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Reversible Filler: A Fresh Look At Butvar-76

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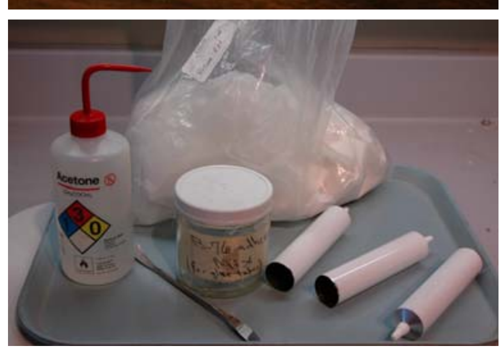
ABSTRACT

B-76 (polyvinyl butyral) has long been used in fossil preparation as an adhesive. By changing the ratio of solvent to solution and using a variety of new techniques, B-76 can be used to create filler that is both reversible and archival and therefore preferable to other more traditional fillers. Due to its several desirable properties, it is ideal for making specimens ready for museum display without detracting from their research value. B-76 filler can be reversed with very little trouble which makes it a better candidate for museum prep than more commonly used fillers which are permanent. Serious damage occurs if permanent fillers must be removed, a process which often involves grinding tools. B-76 filler can be dissolved with the application of acetone. The process can be accelerated by removing the bulk of the filler with cutting tools. B-76 filler is very strong but can easily be removed with a razor, and the remnants can then be dissolved away and cleaned off. B-76 in its purest form is translucent. From a researcher's standpoint this can be desirable as traditional fillers obscure the actual fossil and make it unclear what is real and what is replicated. Yet it still holds the various elements together in a pleasing way suitable for display. If the first priority for the specimen is display and the Preparator so desires, various coloring substances can be mixed into the filler while it is being made. B-76 can also be used to coat the breaks/contacts and then traditional filler can be used to fabricate the missing elements with the B-76 acting as a buffer that can later be removed. B-76 filler is incredibly strong. Even when stretched into thin sheets its performance when stressed is remarkable. Unlike other fillers it is not brittle, it holds a rigid form but should not crack under extreme stress. In fact it should bend somewhat before any tearing occurs. In this way it could be compared to metal where other fillers are more like cement. Due to this strength it can be used to rebuild extremely thin or delicate structures, such as palates more accurately.

CHEMICAL COMPOSITION

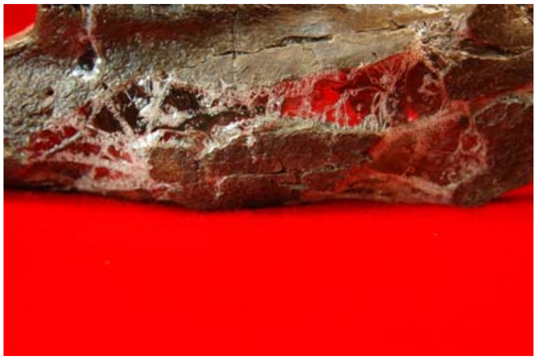
The chemical composition of the B-76 adhesive commonly used in paleontology labs is a simple one to one ratio mix of polyvinyl butyral 76 powder and acetone (Sease, 1997). After the two chemicals are combined a daily stirring is needed during a period of approximately one week. The final product should have a viscosity similar to honey. To create B-76 filler we used a slightly different ratio. Specifically, we mixed 55% B-76 powder to 45% acetone. This mixture had the desired thicker, faster curing properties needed for the application as filler. It is also possible to achieve filler by allowing some evaporation of acetone to occur in the standard adhesive mixture, while monitoring viscosity (Wenz, 1996). The final filler product should have a consistency noticeably thicker than the adhesive yet still workable from a tube. It will also form a skin fairly quickly when extruded from a tube, allowing the preparator to attach a bead and pull a strand much like a spider spins thread.



