The use of low molecular weight Polyethylene Wax in PVC

1. Background

PVC is a thermally unstable polymer and in order to process it effectively at elevated temperatures, it needs to be compounded with a stabilizer system and other additives, including lubricants. All lubricants are inherently incompatible with PVC, and their function during processing depends on their degree of compatibility. Lubricants are often classified as internal or external.

2. Internal lubricant- Trecora OX18

An internal lubricant has a higher degree of compatibility with the PVC resin than an external lubricant, but less than a plasticizer, and acts on the surface between PVC grains during processing, as well as providing metal release at the die tip. This will enhance the surface gloss of the finished PVC product. Internal lubricants are usually incorporated at very low addition levels and tend to increase fusion torque. **Trecora's OX18** is an excellent internal lubricant due to the polar functionalities incorporated during the oxidation step.

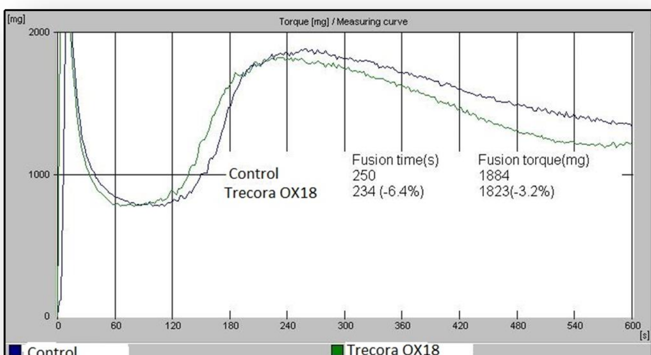

Figure 1: Brabender comparison

Figure 1 shows rheology curves using a torque rheometer comparing **OX18** with an industry standard. The testing was performed in a typical tin-stabilized system. **OX18** compares favorably with the industry standard.

3. External Lubricants – Trecor PVC; CWP400E

External lubricants are typically non-polar, low molecular weight hydrocarbons, and therefore incompatible with PVC resin. They reduce interparticle friction between PVC granules, and also between PVC granules and the walls of the processing equipment. This action controls the heat build-up and prevents rapid discoloration of heat sensitive PVC.

A very common problem in industry is over-lubrication, and this is typically due to the addition of high levels of external lubricant. The result is a product with low impact strength and gloss.

3.1 Comparative studies

A Brabender torque rheometer was used to compare the fusion behavior of three waxes as external lubricants:

- Trecora's CWP400E
- Trecor PVC-1
- High melt synthetic FT wax

The study was performed in a tin and Ca/Zn-stabilized system. Each lubricant was evaluated at 3 addition levels in these two systems.

The conditions to perform the rheology work were:

- Temperature: 190 °C
- Speed: 70 rpm
- Sample mass: 65 g

The samples were prepared using a blender (Bar Blender – Waring Commercial). All the ingredients were incorporated, except the lubricant. This was added afterwards to yield a sample mass of 65 grams.

3.1.1 Tin Stabilized system

The Tin base mix formulation is shown in Table 1.

Table 1

	Phr
PVC	100
Stabilizer (methyl tin mercaptide)	0.40
CaCO3	3.00
TiO2	1.00
Calcium Stearate	0.60
Ox PE	0.20

The lubricants were added at the following addition levels:

- 0.5 phr
- 0.7 phr
- 0.9 phr

3.1.2 Rheology results

Figure 2 shows the comparison of the Brabender curves at 0.7 phr lubricant addition.

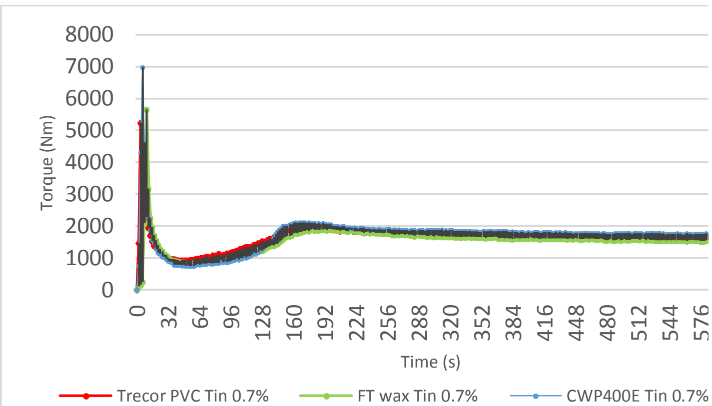

Figure 2: Fusion curve comparison at 0.7 phr

The fusion time, fusion torque and equilibrium torque values are shown in Tables 2, 3 and 4 respectively.

