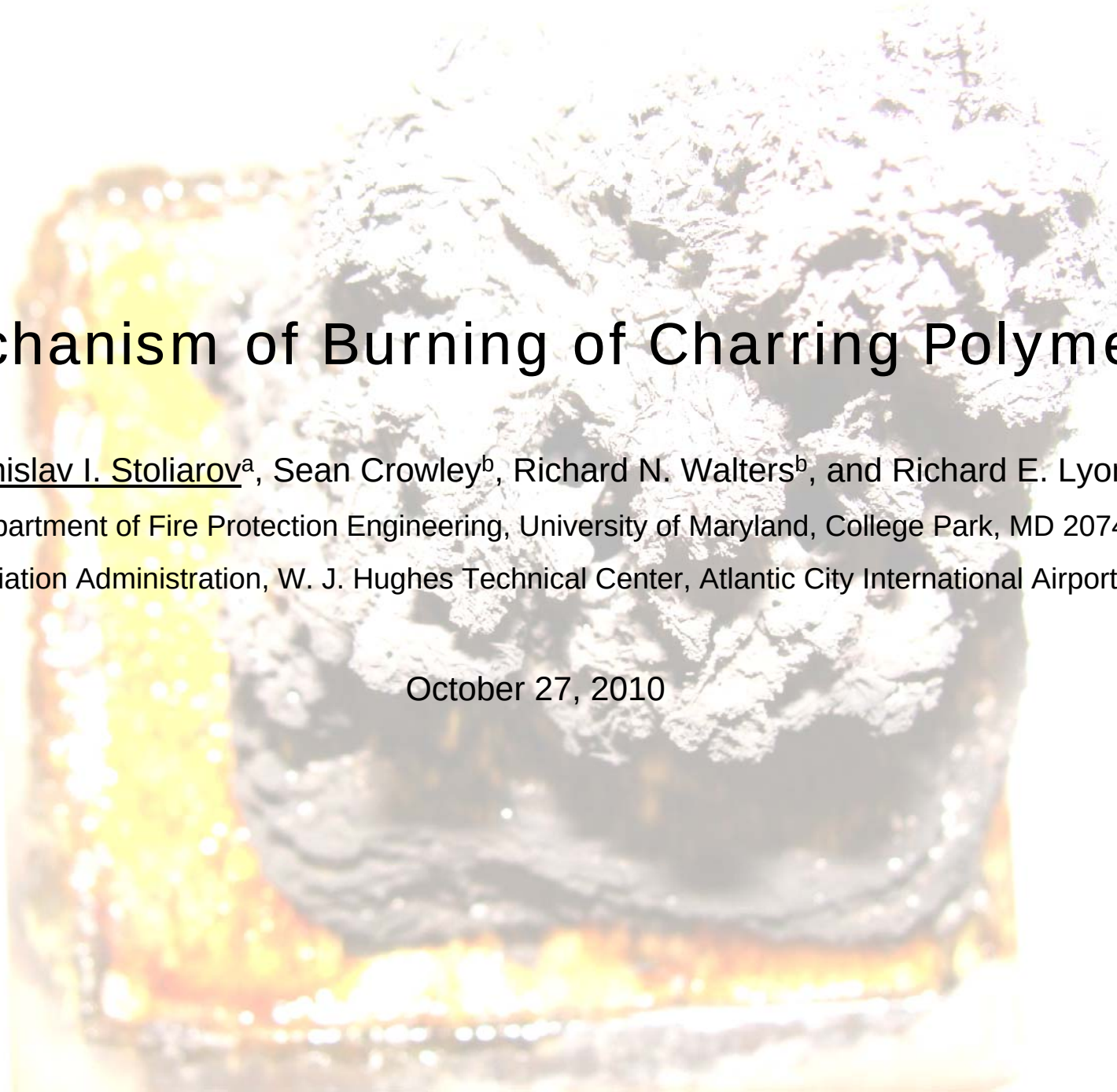

Mechanism of Burning of Charring Polymers

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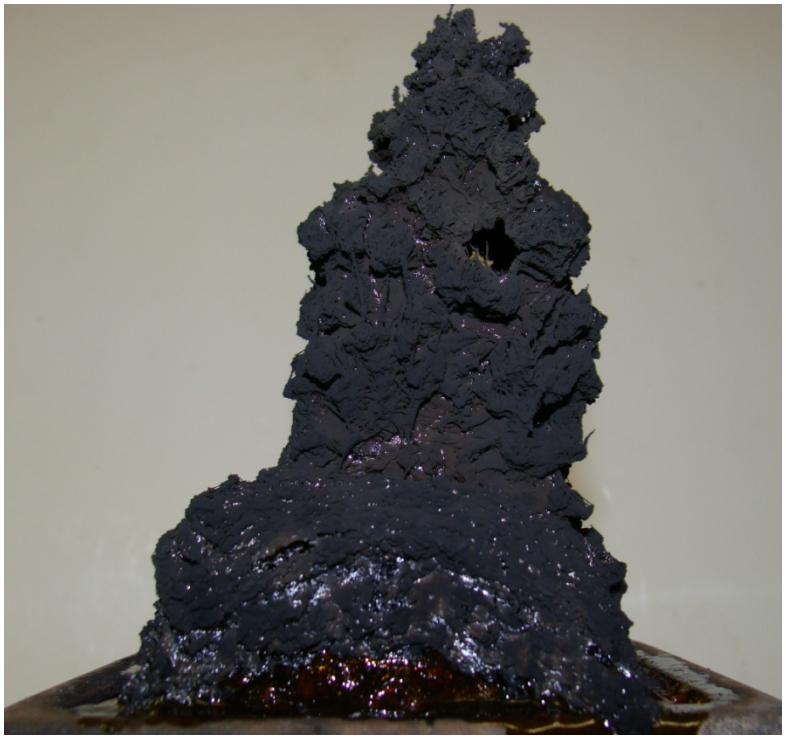
October 27, 2010

