A REPORT ON A MINI-SEMINAR ON ADHESIVES FOR FOSSIL PREPARATION

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Abstract

The Fossil Preparation and Collections Symposium held at Petrified Forest National Park, Arizona on April 10-12, 2008 afforded an opportunity to develop and test a "Mini-Seminar on Adhesives for Fossil Preparation." This report describes the evolution from a short talk to the Mini-Seminar format and then a later day-long workshop. 16 preparators responded to a pre-symposium quiz designed to tailor the Mini-Seminar. Two main "take-home" points were focused on: 1) the importance of knowing the difference between solution and reaction adhesives. 2) the importance of using accurate names for adhesives. The goal of the Mini-Seminar was to communicate these in a reasonable amount of time. Limiting the subject matter and length of the Mini-Seminar proved to be a challenge. Basic points were conveyed but the amount of information that could be absorbed and retained by the participants from this verbal format was limited. The need for hard-copy reference materials tailored for fossil preparation is discussed. Appendices include quiz questions and responses, a list of Mini-Seminar reference materials and a description of the subsequent one-day workshop.

Davidson, A. 2009. A mini-seminar on adhesives for fossil preparation. In: Methods In Fossil Preparation: Proceedings of the First Annual Fossil Preparation and Collections Symposium, pp 111-122. Brown, M.A., Kane, J.F., and Parker, W.G. Eds.

Introduction

Vertebrate Paleontology, more than any other biological science, depends on adhesives. While much information is available about adhesives, very little is tailored specifically to vertebrate fossil preparation. The resources available to conservators through the literature, courses and workshops include much that is not directly relevant to fossil preparation and at the same time tend to skim over important basic details that are assumed to be already understood.

Over the last 13 years I have worked individually and in collaboration with conservators at the American Museum of Natural History to develop an informed approach to adhesives for fossil preparation. This has resulted in a number of 15 minute talks and also posters presented at the annual meetings of the Society of Vertebrate Paleontology (hereafter SVP) (Davidson 2002, 2003, 2004, 2006; Kronthal, 2005, Levinson 1996a and 1996b), the Society for the Preservation of Natural History Collections, the American Institute for the Conservation of Historic and Artistic Works (Bisulca 2008, Davidson 2003) and other venues. Talks at the SVP 2003 and 2004 meetings in particular were intended to be a three part series on adhesives as liquids, through phase change and as solids.

While the 2003 SVP talk did not engender much interest, the 2004 talk was well received, with multiple requests for copies and repeated presentations. The Fossil Preparation and Collections Symposium held at Petrified Forest National Park, Arizona (hereafter PEFO), on April 10-12, 2008, afforded an opportunity to expand this into a one-hour "Mini-Seminar on Adhesives for Fossil Preparation." In the end this ran overtime, to 90 minutes, a problem discussed later. Subsequent to the PEFO Symposium, a presentation at the Royal Tyrrell Museum, Canada, provided an opportunity to expand it further into a one-day format. In the following the evolution of the presentation is described.

Expanding a 15 minute presentation

The 2004 talk was entitled "From Liquid to Solid and Back: Phase Change in Adhesives." It compared solution adhesives (e.g. Butvar B76 and Paraloid (Acryloid) B72), which set by the evaporation of a solvent, with reaction adhesives (i.e., epoxies and cyanoacrylates) which set by chemical reaction. This talk used hand-drawn illustrations of behavior on a molecular level (basic chemistry) to explain the following:

1) Why solution adhesives are weaker, soluble and easier to remove.
2) Why reaction adhesives have great adhesive and cohesive strength, are insoluble and are more difficult to remove.
3) Why, when employed as consolidants, solution adhesives tend to set near the surface whereas reaction adhesive have a greater ability to penetrate and set deeper.

In addition it used specific examples of porous, weak fossils from the Gobi Desert (Cretaceous) and hard, dense fossils from Greenland (Triassic) to illustrate the importance of choosing between solution and reaction adhesives.

The greatest challenge in expanding this talk was limiting the scope of the subject matter. The most frequently asked question in fossil preparation is "what glue should I use on this specimen?" The answer is "it depends." All adhesives have appropriate and inappropriate uses in fossil preparation but the assessment of individual specimens and specific applications is a topic too complex to be addressed in one hour.

