Molecular Weight and Filler Dispersion on the Flammability of PMMA/Layered Silicate Nanocomposites

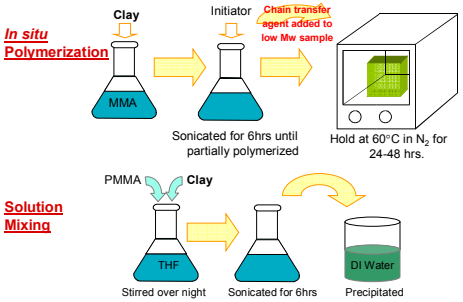
Xin Zhang[1], Robert M. Briber[1] and Takashi Kashiwagi[2]
1. Department of Materials Science and Engineering, University of Maryland, College Park, MD 20742
2. Building and Fire Research Laboratory, NIST, Gaithersburg, MD 20899

Motivation

- Current flame retardants have a number of serious problems
  - Halogen based flame retardants face environmental issues
  - Phosphorus based flame retardants are excluded from certain electric applications
  - Aluminum/magnesium hydroxides need very high loading to be effective
- U.S. fire safety standards are quite extensive
  - UL-94
  - ASTM E 84, ASTM E 162
  - California Technical Bulletin 133
- New flame retardants are under development
  - Melamine
  - Intumescent flame retardants
  - **Nanocomposite materials**
    - A promising approach, but still many issues need to be clarified

Experiment Layout

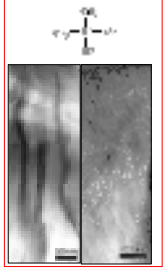
Synthesis - 2 Schemes



Structural Characterization

Cloisite 30B
- Exfoliated structure expected
- Surfactant

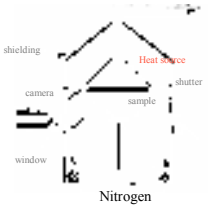
Cloisite 15A
- Intercalated structure expected
- Surfactant



Somasif MAE120
- Intercalated or microcomposite structure expected.
- Surfactant unknown

Flammability Characterization

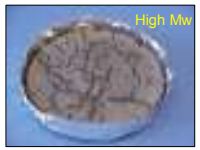
Gasification and cone calorimetry were used to characterize the flammability. Cone calorimetry data are not shown here.

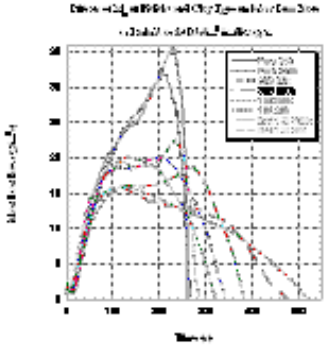


A gasification apparatus is similar to a cone calorimeter but uses a nitrogen environment to suppress flame and soot.

Effect of Molecular Weight and Clay Dispersion

Nanocomposites with different molecular weights were examined.





Nanocomposites with high molecular weight exhibited lower flammability.

The lower flammability is correlated with the coverage and stability of the char layer which forms on the surface of polymer melt.

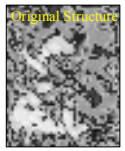
High molecular weight polymer appears to improve the stability.

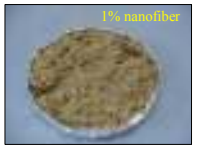
Exfoliated and intercalated structures show little difference in performance.

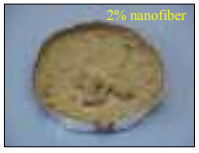
Effect of Adding Carbon Nanofibers on Char Layer Stability

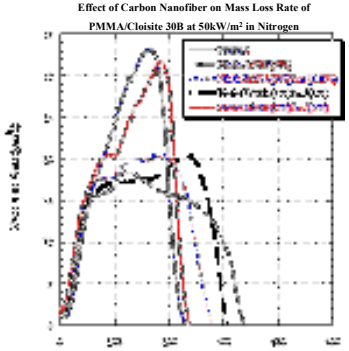
Pyrograf 24HHT carbon nanofiber was mixed with with the polymer to form a series of samples. All samples have a Mw of 100k and 5%wt clay concentration.

Stability of the char layer was *lower* after the introduction of the carbon nanofiber. Cracks and open areas begin to appear upon adding carbon nanofiber.





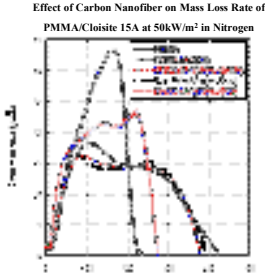




If the char layer collapses, the improved flammability behavior of the nanocomposite is lost. The added nanofibers decreased the performance.

The formation of a coherent and stable char layer is a key to low flammability

Effect of Char Layer Stability Cont.



Effect of prograf 24HHT carbon nanofibers on nanocomposites with Cloisite 15A clay.

Future Work

- Continued work on establishing the relationship between the char layer stability and flammability. The following factors should be addressed:
  - Compatibility between filler and polymer
  - Details of the silicate dispersion
  - Processing effects
  - Viscosity/mobility of polymer melt

Conclusions

- The formation and stability of the char layer is an important factor leading to the relatively low flammability of nanocomposites.
- The higher the stability of the shielding char layer, the lower the flammability of the nanocomposite.
- Increasing the PMMA molecular weight improves the on the flammability resistance of corresponding nanocomposites and this effect should be applicable to other polymers which decompose by “unzipping”.
- Adding nanofibers to the clay/polymer nanocomposite decreased performance.