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ABSTRACT

Unique hot melt adhesives have been formulated for adhesion to dense and recycled corrugated. The adhesive offers improved elevated temperature performance, improved subambient adhesion, excellent thermal stability, and low density. Current typical hot melt adhesives for packaging are designed for use at temperatures around 177°C. A new generation of hot melt adhesives can be applied at 111°C. The advantages of this include reduced risk of thermal burns, lower energy costs, less odor, improved thermal stability, and longer equipment life.

Application:

A comparison of conventional, new technology, and reduced application temperature adhesives. The criteria for today's hot melt adhesives—and how each product meets them—are described.

New developments in case and carton sealing hot melt adhesive technology

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THE DEMANDS BEING PUT ON packaging hot melt adhesives are becoming increasingly more stringent. As hot melt users push their production equipment to new productivity records and use increasingly demanding substrates, innovative new packaging hot melt adhesives are required. Many users of hot melt adhesives are realizing cost savings and corrugated source reduction by using recycled and high-performance linerboard. This board offers cost savings to purchasers but presents them with new adhesion challenges. High-performance linerboard is more dense than standard board, and the surface morphology is characterized by a more closed structure. Yet another challenge to the adhesives industry is recycled linerboard used in corrugated manufacturing. Recycled linerboard is characterized by shorter fiber length, reduced surface porosity, and the presence of chemical additives. Hence, an improved adhesion new technology hot melt ahesive (NTA) is required. Typically, as improved adhesion is formulated into a packaging hot melt, it comes at the expense of heat resistance, thermal stability, and set speed. The first part of this paper addresses the described need with an innovative adhesive characterized by a unique mix of properties.

The second part of this paper addresses a new advance for packaging hot melt adhesives, 121°C application temperatures. This innovation will address the issues of cost savings for adhesive users, improved safety, less volatility, improved pot life, and less production downtime for the adhesive user. Only as more high-melt-index polymers have become readily available has this idea been transformed into reality. Many advantages can be gleaned from this new technology by the user, but the user must be properly sensitized to the *differences* between running a hot melt designed to be used at 177°C and a hot melt designed to be used at 121°C. Subsequently, a marketing program was developed to both promote and educate potential users. This need was addressed by an interactive and informative computer program distributed to potential hot melt users.

NEW TECHNOLOGY HOT MELT ADHESIVE

A unique combination of properties characterizes NTA. In light of the increased presence of recycled and high performance linerboard, new adhesives with improved adhesion as their cornerstone property are a must. Users of hot melt adhesives demand full fiber tearing bonds to ensure the integrity of their package as it experiences the rigors of shipping. Shipping conditions can be as high as 57°C in summer months and as low as –34°C in winter months. Packaging hot melt adhesive users expect one product to meet this wide performance requirement and also to adhere well to high-performance or recycled corrugated.

Table I illustrates the performance properties of conventional EVA and polyethylene hot melt adhesives vs. the NTA. All adhesives are characterized by low viscosity at the application temperature to facilitate good machining. Heat resistance is characterized by a heat stress test that combines heat resistance and adhesion properties in one test procedure. It can be seen that the NTA outperforms both the conventional EVA and polyethylene adhesives. Adhesion testing with the three adhesives on virgin corrugated and high-performance linerboard shows distinct advantages of the NTA. Full fiber tear at –18°C clearly separates this adhesive from the conventional EVA and polyethylene hot melts. Additionally, on virgin corrugated, full fiber tear is realized at temperatures as low as –34°C; the conventional adhesives showed no fiber tear at that temperature. While adhesion is enhanced, set speed of the NTA is not affected. It is identical to the set speed of the conventional adhesives tested.