Table 2: Fusion time (s) comparison

Level (phr)	0.5	0.7	0.9
CWP400E	108	162	230
Trecor PVC-1	118	180	296
FT wax	86	180	248

Table 3: Fusion torque (Nm) comparison

Level (phr)	0.5	0.7	0.9
CWP400E	2537	2098	1911
Trecor PVC-1	2491	1934	1718
FT wax	2440	1880	1680

Table 4: Equilibrium torque (Nm) comparison

Level (phr)	0.5	0.7	0.9
CWP400E	1884	1747	1591
Trecor PVC-1	1896	1633	1521
FT Wax	1890	1531	1510

The fusion time comparison is graphically depicted in Figure 3.

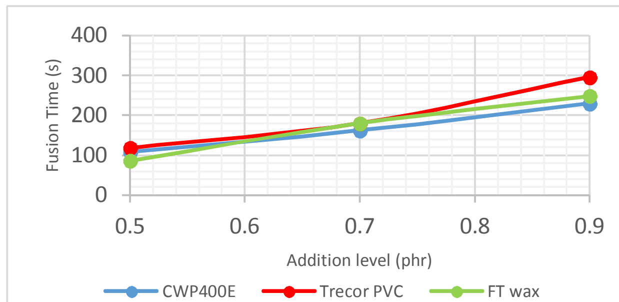

Figure 3: Fusion time comparison

3.2.1 Ca/Zn stabilized system

The Ca/Zn base mix formulation is shown in Table 5.

Table 5: Ca/Zn base mix

	Phr
PVC	100
Stabilizer	2.0
Impact Modifier	1.0
CaCO3	3.0
TiO2	1.0
Calcium Stearate	0.8
OX PE	0.2

The lubricants were added at the following addition levels:

- 0.5 phr
- 0.7 phr
- 0.9 phr

3.2.2 Rheology results

Figure 4 shows the comparison of the Brabender curves at 0.5 phr lubricant addition.

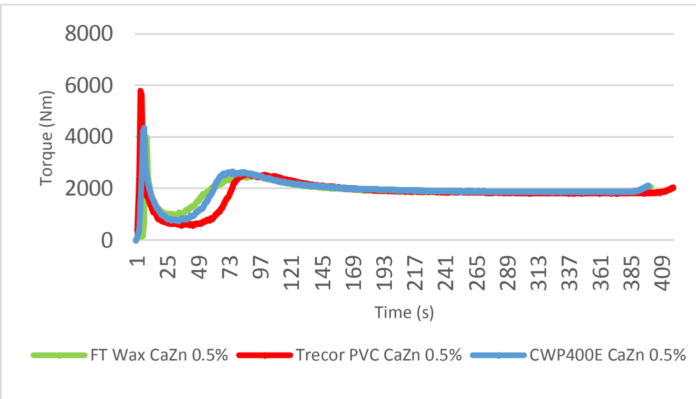

Figure 4: Fusion curve comparison at 0.5 phr

The fusion time, fusion torque and equilibrium values are shown in Table 6, 7 and 8 respectively.

Table 6: Fusion time (s) comparison

Level (phr)	0.5	0.7	0.9
CWP400E	152	230	236
Trecor PVC-1	178	280	316
Ft Wax	176	346	384

Table 7: Fusion torque (Nm) comparison

Level (phr)	0.5	0.7	0.9
CWP400E	2641	2270	1994
Trecor PVC-1	2506	2200	1869
FT Wax	2462	2226	1615

Table 8: Equilibrium Torque (Nm) comparison

Level (phr)	0.5	0.7	0.9
CWP400E	1872	1822	1808
Trecor PVC-1	1819	1856	1835
FT wax	1844	1880	1826

The fusion time comparison is graphically depicted in Figure 5.

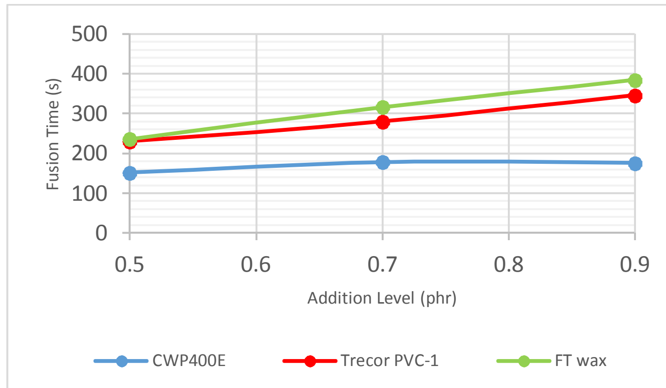

Figure 5: Fusion time (s) comparison

4. Discussion

In the Tin system the fusion behavior of all three waxes are very similar and can be used interchangeably in the compound used.

In the Ca/Zn system the CWP400E is slightly less lubricating than the Trecor PVC and the FT wax, although it is not as sensitive to over-lubrication, because the rate of fusion time increase is not as rapid with increasing lubricant level. The FT wax is particularly sensitive in this regard, and it has the narrowest operating window.

All three waxes act as external lubricants in the two systems tested. The FT wax and Trecor PVC have almost identical behavior in both systems.