SOLVING ADHESION AND DIE BUILDUP PROBLEMS IN EXTRUSION COATING

Bruce Foster
Mica Corporation

ABSTRACT

Poor adhesion and die buildup are common problems in the extrusion coating industry. In the case of polymer systems requiring stabilization packages (e.g.: polypropylenes, linear-low density polyethylenes, and metallocene grades), such problems can sometimes be caused by a mismatch between the resin supplier's stabilization package and the customers' needs. This paper, based on "real-life" examples, shows how a simple lab test -oxidative induction behavior -can be used to optimize additive packages to solve such problems.

BACKGROUND

In all extrusion coating processes, polymers are oxidized to some extent as they go from pellet to coating. In most cases, sufficient oxidation of the melt curtain in the air gap is necessary to effect good adhesion. On the other hand, excessive oxidation during extrusion can result in a buildup of oxidized polymer in the extruder, on the screen pack, and at the die-lips, resulting in streaks or die-lines. Thus, an analytical tool to correlate the oxidative stability of a resin with end-use performance can be an important tool in the development of new or improved resins for extrusion coating. In this paper, we use several product development success stories to illustrate the merits of such a tool-oxidative induction testing.

EXPERIMENTAL

For this work, a Perkin-Elmer DSC-7 differential scanning calorimeter was used, although any similar instrument, when equipped with a gas switching accessory, should be suitable. Also needed are supplies of pure nitrogen and oxygen and a means of regulating and measuring the gas flow rates. The instrument used in this study is shown schematically in Figure 1. The test method used is in accordance with ASTM D3895, and is summarized as follows:

1. A 10 mg. sample is placed in an open test pan.
2. Heat to 200°C (30°C/minute heat rate) with nitrogen purging.
3. Hold at 200°C (i.e. isotherm) for 5 minutes.
4. Switch to oxygen purge at a gas flow rate of 10 cc/min.

The effect then, is to <u>induce oxidation</u> of the exposed polymer surface, which occurs once its limit of resistance to oxidation is reached. Because the oxidation reaction is exothermic, it is easily detected on the test thermogram, as illustrated in Figure 2. The time between switching to oxygen and the extrapolated onset of the exotherm is defined as the polymer's oxidative induction time. (See figure 2)

The effect of temperature on the induction times is rather dramatic, as illustrated in Figure 3. For our purposes in this work, 200°C was determined to give a good balance between induction times long enough to get a good baseline, yet short enough to keep the test time reasonable.

EXAMPLES

The following examples demonstrate use of this method to solve stability-related problems.

EXAMPLE 1: Problem: Poor adhesion

In a commercial extrusion coating operation, Formula A was observed to have poor adhesion to a paper substrate, whereas Formula B exhibited good adhesion. Testing revealed A had a longer oxidative induction time, as illustrated in figure 4. The stabilization package in A was changed to reduce this time from 13 minutes to ~2 minutes, as illustrated in Figure 5. This revised formulation, A' gave excellent adhesion.

EXAMPLE 2: Problem: Die buildup

A second commercial extrusion coating operation, very similar to that discussed above, was using Product C to successfully coat paper in an application requiring a very uniform coating profile. When Product D (a more desirable polymer for economic reasons) was substituted, the process was plagued by die buildup, resulting in die streaks on the coating. Figure 6 shows that Product D had a shorter oxidation time than C, suggesting that degradation in the extruder was causing the problem. When the stabilization package in D was adjusted to improve the oxidation resistance (Formulation D'), as illustrated in figure 7, the die buildup problem was resolved. Figure 7 also illustrates the importance of comparing not only the extrapolated onset, but the slope of the oxidation exotherm. Although the visible onset of oxidation for D' is earlier than that of C, the lesser slope for D' suggests it oxidizes at a slower rate than C, and the result is a product that adequately survives the extrusion process.

CONCLUSION

These examples illustrate the utility of oxidative induction testing for solving polymer stability problems, such as adhesion and die buildup. They also demonstrate the reality that different extrusion operations, although they may be performing similar functions, can have significantly different stability needs. Careful use of this method can successfully pinpoint the additive requirements for meeting these needs.