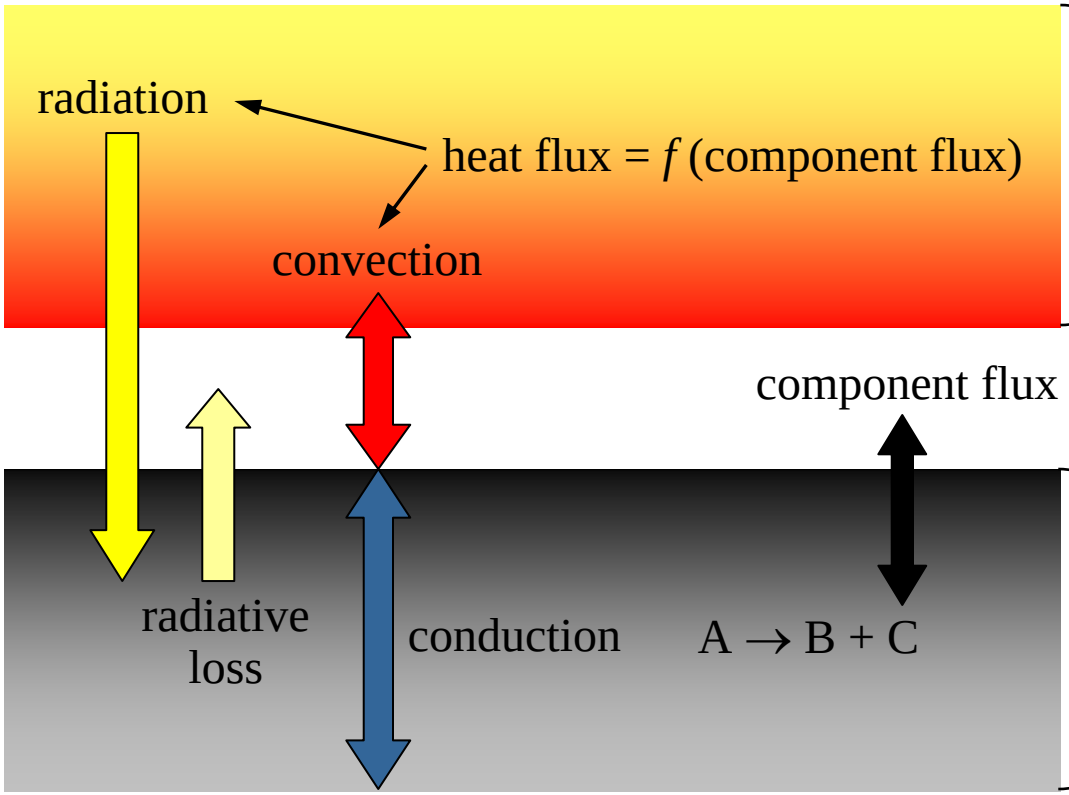
Objective of This Study

Develop quantitative, fundamental-property-based models for burning of

Bisphenol A Polycarbonate (PC) and Poly(Vinyl Chloride) (PVC).



