A Place for PUR in the Bindery

Charles W. Cline, Binding Solutions, LLC, Stockton, New Jersey, USA

Abstract

PUR (PolyUrethane Reactive) adhesives have been available for decades, but have been in bookbinding primarily since 1989. PUR has been chosen over standard hot melt and liquid adhesives for many reasons. These reasons include adhesion, layflat of the book, heat and cold resistance, roundability and durability. Applications systems have improved reducing the overall cost of production. Even though the price per pound of PUR is higher than that of other adhesives, the cost per unit is comparable. Initial concerns centered around one of the components, MDI, but this has proven over the last 20 years to be a minimal concern. The future of PUR is bright. As newer versions emerge additional markets are opening. Some of those markets include photo albums and hard cover books.

PUR (PolyUrethane Reactive) adhesives have been available for decades, but have been in bookbinding primarily since 1989. The first test in North America was run on the west coast using a homemade application system. Since then, the use of PUR has increased dramatically. In 1995, it was reported that there were 28 users of PUR, and by the end of 2010 this number has increased to 100+ users in North America.

Advantages of PUR over standard EVA hot melts

PUR has been chosen over standard hot melt adhesives for many reasons—with superior adhesion and layflat the most important.

- **Adhesion**—PUR is unique in that it will bond to lacquer coatings, UV cured coatings, films such as mylar, as well as paper. Due to the polar nature of the polyurethane molecule these adhesives also bond very well to clay coated papers.
- **Excellent Layflat**—Films of PUR, when applied at the recommended thickness, are considerably more flexible than standard EVA hot melts. PUR is suggested to be applied at .010" because it is twice as strong as standard EVA hot melts. PUR has been approved as an adhesive for the Otabind® style binding.

While the adhesion and layflat qualities are very important in the use of PUR, there are many other qualities that provide benefits for the bookbinder.

- **Heat and Cold Resistance**—Once the PUR adhesive has cross-linked, books bound by these adhesives will not fail at extreme temperatures over 200°F and below -40°F. These properties were especially important to a binder in Utah who sent books to both the Sahara Desert region as well as areas in Siberia. Since turning from hot melt to PUR, this binder's adhesive related complaints have been eliminated.
- **Less Wrinkling of Backbone**—Binding cross-grained paper with standard hot melt adhesives causes considerable wrinkling in the gutter area of the book. The lower operating temperature of PUR does not drive the moisture in the paper away from the backbone the way normal hot melt does. PUR is also somewhat malleable as it cures, allowing the paper fibers to return to their original orientation.
- **Less "Chip-out"**—Since PUR is applied at a low temperature and since it is applied at half the standard thickness of hot melt, there is much less chance for the material to build up on the trimmer knives and nick the cover material during trimming.
- **Square Backbone**—The amount of PUR applied is considerably less than standard hot melt, therefore less material is available to be squeezed out when the cover station and side clinchers attach the cover and form the back.
- **Solvent Resistance**—According to Werner Rebsamen's article "Insidious Solvents" (American Printer, December 1990), PUR is the only binding material today that is totally resistant to solvents and oils. Samples of the cured PUR adhesive have been immersed in oils and solvents, such as MEK and alcohol, that are used in the printing industry and these chemicals have had no effect on the PUR film. Standard hot melt films are softened drastically and even dissolved by some of these chemicals.

In addition to these benefits for the perfect binder, there are some additional benefits that can be realized by those binders who are gluing off the book blocks for hard cover or edition bound books.

- **Cost savings vs. Smythe Sewing**—For many years the standard of the industry to produce rounded, hard cover books was to use Smythe sewing and glue the sewn books with a flexible liquid adhesive prior to rounding. A study in Europe has shown that savings of 30%-40% in cost can be realized by milling off the backbone of the folded signatures and then gluing them off with PUR.
- **Roundability and Round Retention**—Many hard cover books are rounded and backed to provide both aesthetics as well as strength to the final book. By gluing off the book block with PUR, followed by in-line rounding and backing, a significantly greater round can be obtained. As the PUR cures with the book in the rounded state, the retention of the round will be maximized. There will be no "memory" as is found when rounding books that have been glued off with standard hot melts.

