THE PLASTICS AND RUBBER INSTITUTE

ADHESIVES GROUP

ADHESIVES IN PACKAGING

ONE DAY SYMPOSIUM

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PACKAGING ADHESIVES - RECYCLING AND EFFECT ON THE ENVIRONMENT

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The aim of this paper is to examine the environmental effect of packaging adhesives, with specific emphasis on the recycling of paper and board packaging.

The paper will be divided into four sections:

- The importance of paper and board packaging recycling
- Problems encountered by recycling packaging material
- Existing solutions to the problems that packaging adhesives cause in recycling
- Future solutions to these problems

A brief outline of the information to be presented in each area is given below.

1. THE IMPORTANCE OF PAPER AND BOARD RECYCLING

Statistics on the amount of board packaging which is recycled in the UK and Europe will be given. Reasons why the European paper and board packaging industry is dependent on wastepaper as a raw material will be given. Legislation likely to affect this and its possible impacts will be described.

2. PROBLEMS ENCOUNTERED BY RECYCLING PACKAGING MATERIAL

Problems caused by the presence of packaging adhesive in wastepaper and board using mill will be illustrated. Estimates of costs incurred by the wastepaper - using industry through the presence of packaging adhesives will be given.

3. EXISTING SOLUTIONS TO THE PROBLEMS THAT PACKAGING ADHESIVES CAUSE IN RECYCLING

Current techniques employed by mills to remove adhesive particles will be briefly outlined. Problems with both the mechanical and chemical methods currently used will be discussed in relation to packaging adhesives characteristics.

4. FUTURE SOLUTIONS

Options which can be taken in the future to reduce the problems of adhesives in mills will be described. Characteristics of a recyclable packaging adhesive from a wastepaper using mills viewpoint will be discussed.

ENVIRONMENTAL DEVELOPMENTS IN AQUEOUS VINYL DISPERSION ADHESIVES

A RAW MATERIAL SUPPLIER`S VIEWPOINT

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Aqueous adhesives made from dispersions of vinyl acetate polymers are widely used in packaging constructions. These adhesives have been used to bond paper, board, varnished surfaces, foils and plastic films for many years. The resulting packages contain a diverse range of goods from food to electrical appliances, from toys to medicines. The adhesives are used because they generally offer trouble-free machine application, good bond security, and present little hazard in use.

Concern to protect health and the environment has grown dramatically in the 1990`s, as we all know. The use of water-borne adhesives has increased at the expense of solvent-borne systems, because of the inherently safe nature of adhesives based on water. However as we look ever more closely at the impact of modern industry on health and the environment, we must recognise the need to improve even the products having the least adverse effect. We are now starting to see the "Green Revolution" impacting on water-borne adhesives, with most interest currently focused on the packaging sector. The adhesive manufacturers who will be the European technical leaders in the latter half of this decade are responding now.

Adhesive manufacturers will need to consider the whole life cycle of their products:

- Raw material supply
- Adhesive manufacture
- Application of adhesive
- End use
- After use/disposal

This approaches the "cradle to concept" which is advocated for assessing the environmental impact of industrial products. This paper concentrates on the issues of key importance to the packaging adhesive manufacturer, seen through the eyes of a polymer producer, supplying a primary raw material.

Starting with the raw materials, the adhesive industry is now showing concern over the environmental performance of its suppliers. Environmental audits may be carried out, and raw material producers should be able to demonstrate that they have properly considered and controlled waste water, atmospheric emissions and disposal of solid waste such as packaging. Waste and emissions must be minimised for both environmental and economic reasons. A modern polymer factory should be equipped to treat its effluent, whether it be in the form of gas (to atmosphere, probably via incinerator) or liquid (aqueous effluent via treatment plant). Waste which cannot be treated at source should be safely processed by an expert contractor. Ultimately a "zero effluent" manufacturing strategy should be the target.

During manufacture of the adhesive the main concerns are that the polymer dispersion should have low Volatile Organic Compound (VOC) content, and that the minimum loss of adhesive should occur to drains while washing mixing vessels, filters and packing lines. The VOC content of polymer dispersions is inherently very low compared to solvent-borne systems, but currently aqueous adhesive bases are starting to be manufactured with even lower levels of residual monomer and other volatile organic compounds. These products, besides their obvious advantage of lower odour, minimise atmospheric emissions without any loss in performance compared to previous polymers.

