The use of low molecular weight Polyethylene in HMA

1. What is a HMA?

A hot melt adhesive (HMA) is a thermoplastic compound that is applied in its molten form. It forms a bond with the substrate it is applied on and cures by cooling. The main advantages of a HMA are:

- No volatiles
- Fast setting
- Low penetration of substrate
- Water insensitive

A typical HMA consists out of an equal amount of polymer, a tackifying resin and a low molecular weight polyethylene (PE).

The packaging industry is the main market for HMA particularly box assembly, and case and carton sealing. These processes take place at a high speed and require the HMA to act fast.

The functions of the low molecular weight PE are:

- Viscosity reduction during manufacturing of HMA and during application.
- Increase the blocking temperature of HMA to prevent agglomeration during transport
- Affect the performance of the HMA:
  - Heat resistance ie the ability of the bond to withstand elevated temperatures
  - Quick setting times require for high speed packaging lines

2. Performance testing in hot melt adhesive formulation

Trecora Chemical used the services of an independent laboratory to benchmark the performance of Trecora Chemical's waxes with other commercially available waxes used in the hot melt adhesive industry.

2.1 HMA formulation

A standard formulation was used for this evaluation, which composed of:

Metallocene ethylene-octene copolymer	37%
Partially hydrogenated C5-resin	37.5%
Anti-oxidant	0.5%
Wax	25%

2.2 Waxes evaluated

The waxes evaluated were:

- FT1 – A hard Fischer-Tropsch wax with a high crystallinity and low viscosity.
- FT2 – A hard, high molecular weight Fischer-Tropsch wax
- BPPE – A by-product Polyethylene wax
- PE wax – A synthesized high molecular weight polyethylene wax
- Trecor HMA-1 – A narrow cut crystalline, high melting point by-product Polyethylene wax
- Trecor CWP400E – A high melting point by-product Polyethylene wax

2.3 Performance Tests and results

2.3.1 Viscosity at 177 °C (cP)

One of the main reasons waxes are used in hot melt adhesives is to reduce the viscosity of the blend. The viscosity comparison is shown in Figure 1

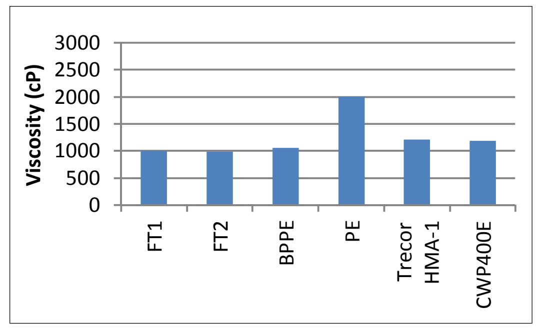
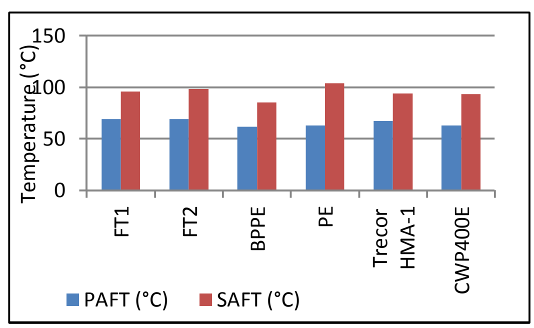


Figure 1: Viscosity comparison at 177 °C

2.3.2 Heat Resistance

The heat resistance is determined by measuring the shear adhesion failure temperature (SAFT) and Peel adhesion failure temperature (PAFT). Both tests involved measuring the temperature at which the adhesive bond fails under shear and peel stress when subjected by increasing temperatures in an oven. The results are depicted in Figure 2.



2.3.3 Cloud Point (°C)

The cloud point gives an indication of the compatibility of the system. An incompatible ingredient will settle out at a certain temperature in the HMA blend. A lower cloud point indicates better compatibility. Figure 3 depicts the cloud point analysis.

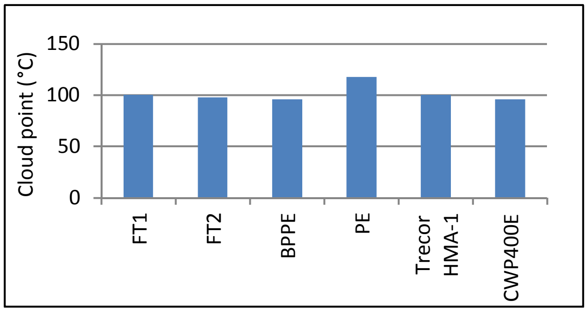


Figure 3: Cloud point (°C)

2.3.4 Mechanical Properties

The elongation (%) and tensile strength of the HMA were determined on an Instron tensile tester by casting dogbone samples. The results are depicted in Figure 4.

