Is An Encasement Project Right for This Object?

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Introduction

Anoxic/hypoxic encasements for significant* objects are expensive, long-term investments. Whether one is appropriate for a particular project depends on both the preservation risks to an object as well as an institution's resources (conservation and scientific staff, financial support, etc., balanced against the broader preservation needs of the entire collection). This paper discusses issues to consider in evaluating whether to choose an anoxic/hypoxic encasement rather than a high-quality display case that has atmospheric oxygen but which may provide excellent protection at a lower cost with less challenging long-term commitments. Whether anoxia/hypoxia would be beneficial, of little benefit, or even harmful depends on the specific combination of materials in an object, its previous exposure to light, its conservation treatment history, etc. The scientific aspects of these issues are complex, and a thorough examination is beyond the scope of this paper. While some general guidelines are offered, each object is unique. The primary goal of this discussion is to highlight a broader range of issues for decision makers to evaluate when considering an anoxic/hypoxic encasement.

*Significance can refer to iconic objects, importance to the collection, or importance to society, the public trust, or a specific community.

What is the definition of anoxic and hypoxic and their relationship to encasements?

For the purposes of this paper, an anoxic environment is defined as having an oxygen level between zero and 0.5% while a hypoxic environment has an oxygen level between 0.5% and anything less than ambient atmospheric levels (20.9% in air). Depending on sensors and equipment, the difference between anoxic and very low hypoxic may be hard to measure.

Encasements can utilize either passive or active techniques to create an anoxic or hypoxic environment. Passive anoxic preservation tends to rely on sealed encasements to hold a pressurized inert environment, often humidified argon or nitrogen, around the object. The inert gas is flushed through the encasement after installing the object and then the encasement is sealed with a positive pressure to minimize the diffusion of oxygen back into the encasement. Periodic leak testing may be used to ensure that the encasement can maintain the inert environment during the lifetime of the encasement, but sensors can be installed before flushing and sealing to allow the interior humidity, temperature, and oxygen level to be monitored long-term. Active anoxic display requires a constant supply of inert gas, usually nitrogen, to be flushed through the encasement in order to remove oxygen. If the flow of gas is removed, oxygen levels within the case will tend to rise quickly to reach equilibrium with ambient atmospheric levels.

Specific examples:	**Institution**	**Environment**
Declaration of Independence, Constitution, and Bill of Rights (U.S. Founding Documents)	National Archives and Records Administration, permanent display, illumination only during viewing hours	Passive Anoxic (less than 0.5% oxygen) Low light levels
Abel Buell's 1783 map of the United States	Library of Congress, permanent display, motion sensor for illumination	Passive Hypoxic (between 5-6% oxygen) Low light levels
Star Spangled Banner	Smithsonian National Museum of American History, permanent display	Actively Lowered Oxygen (13% oxygen) Low light levels

What are the reasons that some objects have anoxic encasements?

Many -- but not all -- chemical reactions responsible for the deterioration of objects depend on the presence of oxygen. The goal of an anoxic encasement is to reduce the rate of these reactions by limiting the amount of oxygen available. The Getty publication*, Oxygen-Free Museum Cases*, gives a general overview of anoxic preservation research.

The white paper "Trajectory of Anoxic Encasements in Museum Use" lists examples of how this approach has been applied. Some are intended to reduce deterioration of proteinaceous materials while hindering biological degradation during permanent display. Other applications include the preservation of meteorites or protection of objects in particularly challenging environments. However, the majority of research into the potential benefits of low oxygen display or storage has focused on reducing damage to objects from light exposure during long-term or permanent exhibition. Many inks, dyes, and other colorants, including Crystal Violet, Patent Blue, and Rose Bengal, that are prone to light fading have been found to be more stable when exhibited in an anoxic encasement (Casella & Tsukada, 2012; Beltran, et al. 2012). Paper, parchment, and other supports for documents, paintings, etc., may discolor from light damage while also losing mechanical strength. In some cases, an anoxic environment may reduce the risk of this deterioration.

However, there are important exceptions to the benefit of anoxic environments. Some studies have raised concerns regarding the stability of certain colorants in anoxia, including Prussian blue, Antwerp blue, verdigris, orpiment, and Fluorescent Yellow Winsor & Newton Gouache (Beltran, et al. 2014, Beltran, et al. 2021). Anoxia has been reported to be of limited benefit in reducing fading of iron gall inks, and in some cases appears to accelerate the process (Ford, 2014). Therefore, it is possible that anoxia may be beneficial for one component of an object (e.g. the paper substrate or a certain ink) but harmful to another (e.g. a specific ink among many colorants). Objects prone to off-gassing present other issues as the build-up of harmful degradation products within a sealed encasement could influence degradation (Strlic, et al., 2011).