Low VOC content will lead to benefits wherever the adhesives are used. The most obvious improvement again will be the reduced odour of the new adhesives. With lower VOC contents we have reached the stage that when the adhesive is used, the volatile liberated during drying is almost pure water. This clearly gives a near ideal situation regarding atmospheric emissions, and compliance with more stringent legislation which is to be expected in future.

In packaging end uses constructions bonded with aqueous vinyl dispersion adhesives are already considered to be safe, as exemplified by the wide food use clearances granted to this type of product under FDA and BGA recommendations. Recently in some European countries concern has been expressed over the use of external plasticisers in adhesives for sensitive applications. Plasticisers, typically phthalate esters are commonly used in adhesives to facilitate bond formation, and to increase adhesion to difficult-to-bond surfaces such as polyolefin films. The use of plastic films in packaging is very widespread, and currently raw material suppliers and adhesive manufacturers are working to eliminate plasticiser. Recent developments are showing promise; high adhesion to treated films is possible without plasticiser and without compromising other aspects of adhesive performance. As a result of this research new vinyl acetate-ethylene copolymer dispersions for plasticiser-free adhesives are likely to become available in the near future.

What happens to the adhesive after the package has been produced, used and then thrown away? Disposal and recycling of packaging materials is receiving a high profile today, but because of their small volume compared to the total package the attention focused on adhesives has been limited until recently. Recycling of paper and board packaging by repulping has gained in priority, and here the impact of the adhesive on the repulping process is critical. Formation of "stickies" in reconstituted paper or board is a significant problem, caused by polymeric residue from adhesives carrying through the repulping process. There are currently two schools of thought within the paper industry on solving the stickies issue; either the adhesive should be totally redispersible in water so that it effectively disappears into the repulping liquor, or alternatively the adhesive should be completely immiscible with water and easily removed from the pulp by filtration. Either solution is feasible in the design of the adhesive base polymer, but a clear direction is now required. Other methods of disposal at the end of the package's life cycle include incineration and landfill. Factors to consider here include absence of toxic gases from incineration, absence of toxic leachate from landfill (most unlikely since these aqueous adhesives are frequently accepted as components of food packaging), and ultimate fate in landfill after possible biodeterioration.

The aqueous vinyl dispersion adhesives which have been used by the packaging industry for many years clearly have very limited adverse effect on health and the environment, when compared to solvent-borne systems. However as environmental awareness and concern increases, the adhesives industry and its suppliers share an opportunity to improve the already good record of water-borne adhesives. Those companies which can develop the technology to respond to the new environmental awareness, while maintaining the performance of their products, will be the market leaders of the future and will make a positive contribution to the protection of our environment.

ADVANCES IN HOT MELT ADHESIVES
A RAW MATERIAL SUPPLIER`S PERSPECTIVE

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Since the beginning of the packaging industry paper and cardboard attachment and bonding has been the main aim of producers world wide. There are many methods to choose from: tapes, mechanical fixings, solvent adhesives, water based adhesives and hot melts. The hot melt technology is perhaps the most recent but over the last few decades has been one of the most successful and fastest growing.

The reasons for this success lie mainly in the number of technical advances that have been made in the industry.
Exxon Chemical Ltd is a major supplier to the producers of hot melt adhesives and this paper will outline its view of the current advances in hot melt adhesives, based on the development of the raw materials involved. The vital role of the adhesive manufacturer should not be ignored in this topic but since the experience of Exxon Chemical Ltd lies outside this area the paper will concentrate on raw materials.

To cover this a typical formulation for a packaging hot melt adhesive will be discussed and the role of the major constituents highlighted. Taking the subtitles of polymers, tackifiers and waxes the paper will provide an overview of where raw materials stand today and the areas in which Exxon Chemical Ltd is working to evolve and advance these raw materials. Where appropriate it will cover new materials available for the formulator of packaging hot melts (for example styrenic block copolymers).

Within the section on polymers the role of Ethylene Vinyl Acetate (EVA) copolymers will be dealt with in terms of how developments in the range of EVAs have allowed the properties of the adhesive "backbone" to be enhanced. Exxon Chemical Ltd`s recent development of second generation EVAs will be used as an example.