It is my opinion that making educated choices between solution and reaction adhesives and also using accurate names are fundamental first steps in selecting the right adhesive for the job at hand. Therefore, a choice was made to focus the Mini-Seminar on two "take-home" points:

1) the importance of knowing the difference between solution and reaction adhesives.
2) the importance of using accurate names for adhesives.

The goal of the Mini-Seminar was to communicate this effectively and the greatest obstacle to achieving this goal was the difficulty of "sticking to the point" (and avoiding glue jokes!).

Pre-Symposium Reference Materials— Some reference materials were provided in advance of the Symposium (Appendix 1). This included a recommendation to purchase the excellent self-teaching series "Science for Conservators" which was the primary source of information for the 15 minute Powerpoint© presentation.

A Pre- Symposium Quiz— A request for a voluntary response to a short quiz (Appendix 2) was sent to participants in advance of the PEFO Symposium. The request was later posted on the PREPLIST preparators' e-mail discussion list to include non-participants. This quiz was designed to:

1) find out what adhesives the participants are using.
2) identify any particular confusion about setting mechanisms.
3) coach the respondents to use accurate names.

Sixteen preparators responded to the quiz. A compilation of their adhesives is shown in Appendix 3.

Of the 16 preparators, 12 use both solution and reaction adhesives, two use only solution adhesives, and two use only reaction adhesives.

Regarding setting mechanisms, most of the questions were answered correctly but there was significant confusion about how cyanoacrylates (CAs) set, and some confusion about other adhesives in the following responses:

CAs do not set by the evaporation of a solvent or by chemical reaction. They set by exposure to water molecules in the air, according to one response.

CAs bond by chemical reaction but not sure of the mechanism - one response.

CAs bond by a combination of chemical reaction and solvent evaporation - one response.

CAs set by the evaporation of a solvent - two responses.

CAs air dry on their own (set by the evaporation of a solvent), but when an accelerator is used it sets by chemical reaction - two responses.

Epoxies bond by solvent evaporation - one response.

Not sure how Elmer's Glue© sets - evaporation of water? - two responses.

Durham's Rock-Hard Water Putty© sets by the evaporation of a solvent - one response.

Duco© cement may set by chemical reaction and solvent evaporation - one response.

Regarding names, it is obvious from the responses compiled in Appendix 3 that, while most of the adhesives are accurately identified, quite a few answers are vague and confusing despite the coaching in the quiz instructions. This confirmed my view that these respondents would have difficulty discussing the adhesives they and others are using.

In retrospect, it would have been better to include instructions to identify each adhesive by chemical family in addition to the commercial brand names, etc., since chemical family names are very useful for accurately identifying adhesives, especially in combination with the commercial name and grade (e.g. PVAC Vinac B15).

The 90 minute PEFO adhesives mini-seminar

The Mini-Seminar was attended by 42 people, half of them professional fossil preparators and half highly motivated volunteers. It was organized into four parts:

Part one: Powerpoint presentation - "Liquid to Solid and Back: Phase Change in Adhesives "(as previously described).

Part two: Questions for the Participants.

a) Naming Adhesives. The group was asked to make a collective list of what adhesives they use and taught to use complete and accurate names to identify products. The problems of confusing industrial grading systems (e.g. the various "B" grades), shifting manufacturers and changes in formulas were discussed using Powerpoint diagrams.
b) Classifying Adhesives by How They Set. The group was asked to classify the adhesives on the collective list as either solution or reaction adhesives. Powerpoint diagrams were used to explain polymerization and how cyanoacrylates and epoxies set.
c) A Long Group Quiz. The group was asked to respond to a list of questions about adhesives terminology, setting mechanisms, working properties and aging (physical and chemical changes over time) (see Appendix 4). About an hour had elapsed at this point which was too long without a break for many participants.