Figure 1

Laboratory Apparatus for Oxidative Induction Testing

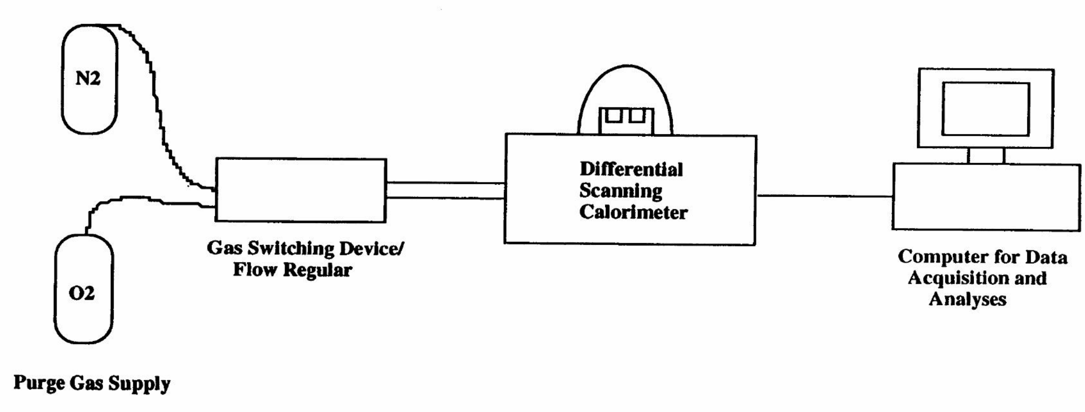

Figure 2. Typical Thermogram

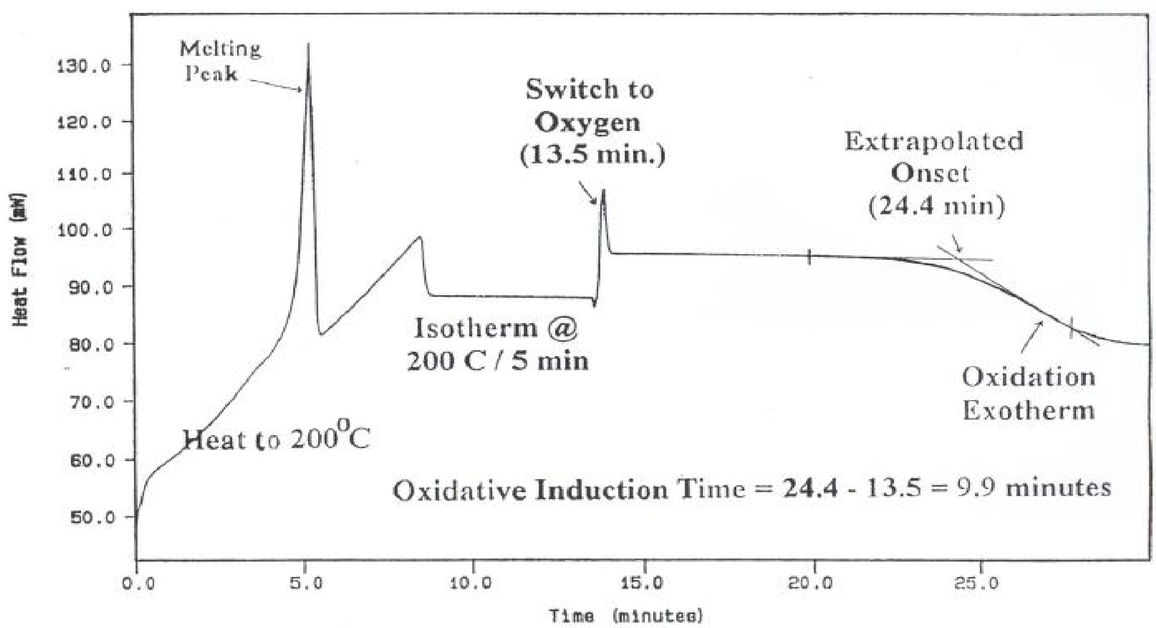

