UnitedStates Postal Service Efforts to Develop an Environmentally Benign Pressure-Sensitive Adhesive for Postage Stamp Applications

Joe Peng, Program Manager
U.S. Postal Service
Washington, D.C. USA

Said AbuBakr, Research Project Leader
Carl Houtman, Research Chemical Engineer
David Bormett, Chemical Engineer
Nancy Ross Sutherland, General Engineer
USDA Forest Service, Forest Products Laboratory
Madison, Wisconsin USA

Lynne A. Thoma, Department Manager
Donald Donermyer, Senior Scientist
Daniel F. Seiter, Chemical Engineer
Specialized Technology Resources, Inc.
Enfield, Connecticut USA

Abstract

The United States Postal Service initiated the Environmentally Benign Pressure-Sensitive Adhesives for Postal Applications program as part of its commitment to develop products that do not adversely affect the environment. This program led to the development of teams from industry and government who worked together on developing a recyclable pressure-sensitive adhesive (PSA). This paper describes lessons learned from the process of initiating, developing, evaluating, and implementing the PSA program. The program started with a problem and finger pointing and ended with a solution and useful products, developed with ownership from all parties participating in the process. This paper briefly describes a new Executive Order signed by President Clinton on April 21, 2000, which includes implementation strategies for government agencies to purchase and use the new environmentally benign PSA products. The effects of PSA on the paper recycling process and criteria for PSA material properties are also described.

Introduction

The popularity and use of a wide variety of pressure-sensitive products, such as stamps, stickers, tapes, and labels, have increased. The problem that led to the development of the United States Postal Service program is that pressure-sensitive adhesive (PSA) materials, when present in the recovered paper stream in sufficient volume, can have an adverse impact on recycling processes and products. The PSA material tends to form into globs of "stickies" during the recycling processes, creating enormous difficulties for paper recyclers. Stickies that survive the recycling process reappear as dirt and irregularities that are unacceptable in finer grades of writing paper.
What is needed is an environmentally benign PSA that satisfies stringent performance requirements as an adhesive and yet is easily removed during early stages of recycling processes. The USPS was uniquely positioned to take a

FEICA Member associations

- Vereinigung der österreichischen Klebstoffindustrie
- DETIC Comité Professionnel BELCAM
- Fachverband Klebstoffindustrie Schweiz
- Industrieverband Klebstoffe e.V.
- Brancheforeningen for Lim og Fugemasser
- Asociación Española de Fabricantes de Colas y Adhesivos (ASEFCA)
- Syndicat Français des Colles et Adhésifs(S.F.C.A.)
- Kemianteollisuus RY
- British Adhesives & Sealants Association (BASA)
- Associazione Nazionale Vernici Inchiostri Sigillanti e Adesivi (AVISA)
- Maling og Lakkfabrikkenes Forbund
- Vereniging Nederlandse Lijmindustrie (VNL)
- Associação da Indústria e Comércio de Colas e Similares
- Sveriges Limleverantörers Förening
- Združenje kemijske in gumarske industrije (APA)

www.feica.com

FEICA
Association of European Adhesives Manufacturers
P.O. Box 23 01 69 · D-40087 Düsseldorf

leadership role in addressing this complex problem. In addition to producing PSA stamps, the USPS consumes a significant volume of PSA office labels and forms that are affixed to mail pieces to expedite mail processing and decrease costs. In fact, the USPS is one of the largest single purchasers of PSA materials for a variety of applications, accounting for about 12% of U.S. PSA production. For this reason, the USPS is concerned with the adhesives used for all PSA products, not just that used on stamps.

One complicating factor of this problem is the diverse nature of the various industries involved in the creation, use, and recycling of PSA products. The USPS recognized the need for an innovative approach to solving this problem and consequently initiated the formation of vertical, integrated teams. The teams, composed of representatives from the adhesive, converting, printing, and paper industries, testing laboratories, and other groups, worked cooperatively toward a solution to the PSA recycling problem. Each industry learned about the other's challenges and needs.

