small tablets at the lower left side of the pile of Ageless™ in figure 1. These are the oxygen indicators and they come with the sealed envelopes of Ageless™ packets. These tablets are to be placed inside the barrier film with the object and theoretically as the oxygen level falls below 0.1% they will turn pink in color, or if the oxygen level rises the tablets turn blue. In our experience the indicators did not work and when the supplier was questioned about this he admitted to the unreliability of the tablets. The other component needed for this treatment is an airtight barrier film large enough to hold the object. You have the option of purchasing a custom-sized ready-made bag or obtaining a roll of barrier film and then making your own bag. These barrier films are heat-sealable and can be made any size by joining pieces together with a tacking iron. The process of making a custom-sized bag is not very difficult and it is recommended to achieve a well-fitted envelope around the object. If a ready-made bag is used there are some drawbacks to be aware of. For example, a table that is 30" tall, 36" long, and 24" wide (fig. 2) requires a bag that is 60" wide by 96" long. That's quite a large bag to gracefully slide around a three-dimensional object. Notice also that there is a wooden chest under the table and inside the same bag in figure 2. Including more than one object in a bag is an efficiency that can be used to your advantage when the geometry of the objects works out right. In this case the bag had to be gently slipped around two objects at once. This is not easy for two people to do while at the same time being careful not to damage the objects or cause a puncture in the barrier film. In practice it is much easier and safer to lay out enough barrier film to envelop the object,

place the object on top of the film and then build the bag around the object by heat-sealing the three sides. The advantages of making your own bag are: 1) it is easier for you and safer for the object, 2) there is less likelihood of creating a tear or puncture in the film, 3) it is cheaper than purchasing a custom sized bag, 4) you can make the bag fit your object more precisely. It is also a good idea to pad the objects inside the bag using blankets or furniture pads. This padding can act as a buffer in the event of temperature or humidity fluctuations and will also protect and prevent tearing of the barrier film around sharp corners of the object. Padding is not shown in the photo.

Once the object is in the bag you are ready to seal the envelope. Do not open the plastic bag containing the Ageless™ until you are ready to do this. You can use a heat sealer, a regular hand iron or a tacking iron. It's a good idea to make some test seals to make sure that the iron is at the right temperature and to give yourself some practice. If you are using

a household iron, a good starting point is setting the iron to “cool polyester” or about 250° F and then make temperature adjustments as necessary. The seal should be at least ¾-inch wide with no folds or paths for air to enter the envelope. When you feel confident of your sealing abilities, open the envelope containing the Ageless™ and arrange it at one end of the bag or around the periphery of the object. It can be kept in a loose pile as long as it does not come in contact with the object. The reaction of the oxygen absorber is exothermic and the packets do become slightly warm during the treatment. Before sealing the bag completely gently push out the excess air leaving a little room around the object. Over the next day or so the scavenger will absorb the oxygen in the sealed bag, which will reduce the volume of the envelope by about 20%. You don't need to rush but the envelope should be sealed within fifteen minutes of opening the envelope of Ageless.™



Figure 2. Table and chest inside a sealed envelope.

Determining the amount of Ageless™ required is an easy calculation and it is best carried out using the metric system. Measure the total volume of the sealed envelope in centimeters and convert the volume to liters. Given that the oxygen content of normal air is 20% of the total volume, divide the total volume of the envelope by five to arrive at the approximate oxygen content inside the envelope. The individual Ageless™ packets are rated by their capacity to absorb oxygen. One packet of Z-1000 will absorb one liter of oxygen and one packet of Z-2000 will absorb two liters of oxygen. For example, if you are using Z-1000 and your bag has a calculated volume of thirty liters of oxygen, the minimum required amount of Ageless™ is thirty packets. It is recommended to use 25% more than necessary to be sure there is an excess amount of scavenger. In addition, the manufacturer purposely builds in excess capacity in the packets. The idea here is to err on the side of too much rather than too little. You should notice slight shrinkage or tightening of the bag around the object as the scavenger absorbs oxygen inside the bag. Be aware of this shrinkage and allow for it as you build your bag.

The recommended time of treatment is a minimum of 21 days and there is no harm in extending this time frame. In the case of the treatment shown in figure 2, the objects were left in the sealed envelopes for six weeks. When the time has expired the bag may be opened up and the treatment is complete. The barrier film may be saved and used for future treatments. One way to know if you used an excess amount of scavenger is to feel the packets after opening the bag. If there is excess or un-reacted Ageless™ the packets will feel warm to the touch as they once again begin to absorb oxygen from the fresh air.

CONCLUSION

By encapsulating objects in bags created from a plastic with a low oxygen permeability and using Ageless™ as an oxygen scavenger it is easy to create a low oxygen environment which will kill any insects infesting an object.

The use of low oxygen atmospheres for eradicating insect infestation is a viable alternative to toxic gas and chemical treatments. The additional advantages of this method is that it is safe for the person performing the treatment, low cost and can be carried out in a range of situations, such as private homes, galleries, storerooms or conservation laboratories.

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LIST OF SUPPLIERS

Conservation Support Systems, 924 West Pedregosa Street, Santa Barbara, CA 93101. Tel: (805) 682-9843. www.silcom.com (Films, oxygen scavengers, heat sealers).

DryPak Industries, 3940 Laurel Canyon Blvd, Suite 572, Studio City, CA 91604. Tel: (520)270-0884. www.drypak.com (oxygen scavengers).

Edco Supply, 323 36th Street, Brooklyn, NY 11232. Tel: (718) 788-8108. (Barrier films.)

Gaylord Bros. P.O.Box 4901, Syracuse, NY 13221-4901. Tel: (800) 448-6160. www.Gaylord.com (Barrier films, oxygen scavenger.)

Keepsake Systems, Inc. 59 Glenmount Park Road, Toronto, Ontario M4E 2N1. Tel: (416) 691-8854. www.keepsafe.ca (Barrier films, ready made bags, oxygen scavenger, heat sealer).

Talas, 568 Broadway, New York, NY 10012. Tel: (212) 219-0770. www.talasonline.com (Barrier films.)