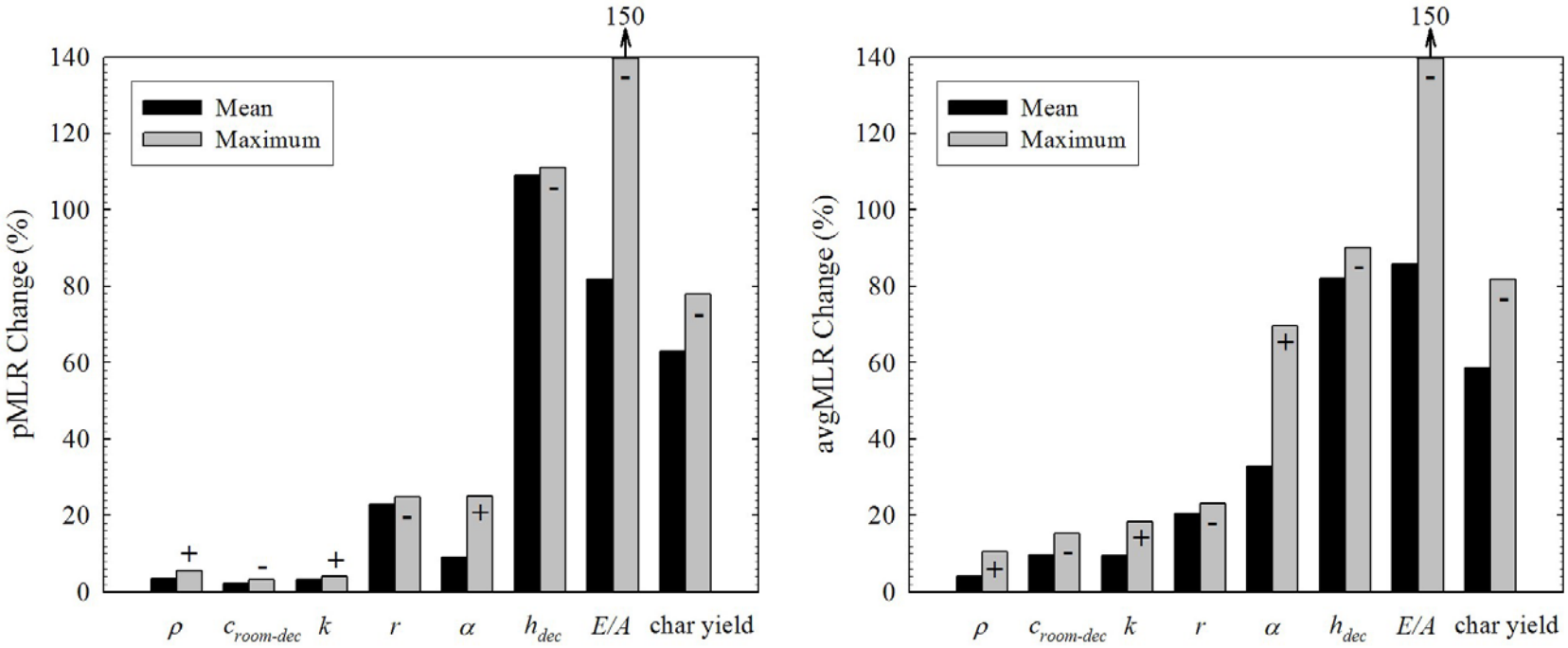
ThermaKin Framework



Gas phase is represented by empirical relations between heat flux and component fluxes. The relations are derived from experiments.

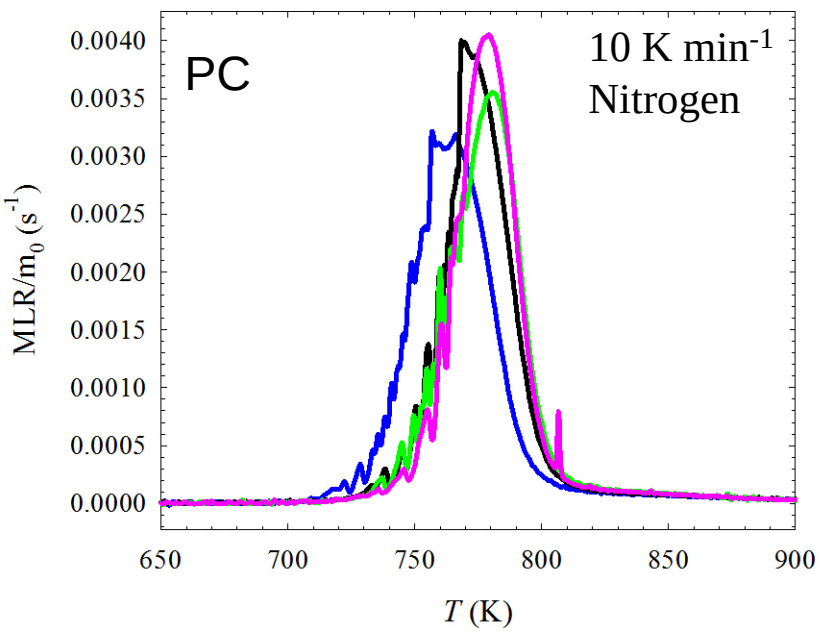
Condensed phase is represented by a mixture of components (A, B, C), which interact chemically and physically.

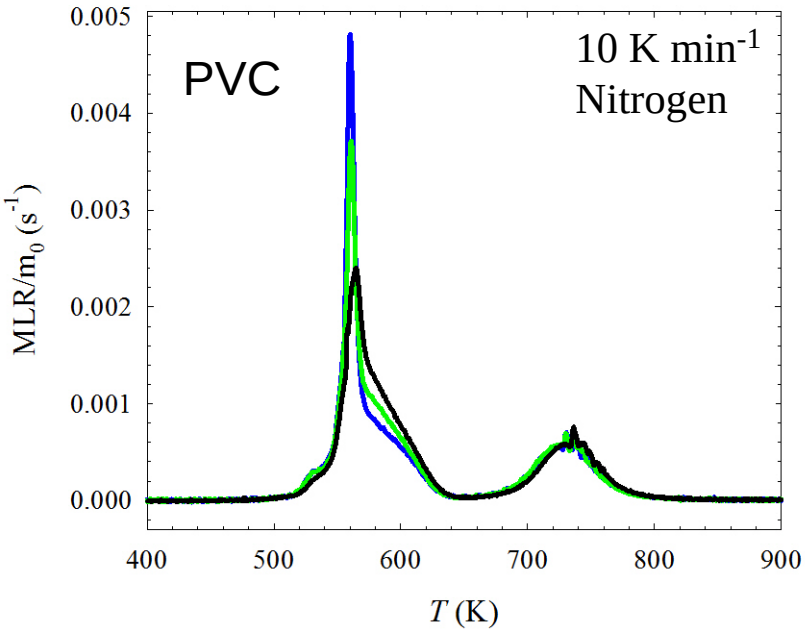
Sensitivity of Burning Rate to Property Variation*