While preservation research is often based on modern materials or study collection samples, these materials may respond differently than historic objects so the use of non-invasive or micro-destructive techniques for analysis has been critical to the study of actual historic objects. This issue is particularly relevant for evaluating the risk of damage from light. Each object is unique not only in terms of its components but also its previous light exposure. For example, an object may contain a dye known to be particularly light sensitive. Unknown display history can affect future light sensitivity. Microfade testing attempts to evaluate these issues by measuring the light sensitivity of the actual historic objects (Beltran, et al., 2021).

As noted above, the complex science of how anoxia may affect deterioration rates is beyond the scope of this paper, which instead provides an overview of technical considerations while emphasizing the unique nature of each object and its previous environmental exposure. In general, anoxic encasements are rarely the best choice for most cultural heritage items. Many simpler and less costly display methods are available that are easier to construct, maintain, and use. Display cases fabricated from conservation grade materials with specified air exchange rates, carefully controlled lighting levels, and well maintained, appropriate environmental conditions may be more beneficial, sustainable, and cost effective.

Beyond the scientific issues, there are a number of other factors to consider in evaluating the use of an anoxic encasement. These are discussed further below.

What object constraints exist that may complicate a sealed encasement?

To answer this question, material composition of the object, including composite materials, as well as overall dimensions should be researched and considered for the specific object. Examples of issues to consider in the decision-making process include:

- What is the expected lifetime of the object?
- What is the exhibit lifetime of the object?
- Is the object an icon that must be on display indefinitely?
- Is the object meant to be viewed from multiple directions?
- Will the object off-gas harmful volatiles?
- What is the previous history of the object (including any previous conservation treatments)?
- How might previous aging or treatment of the object be affected by anoxia?
- Will the encasement atmosphere need to be re-flushed periodically to maintain the internal environment?

Some two-dimensional objects may be appropriate for long-term display and storage in anoxic encasements if oxidative degradation is a main pathway of deterioration. Designing and maintaining anoxic encasements is more challenging for three-dimensional objects or artifacts meant to be viewed from more than one side.

What are your institutional technical capabilities for the lifetime of the encasement?

Even if the preservation needs of an object may support anoxic/hypoxic encasement, the technical capabilities of an institution must be considered prior to deciding if an encasement is an appropriate preservation strategy. Designated staff with specialized technical skills are required to create the anoxic/hypoxic environment and perform long-term monitoring and maintenance. The knowledge retained by these staff will also be necessary for responding to future problems and understanding/interpreting data.

Long-term planning and routine maintenance are required to ensure that staff with the appropriate knowledge remain at the institution or are able to pass on their expertise to replacement staff. Such decisions may require an endowment to ensure continued monitoring and maintenance of the encasement. The object inside the encasement must continue to be monitored properly once encased. Sensors and other parts may need to be replaced to verify the internal environment remains anoxic/hypoxic. Maintaining an inventory of spare parts, especially custom-made parts, is important for the lifetime of the encasement. These parts must be replaced when necessary throughout the project. If spare parts can no longer be found, more research and resources will need to be designated to ensure the encasement continues to function as designed. Building upgrades, including changing wiring (electrical, lighting, Wi-Fi) configurations and exhibit renovations, may also influence the encasement lifetime.

During the planning stage, a decision should be made in consultation with the fabricators about whether the monitoring and maintenance of the encasement will be done in-house or by contract. If the monitoring and maintenance will be done by contract, the institution with the encasement needs to develop a long-term relationship with the company that will be handling the monitoring and maintenance in order to have consistency throughout the encasement lifetime.

Will your encasement ever need to be moved?

