

Novel Concept to supply Hot Melt Pressure-sensitive Adhesives

Novamelt GmbH: Harald Braun, Marko Beitmann

Fourth European Tape & Label Conference; May 16th- 18th, 2001; Munich/Germany

1. Introduction

Ecological aspects and the increasing acceptance of hot melt pressure-sensitive adhesives (HMPSAs) for the production of label stock and tapes are going to result in an extraordinary growth in this branch of technology.

The special requirements for the labelling of food packages such as strong adhesion even on moist, non-polar surfaces at low temperatures, the increasing demand for logistic labels and many other aspects are pushing forward the use of HMPSAs for label stock constructions. In addition, the tape industry does more and more consider the HMPSA technology a good alternative to solvent-based adhesives. Recent developments in the field of HMPSAs help to advance the use of these products. As a consequence, coating units for HMPSAs or combined coating machines for hot melts and water-based adhesives are favoured nowadays whenever investments are made to replace existing equipment or to establish new production sites.

It has been a tradition within this industry to perform both the development and the production of solvent-based and partially even of water-based adhesives. This situation is constantly changing in the domain of HMPSAs. Compared to the manufacturing process of solvent-based and water-based adhesives, the economic production of hot melts requires large investments. To allow a cost-effective in-house production, very large quantities have to be manufactured. Since Novamelt, a specialist in adhesive production, has taken the necessary steps, it can offer hot melts on favourable terms.

One of the most important restrictions for the economic use of purchased HMPSAs in large industrial productions are the available delivery forms. While water-based adhesives are usually taken out of tanks and conveyed to the 1 to 2 m wide coating units, HMPSAs are habitually supplied in drums or blocks. This demands the time-consuming use of drum and block melters respectively, which has always been a crucial limitation for coating widths and coating speeds.

Novamelt does not see any significant reason why a coating unit for HMPSAs could not have a width of 2 m and be operated at a speed of 600 to 1000 m/min, all the more that such a lay-out would make the energy-consuming drying and the installation of very long dryers unnecessary. The only condition to be fulfilled for such a high-performance installation is the liquid supply of the HMPSAs in bulk containers.

The technical and economical advantages of tank supplies are summarised in figure 1.

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Figure 1: Technical and economical advantages of bulk container supply

- Reduced handling costs in hot melt manufacturing and coating process.
- Plug and ready for coating.
- No packaging waste and waste disposal.
- No storage requirements for drums and blocks on both sites.
- Energy savings as HMPSAs do not have to be re-melted.

Why has the adhesive industry been reluctant up to now to deliver hot, liquid HMPSAs for label stock and tape productions? Figure 2 lists the requirements for supplying HMPSAs in liquid form.

Figure 2: Requirements for liquid deliveries of hot melts

- Thermal stability of HPMAs in a temperature range of 130 to 150 °C for approx. 21 days.
- Minimum demand of 2 deliveries per month to allow alternation of tank trucks.
- Suitable feeding equipment on site.

In the past, the main obstacles were the lack of thermal stability of HMPSAs designed for label stock and tape applications as well as the monthly minimum demand, which is indispensable to grant an economic operation.

During the past years, Novamelt has developed a solution to sufficiently thermally stabilise HMPSAs for label stock applications in order to allow transport in bulk containers. Furthermore, its automated high-tech production plant has been fitted with the equipment required for filling tank trucks.

In the following, you will get to know the measurements for stabilising HMPSAs as well as the modifications that have to be carried out at the converter lines.

2. Thermal stability

Bulk tank supply of water-based PSAs as well as of hot melts based on EVA-, amorphous poly-alpha-olefin- and acrylic technology are currently the most efficient basis for high-volume productions of label stock, tape and diaper applications.

However, the limitation in thermal stability of HMPSAs based on thermoplastic copolymers such as styrene-isopren and/or styrene-butadien block copolymers prevented large users from converting such HMPSAs in hot, liquid form. In the past,

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thermal decomposition of ingredients occurred – resulting in higher viscosity, darker colour and change of physical properties. Novamelt has developed thermally stable thermoplastic rubber-based HMPSAs which can be supplied to the label stock industry in heatable mobile tanks.

Novamelt guarantees a thermal stability and an unchanging physical behaviour for an ageing period of 21 days in a temperature range of 130 to 150 °C. This achievement is the result of extensive research work in our laboratories and various industrial trials. It can give the converter all the benefits he knows from other adhesive systems supplied in tank trucks.

2.1. Thermal stability of conventional SIS/SBS-based HMPSAs

Figure 3 lists the negative effects of thermal degradation on conventional SIS- and/or SBS-based HMPSAs.