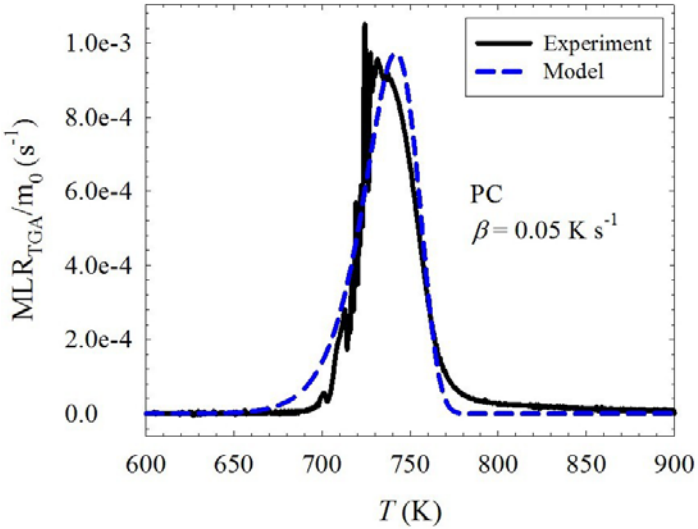
*Stoliarov S. I., Safronava N., Lyon R. E., *Fire and Materials,* vol. 33, pp. 257-271 (2009).

Thermogravimetric Analysis of Thermal Degradation

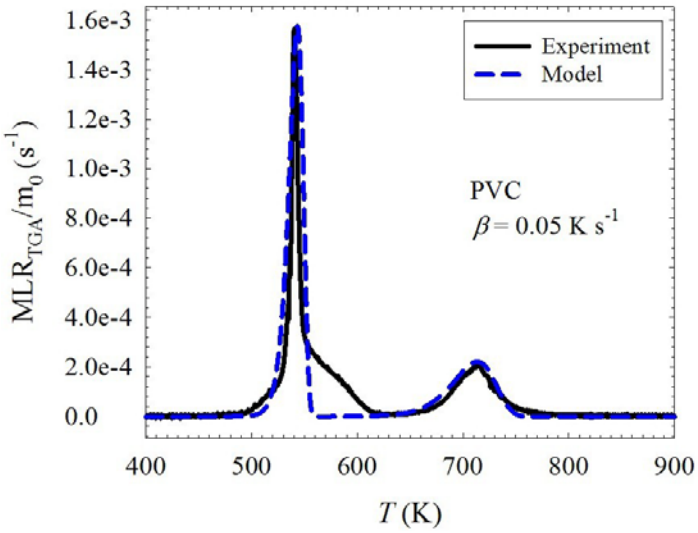




Thermogravimetric Analysis of Thermal Degradation



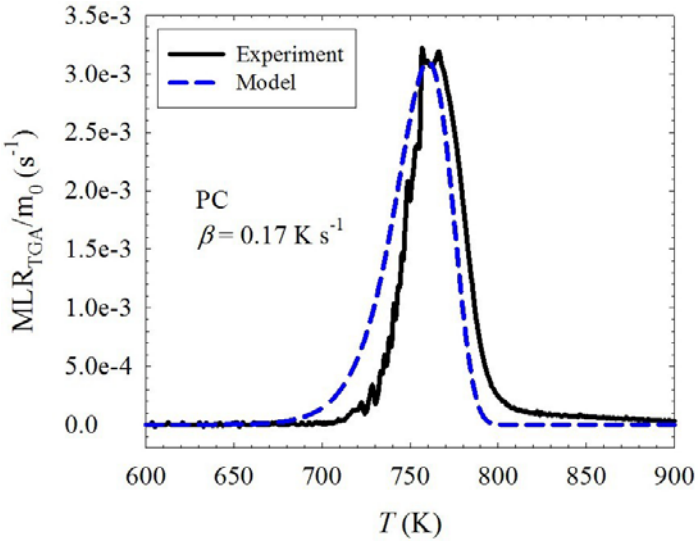
PC_pol $\rightarrow$ μ PC_char + (1-μ) PC_gas