Figure 3. Effect of Temperature on Oxidative Induction Time

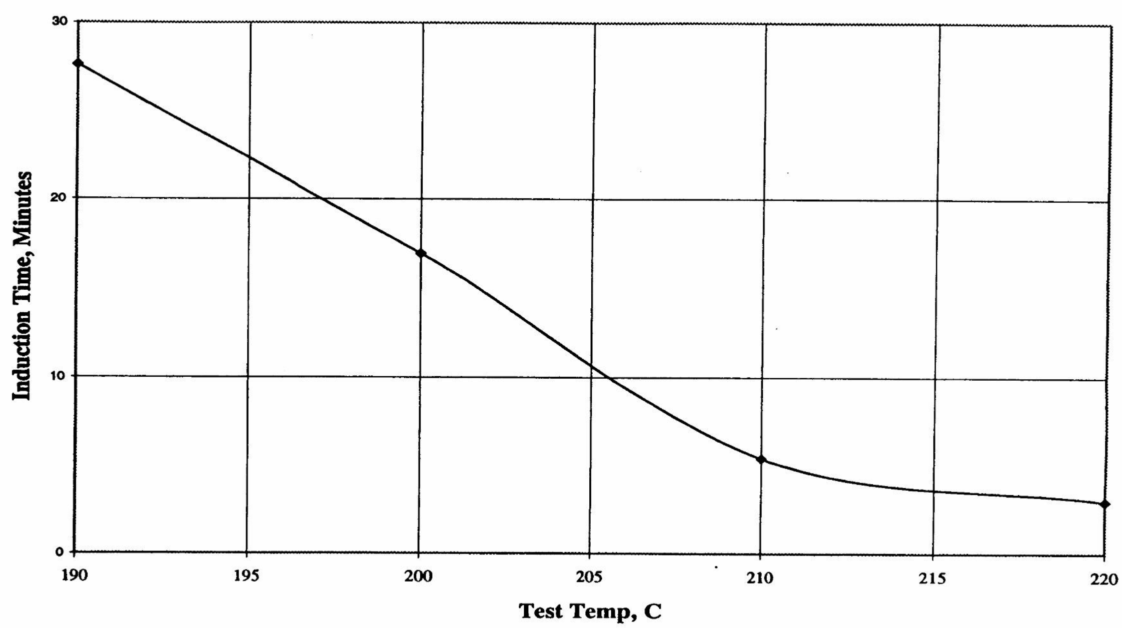

Figure 4. Problem: Poor Adhesion

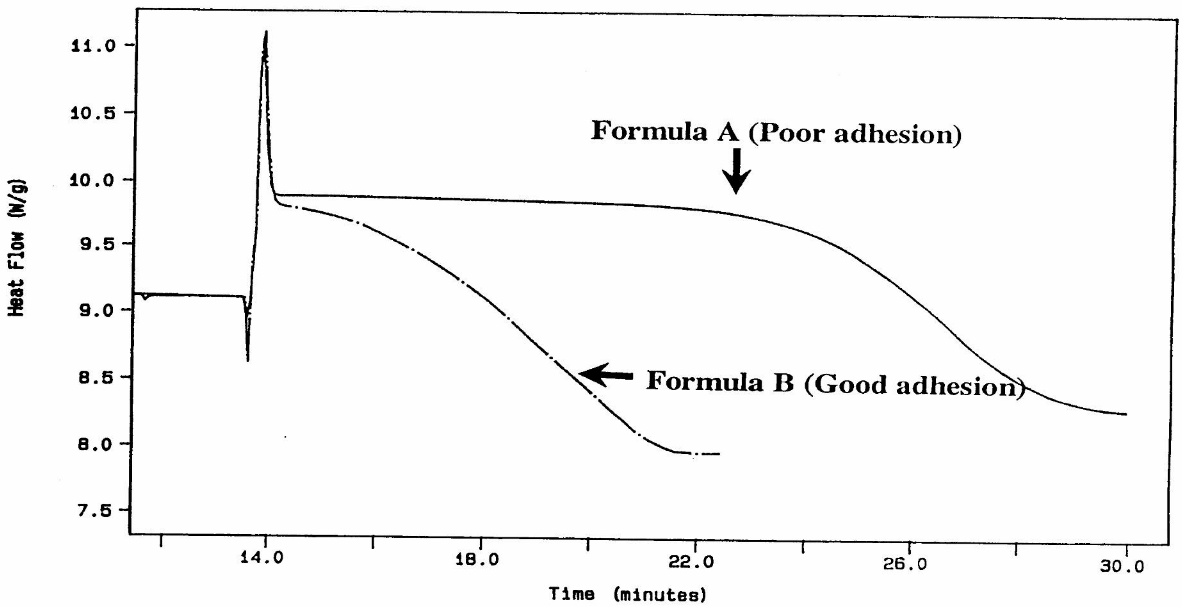