This vertical team approach led to the submission of numerous PSA products by the adhesive industry that were designed to perform as a stamp adhesive and to exhibit higher removal efficiency during the paper recycling process, as desired by recycling mills. These products were evaluated at the laboratory and pilot level using recycling protocols developed cooperatively with the recycling mills. The ultimate accomplishment was to use the data generated to convince six recycling mills to agree to process printed versions of the stamp material through their mills. A total of more than 20 mill trials have been conducted with more than 15 adhesive products. Although the data are still being collected and analyzed, the preliminary mill findings are very promising.

The efforts to develop environmentally benign PSA products have led to the establishment of new PSA purchasing policies. The USPS is requiring the use of the improved adhesives in future stamp and paper-to-paper label purchases. This technology has also been extended to other government agencies who likewise are being urged to purchase PSA products by complying with the newly signed Executive Order 113148. Section 702 of this Executive Order, Environmentally Benign Adhesives, reads as follows:

> Within 12 months after environmentally benign pressure sensitive adhesives for paper products become commercially available, each agency shall revise its specifications for paper products using adhesives and direct the purchase of paper products using those adhesives, whenever technically practicable and cost effective. Each agency should consider products using the environmentally benign pressure sensitive adhesives approved by the U.S. Postal Service (USPS) and listed on the USPS Qualified Products List of pressure sensitive recyclable adhesives.

The final objectives of this project are to produce clean, acceptable final pulp in a typical recycling operation from paper containing PSAs and to establish universal test methods and protocols that can be confirmed and accepted by the industry.

Discussion

The USPS took the initiative, provided the resources, and formed vertical teams to represent and address all aspects of the issue associated with recycling paper containing PSA. The adhesive industry was asked to meet the

challenge of developing PSA products that would meet the strict performance requirements of the USPS postage stamp product, but would also satisfy the needs of the paper recycler. This challenge required a full understanding of the problems associated with PSAs in the paper recycling process in order to design adhesives with properties that would best meet recyclers' needs and minimize problems.

Since most of the post-consumer stamp material, e.g., discarded mail pieces, was collected in mixed office waste streams, the effort concentrated on the fine grade writing paper industry, one of the primary consumers of this type of feed stream. Each participating industry contributed knowledge and resources, enabling better insight into all the issues and alternative solutions.

The USDA Forest Service, Forest Products Laboratory (FPL) took the responsibility of working with all concerned parties to develop a widely accepted standard method for evaluating the recyclability of paper containing PSA.

Two protocols were developed, with the review and concurrence of the USPS and vertical teams. The first is a pilot-scale testing protocol to evaluate removal efficiency after each recycling unit operation; the second is an image analysis (IA) protocol to evaluate handsheets for PSA content. Pilot-scale testing includes feeding 100 kg of copy–envelopepaper with a controlled amount of PSA to semicontinuous recycling unit operations that include high consistency pulping, coarse and fine screening, forward and reverse cleaning, and flotation and washing. Samples are taken at 16 sample points, handsheets are made, and IA is used to measure the level of contaminants and to evaluate the removal efficiency of each unit operation and the cleanliness of the final products. Three other pilot testing facilities were selected to confirm the FPL protocols.

Specialized Technology Resources, Inc., was assigned the responsibility of conducting the initial screening of new PSAs for both functionality and recyclability using a lab-scale protocol. National and international universities took on the tasks of investigating the mechanism of PSA breakdown during pulping, the interactions between ink and PSA, and the testing of final products. Printers, converters, and chemical suppliers committed themselves to conducting whole stamp construction trials to be used for laboratory, pilot, and mill testing of recyclability. The recyclers established the final acceptable PSA levels in both parts per million and particle size.

Selection of Screening for PSA Removal

The old paradigm for removing PSAs was to reduce the size of contaminant particles by using more severe pulping conditions. The theory was that particles could be made small enough to be removed by flotation and could be further removed from the wastewater by clarification. Adhesives designed for this removal technique were primarily dispersible types, and emphasis was placed on the size of dispersed adhesive particles as a result of pulping.

Negative factors associated with dispersible adhesives included the possibility of reagglomeration later in the paper recycling process and build-up effects (especially in closed-loop systems). In addition, the dispersible-type adhesives were not successful at meeting the USPS high humidity aging performance requirements. This option for removing PSAs was therefore not pursued.