Part three: A Group Discussion of Adhesive Choice and Paraloid (Acryloid) B72. There was not enough time to cover the topic of adhesive choice adequately, but the intention of this section was twofold:

a) briefly touch on the many factors taken into consideration when choosing an adhesive, using a Powerpoint diagram.
b) discuss particularly the advantages of Paraloid (Acryloid) B72, especially its long-term stability. Paraloid (Acryloid) B72 was recommended as a "default" adhesive (i.e. if it can do the job, use it), which should be in stock in every lab and available for experimentation, along with acetone, ethanol and self-loading

tubes for applying thick solutions ("Koob Tubes" as described in Koob, 1986). A broken flowerpot was used to demonstrate the rapid bonding possible with thick Paraloid (Acryloid) B72 in acetone. This was an effective demonstration and breaking a flowerpot could be used to spark renewed interest for those with lagging attention.

Part four: Case Studies. A series of slides was shown of examples of adhesive failures. This required lowering the lights again and was the least effective part of the Mini-Seminar which was approaching 90 minutes at this stage. In retrospect this should have been cut out and the time limited to one hour, beyond which it is difficult to speak and for the participants to listen.

A subsequent one day adhesives workshop

The Mini-Seminar was effective at least in part, because directly afterwards I was invited by two participants, Jim McCabe, Senior Technician, and Brandon Strilisky, Acting Head, Collections Management Program, to teach a workshop on adhesives at the Royal Tyrrell Museum, Drumheller, Canada. In subsequent conversations it was decided that, in addition to repeating what was covered in the PEFO Mini-Seminar, the workshop should include archival marking (since labels depend on adhesion to the specimen) and archival housings (since these are an important alternative to gluing specimens back together). A day-long workshop entitled "Materials for Fossil Preparation (Adhesives, Archival Marking and Archival Housings)" was held on May 21, 2008, at the Royal Tyrrell Museum. Approximately 20 people participated, mostly professional fossil preparators and paleontological collections workers. The schedule is outlined in Appendix 5.

Conclusion

As previously stated, the goal of the Mini-Seminar was to communicate the important differences between solution and reaction adhesives effectively and also the need to use accurate names. I believe this goal was achieved although much could be streamlined and improved, especially in regard to amount of time necessary.

Participants seemed reluctant to criticize directly and an anonymous follow-up questionnaire would have been useful. It is my assessment that the participants "got" the take-home points enough to seek out additional information when needed. Months after the Mini-Seminar an exchange with one of the participants regarding a suspected mistaken purchase of Butvar B72 instead of Paraloid (Acryloid) B72 supports this assessment. The Mini-Seminar did not communicate the specific information necessary to answer the participant's question, but it did raise their awareness of problems stemming from inaccurate names.

The strong point of the Mini-Seminar was probably the 15 minute Powerpoint presentation, especially the hand-drawn illustrations, which received numerous favorable comments. In retrospect the following important topics should have been moved from Part 2b and incorporated into the Powerpoint:

a) polymerization.
b) a detailed description of the setting mechanisms of cyanoacrylates and emulsions (e.g. Elmer's Glue).
c) an explanation of undesirable crosslinking in solution adhesives over time.

Regarding time, in retrospect it is clear that expanding a quarter-hour talk to one hour is not the same as presenting four consecutive fifteen minute talks. There is a limit to what the participants can absorb and pushing that yields diminishing returns. Part three should have been abbreviated and part four should have been omitted. The group quiz (Part 2b) was too long and repetitive. One person suggested it be cut by one third. Perhaps some of the questions could be incorporated into other parts of the presentation.

One person commented that the results of the Pre-Symposium Quiz should be shared with the group, and several expressed particular interest in knowing what other people are using.

Two people said they would have preferred to be presented with a case study to discuss and then decide which adhesive to use. The idea of case studies is attractive but I believe they would be more useful for advanced audiences well schooled in adhesives. It is hard to have a useful discussion if the participants are not speaking the same language.

One person wanted a wall chart of useful adhesive properties (specifically not including glass transition temperature) as a quick reference for selecting an adhesive. I have often heard similar comments from frustrated preparators who just want

to know what adhesive they should use. Selecting the right adhesive is not straightforward. It depends in part on an ability to evaluate the specimen and the job at hand. Using an adhesive successfully also depends on the skill of the preparator, something that requires a feel for materials that some people have and some do not, despite years of experience. This might be something that cannot be taught.