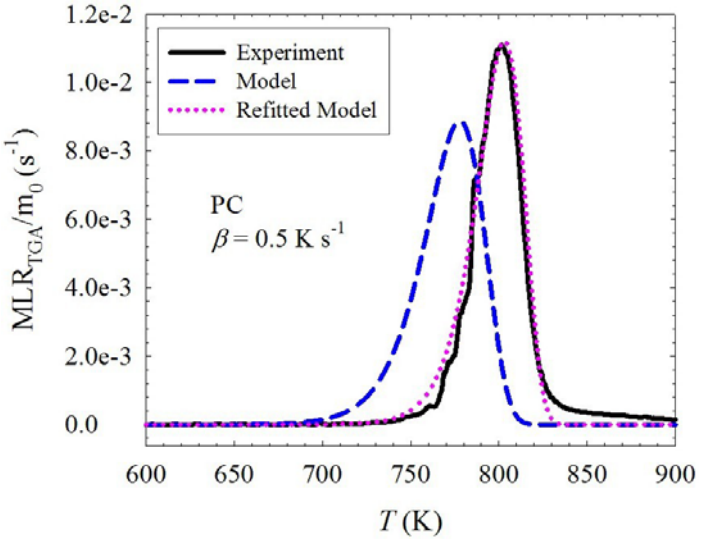


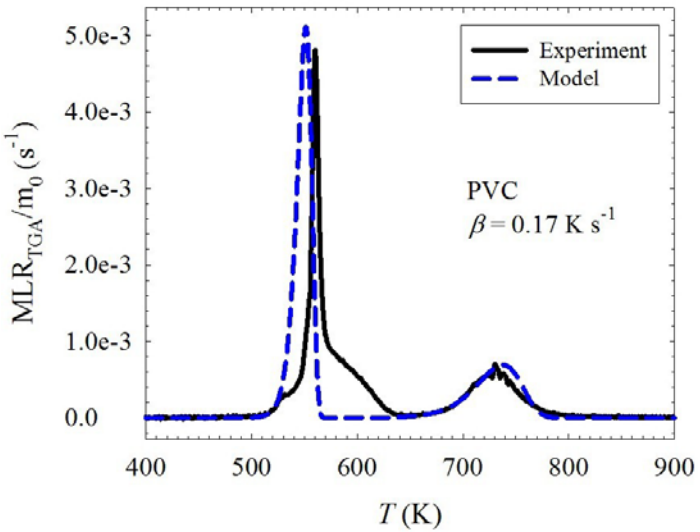
PVC_pol $\rightarrow$ μ PVC_int + (1-μ) PVC_gas1

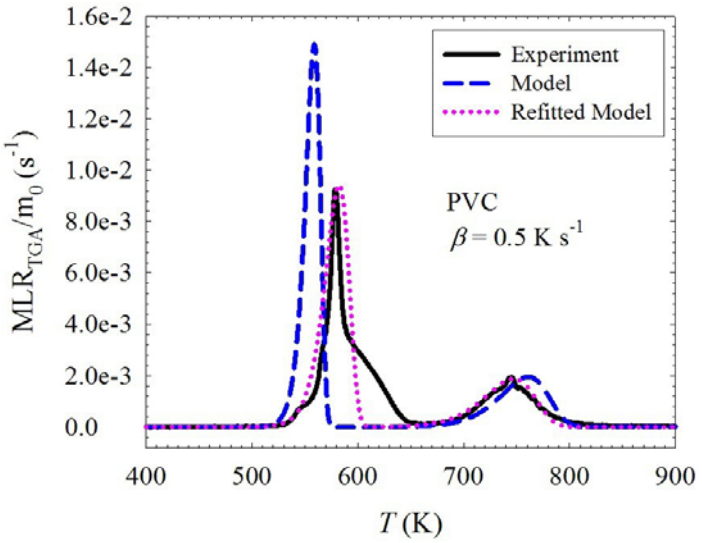
PVC_int $\rightarrow$ μ PVC_char + (1-μ) PVC_gas2