Screening was selected as the preferred strategy for removing PSAs. Screening has many advantages over other removal methods. The earlier that PSAs are removed from the recycling process, the lower the total cost and

the less likely that the PSAs will be deposited throughout the mill water system. In general, papermakers (recyclers) prefer screening as the primary strategy for removing PSAs because it allows PSAs to be easily removed by size at the start of unit operations. Residual PSAs can be removed efficiently during the remaining unit operations, including flotation. In addition, removing stickies in the early stage of screening minimizes the amount of microstickies in the process water. Pressure screening is also independent of density, which is important because other contaminants may modify the PSA density and nullify the subsequent centrifugal cleaning stage.

Even though paper mills vary in their technology for deinking and stickies removal, they all have pressure screens. Screening does not require intensive capital investment, and the operation can be optimized to increase the removalefficiency.

The papermakers agreed to make their mills available for field testing and monitoring of PSA impact on operations. The adhesive industry reformulated their adhesive so that most of it could be removed in the pressure screening stage.

Operating Conditions

Consistency, temperature, and screen slot velocity are among the operating conditions or parameters to examine for optimization. Higher consistency pulping provides gentle fiber-to-fiber actions and causes the adhesive to stay large and so be easily removed by screening. Lower temperature during high consistency pulping, lower consistency through the screens, and lower velocity through the screens have been shown lo increase the efficiency of the screeningprocess.

The forum of industry communication created by vertical teams revealed that PSAs that are introduced to a fiber recycling plant have the potential to cause significant problems, such as limitations in plant processability (equipment scaling), productivity (equipment failure and shut down), and product quality (contamination in the final product). These problems are not encountered if the PSA is properly formulated. Criteria for PSA material properties can be developed by analyzing each unit operation of the recycling process. These criteria include sufficient strength to survive pulping and screening as large particles, limited elasticity to prevent extrusion of the material through screen slots, no adhesion to equipment surfaces, suitable surface chemistry that promotes removal by flotation, and no soluble colloidal component that can contaminate wash water.

Testing and Evaluation

The vertical teams also addressed how to evaluate adhesive products, designed for performance and improved recyclability, at the laboratory and pilot levels. Most of the available small-scale recycling protocols are used for quality assurance purposes and address only the specific needs of the organization that uses them, An assessment by the project team revealed a need for a universal, standard method fortesting since each mill, university, and testing laboratory use their own particular testing procedure to meet their own needs, rather than the needs of the industry at large. No small-scale universally accepted recycling test method or protocol was available; all recycling procedures reviewed seemed to be dependent upon the recycling mill,

the end products made from the recycled pulp, or the adhesive company that designed the adhesive. There was a clear need to develop a reasonable method that combines recycling evaluation and subsequent analysis methods. In addition, there was a lack of published information on adhesive removal efficiencies during recycling unit operations.

Many mill experts talk about dirt and adhesive content by stating numbers, such as 5 or 10 ppm. This description of contaminant content is loosely defined when the method or equipment and settings used are not specified. As we have learned from extensive work with Various image analysis systems, much is dependent upon the system and the way it is calibrated and set up. In other words, by adjusting certain detection settings, any desired level (ppm) of contaminants can be obtained.

The materials and processes involved in the PSA program tend to be concentrated in highly capitalized and tightly scheduled production facilities such as paper mills, converting and printing facilities, and recycling plants. It is very difficult to schedule meaningful tests of materials in real-life scenarios under these conditions because of the costs, which are borne in large part by voluntary participants in the program. This obstacle was mitigated to a large extent by the good faith efforts and continuing cooperation of the program's industrialparticipants.

During earlier phases of this work, industry-wide acceptable laboratory and pilot recycling and image analysis protocols were prepared and refined. With these evaluation protocols in place, a large database for new qualified adhesives was created for both pre- and post-consumer waste recycling.