Test	New technology adhesive	Conventional EVA adhesive	Conventional polyethylene adhesive
Viscosity, cP (177°C) [a]	850	900	1000
Heat stress, °C [b]	57	46	54
Adhesion to virgin corrugated [c]			
Minimum full fiber tear temp., °C	-34	-18	+2
Adhesion to high-performance linerboard (-18°C)	Full fiber tear	Partial fiber tear	No fiber tear
Thermal stability[d]			
72 h at 177°C	No char	Slight char	Gel
Appearance, %	+0.5	+5	+1200
Δ Viscosity			
Set speed, s [e]	1.5	1.5	1.5

[a]Viscosity measured using a Brookfield RVTD viscometer using a SC4-27 spindle.
[b]Heat stress is a cantilever heat resistance test that gives a joint measurement of adhesion and elevated temperature resistance. A 6 in. x 2 in. corrugated sample isbonded across the 2 in. dimension with 2 in. overlap. A 300-g weight is placed at the far bond end while the rear bond is clamped in a test apparatus. The entire apparatus is placed in a constant temperature oven for 24 h. Value reported is the highest temperature bonds pass.
[c]Standard virgin corrugated, 300 lb burst strength.
[d]Glass vessel, covered.
[e]Measured in a 3-mil adhesive film.

I. Improved performance packaging hot melt adhesive properties

Density has been identified as an important parameter for separation of the adhesive from paper fibers in the repulping process. Hot melt adhesives with density less than 0.98 g/cm^3 have proven to be more easily separated from pulp at repulpers equipped with reverse cleaners[1]. The proposed NTA is not only lower in density than the conventional EVA hot melt adhesive, but below that threshold limit. See **Fig. 1** for details.

Figures 2 and 3 show the improved heat and cold resistance of the NTA vs. conventional adhesives. Improvements in elevated temperature performance and cold temperature performance provide tangible benefits for hot melt adhesive users. Having one adhesive for unsurpassed year-round performance is a distinct advantage.

Thermal stability is an adhesive's ability to resist degradation in the molten state. Degradation can appear as edge ring char, sedimentation char, volatile char, gelation, or viscosity change. The NTA offers the user char-free properties, no gelation, and minimal viscosity change. **Figures 4 and 5** show the NTA to undergo a trivial 0.5% viscosity change after 72-hour exposure at 177°C, and 3% viscosity change after 300-hour exposure at 177°C. Comparing this impressive thermal stability property to that of the EVA and polyethylene adhesives clearly illustrates the long-term stability superiority of this NTA. For the hot melt user, this means trouble-free adhesive usage. Excellent thermal stability contributes to fewer clogged nozzles, minimal viscosity fluctuation, resistance to hot spots in a melt tank, and reduced production downtime.

It is clearly a unique adhesive that boasts performance advantages in heat resistance, cold resistance, adhesion to recycled and high performance linerboard, and unsurpassed thermal stability while maintaining the same fast set speed as the conventional EVA and polyethylene hot melt adhesives.

REDUCED APPLICATION TEMPERATURE HOT MELT ADHESIVE

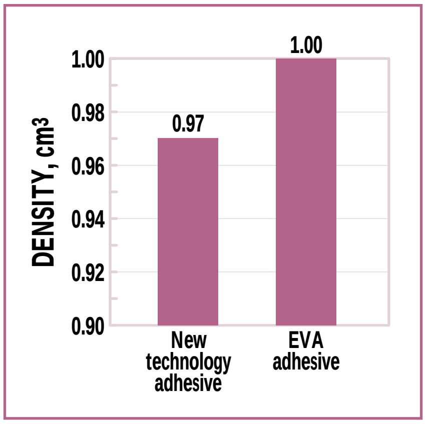
Typically, packaging hot melt adhesives are applied at approximately 177°C. A new generation of hot melt adhesives that can be applied at 111°C and offer no compromise in performance when compared with typical 177°C hot melt adhesives has been developed. Formulating these adhesives was challenging, as was planning the product launch. To most effectively promote this new generation of adhesives and educate the potential users, an interactive computer program was developed and distributed. The computer disk was offered in lieu of the more conventional written promotional information. Advantages to this type of marketing tool are: interactive learning on behalf of the user, longevity of the advertisement (installed on the user's hard disk), and less waste upon disposal.[2] The computer disk served as a one-stop source for relevant technical data, sales informa-

[1] Arnold, J. M. and Wise, E. M., *TAPPI 1992 Hot Melt Symposium Proceedings*, TAPPI PRESS, Atlanta, p. 31.