Application Equipment

Due to the nature of PUR, special precautions must be taken in order to prevent premature cross-linking and to facilitate clean up of the PUR. Both open pot systems and closed extrusion

systems have been developed since 1989 to specifically deal with these special needs.

- **Open Pot Systems**—The initial North American open pot designed specifically for PUR was produced by Commercial Printing in Medford, Oregon. It was on a Muller Martini Star Plus binder. In order to take advantage of PUR, some of the binders on the west coast adopted this application technique. The Nordson Corporation developed an innovative single wheel, which opened the door wider for the use of PUR since this system could be retrofitted on many existing binders. Within a few years, Kolbus began offering a specially designed open pot that would fit their binders. Soon after, Muller Martini began offering a PUR glue pot for certain models, such as the Corona, Acoro, and Star binders.
- **Closed Extrusion Systems**—The initial closed extrusion system consisted of a premelter, a holding tank, and recirculating hoses feeding the application head. This technology had limited success in the US. A number of years were spent attempting to improve this system with little success. A novel system was developed by the Inatec Corporation in Europe. This involved extruding PUR onto the cover as it traveled from the feeder to the cover station on the binder, where it is attached to the book block. Initially, this worked well when the paper stock was easy to bind, and the roughing station produced a smooth backbone, but more recently these systems have been replaced by other technology. Penetration depended on the pressure of the cover station. The newest technology has been developed by Nordson and was presented in an article titled "Almost Perfect" (American Printer, April, 2002). Since that article, there have been many systems installed in the US. This system is a vast improvement over the earlier technology. Many of these systems are being supplied on small 1-4 clamp binders serving the On-Demand market. The cover station continues to supply the pressure to allow the PUR to penetrate into the backbone.

One of the major concerns for the use of PUR is the price of the material. While the price of PUR is about three times that of standard hot melts, the application amount is generally half or less than the amount of hot melt normally applied. While these numbers may seem to be highly significant, when taken in context of the cost of the entire book, they pale to insignificance. On a typical 8 ½" X 11" book that is 1" thick, the cost of using standard hot melt would be $.013 per book (assuming .025 mils and $1.35 per pound for hot melt). The cost of using PUR on the same book would be $.02. As one plant manager put it "this small increase in cost(seventy cents per thousand books) more than justifies the use of PUR and I can sleep at night, knowing that the job will not be rejected."

Many users of PUR have found that switching back and forth from PUR to hot melt is not justified because of this small difference in cost. In addition, operators become much more familiar with the machine settings and are able to maintain the low application levels when PUR is used exclusively.

A second concern involves the cost of retrofitting the binder to be able to use the PUR. Since PUR is supplied in 55 gallon drums (or 5 gallon pails for small users), a method of transferring the material into the open pot or to the extrusion head is necessary. The most common method is the use of a drum (or pail) unloader. These typically range from $25,000 to $50,000 just for the unloader. The application system is an additional cost, typically from $25,000 to $35,000.

A third concern involves the emission of MDI, one of the ingredients used to make PUR. The MDI is present in very small concentrations (parts per billion) and newer generations have cut the levels in half. The ultimate goal is to achieve 0 ppb and work continues to achieve this goal. Even at the current levels, independent tests by professional hygienists have shown that there is no detectable PUR found two feet from the open pots of PUR. In addition, PUR is heavier than air and will travel downward from the glue pot, all the time reacting with any existing moisture, forming microscopic amounts of polyurethane. However, any glue system, whether hot melt or PUR, should have an exhaust system over the pot.

A fourth concern involves the length of time it takes the PUR to cure so the books can be trimmed and shipped. PUR was first introduced into the United States bookbinding industry by National Adhesives in 1989. The first generation of PUR, while it could be trimmed in line, needed almost 24 hours before enough strength developed so the books could be shipped. This delay in shipping was found to be completely unsatisfactory for most of the industry.

The second generation PUR was developed in 1994 that allowed in-line trimming and sufficient strength within 4 hours of binding, if enough moisture was present in the paper and the relative humidity of the binding area was high enough. In winter months, this proved to be a problem as the relative humidity in many northern and western plants dipped below 20%.