PROCEDURE

The series of three photographs at right are meant to better illustrate the processes the authors will be discussing in the following sections of this poster. This specimen is a jaw that required extensive filler work in order to make it a complete specimen, as opposed to several large, unattached sections that could not be measured for research. For example, the large section at the bottom of the jaw does have a true contact with the symphysis to the left. However, this contact was approximately 1 centimeter wide and therefore was insufficient on its own to be stable enough to support the remaining section of jaw.

First, the pieces were evaluated for overall stability. The specimen was placed symphysis down in a large sandbox and the single true contact was glued. This orientation minimized stress on the weak joint. Further, a temporary splint (toothpick) was glued into place to stabilize the section during the filler process.



Once this glue joint had cured, proper attachment points were chosen to create the correct shaping, maximizing the stability of the section. To create the primary threads, the glue tube was placed in contact with an attachment point and squeezed slightly. After a few seconds the glue between the tube and the attachment point became tacky, at which point the tube was slowly moved towards attachment point B on the opposite side of the void. As the tube moved, the initial bead remained attached to the nozzle and began to pull into a thread. *Note: It is important to consider the thickness and length of the thread required during this process and to adjust the amount of pressure applied to the tube accordingly. If the gap is small, the initial glue bead can simply be applied to the first contact and stretched to the second contact without squeezing the tube for additional glue. For larger gaps, some pressure should be applied to the tube while stretching, allowing additional glue to be added to the strand while being formed. This prevents the thread from becoming too thin or snapping.* This process is repeated for several pairs of attachment points to create the initial framework of primary threads referred to as the spider web. This structure is illustrated to the right in light blue.

Next, the secondary thread was applied. This thread is one continuous thread which links all the primary threads and essentially divides the cells in half, reducing the size of sheeting needed. It also provides strength by linking all the primary threads into one network. This thread was created by affixing a bead of glue to one of the outer primary threads and stretching it to a neighboring primary thread, which it is touched against. Each time the secondary thread intersects with a primary thread, a small amount of additional glue is added to the thread to prevent it from becoming too thin. The secondary thread is illustrated in purple.

The cells (illustrated in green) are the voids between threads. These can finally be filled with sheets of B-76 filler. Starting at the apex of the triangular cell, a bead is applied and stretched in a zigzag pattern (this motion is illustrated in red) from one primary thread to the other, which stretches the bead of B-76 filler into a sheet instead of a thread. This sheet should cover all secondary threads present, which helps stabilize the sheet. Each cell should be filled in one step without removing the tube before continuing to another cell. *Note: It is important to always start at the narrowest part of a cell to ensure a proper sheet. Two problems may occur if the sheet is started at the base of the triangular cell. 1. The sheet may become overstretched too quickly and popped like a bubble. 2. As you pull the glue into an increasingly narrow section, it begins to build up and become too thick, collapsing under its own weight.*

This sheeting process produces a thin fill that is transparent enough to allow one to look at the inside structure, light weight, and strong enough to stabilize the specimen, allowing handling. Because it is clear in appearance, it is easy for a researcher to distinguish the original bone from the filler. This filler can readily be dissolved with acetone. Also, though it is very resistant to tearing and breakage, it is easily cut with a razor and can be manually removed. *Note: Though the windows are clear, some bubbling will occur where sheets intersect with threads, giving the filler a white appearance in these areas. Some preparators might have objections with this concerning aesthetics, but this aspect of B-76 filler is acceptable when considering its numerous positive qualities when compared to available alternatives.*

Cob webbing was not used on this specimen due to its light weight and small size, but is recommended for larger projects. Cob webbing is an internal structure that mimics the missing cancellous bone in both appearance and function. This structure can be covered over using the above methods.

FINAL PRODUCT

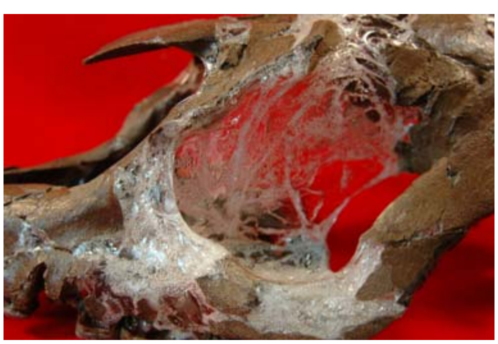
ETMNH 3719 (SKULL)
This specimen is a nearly complete tapir skull weighing approximately 18.65 oz. Due to weathering, the left zygomatic arch and brain case were missing. Otherwise, this skull was almost complete with excellent preservation. Filler was used for minor cosmetic work to replace the very thin bone behind the orbit and any missing fragments, as seen in the picture. This helped stabilize the skull and made it more aesthetically pleasing.