An encasement used for permanent visual display/storage will likely not be moved except in unusual circumstances. If the encased object does need to travel between storage and exhibit, displayed in multiple buildings, loaned, or moved during renovations, the plan for moving and storage must consider special issues with anoxic encasements. When encased objects need to be moved, the object must be safely secured, and the encasement must be robust enough to withstand travel. The NIST design team faced these challenges when creating an encasement for the New York Public Library:

> Plans call for this copy to be displayed in various cities on a rotating basis. That raises unprecedented issues for the designer and fabricator, because the encasement will have to maintain its integrity during periodic travel to different locations, and do so under highly variable weather conditions. https://www.nist.gov/news-events/news/2013/07/making-case-history

A pressure differential between land and air travel (if air transport is required) may make it difficult or impractical to use a sealed encasement if the encasement is only for temporary loan or display. Specialized equipment may need to be obtained or designed to help move the encasement from place to place. If an encasement is not meant for permanent display, considerations must be made in storage for the added weight and size of the encasement, as it may not be able to be placed on regular shelving units. Even for an encasement that is expected to remain in one place, the institution must consider how to transfer it to the display area after fabrication, loading, and sealing, and if the encasement will need to be moved during monitoring and maintenance. These concerns need to be addressed in the early planning phases.

Before moving an encasement, the route should be planned and then checked to ensure that no other work has been initiated that may complicate the planned route. Considerations of the angles of motion must be addressed, including whether the encasement can be oriented horizontally or vertically during transport, even if the display angle will be different. Egress through elevators and doorways with encasements, either within or without shipping containers, should be considered. Floor load capacity, especially in historic structures, must also be considered when deciding to move an encasement.

How will an encasement fit into risk management and emergency preparedness plans?

An encasement may need to be moved during an emergency. Having a detailed emergency plan is necessary to efficiently and safely move an encasement. Knowing how many people are required to safely move and secure the encasement during an emergency situation, understanding the built-in safety measures of the encasement, and having a planned evacuation location with multiple exit routes is essential to the emergency plan. Staff familiar with the encasement, specialized equipment, and the emergency plan should be involved if possible. Staff safety should be the first priority. During emergency access, the correct angle and orientation of the encasement may not be able to be maintained, so risk of potential damage to the object must be considered. Sometimes, even in an emergency, it may be safer to leave the encasement where it is rather than try to move it.

A passive encasement, especially a large encasement, is most at risk of differential pressure breakage during an extreme weather event when staff may not be able to access the encasement safely. If staff can access the encasement in such an event, an informed decision may be required to determine if it is necessary to release pressure using built-in safety features and allow air to enter the encasement, rather than risk the glass breaking and possibly damaging the object. Preserving the object as well as the mechanical integrity and protective stability of the encasement is often more important in this situation than the risk of the object being temporarily exposed to higher levels of oxygen. The encasement can be refilled with an inert environment after the danger has passed.

An active encasement may face more direct concerns during an emergency event. Loss of the active control during power outages will affect the internal environment and positive pressure. The case will require management after the event to restore the proper environment and function of the active control. This process should be included in the emergency plan.

What determines if an anoxic/hypoxic encasement is right for this project?

Anoxic/hypoxic encasements are a significant undertaking of personnel, resources, and costs, which continue long after the initial installation of the encasement. They should be carefully considered, focusing on the specific materiality of the object planned for encasement. Composite objects may have complicated off-gassing or other issues that should be carefully considered when determining the type of display. However, in the right set of circumstances, particularly those related to permanent exhibition, anoxic/hypoxic displays can provide unique preservation benefits.

Synopsis of the Benefits of Good Displays with Additional Considerations for Anoxic Encasements (Table 1)

Benefits of Good Displays & Encasements	**Additional Considerations for Anoxic Encasements**
Long-term preservation technique for highly significant holdings	Requires technical knowledge and succession planning as well as specialized equipment that must be maintained and replaced due to breakage or obsolescence
Allows long-term exhibit of objects that may otherwise be difficult to display without a protective microclimate	Restricts physical access to object - examples: future research requests like DNA analysis; new imaging and scanning techniques and opportunities
Provides physical protection from accidental touch, vandalism, theft	Provides protection from oxidative degradation for certain objects
Provides control of humidity and temperature within a smaller space than the entire room setting	Expensive to create and to open/reseal
Provides protection from outside pollutants	Transport and moving considerations, examples: vibrations/movement causing shifting or pressure changes during flying
Hinders biological deterioration by minimizing the introduction of biological agents, including mold, fungi, insects, etc.	Creates difficulty in emergency situations, including pressure changes during extreme weather, or evacuation concerns

If an anoxic/hypoxic encasement is appropriate for the preservation and display of the specific object, please see our third white paper, A GENERAL OUTLINE FOR AN ENCASEMENT PROJECT, which discusses considerations for planning and caring for encasements.

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