The third generation PUR was developed in 1997. This generation's page pull development was achieved within 1 hour of manufacture and only required the moisture of the paper to achieve final cure. This was considered satisfactory by the industry as most binders held books for at least one hour. It also meant that these books could be shrink wrapped directly off line. However, this modification came with a negative property. Since the green strength was very high at an early time, some customers, especially in humid areas, found that the PUR was becoming very heavy in the glue pot. This was especially true when thin books were being produced and the PUR was not replaced in the application pot for long periods of time.

Finally, the fourth generation of PUR was developed. This was a lower viscosity version of the third generation and maintained the high green strength, but extended the pot life. This generation has replaced most of the third and second generation PUR, and is especially successful in the new extrusion systems and continues to be used in many systems today.

The Future of PUR

PUR began its usefulness in medium size trade binderies that produced a large percentage of trade journals and annual

reports. Since many of these binderies continue to bind a large percentage of highly coated paper and cross grained paper, this market will continue to be the highest user of PUR. More and more printers and publishers have been exposed to the benefits of PUR and are demanding this type of binding to assure quality and longevity. Even the smaller binderies have recently been asked to provide PUR binding, leading to expanded use in many areas of the country. The onset of very small binding jobs has significantly increased the use of PUR and exposure in the publishing industry. Many books that are "out of print" are now available through web sites such as Amazon.com. These books must be printed and bound quickly. Since they are ordered in the range of 1-10 books, a small, easy to set up, binder is frequently used.

Another emerging market for PUR usage is that of photograph albums. These books typically are very high quality paper stock and the purchasers require durability, flexibility, and strength only obtained by using PUR.

The next large increase for PUR will be in the hard cover binding area. Because of the cost advantage of PUR binding over Smythe sewing, and the ability of the fourth generation of PUR to be rounded in line, many hard cover book manufacturers have been investigating PUR. In an article printed in the March, 1996 issue of Adhesives and Sealants Industry magazine, titled "PURFECT LOK® Adhesive Solves Bookbinding Problems", one west coast binder relates his positive experience using PUR for hard cover binding. The use of PUR for hard cover binding will escalate as binders gain confidence that this technology can show cost savings over Smythe and McCain sewing, without sacrificing quality.

Biography

I am a graduate of Lafayette College, Easton, Pa with a bachelor's degree in Chemistry. After 7 years as a research chemist for NL Industries, I joined National Starch and Chemical Company in 1970. After 5 years of developing new adhesives for many different applications, I was promoted to Technical Service Supervisor and provided support for sales in the New York and Philadelphia regions. In 1982 I was promoted to Technical Service Manager with responsibility for the paper bag manufacturing industry. In 1985 my responsibilities were expanded to include the bookbinding industry.

I became the primary delegate to the BMI at this time and have served on the Cover Committee between 1993 and 2000. I am also a member of the Research & Engineering Council of the Graphic Arts Industry and have served on the executive committee between 1997 and 2000. Between 1992 and 2000 I made four presentations of new technology to the Bindery Seminar.

In 1989 I was promoted to Technical Marketing Manager and was involved with the first commercial application of PUR for perfect binding at Commercial Printing in Medford, Oregon. Since that time I have been instrumental in the development and roll out of four generations of PUR for the industry.

In 1995, the first low temperature hot melt for bookbinding, COOL BIND® was introduced at Banta Information Services, in Spanish Fork, Utah. After a successful six month test period, I took the product and demonstrated it at many binderies and it became the best selling binding hot melt for National Starch.

In 2000, testing of ULTRACASE®, novel technology to eliminate the warping of cases in the case making operation, began with the help of Malloy Lithograph Co. After I proved the viability of this approach, Original Equipment Manufacturers (OEMs) were apprised of the success and application technology was begun. This project is ongoing.

In 2001, after retirement from National Starch, I started my own consulting company, Binding Solutions, LLC and have been involved in examination of quality problems with all the major bookbinders. I have also remained active in the BMI and was elected to the Cased-in Club in 2002.