Fraunhofer Institut
Fertigungstechnik
Materialforschung

Flame Retardant Coatings, Adhesives and Thermosets

The Fraunhofer Institute IFAM in Bremen has been involved in the development of nanocomposites already since 1997. One main focus is the design of flame resistant polymers by using nano-sized particles. The polymers are mostly thermosets and thermoplastics especially for adhesives and coatings or similar applications.

The overwhelming majority of papers regarding the improvement of flame resistance of polymers with nano-sized particles (nanocomposites) are discussing the influence of layered silicates (organophilic montmorillonites). Beside the layered silicates the IFAM has furthermore a broad experience with spherical nano-sized particles. It is well known that a concentration of nano-sized particles as low as 5 wt.-% is sufficient to reach the maximum benefit of many properties. Because of the low necessary concentration the nano-sized particles shall be classified as an additive material rather than a filler material. The idea using nano-sized particles as flame retardants is based on one or more of the following effects:

- In situ blockade formation,
- Pyrolysis gas permeation barrier,
- Anti-dropping agent,
- Synergistic effects in combination with other flame retardants.

It is known that the measured efficiency of flame retardants depends on the type of test-method. Most nanocomposites decrease significantly the peak of heat release in cone calorimetry measurements. On the other hand nanocomposites often show only small improvements in burn-tests. Improper combinations of polymers and particles can even accelerate combustion.

Another tool to determine the thermal stability of polymers is thermogravimetry (TGA). Fig. 1 shows an example where 5 wt.-% organophilic layered silicate increases the degradation onset temperature of a homopolymerized epoxy resin by 120°C depending on the modification of the layered silicate. The higher thermal stability was confirmed by a horizontal burn-test. Those results emphasize the necessity of a proper surface modification of nano particles in order to obtain desired effects.

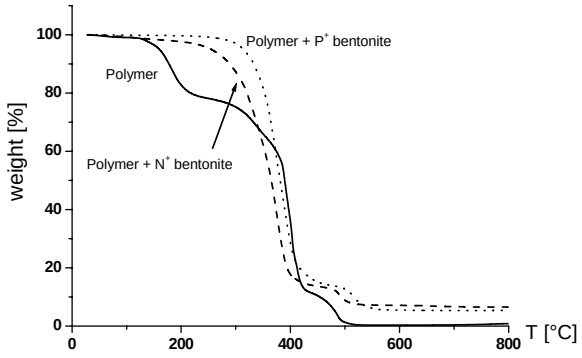

Fig. 1: Organophilic layered silicates can increases the degradation onset temperature of an epoxy resin by 120°C depending on the modification of the layered silicate.

In many cases the combination of conventional flame retardants and nano-sized particles leads to synergistic effects. Those combinations increase flame retardance significantly compared to a standalone usage of the components. Examples are blends of nano-sized particles with aluminum trihydrate (ATH) or phosphor based flame retardants.

Combinations of nano-sized particles and conventional flame retardants can be used for flame resistant coatings. The following example coating is a common amine curable two part epoxy resin modified with a blend of nano-sized particles and phosphor based flame retardants.

Fig. 2 shows ABS samples after a burning test. The right sample shows pure ABS – a polymer with only very low fire retardant properties – which deflagrates completely with drops of melted polymer. The other three ABS samples were coated with 0.1 mm of the flame resistant coating. The fire retardant coating extinguishes the fire after seconds combined with a decreased amount of submitted black carbon. This is quite impressive for ABS, since the fire retardants were only used as a coating and in a small concentration compared to the polymer matrix.

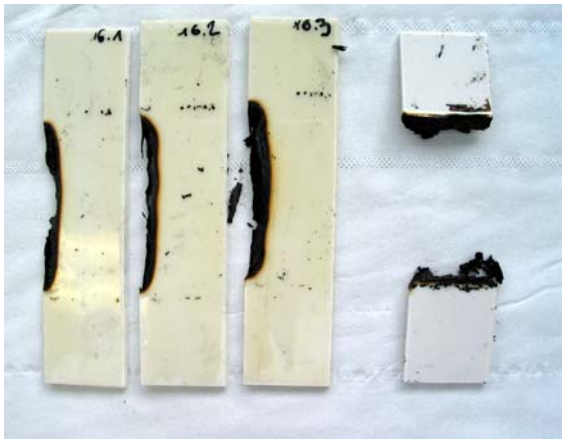

Fig. 2: ABS samples (thickness 3 mm) after horizontal burning test. Left modified with flame resistant coating (0.1 mm), right pure ABS control.

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