ETMNH 3719 (SKULL)
This photograph shows a dorsal view of the left maxilla. The thin bone above the teeth has been weathered away. This was left open to provide access to the teeth roots for research and to show an example of the effects of weathering. In the future we may opt to return to this specimen and insert a window fill to prevent the thin ragged edge from crumbling over time. We may also choose to reconstruct the braincase and missing zygomatic arch.

ETMNH 3719 (SKULL)
This photograph shows the dorsal view of the right maxilla. This area was also weathered and any remaining fragments were approximately one millimeter thick. This side of the skull was reconstructed by first creating a spider web with the B-76 filler, then fragments were placed on top of the web in their approximate positions. All open spaces were sheeted over with the filler.

ETMNH 3719 (JAW) "HYBRID TECHNIQUE"
This photograph shows the jaw of the specimen in the above pictures. This represents the first test of what we call the "hybrid technique." It is important to note that the back of the jaw is very thin (one millimeter thick in some places). Because we wanted to reconstruct the coronoid process and test the adhesive properties of B-76 filler to traditional fillers, a two part non-reversible filler was used to recreate missing sections of the jaw. B-76 filler was applied to the contact areas all around the broken edges and allowed to cure. Non-reversible filler was then used to span the gap between these contacts. The B-76 filler served as a buffer and can be dissolved with acetone to remove the traditional filler. This method is ideal for preparators wishing to have a more aesthetically pleasing color match between filler and bone. It will also allow filler work on larger specimens where cold sag rules out B-76 alone.

ETMNH 683 (SKULL)
The specimen in the photograph to the right is an adult tapir skull, which is approximately 50% complete. Since several of the key characters were preserved and definite contact points were present (although small and unstable), it was determined that this specimen would be reassembled 3-Dimensionally. Traditionally, this specimen would have remained in pieces due to the weakness of the contact points. The B-76 filler allowed us to reconstruct it to a nearly complete skull. After reconstruction, its overall weight is approximately 17.8 oz. ETMNH 3719 to the left was used as a reconstruction for this specimen.



ETMNH 683 (SKULL)
This photograph shows the left lateral view of the same specimen. Spider webbing was used to create a framework to replace the missing thin bone behind the orbit. Sheeting was used to fill in the cells of the spider web. This finished structure is an average of one millimeter thick but is structurally sound enough to hold both the anterior and posterior sections of the skull together.
Spider webbing was also used to make a similar geometric framework for the missing lacrimal and zygomatic arch. Sheeting was

used to cover most of the cells. Filler was extruded through the open cells to completely fill the framework, making these solid pieces. This infilling temporarily softened the framework on the inside, while leaving a non-tacky skin on the outside. This allowed the structure to be manipulated into a more correct organic shape.

ETMNH 683 (SKULL)
This photograph shows and example of a more advanced technique on the same side of this specimen. First, foam blocks were used to hold sections at the correct height relative to each other. Spider webbing was then used to create the framework for the missing segments. Due to the complex structure of this area with its many curvatures, special attention was given to proper placement of the primary threads to achieve the desired shape. This also required that the overall framework be done in more than one stage and that the threads were physically manipulated while still pliable to achieve curvature. Once the entire framework was in place, sheeting was used to cover all cells. *Note: More complex shapes require more threads per area with smaller cells to ensure that the sheeting mimics the missing bone correctly.*

ETMNH 683 (SKULL)
This photograph shows the ventral view of the same specimen and showcases the finished structures. Notice the minimalism of the finished structures and their transparency. All of this work may seem delicate, but when cured is more than capable of holding together the skull. This technique effectively gives a preparator access to considerable strength while keeping the total weight of the specimen at a minimum.