Figure 3: Thermal stability of conventional thermoplastic rubber-based HMPSAs

- Skin and gel formation.
- Darkening of colour.
- Viscosity decrease followed by a strong viscosity increase.

HMPSAs of the former generation, which are used for different industrial applications, show a limited thermal stability just after a few days at a typical temperature range of 130 to 150 °C. After this short ageing time, thermal degradation can be recognised in skin and gel formation, a decrease and a subsequent strong increase of viscosity and the change of colour. The thermal degradation has such a negative impact on product conversion properties that it is impossible to present any values or charts.

As a consequence, Novamelt developed a new line of thermally stable thermoplastic rubber-based HMPSAs which can also be supplied in hot, liquid form.

2.2. Thermal stability of modified SIS/SBS-based HMPSAs

In a first step, Novamelt evaluated in a screening programme a variety of stabiliser systems offered by the industry. As a typical formula, Novamelt® PS 2029 was selected as this product is widely used for label stock constructions. This formula does traditionally contain an SIS/SB blend, tackified with a combination of rosin-ester tackifiers and hydro-carbon resins and modified with plasticisers. The ageing tests were performed both under normal air conditions and in a nitrogen atmosphere for a period of

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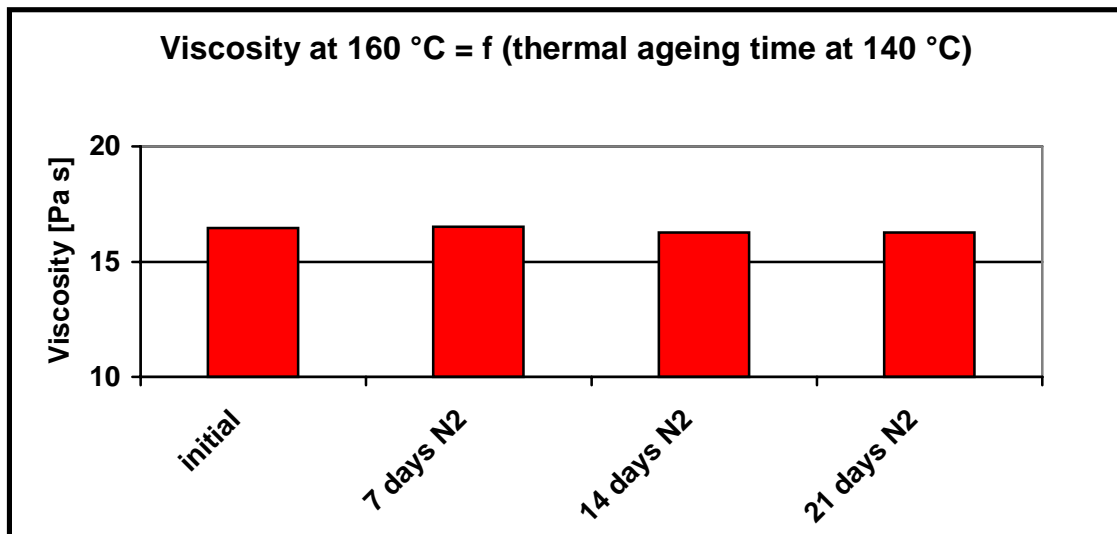
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21 days at 130 and 140 °C in a 1-litre tin can in an oven. This first test series showed the necessity of an inert gas atmosphere as all test samples exposed to air showed skin and gel formation after a maximum of 7 days, depending on the used stabiliser package. Under a nitrogen blanket, 10 days of ageing could be accomplished without a change of the product performance.

Together with experts in the stabiliser industry, new stabiliser packages were developed to grant ageing periods of at least 21 days at the above mentioned temperature range. We found new stabiliser combinations that led to the desired ageing behaviour.

In a next step, a scale-up process was performed with 5 tons of the differently stabilised HPMSA version Novamelt® PS 2029 T. The storing and ageing of this quantity took place in an industrial heated mobile tank at 140 °C and under a nitrogen blanket. We took samples after 7, 14 and 21 days to control the physical data. The results can be seen from figures 4 and 5.