Thermogravimetric Analysis of Thermal Degradation

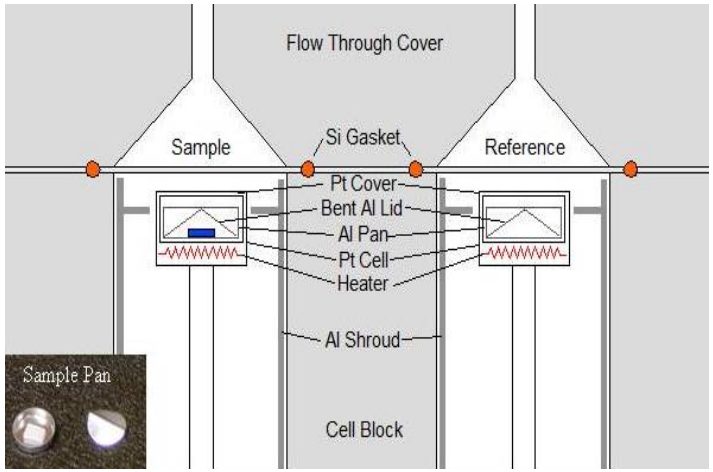


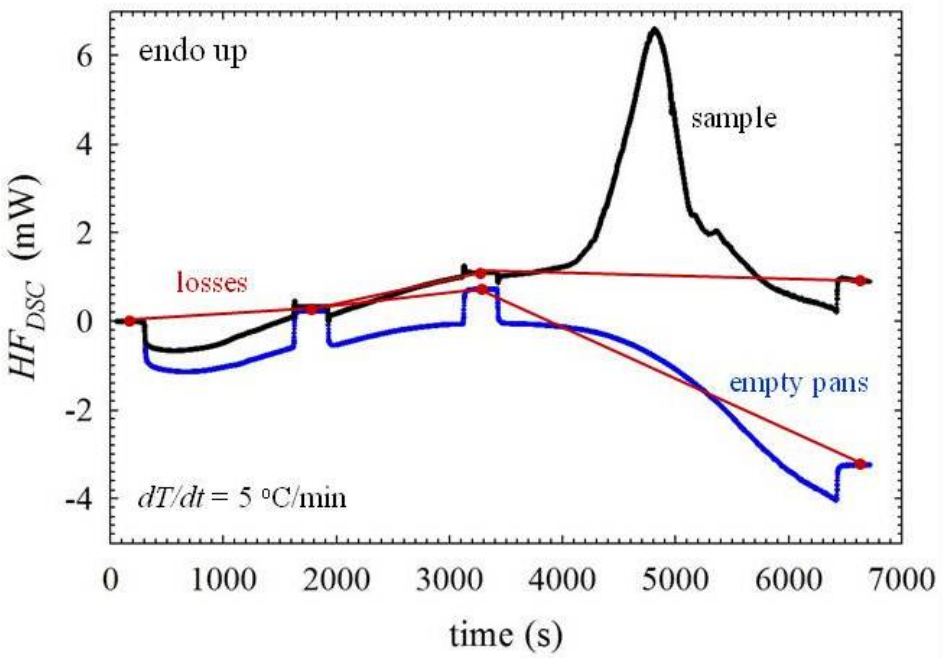






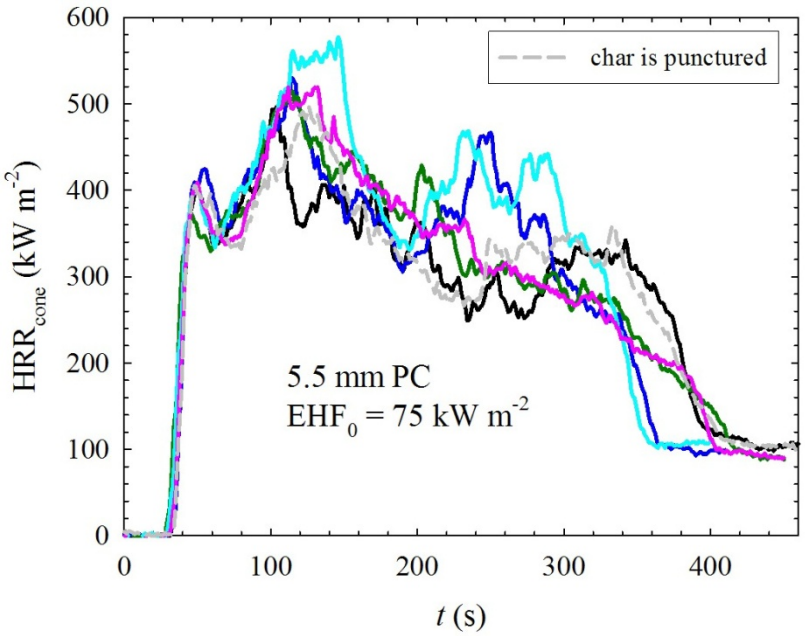
Differential Calorimetry of Thermal Degradation