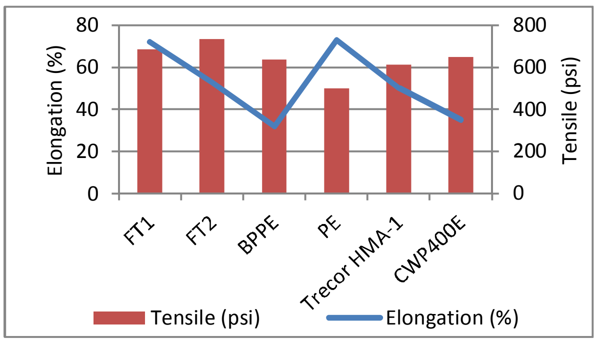


Figure 4: Mechanical properties

2.3.5 Thermal Stability

The thermal stability was measured by the change in Gardner color when the samples were placed in a forced air convection oven at 177°C for 100 hours. The change in color results are shown in Figure 5.

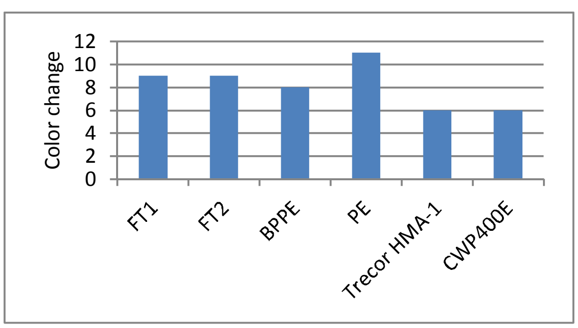


Figure 5: Color change after 100h at 177 °C

2.3.6 Speed of set

Table 1 summarizes the comparative set speed when compared to PE, which was given a set speed of "Fastest".

Table 1: Speed of set comparison

	FT1	FT2	BPPE	PE	Trecor HMA-1	CWP400E
Speed	Med fast	Med Fast	Slowest	Fastest	Med Fast	Medium

2.3.7 Bonding test

Bonding tests were performed on a white corrugated substrate. This substrate is standard in industry and estimated to be harder than average to bond. The amount of fiber tear was used as an indication of the quality of bond formed. It was categorized into the following:

FFT = Full fiber tearing bond (85-100%)

PFT = Partial Fiber tearing bond (50 – 84%)

SFT = Slight Fiber Tearing bond (20 – 49%)

NFT = No Fiber Tearing bond (0 - 19%)

The results are shown in Table 2.

Table 2: Bonding results on white corrugated substrate

	FT1	FT2	BPPE	PE	Trecor HM	CWP400E
-17°C	PFT	PFT	PFT	SFT	PFT	PFT
4 °C	FFT	FFT	FFT	PFT	FFT	FFT
25 °C	FFT	FFT	FFT	FFT	FFT	FFT

3 Discussion

These six waxes were tested for both physical properties and performance in a standard mPE polymer based formulation for the packaging application. All of these waxes, except for PE wax, gave a formulation that was comparable in viscosity. The viscosities were all about 1000 cPs, but the viscosity of the PE wax was twice this value. The high viscosity of the PE wax may suggest an interaction between the PE wax and the mPE polymer that is not desirable.

The set times measured show that the Trecora waxes are on par with the other waxes studied, with the PE wax being the fastest and the BPPE being the slowest. The heat resistance for the Trecor HMA-1 wax shows to be similar in PAFT to the FT1 and FT2, while the CWP-400 E is similar to the BPPE and the PE wax. The elongation of Trecor HMA-1 was equivalent to the FT2, but slightly less than that of FT1.

The thermal stability of the formulations with the Trecora waxes proved to be better than all of the other waxes in terms of color change and all of the formulations were very good with respect to viscosity stability. The one thing of note is that the PE wax sample darkened quite a bit more than the other samples.

The bonding performance of all of these products was about the same with the two waxes from Trecora performing quite well. It is safe to say that with this particular formulation, these waxes are comparable to the other waxes used in this study. The substrate used for this bonding test is standard in the industry and is estimated to be harder than average to bond.

4. Conclusion:

The Trecor HMA-1 and CWP400E showed that their performance attributes were comparable with FT1 and FT2 and better than the other waxes tested.