Figure 4: Viscosity at 160 °C = f (thermal ageing time at 140 °C)



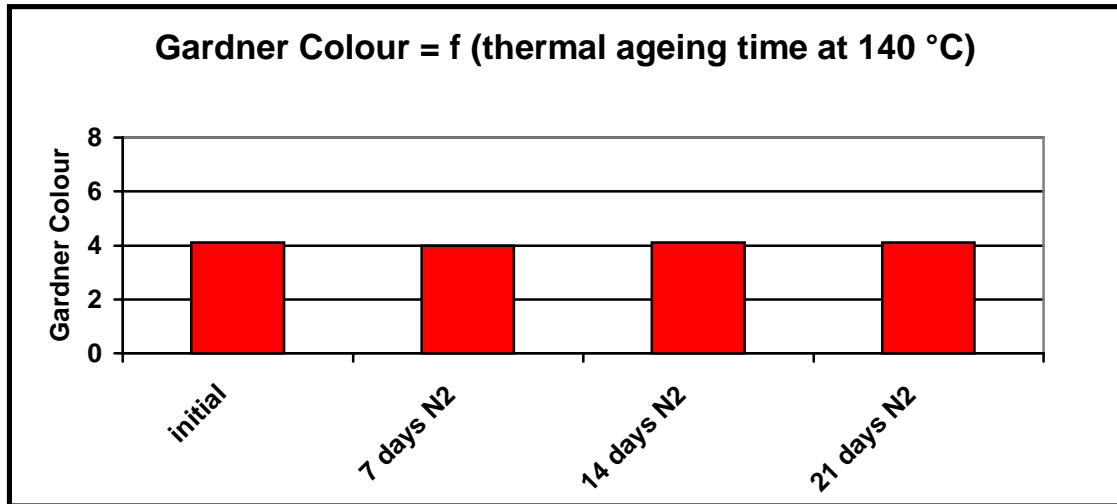
The above diagram underlines that the viscosity of Novamelt® PS 2029 T remained almost unchanged for a period of 21 days. Furthermore, the differently stabilised product Novamelt® PS 2029 T did not show any skin and/or gel formation during the ageing process.

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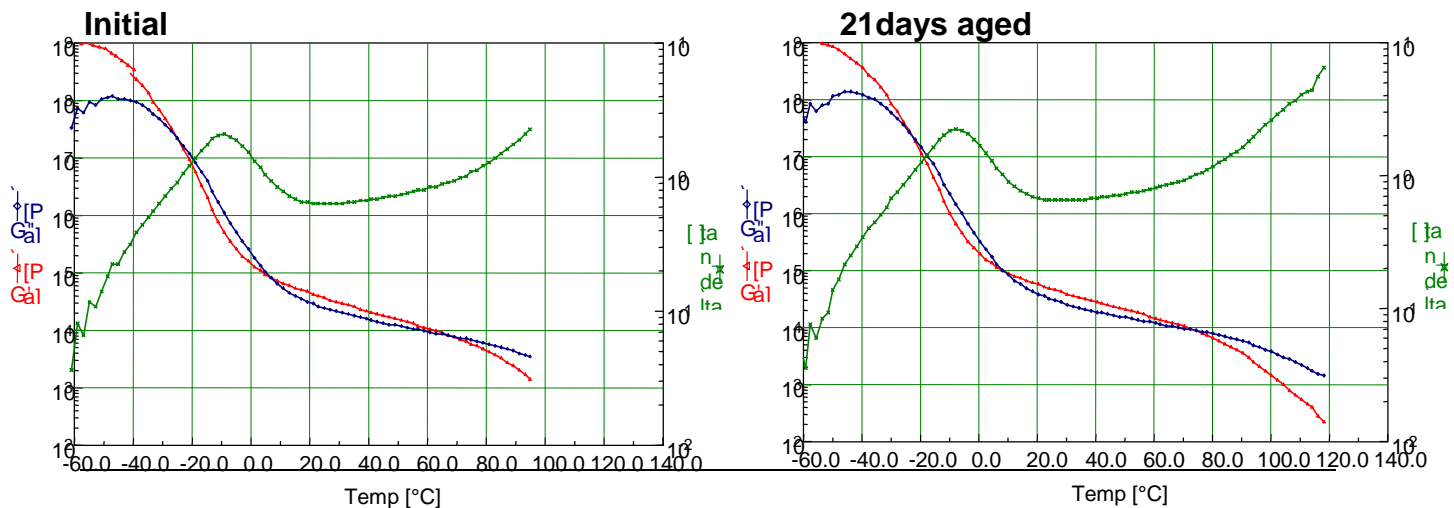
Figure 5: Gardner Colour = f (thermal ageing time at 140 °C)



The Gardner Colour was stable during the entire testing time, which indicates that no oxidation or chemical degradation occurred.