Various methods were studied to evaluate PSA removal efficiency throughout the recycling process. Among these, one common technique used by the paper industry is image analysis. For reasons of economics, timeliness, and efficiency, many in the industry have used flatbed scanners and image analysis software for quantification of stickies or contaminants in the handsheets of the pulp accepts and rejects from various steps in the recycling process. However, it quickly became obvious that several unresolved issues are associated with this type of analysis. Another problem is the lack of a universal method. Although the Technical Association of the Pulp and Paper Industry (TAPPI) was in the process of developing standards for calibration of the equipment and software and a standard test method, these were not available during the developmental stage of the PSA program. In addition, such standards would not have been appropriate because an image analysis protocol had to be developed to provide "relative" removal efficiencies of adhesive in the pulp for evaluating the recycling behavior of various adhesives.

The mill trial design was accepted by most fine writing grade paper recycling mills. Representatives from the recycling community supplied valuable advice and expertise with respect to the design of the USPS recycling protocols. Laboratory and pilot protocols were developed through these collaborative efforts, both of which were regarded as indicative of likely commercial recycling systems. Given the ambitious nature of the environmentally benign adhesive (EBA) program and the likely extension to nonpostal products, the recycling industry impressed upon the USPS the need for one final testing arena in the qualification of benign PSAs: full-scale commercial recycling trials. Such trials would serve to confirm all the research and development findings. Successful commercial trials would also supply strong evidence to the recycling community regarding the benign nature of the USPS PSA products.

There is no single representative recycling mill. An easy and straightforward approach would have been the commissioning of a single recycling mill, through which all candidate PSAs would be qualified. The EBA team soon

recognized that, even within the limited arena of fine paper grade recycling mills, no single mill sufficiently represents the industry. There are a vast assortment of process configurations and capital employment. Not all standard secondary fiber unit operations are employed at all sites. Therefore, the USPS chose to solicit commercial sites that represent the full range of commercial recycling facilities, all serving the fine paper grade community.

All recycling mills encounter significant problems with stickies at times. Although each of the participating mills proved capable of controlling and removing contaminants within their systems, stickies can potentially cause significant problems for all mills. These problems could manifest themselves as out-of-spec quality control parameters (dirt or stickies), process runability problems (screens, cleaners, paper machines), or a combination of these.

Candidate PSAs evaluated within the commercial recycling trials must be compared relative to one another, despite differences in recycling facilities. The risk of failing a given candidate PSA in the mill recycling stage must clearly indicate recyclability deficiencies of that candidate, not differences in mill recycling process configurations. Therefore, the mill trial protocol required a standard benchmark PSA to be run through each participating mill. This benchmark PSA served as a performance standard, which allowed discrimination between candidate PSAs having better or poorer performance.

Sufficient PSA material had to be added to establish a significant increase in the contaminant level compared with that of the baseline furnish. Background stickies in current sorted office waste can be appreciable and difficult to remove for some mills, and they limit the feedstocks that recycling mills can use.

One part of the PSA program was a mail test, which evaluated the performance of a candidate stamp through the highly automated mail processing systems and generated feed material for mill recycling trials. This study is probably one of the most extensive ever conducted by the USPS. However, even though 4 million test pieces were generated, this was not enough material to be the sole feed for the mill recycling trials.

Dissemination of Results

The preliminary results of this work were presented by program participants at the 1998 TAPPI recycling symposium co-sponsored by the USPS and the Forest Products Laboratory in New Orleans on March 8–12,1998. In addition, invited presentations were given at the 1998 Paper Industry Research Association (PIRA) deinking conference in England and the PTS/CTP deinking symposium in Germany.

At the TAPPI 2000 recycling conference sponsored by the USPS, Forest Products Laboratory, Adhesive Sealant Council (ASC), American Forest and Paper Association (AF&PA), and TAPPI, all information collected to date was disseminated through formal presentations. The information shared at this conference is available in the proceedings. The papers describe the findings from laboratory, pilot-scale, and full mill-scale recycling trials using post-consumer PSA products as feed materials.

Future work will involve the development and testing of environmentally benign release liners as part of the effort to render both pre-consumer and

post-consumer stamp products fully recyclable.