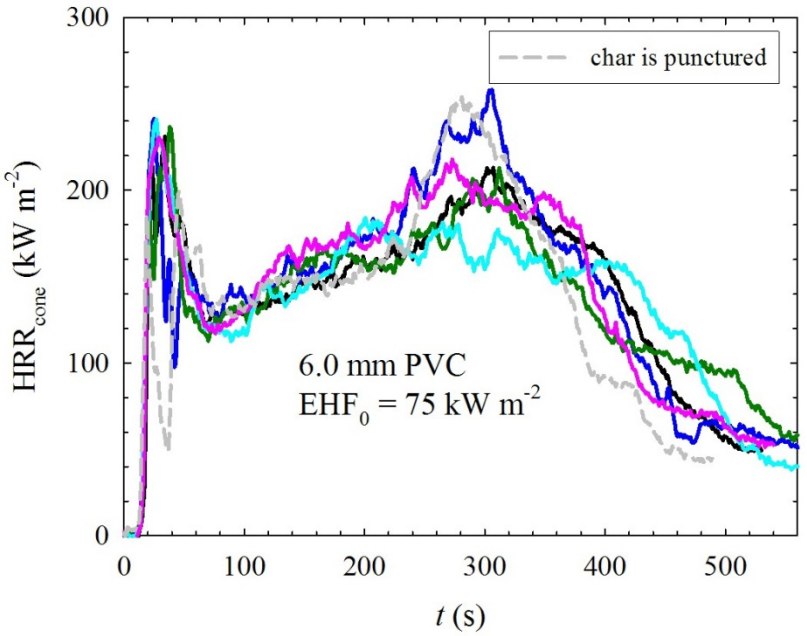




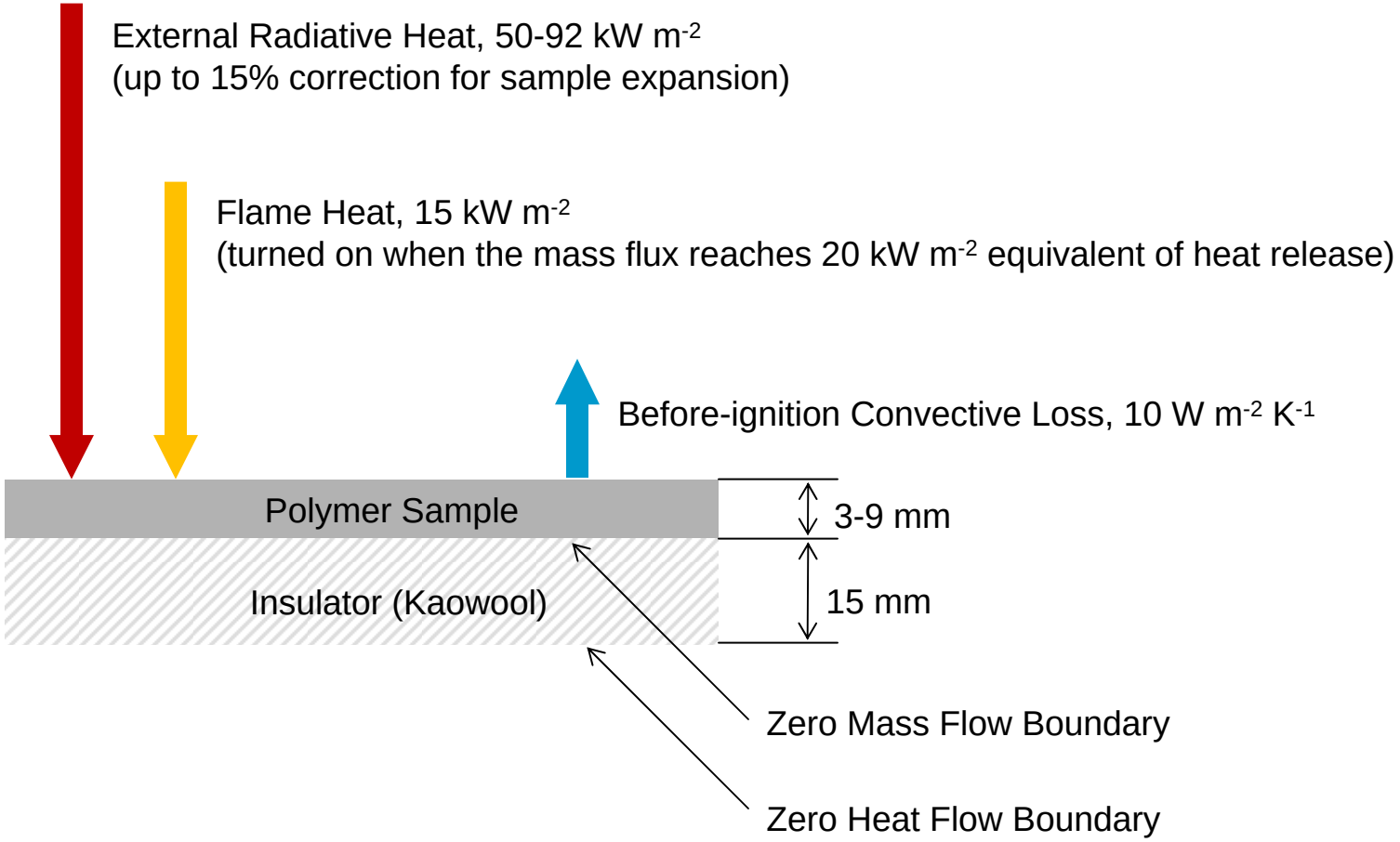
Polymer	T_{dec} °C	h_{dec} J/g
PC	499	830 ±150
PVC	276 475	170 ±170 540 ±390

Cone Calorimetry





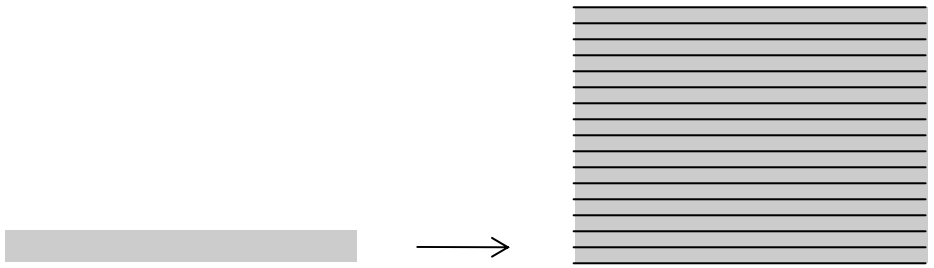
Model of Cone Calorimetry Experiment



Model of Char

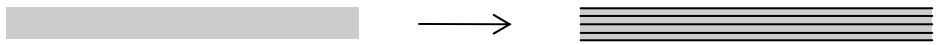
- Gas transport is fast.
- Char has emissivity and heat capacity of graphite.
- Decomposition kinetics defines char layer formation.

