# Effects of SureFlo® on the Thermo-Oxidative Stability of Polyethylene (PE), Polypropylene (PP) and Polystyrene (PS) Systems

*Xiaofan Luo, PhD, Product Innovation Scientist*

*Flow Polymers, LLC*

SureFlo® is a new and cost-effective process additive for general-purpose plastics such as polyethylene (PE), polypropylene (PP), polystyrene (PS), ABS, Nylon and PET. It is a proprietary blend of hydrocarbon resins in an easily handled pellet form that flows at normal plastic processing temperatures. The benefits of SureFlo® include

- Enhances the processibility of the material by reducing melt viscosities
- Delays the crystallization of semi-crystalline polymers to facilitate mold flow
- Helps compatiblize dissimilar plastic components and contaminants
- Serves as a cost-effective black colorant

The aim of this study is to determine the effects of adding SureFlo® on thermo-oxidative stability of PE, PP and PS systems.

## Experimental

The materials used in this study include HDPE (HD100 from M. Holland Company), PP (Polypropylene 3281 from Total Petrochemicals USA, Inc.) and HIPS (IS200 from M. Holland Company). Each polymer was then compounded with SureFlo® at two different levels, 5 and 10%. A Q-500 thermogravemetric analyzer (TGA) was used for the study. In each experiment, the sample (typical size ~ 10 mg) was heated from room temperature to 600 °C at a heating rate of 10 °C/min. Dried air was used as the purge gas at a rate of 60 mL/min.

## Results and Discussion

**Fig. 1** shows a typical set of TGA results for the PP system. Surprisingly, the polymers with SureFlo® showed substantially higher stability under thermo-oxidative environment. The curves are shifted to much higher temperatures with the addition of SureFlo®. Similar trends were also observed for PE and HIPS.

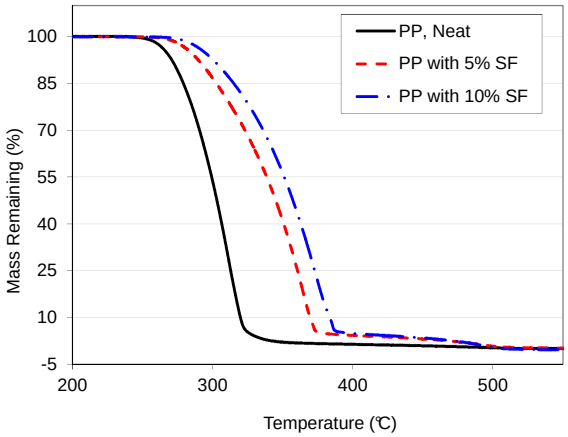


**Fig. 1** TGA results for neat PP, PP with 5% SureFlo® and PP with 10% SureFlo®.

The TGA results were further analyzed to obtain two characteristic temperatures, as shown in **Fig. 2**. The 1st derivative of weight (d*m*/d*T*), which indicates the rate of degradation (weight loss), was plotted. $\mathbf{T_{onset}}$, defined as the temperature where the derivative weight curve first starts to rise, indicates the onset point of degradation. $\mathbf{T_{max}}$, the maximum value on the derivative weight curve, is the temperature at which the degradation rate is fastest. The obtained $T_{onset}$ and $T_{max}$ values for PP, PE and HIPS are

plotted as functions of SureFlo® loading in **Fig. 3**.

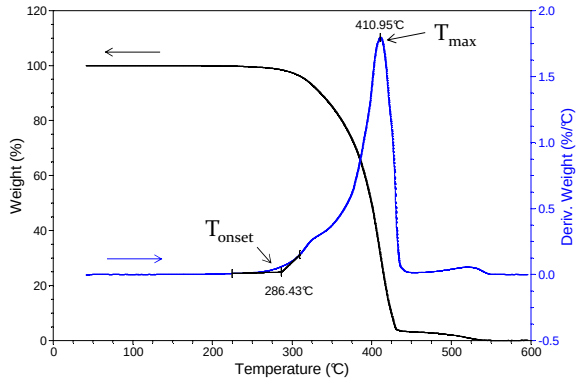


**Fig. 2** An example showing the analysis of TGA results to obtain $T_{onset}$ and $T_{max}$.

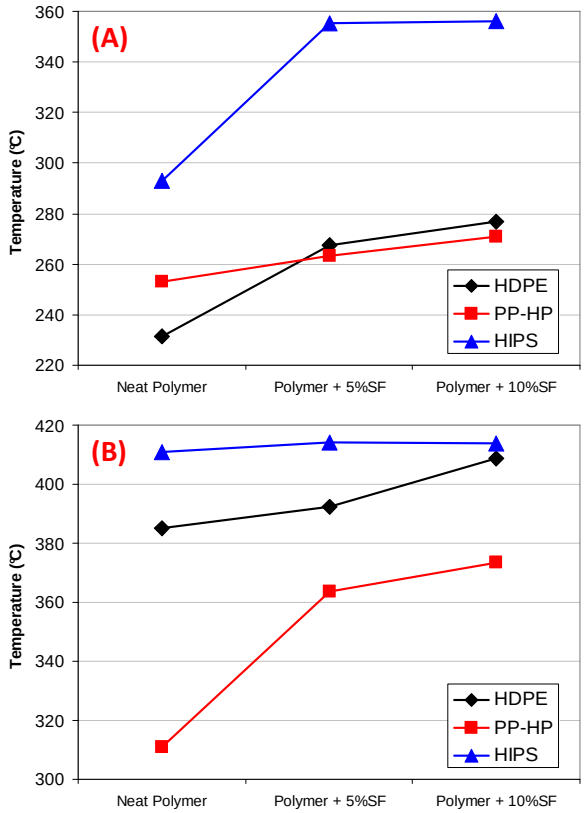


**Fig. 3** (A) $T_{onset}$ and (B) $T_{max}$ values of PE, PP and HIPS with different SureFlo® loadings.

As shown in **Fig. 3**, both $T_{onset}$ and $T_{max}$ increase with increasing levels of SureFlo®, in all three polymer systems. In other words, the thermo-oxidative stability is significantly enhanced by the addition of SureFlo®. Comparing among the different polymers, slightly different effects of SureFlo® can be seen. For HIPS, SureFlo® leads to mainly an increase of $T_{max}$ ($T_{onset}$ is also increased but to a lesser extent). For PP, the predominant effect of SureFlo® is the increase of $T_{onset}$. For HDPE, the two effects were observed to be more even.

The observed enhancement in thermo-oxidative stability, although surprising, can still be mechanistically justified. SureFlo® is a complex blend of hydrocarbon resins and has a relatively high aromatic content that can be well dispersed in a polymer matrix. Upon heating, these aromatic components undergo dehydrogenation and form a continuous, more oxidatively stable (less flammable) carbonaceous coating on the surface that slows down the bulk degradation. Therefore the overall stability of the polymer is enhanced.

## Conclusions

To conclude, adding SureFlo to PE, PP and HIPS leads to significant improvement of thermo-oxidative stability. Such an effect can potentially translate to enhanced flame retardance of these polymers. More rigorous flammability tests will be conducted in the future to study the burning characteristics of SureFlo added polymers.