The tackifier section will review the development of tackifiers specific to hot melt packaging adhesives, covering such areas as increased heat stability and adhesion levels.

Developments in waxes will be covered from the viewpoint of the increased range of synthetic and functionalised waxes and the role these can play in increasing the performance of hot melts.

Such advances must eventually stand the scrutiny of the packaging industry. Adhesive consumers will view such developments in the light of problems solved, or perhaps by the new areas of application opened up to them. To conclude, this paper will review these areas as perceived by a raw material supplier, topics such as increased performance at the extremes of temperature or greater thermal stability and operating windows.

A raw material supplier is a crucial link in the chain that brings technical advances to the adhesive user`s door. In many cases it is the development of new, better or simply different raw materials that enables the hot melt adhesive producer to formulate adhesives that solve problems for the industry and expand an adhesive`s capabilities. The aim of this paper will be to demonstrate some of the ways in which a raw material supplier can contribute to this partnership.

ADVANCES IN ADHESIVE APPLICATION TECHNOLOGY

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Nordson (UK) Ltd, Thame

1) 180 cartons per minute minimum

2) 300 meters per minute conveyor speed

3) Variable speed packaging machines up to 900 feet per minute.

4) The product must be packed and sealed within 30 seconds.

5) Must withstand temperature ranges of $-40^{o}C$ to $180^{o}C$.

6) Must withstand the journey from London to Harwich and return without slippage, twisting, distortion or collapse of the pallet load.

7) Must pass the "Hurle Test", "Jrope Test" or "Phoofe Test".

The statements above are just a few of the many specifications that are required before a packaging line, containing an adhesive applicator system, can even be considered for acceptance.

These conditions would not have even been considered 15/20 years ago so what has changed that makes these statements common place today.

How is it possible that output per line can be increased at a lower cost than even five years ago?

Technology is the answer. Who needs cranks, pulleys, wheels, grease when a micro chip is available? Why have a drawing board when CAD/CAM can be used?

Today various methods of adhesive application are available from simple hand applications to fully automated micro processor controlled packaging lines. Adhesive can be applied at random or with a precise deposit; by robot or by screen printing, to paper/board products and to dissimilar substrates (polystyrene, wood, leather etc) using various adhesives such as PVA, EVA and PUR for instance).

Advances in technology can and do give confidence in the product, peace of mind for the users and profit for the company.

NEW IN-LINE PROCESSES FOR RELEASE COATING/PSA COMBINATIONS FOR THE PRODUCTION OF SELF-ADHESIVE LAMINATES

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CURRENT IN-LINE PROCESSES

Labels, in one form or another, account for some 75% of all self-adhesive (s/a) laminates produced worldwide. Large volume production of a s/a label laminate is dominated by the in-line process and accounts for over 50% of the label laminate market. In this technology a glassine calendered, supercalendered or clay coated kraft paper is coated with silicone, mostly using a 5-roll applicator at just over two metres wide. The silicone is a solvent-free 100% solids fluid with a viscosity of 300 - 500 cps, applied at a coating weight of about 1g/sqm. The coated paper passes through a recirculating hot air oven at 200°C - 250°C for 2-5 secs to cure the silicone to a hard, abrasion-resistant film . Since paper tends to lose its moisture under such conditions, causing edge curl and surface cockle, the web must pass through a remoistening unit to replace this moisture and flatter the web.

The silicone coated side of the paper is then coated with adhesive, usually an acrylic emulsion, which is dried by passing the web through a second oven. Again the sheet must be rehumidified to ensure dimensional stability. The web then passes to the laminating unit where it is bonded to the face material. This whole process is characterised by physically large equipment with a large space requirement, a large energy demand, and a very large capital outlay.

NEW PROCESSES

These are identified with much lower capital expenditure for much smaller, more compact equipment, occupying a great deal less space. They feature lower energy absorption and production rates are potentially higher.

Depending on requirements, silicone can be applied on 2-roll or 3-roll units. Such simpler mechanisms are easy to install and operate.

The solvent-free, 100% solids silicone has a nominal viscosity in the 300 - 500 cps range but the viscosity can be varied to suit the applicator or the substrate. The silicone is cured by exposure to high powered UV room temperature. There is no loss of moisture from paper substrates. Remoistening units are not required.