Concluding Remarks

The USPS has put forth an extensive effort to define and identify adhesive products that not only meet their product performance requirements but are also compatible with paper recycling operations. The information generated by the PSA program is not only benefiting the USPS; it is being shared with industry to assist them in their efforts to be' environmentally responsible. Some key lessons learned through the course of this work are as follows:

- The procedure developed for qualifying stamps and other self-adhesive label products by recyclability can likely be adapted for other self-adhesive labels and is helping the government and industry learn how to qualify adhesive-based products on the basis of recyclability.
- It is difficult to schedule meaningful tests of materials in real-life scenarios when the materials and processes are concentrated in highly capitalized and tightly scheduled production facilities, such as paper mills, converting and printing facilities, and recycling plants. The costs of such tests are borne in large part by voluntary program participants. This obstacle was mitigated to a great extent by the good faith efforts and continuing cooperation of the program's industrial participants.
- The vertical team approach resulted in collaboration amongst diverse industries and has led to several solutions to the PSA recycling issues. However, this forum may not have been possible without the backing, industry clout, and purchasing power of an organization such as the USPS. Because the USPS is the largest PSA label user (though not a producer), it was the best convener for vertical teams.
- The overall situation of the U.S. recycling industry with respect to PSAs will not likely change unless the USPS, other government agencies, and the private sector make use of these new PSAs. The new Executive Order provides implementing strategies for this within the Federal government.
- Because existing recycling mills are at various stages of deinking–contaminant removal technology, removing contaminants by screening and flotation is preferable to dispersion.
- Consumer preference for PSAs outweighs environmental concerns.
- Public research institutions, such as the Forest Products Laboratory and academic institutions, can play a significant role in bringing unbiased scientific problem-solving and fundamental research capabilities to bear on solving the problem.
- Organizing and developing consensus within the vertical team concept in problem solving takes time, but in this case, it appears to have resulted in a process and outcome are supported by all interested and affected organizations.
- Because industries are closely involved with the development of universal test methods, the methods are widely accepted.
- Along with private sector, academia, and special interest groups, government agencies need to be involved in the process to make significant progress.
- Technical societies, such as TAPPI, are very useful in providing a neutral forum to present technical data and results on an industry-wide scale.
- A PSA user's conference is needed to best disseminate information on environmentally benign PSAs and to increase dialogue among the various groups involved. The conference should involve all the large businesses in

the private sector that use PSA labels and tapes to conduct their operations.

- More work needs to be done. Although the recyclability work on the stamp (face paper and adhesive, post-consumer) is nearly complete, the recyclability of the entire stamp laminate system—i.e., face paper, adhesive, and release liner (pre-consumer)—still needs to be developed. This is primarily the result of the need to improve the recyclability of the release liners to make the entire stamp laminate construction.

Bibliography

J. Peng, A Case History Study: Environmentally Benign Pressure Sensitive Adhesive Program, In: Proceedings of Adhesive and Sealant Council, Inc., 1999 Spring Convention and EXPO. Toronto, Canada, April 11–14, 1999.

Proceedings of USPS/STR Joint Conference Covering Environmentally Benign PSA for Postal Applications, Windsor, CT, February 14, 1995.

Proceedings of USPS/AF&PA Joint Conference on PSA Issues, Washington, DC, June 25,1996.

Proceedings of Environmentally Benign PSAs for Postal Applications, Washington, DC, July 7–9, 1997.

Proceedings of 5th International Recycling Technology Conference, Brighton, England, February 9–10, 1998.

Proceedings of 1998 TAPPI/USPS/FPL Recycling Symposium, New Orleans, March 9–11, 1998.

Proceedings of 1998 PTS/CTP Deinking Symposium, Munich, Germany, May 5-8,1998.

Problem 3 **Develop new recycling technologies to Increase the use of wastepaper.**

FY2001 Research Attainments

Publications

Extramural

Peng, Joe; Abubakr, Said; Houtman, Carl; Bormett, David; Ross Sutherland, Nancy; Thoma, Lynne A.; Donermeyer, Donald; Selter, Daniel F. 2000. United States postal service efforts to develop an environmentally benign pressure–sensitive adhesive for postage stamp applications. In: Proceedings of the world adhesives conference 2000; 2000 September 20-22: Barcelona, Spain. Dusseldorf, Germany: Association of European Adhesives Manufacturers: Available on CD Rom. Online: http//www.felca.com. 8 p.