MAJOR RECONSTRUCTION
ETMNH 687 is a partial skull and jaw of a tapir. These remains were extremely fragmentary and consisted mostly of teeth and a few fragments of bone. This specimen was used to test the strength of B-76 filler and its performance when replicating sections that are completely missing as opposed to just filling in holes. Gluing the teeth together gave the length of the jaw. Next, a temporary framework of toothpicks was glued into place to hold what few sections of jaw were present and to make sure their alignment was correct. Spider webbing was then applied, followed by cob webbing for internal strength. Cob webbing is similar to cancellous bone in appearance and function. Then the entire structure was sealed with sheeting.



USES TO DATE

As of the date of this publication, application of this technique has only been applied to specimens from the Gray Fossil Site. Discovered in May 2000, this site represents a Late Miocene-Early Pliocene (cf. Hemphillian) deposit. The matrix found at the Gray Fossil Site is primarily a soft, wet clay with a high concentration of organic material, which give the fossils a dark, chocolate brown appearance. The fossils have little mineralization and are for the most part original bone. Specimens are often found crushed flat into numerous shards with much of the material weathered beyond repair (Parmalee, Klippel, Meylan & Holman, 2002). This often leaves well preserved pieces or sections of bone with few if any connection points to adjacent sections. Therefore, filler is needed to bridge the gaps and stabilize the overall structure of the specimen.

The initial testing of this filler was conducted on a fossil red panda skull (ETNMH 3596). Though it was crushed flat, the fact that this specimen represented the only nearly complete fossil red panda skull in the world, the desire to reconstruct it 3-Dimensionally was justified. By using the B-76 filler, the reconstruction was successful.

Next, extensive use was applied to numerous tapir specimens from the site, such as the examples shown here. Due to the high quantity of tapirs at the Gray Fossil Site, they represent excellent candidates for filler testing and usage, with several complete specimens to serve as guides. Gaps up to 8 cm were spanned using this technique.

The heaviest specimen used was a tapir skull weighing 18.65 oz.

It is highly probable that even larger gaps can be spanned using the B-76 filler. The filler may also be suitable for projects with heavier weights. A current project underway at the ETSU Natural History Museum is an adult male *Teleoceras* cf. *T. hicksi* (ETMNH 601). This specimen is a jaw, which will be approximately 50 cm long and weigh several pounds when complete. So far, filler has been used successfully.

The upward limitations of B-76 filler are not yet known, but will likely depend on the applied structure of the filler, similar to an engineer altering an established design for a larger structure. The B-76 filler can be applied in different ways to yield stronger results. It may not be suitable for large, heavily mineralized fossils, such as dinosaur bones. However, use of a hybrid filler technique should create stronger fillers and serve well for even larger specimens. Hybrid filler has already proven successful for fossil tapir reconstruction from the Gray Fossil Site.

TERMS

Attachment Point - When using reversible filler it is important to pick the right points of attachment for the primary threads. Projections of bone that stick out furthest in the void to be filled make the most suitable attachment points. When working with a curved surface, attachment point A should correspond directly with attachment point B. If one is at the apex of the curve and the other is not, then the sheet will not have the same curvature as the original bone.

Bead - The initial glue contact with the attachment point. It is allowed to form a skin before being pulled into a thread or sheet.

Cell - The void between threads. It is filled by the sheet.

Cob Web - An internal framework of threads with a similar appearance and function as cancellous bone.

Pick and Pull - After allowing a large bead to form a skin, a sharp instrument is used to puncture the skin and pull the tacky glue into a thread or sheet.
Primary Thread - A simple thread from one attachment point to a corresponding attachment point on the other side of the void.
Secondary Thread - Usually a continuous, thin thread that spans between all of the primary threads.
Sheeting - Thin sheets of clear B-76 filler formed between primary threads and resting on the secondary threads.
Spider Web - The network of primary and secondary threads.
Window - Extremely thin and transparent sheets used for cosmetic work and small projects.

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