Water-based emulsion pressure sensitive adhesives (PSA) may be used if that is desired, but these will require hot air drying, followed by remoistening. In these new processes the PSA is a hot melt coated by a slot die or other applicator. No drying is required, Present day hot melt PSAs can match most, if not all, of the performance characteristics of emulsion PSAs. Hot melts can also be run at speeds which match the high speed cure potential of some UV-curable silicone systems.

THE UV CURING TECHNOLOGY

UV curing offers a host of advantages for the production of release liners. The UV unit itself can be tailored to meet given cure speed requirements by installing lamps on a modular basis. In general, a recirculating hot air oven is between five and ten times as long as a UV unit. Since cure takes place at room temperature thin thermoplastic films can replace paper substrates where this is appropriate. Release film liners offer numerous advantages, including easy recyclability.

Papers with high `post consumer` waste content have been developed for release liners at significantly reduced cost. Thermal cure silicones are, however, often poisoned by such inclusions and these bases cannot be run on conventional processes. UV formulations are available that give good cure performance regardless of the waste content.

INDUSTRY INTEREST

Whilst large volume producers of s/a laminate are interested in these processes the focus of attention is on the smaller volume, narrow width manufacturers of laminate, producing a wide variety of products. In particular, off-line producers of s/a label and other laminates are actively evaluating this technology.
In this case bought-in release liner some 1000 - 1600 mm wide is coated with adhesive, usually with emulsion, before laminating to the face material.

Label printer/converters are also showing interest; some have already made purchasing decisions. The UV silicone/PSA combination offers cost reductions, and a much wider choice of laminate material and design.

Business form producers now use this technology to make new and innovative products incorporating s/a features. The key element for the narrow width converter is the ease with which this new technology can be retrofitted on to existing process lines. Despite the obvious advantages offered by UV silicone and PSA they are regarded by some as a technologically daunting addition to an already sensitive train of processes requiring a high level of expertise and attention to achieve optimum process and product performance. In such cases the new processes can be assembled in a separate area dedicated to manufacturing either the release liner alone, or the complete laminate, to benefit from their advantages. This route is of prime importance to label converters.

CONCLUSION

The combination of UV silicone and HMA gives the s/a laminate industry in all its varied forms a tool to build higher performance diversity and added value into its product ranges. The extent to which this is done is limited only by the imagination.

REVIEW OF LIKELY FUTURE TRENDS IN PACKAGING ADHESIVE TECHNOLOGY

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Swift Adhesives

Until recent times, that is the last 3-4 years the development of adhesives for packaging applications was usually dictated by four main parameters.

PERFORMANCE
ECONOMICS
ENERGY
END USE

To these parameters has now been added ENVIRONMENTAL AND HEALTH ISSUES which in particular encompasses the disposal of adhesive residues and the recycling characteristics of the applied adhesive on the various substrates utilised.

PERFORMANCE Improvements will be governed by the changing requirements of the end product, the machinery involved in the packaging operation and the substrates utilised to form the packaging.

ECONOMICS Will lead to utilising products with the best cost/performance capabilities. Good mileage, good cleanup, less down time often scores over price/kg.

ENERGY Requirements will be reduced by utilising less solvent and less Hot Melt adhesives. As application machinery becomes more sophisticated, water based and low application temperature hot melt will gain ground.

END-USE Specific adhesive grades are designed to suit various end use environments eg deep freeze, high moisture (ice-proof). Adhesives will be developed with wider performance windows to allow use over wide temperature range. Products are currently available for deep freeze/microwave packs.

ENVIRONMENTAL AND HEALTH ISSUES

These will have the greatest influence over formulation technology in the next few years. Particular items to address will include.

1. Returnable Packaging
2. Solvent Free
3. Plasticiser Free
4. Formaldehyde Free
5. Lower Volatile Organic Component (VOC) contents
6. Returnable Plastic Bottles
7. Recycled Board
8. Disposal of Adhesive Residues

This paper will consider the effect of these items on selected Packaging and Converting markets. viz

1. Labelling
2. Case and Carton Sealing
3. Cigarette
4. Corrugating
5. Tissue Converting
6. Film lamination
7. Bookbinding

CONCLUSION

The paper has outlined the likely future trends in packaging adhesive technology and laid particular emphasis on the effect of ENVIRONMENTAL and HEALTH ISSUES.