Figure 5. Solution: *Reduce* Stabilization

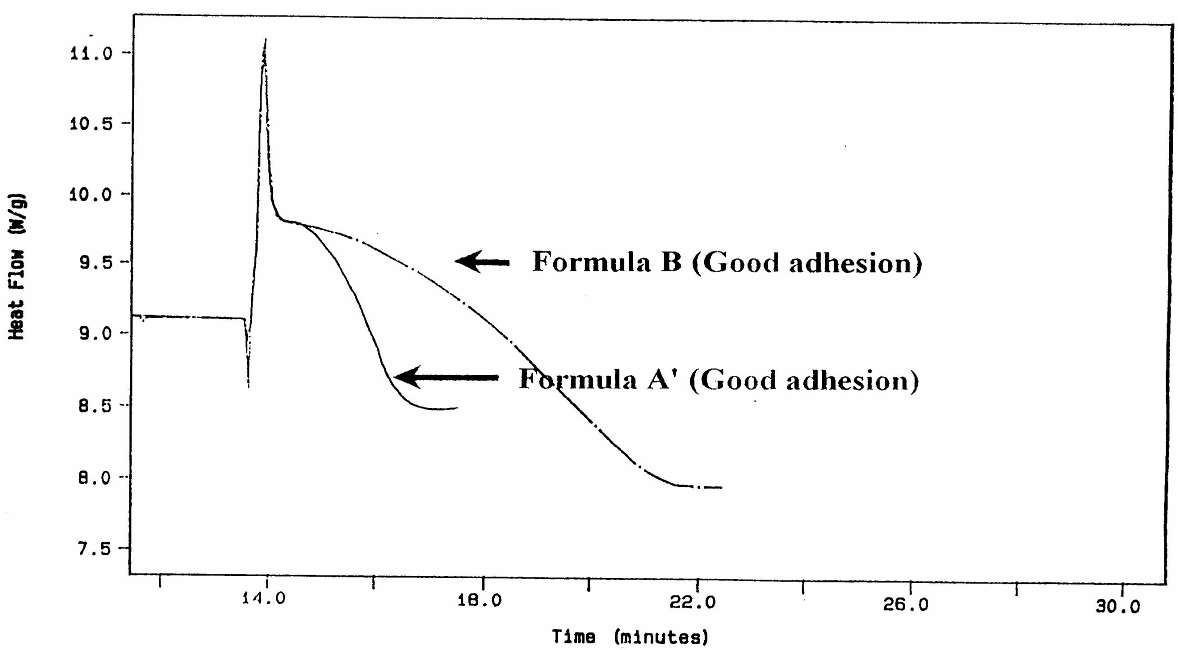

Figure 6. Problem: Die Buildup

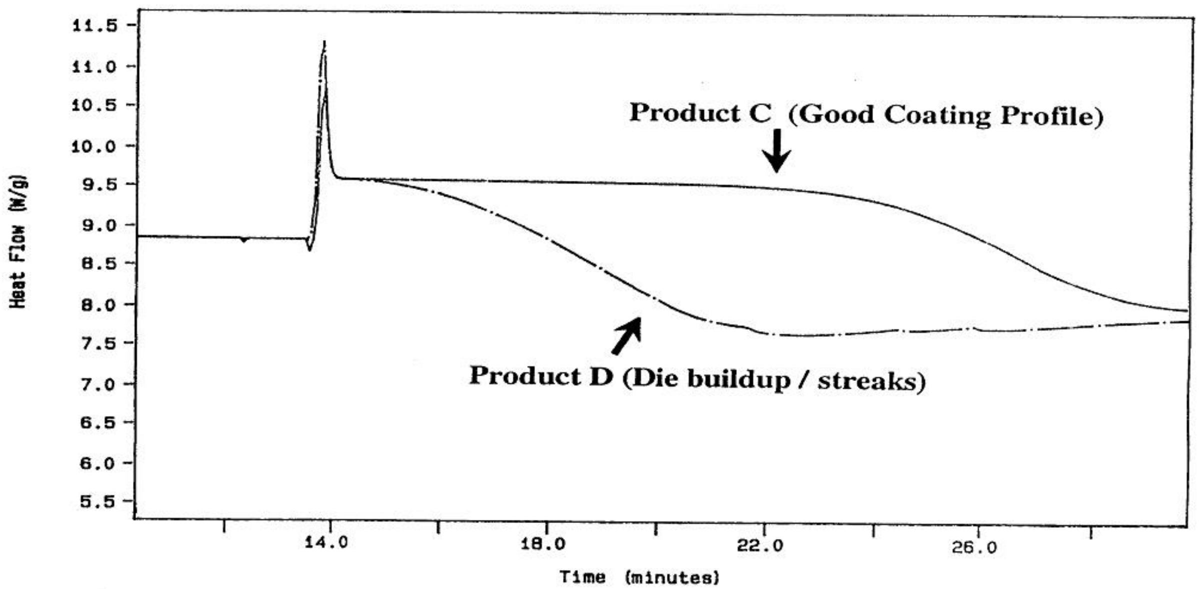

Figure 7. Solution: *Increase* Stabilization