The initial results showed, that the conversion properties had not changed. However, with regard to the final applications, it was more important to find out if there were any changes of the PSA properties after coating, that means to which extent peel-, tack- and shear-values might be affected. We used DMA-analyses, which have become a valuable method in our industry to detect possible changes in mechanical properties of adhesives and allow us to forecast PSA properties and die cutting behaviour of label stock adhesives. For figure 6, the shear modulus G' and G'' as well as the tan delta of Novamelt® PS 2029 T version have been plotted in a temperature range from -60 to +120 °C.

Figure 6: DMA figures initial and thermally aged for 21 days at 140 °C



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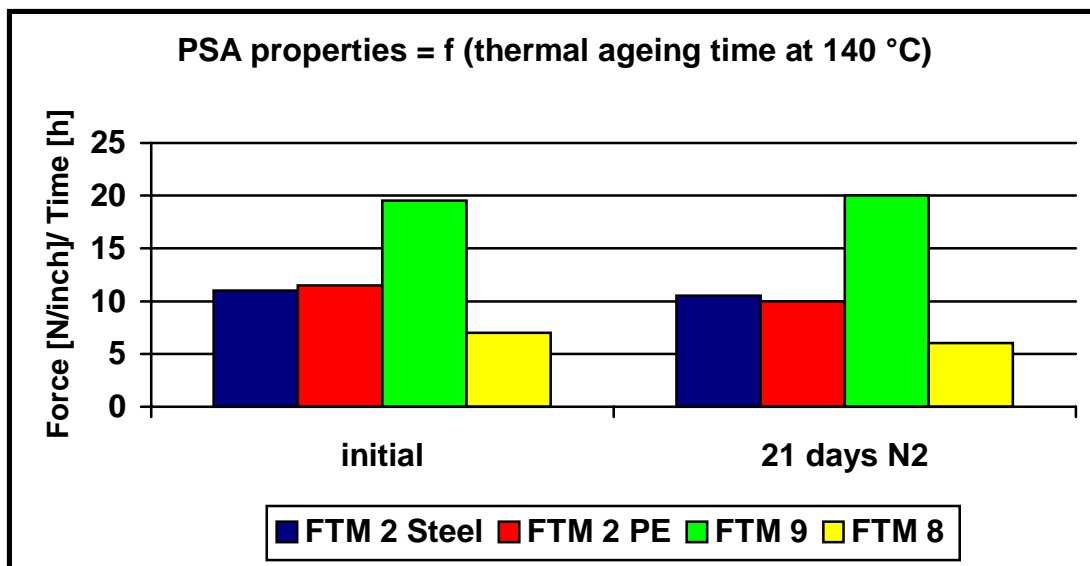
Figure 6 illustrates impressively that, across the plotted temperature range, the mechanical properties were no longer influenced by the ageing process. The identical behaviour around the G' and G'' plateau underlines that we could expect unchanged die cutting and PSA properties.

In addition to the DMA-analyses, we evaluated the PSA performance on coated label stock constructions. Novamelt® PS 2029 T non-aged and aged material was coated on Vellum 80 gsm using a coating weight of 18 gsm. The samples were measured in accordance with the following FINAT test methods:

- Peel adhesion 90° on steel and PE as per FTM 2, dwell time 20 min [N/inch].
- Loop tack on glass as per FTM 9 [N/inch].
- Shear adhesion on steel as per FTM 8 at 23 °C, 1000 g load per square inch [h].

In figure 7 we have summarised the measured PSA data.

Figure 7: PSA properties = f (thermal ageing time at 140 °C)



Novamelt has also evaluated other HMPSA formulas in their existing programme to see to which extent the new stabilisation technology can be transferred to other recipes. Its permanent HMPSA product range for label stock applications can already be supplied in heatable mobile bulk containers of 24 tons. Novamelt is currently working on the adaptation of this technology to its tape range as well.

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Novamelt invested in all the necessary equipment to fill HMPSAs in hot, liquid form safely into the bulk containers and to apply a nitrogen blanket. A system concept featured by Novamelt will help converters to define how to adapt their existing coating plants in order to secure a continuous coating process.

3. Modification of existing coating lines

What are the important criteria for a continuous coating process using hot HMPSAs in liquid form from a mobile bulk container? Figure 8 mentions all relevant parameters for the planning phase.

Figure 8: Required parameters

- Volume or mass flow, which is defined by coating width, weight and speed.
- Difference between product temperature in bulk container and coating temperature.
- Heat capacity figures of HMPSA type.