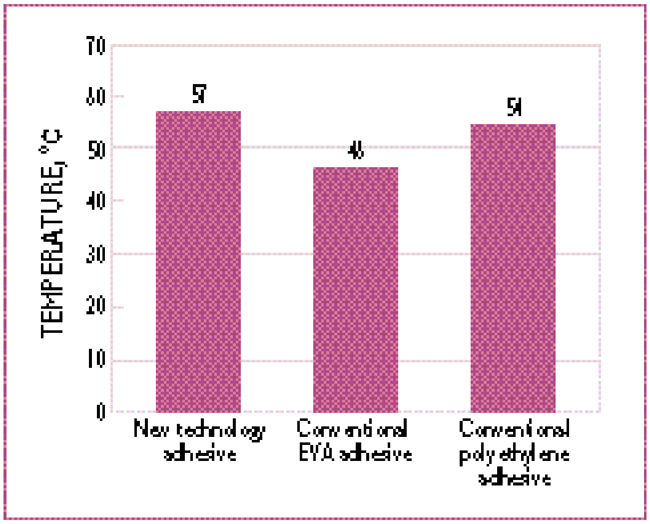
[2] Cherubini, V., *TAPPI 1994 TAPPI Hot Melt Symposium Proceedings*, TAPPI PRESS, Atlanta, p. 137.

121°C Test	Typical 177°C hot melt	hot melt
Viscosity, cP	1000 at 111°C	900 at 177°C
Heat stress, °C	46	46
Adhesion to virgin corrugated		
Minimum full fiber tear temp., °C	-18	-18
Thermal stability		
72 h at app. temp.	No char	Slight char
Appearance, %	Minimal color change	Very dark amber color
Δ Viscosity	0	+5
Set speed, s	1.5	1.5

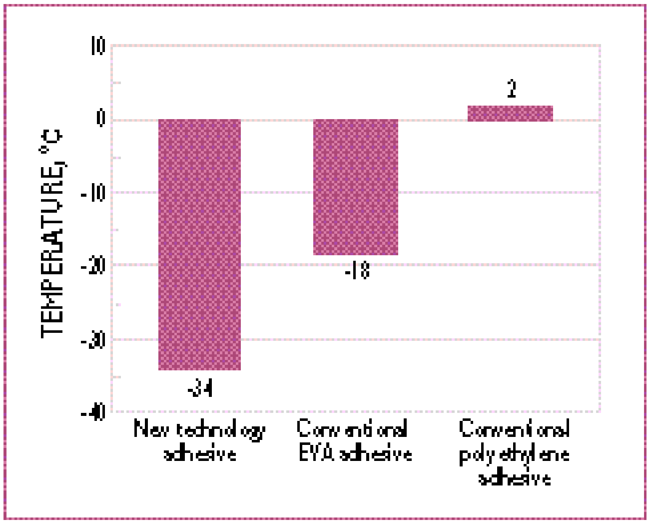
II. Reduced application temperature packaging hot melt adhesive properties



1. Density of new technology adhesive vs. EVA adhesive



2. Adhesive heat resistance



3. Adhesive cold resistance

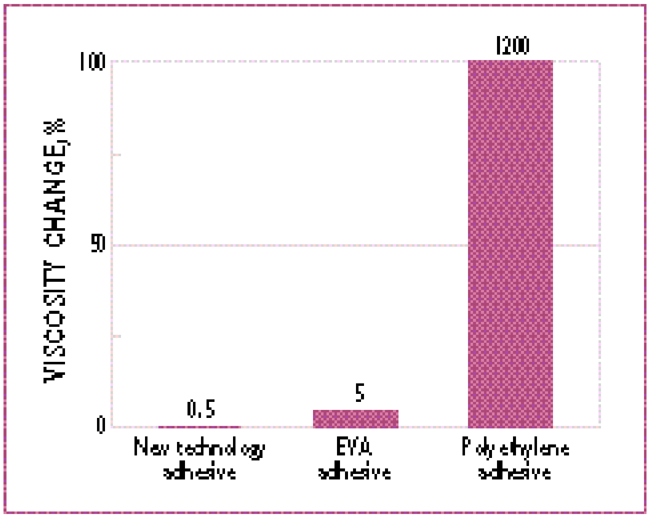
tion, features and benefits summary, and interesting company background information. This unique, high-tech product launch complements the new advance in adhesive technology. Both the computer program and the lo- application-temperature hot melt adhesive have gained market acceptance.