An understanding of adhesives can however be taught. Two participants wanted hard- copy handouts of the following Powerpoint diagrams used during the presentations:

Diagram 1. Summary of solution and reaction adhesive properties from liquid to solid.

Diagram 2. List of the many grades sold within four adhesive product lines.

Diagram 3. Outline of many factors which must be considered when selecting an adhesive: properties as a liquid, through phase change and as a solid over time, the job at hand and other practical considerations.

Hard-copy reference material would greatly improve the effectiveness of any presentation on adhesives. Ideally a workshop or course on adhesives for fossil preparation would be based on a reference text or a series of reference papers which cover the material in detail. With this in hand, the verbal, visual and interactive format of a speaker in front of a group could serve as a vivid introduction and the texts as the ultimate source of information.

It is my hope that this report will serve to aid and encourage anyone charged with teaching adhesives for fossil preparation.

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Appendix 1
Reference materials sent to participants in advance of the Mini-Seminar.

1) A PDF of "Adhesives and Adhesion" by Jonathan Thornton, professor of Objects Conservation at Buffalo State. Professor Thornton was on the advisory group of an American Institute for the Conservation of Historic and Artistic Works "Adhesives for Conservation" workshop held in September 2005 in Nebraska. As a participant I received his paper in advance of the workshop. It is written for conservators, with an emphasis on adhesives for use on wood. Fossil preparators use relatively few of the adhesives listed but this paper provides a good general overview on the use and classification of adhesives and could also be useful in identifying old adhesives used on fossils in the past.

2) A link to SPNHC Leaflet #2, Spring 1997
Adhesives and Consolidants in Geological and Paleontological Applications
Part One: Introduction, Guide, Health and Safety, Definitions
Part Two: Wall chart
This is available from the website for the Society for the Preservation of
Natural History Collections (SPNHC)
<http://www.spnhc.org/?q=publications/leaflets.html>

3) A recommendation to purchase all three volumes of Science for Conservators
Conservation Science Teaching Series, The Conservation Unit
Vol.1. Introduction to Materials
Vol.2. Cleaning
Vol.3. Adhesives and Coatings

These three volumes are an invaluable resource for the conservator and fossil preparator who want to teach themselves basic materials science. The books are clearly and simply written and must be read slowly in sequence from volume 1 to 3. Do not be fooled by the titles. Vol. 2 (Cleaning) includes important concepts such as solubility and Vol. 3 (Adhesives and Coatings) is of little use without the first two.

Appendix 2
A Short Quiz on Adhesives for Fossil Preparation sent to participants in advance of the Mini-Seminar.

What adhesives do you use on fossils in your lab and how do they set (solidify)?

Note: the term "adhesive" is used here to include all "glues", "sealants", "hardeners", "stabilizers", "fillers", and "consolidants".

List each one by name and be as specific as possible, using the commercial brand name and including any commercial grades, types, numbers or formulations in the name. Also include all components of any mixtures you have made.

You may choose from one of the following to explain how they set:

a) a chemical reaction.
b) the evaporation of a solvent.
c) other (explain).

For example:
Butvar B76 in acetone sets by the evaporation of a solvent
Devcon 2 Ton epoxy sets by a chemical reaction

Appendix 3

Adhesives Used on Fossils as Reported by 16 Preparators in Response to a Short Quiz (Appendix 2).

Solution Adhesives:

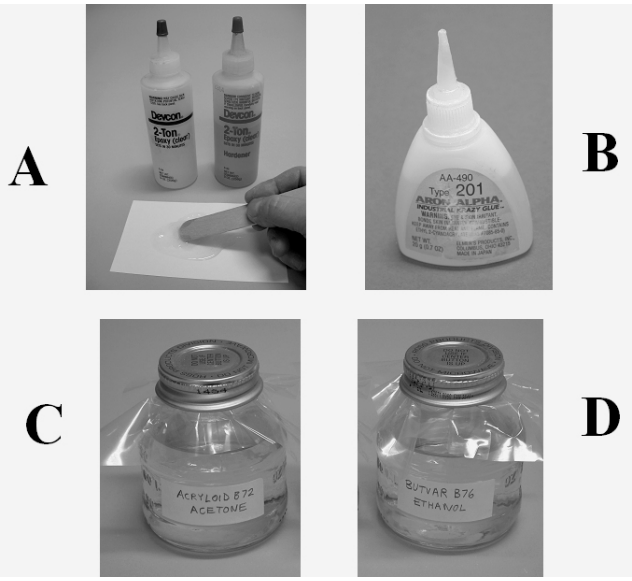
Adhesive	Report	Adhesive	Report	Adhesive	Report
Butvar B76	7	B67 (trade name unknown)	1	UHU All-Purpose Adhesive	1
B76 (trade name unknown)	2	Vinac B15	1	Elmer's Glue or School Glue	2
Butvar B98	1	Vinac B-25	1	Elmer's Wood Glue	1
B98 (trade name unknown)	1	Vinac (grade unknown)	2	White Glue (trade name unknown)	1
Butvar (grade unknown)	1	Poly n-butyl methacrylate	1	Archival Herbarium Glue (trade name unknown)	1
Paraloid (Acryloid) B72	5	Duco Cement	1	Sahara Brand Acrylic Masonry Sealer	1
B72 (trade name unknown)	1	Krylon Workable Matte Fixative	1	Acryl 60 (liquid admixture for cement)	1

Reaction Adhesives

Adhesive	Report	Adhesive	Report	Adhesive	Report	Adhesive	Report
Devcon 2 Ton Epoxy	5	Magic Sculpt Epoxy Putty	1	Paleobond 750	1	Super Glues (unknown trade names or grades)	1
Devcon 5 minute Epoxy	3	All Game Epoxy Putty	1	Paleobond 4540	1	Cyanoacrylate Glue (unknown trade names or grades)	1
West System Inc. Epoxy 105-B resin with 205-B hardener	1	Epoxy Paste (taxidermist putty) (unknown trade name)	1	Paleobond (thick gel) (grade?)	2	Zap Pink (grade?)	1
G5 Five Minute Epoxy	1	Wood Putty (unknown trade name)	1	Paleobond Cyanoacrylate (unknown grades)	4	Zap Green (grade?)	1
Epoxy 330 (trade name?)	1	Paleobond Penetrant/ Stabilizer	4	Starbrand Cyanoacrylate EM-02	1	Durham's Rock Hard Water Putty	2
Lamination Epoxy 110 (trade name?)	1	Paleobond 40	3	Starbrand Cyanoacrylate EM-2000	1	Hydrocal Plaster	1
Epoxy Resins (slow cure) (unknown trade names or grades)	1	Paleobond 100	3	3M Scotchweld Cyanoacrylate CA40	1	Gypsum cement	1
Keypoxy Putty 2 part EA1161 Resin and Hardener	1	Paleobond Paleosculpt	1	3M Scotchweld Cyanoacrylate CA8	1		

Appendix 4

A Long Quiz on Terminology, Setting Mechanisms, Working Properties and Aging.



A photograph of the following adhesives in their labeled jars/dispensers is shown:

A) Devcon 2-ton epoxy
B) Aron Alpha 201 cyanoacrylate (low viscosity)
C) Paraloid (Acryloid) B72 in acetone
D) Butvar B76 in ethanol

Terminology

1. C has two trade names- Acryloid /Paraloid. Explain why. Is it necessary to use both names?

2. C and D both have a "B" number after their trade name. Does this mean they are similar chemically? Why is it important to use both the trade name and the "B" number? Explain.

3. Which ones can be referred to as "glue"

4. Which ones can be referred to as solution adhesives?

5. Which ones can be referred to as reaction adhesives?

6. Which ones can be referred to in solid form as a polymer?

7. Which ones are solvent release polymers?

8. Which ones have a solvent carrier?

9. Which ones can be referred to in solid form as a resin?

10. Which one, in solid form, is a synthetic resin?

11. Which one, in solid form, is an organic resin?

Setting Mechanisms

12. Which ones are polymers in their solid state after they set?

13. Which ones contain polymers in their liquid state?

14. Are there any monomers in this picture?

15. Which ones set by crosslinking?

16. C and D each have two components. List them.

17. Could you switch solvents and make C with ethanol and D with acetone instead?

18. Which one will set faster- C or D and why?

19. Which ones shrink the most upon setting and why?

20. Which ones shrink the least upon setting?

Working Properties

21. Which ones could be used as an adhesive to join pieces together if appropriate?

22. Which ones could be used as a consolident if appropriate?

23. Which ones could be used as a coating if appropriate?

24. Which ones could be mixed with a filler (such as crushed matrix or another bulking agent) to fill gaps if appropriate?