The most important parameters are the mass flow and temperature differences to be adapted. For example, a coating line with a width of 1 m and a line speed of 300 m/min requires a mass flow of 324 kg/h for a coating weight of 18 gsm; for a line with a width of 2 m running at 450 m/min and for the same coating weight, a mass flow of 972 kg/h is requested.

As the temperature in the bulk container will be approx. 130 to 140 °C and the coating temperature is approx. 170 °C the above mass flow has to overcome a temperature difference of 30 to 40 °C.

There are basically two design concepts to adjust the coating temperature. One option is the use of a dual-tank system. While the coating machine is charged from the first, pre-filled and temperature-adapted tank, the second tank is filled. The main disadvantage of this concept is the time needed for filling and adjusting the temperature at the beginning of the coating process.

Novamelt prefers the use of a heat exchanger system in order to provide a continuous mass flow and coating temperature of the HMPSAs. Figure 9a is a CAD drawing of such a continuous supply concept. The relevant components are listed in figure 9b.

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Figure 9a: CAD-Drawing “Providing a continuous flow of HMPSA”

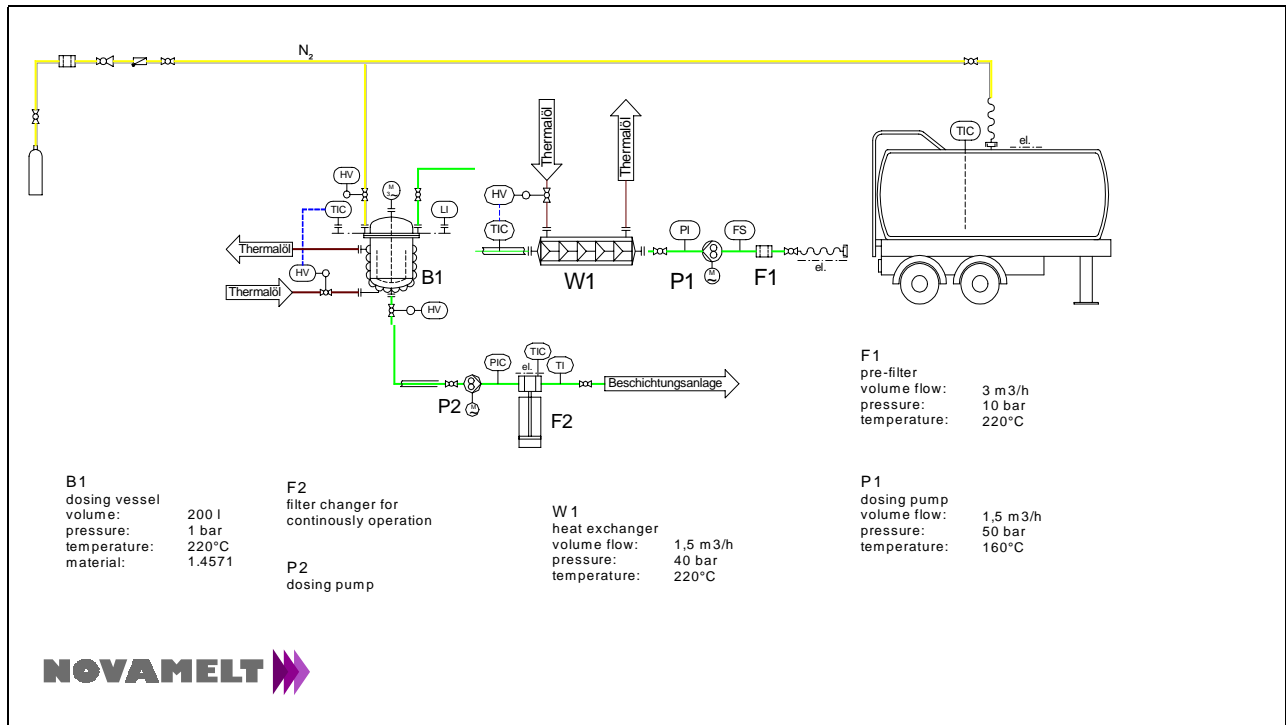


Figure 9b: Components for modification of existing coating lines

- Bulk container connected to flexible, heatable pipe with pre-filter and dosing pump.
- Connection to Nitrogen inertisation (required when emptying the container).
- Heat-exchanger.
- Buffer vessel with filling level probes, connected to filter changer and dosing pump.
- Coating head.

The new HMPSA supply concept for industrial production of label stock constructions is ready for use. Now it is up to you to take advantage of this new supply method in order to improve productivity in your HMPSA coating process. Novamelt as your experienced partner in HMPSA technology will be pleased to discuss the details with you.