KEYWORDS

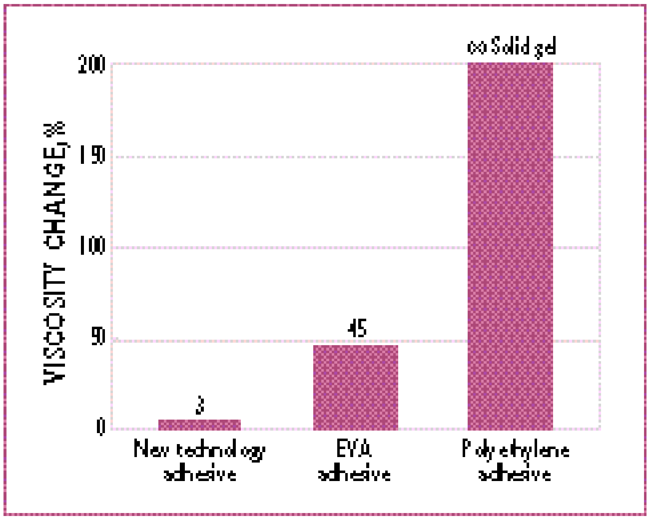
Adhesives, bonding strength, boxes, hot melts, low temperature mechanical properties, packaging, paperboard containers (paper board containers), rheological properties, sealants, temperature, thermal properties, thermal stability, viscosity.

Table II illustrates the very comparable performance data of the 121°C hot melt adhesive and the 177°C hot melt adhesive. Both display low viscosity at their respective application temperatures, yielding excellent machinability. Heat resistance and cold resistance of the conventional adhesive and the low application temperature adhesive are very comparable and acceptable for the bulk of packaging applications. Similarly, the set speeds of the adhesives are identical.

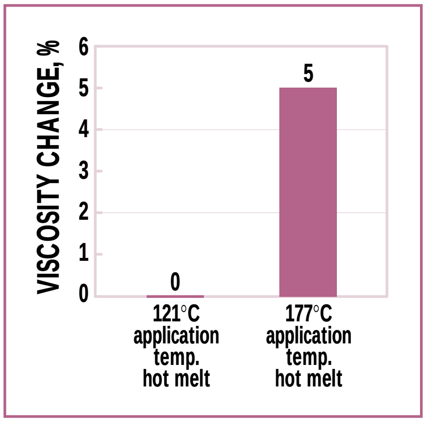
Thermal stability of the low application temperature hot melt adhesive offers a solid advantage over conventional hot melt adhesives. No char, minimal color change, and 0% viscosity change in 72-hour testing at application temperature test conditions make the reduced application temperature hot melt adhesive very desirable from a user's perspective. (See **Figs. 6 and 7**.) Viscosity change of the reduced application temperature hot melt adhesive after 300-hour aging at application temperature was <1%. For a typical 177°C application temperature hot melt adhesive, viscosity change



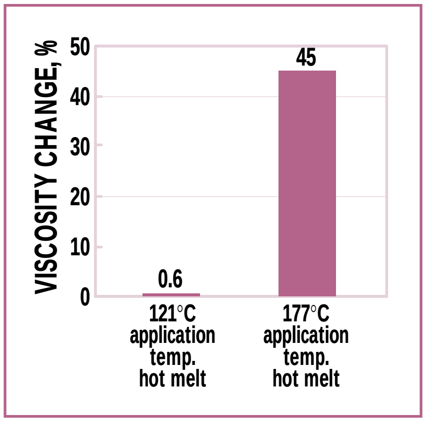
4. Adhesive viscosity change after thermal aging 72 h at 177°C