25. Which one has the longest set time?

26. Name two ways to make D set faster.

27. Name two ways you could make C set slower.

28. Name two ways to increase the viscosity of D.

29. Name two ways you could increase the viscosity of A.

30. Some of these are difficult to apply as tiny drops because they set so fast. Which ones and why?

31. Which one has the longest working time as tiny drops and why?

32. How might very high or very low relative humidity affect the set time of B and why?

33. Is A soluble after it is set?

34. Is B soluble after it is set?

35. Are C and D soluble after they are set?

Aging (Physical or Chemical Change)

36. Which of these could be past its shelf life as a liquid? Can you tell by looking?

37. A is five years old but still sets when mixed. Is there a reason why you might want to discard it anyways?

38. Could D crosslink over time? How might you know?

39. Is it possible for a reaction adhesive to continue changing chemically after it is set?

40. Is it possible for a solution adhesive to change chemically after it is set?

41. Which one is most likely to remain unchanged over time and why do we think that?

42. Which one is most commonly used by conservators and why?

43. Name two adhesives which have been used on fossils in the past which often change physically and/or chemically with age.

44. Name four observable properties that indicate the adhesive used on a specimen has changed physically and/or chemically over time.

45. Which of these is particularly prone to yellow over time? Name three ways to minimize the chances of this happening.

46. Which of these is associated with the development of yellow or green staining shortly after use, and why?

Bonus Million Dollar Question:

What is the best adhesive to use on fossils?
(the answer is “it depends”)

Appendix 5

A Day-Long Workshop on Materials for Fossil Preparation (Adhesives, Archival Marking and Archival Housings)
held on May 21, 2008, at the Royal Tyrrell Museum, Drumheller, Canada.

10:00-10:45 am (in the classroom)
Participants introduced themselves.
Powerpoint presentation "Liquid to Solid and Back: Phase Change in Adhesives"

Break

11:15-12:15 pm (in the classroom)
Group quiz and discussion:

Naming Adhesives. The group was asked to make a collective list of what adhesives they use and taught to use complete and accurate names to identify products. The problems of confusing industrial grading systems (e.g. the various "B" grades), shifting manufacturers and changes in formulas were discussed using Powerpoint diagrams.

Classifying Adhesives by How They Set. The group was asked to classify the adhesives on the collective list as either solution or reaction adhesives. Powerpoint diagrams were used to explain polymerization and how cyanoacrylates and epoxies set. There was an extended discussion about 5 minute epoxy; how it sets, potential problems and why it is not recommended.

Additional Group Quiz. The group was asked to respond to a list of questions about adhesives terminology, setting mechanisms, working properties and aging (physical and chemical changes over time).

Choosing Adhesives. Powerpoint diagrams were used to discuss Paraloid (Acryloid) B72 as a recommended "default" adhesive. Exceptional cases were discussed.

Archival Housings. Examples were shown using Powerpoint as an introduction to the afternoon demonstration.

Recommended books on adhesives and other literature were available for perusal.

Lunch

1:15- 4:00 pm (in the lab)
Hands-on demonstration with samples:

Using Adhesives. Paraloid (Acryloid) B72 joins were demonstrated by me and Jim McCabe to compare methods for large and tiny joins. Also covered were techniques for making a good join in general. Methods for mixing, dispensing and storing B72 were demonstrated. The bulking of B72 and other adhesives with various fillers was discussed and demonstrated. Problematic specimens and the removal of adhesives were discussed.

Archival Marking. An archival marking kit and a reference poster on materials and techniques were introduced and marking was demonstrated, after which participants practiced making archival marks on sample material.

Archival Housings. The group was asked to consider archival supports as a possible alternative to adhering specimens together in some cases. A special technique using cut ethafoam, polyester batting, Tyvek© and thumbnail reference photos was demonstrated and participants had the opportunity to try this technique and keep samples for future reference.