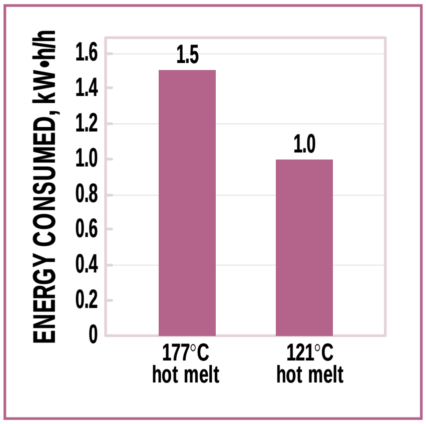
5. Adhesive viscosity change after thermal aging 300 h at 177°C



6. Adhesive viscosity change after thermal aging for 72 h at application temperature



7. Adhesive viscosity change after thermal aging for 300 h at application temperature

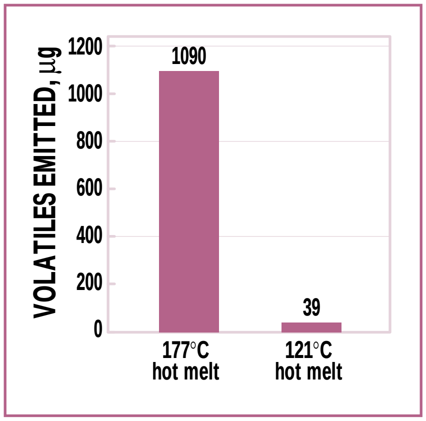


8. Energy consumption of hot melts. Average over 72-h measurement period.

over 300 hours is approximately 45%. Having a product that undergoes no viscosity change offers a user the ultimate in machining consistency. The lack of char also is assurance that the hot melt adhesive will not cause production loss at the user's plant. Lost production can be devastating to packaging hot melt users, since their equipment will typically run between 100 and 400 cartons per minute, so each minute is precious to a production facility, and keeping the equipment running is paramount.

Figure 8 graphically depicts the 30% energy savings associated with running hot melt equipment at 121°C vs. 177°C. Testing was performed over a 72-hour time frame using Nordson equipment. Very real and significant cost savings can be linked to the use of hot melt adhesives at lower application temperatures.

Additionally, hot melt volatile emissions are significantly reduced, as seen by the data in **Fig. 9**. Volatile emissions are the cause of strong odors. The reduced application temperature hot melt adhesive emits 96.5% less volatile emissions than 177°C application temperature hot melt adhesives. Gas chromatography testing showed the 177°C hot melt adhesive to emit 1090 µg of volatile emissions, and the 121°C hot melt to emit 39 µg of volatiles after heating 100 g at operating temperature for 1 hour.



9. Hot melt volatile emissions—100 g of hot melt heated to operating temperature for 1 h.

Precautionary measures should be taken with any hot melt adhesive, whether it is applied at 121°C or

177ºC. Always wear proper protective equipment to minimize the risk of burn. The safety aspect, however, of using a hot melt adhesive at reduced application temperature is an important consideration for hot melt users. Lost time accidents are a great hindrance to both employers and employees. Minimizing worker exposure to hazards is a sure way for employers to minimize the number of lost-time accidents in the workplace. Lowering the temperature of the adhesive tank is a good place to start. While safety is often difficult to quantify, anyone who has experienced a thermal burn caused by a hot melt adhesive will appreciate the improved safety of a reduced temperature hot melt adhesive.

CONCLUSIONS

New packaging technologies offer improved performance for value-added applications.

A new technology hot melt adhesives (NTA) offers the following advantages:

- Low viscosity
- Enhanced adhesion to virgin, recycled, and high-performance board.
- High heat resistance
- Excellent cold-temperature performance
- Superb thermal stability at 177°C
- Low density.

Low application temperature hot melt adhesive offers the following:

- Application temperature of 121°C
- Low viscosity
- Unsurpassed thermal stability
- Low odor
- Reduced energy consumption
- Improved plant safety. **TJ**

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