PC_pol $\longrightarrow$ μ PC_char + (1-μ) PC_gas



$$\rho_{PC\_char} = \frac{\mu \rho_{PC\_pol}}{\text{Experimental Expansion Factor}}$$

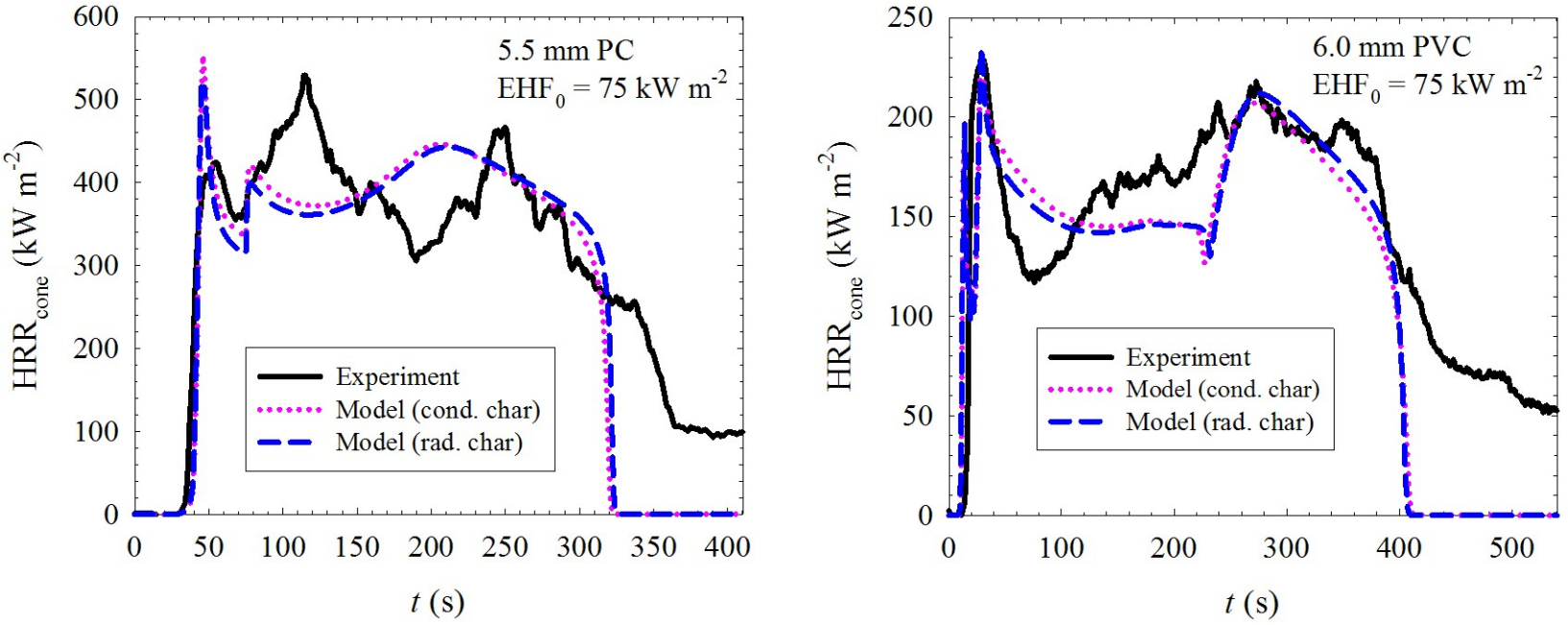
k_{PC_char} – fitting parameter



$$\rho^{*}_{PC\_char} = \mu \rho_{PC\_pol}$$

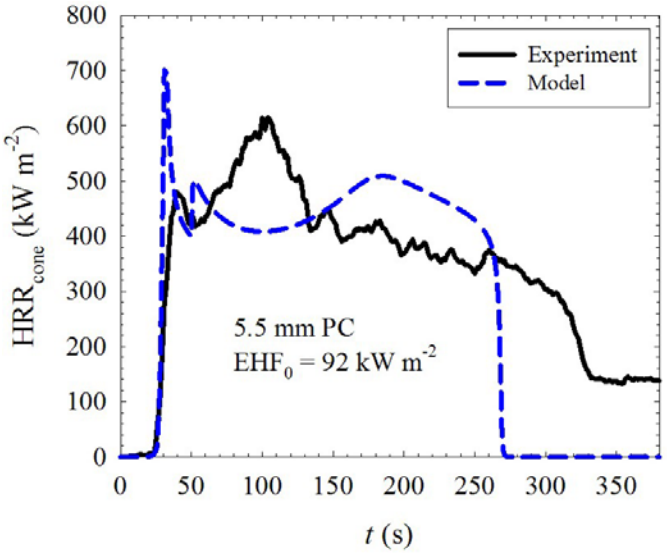
$$k^{*}_{PC\_char} = \frac{k_{PC\_char}}{\text{Experimental Expansion Factor}}$$

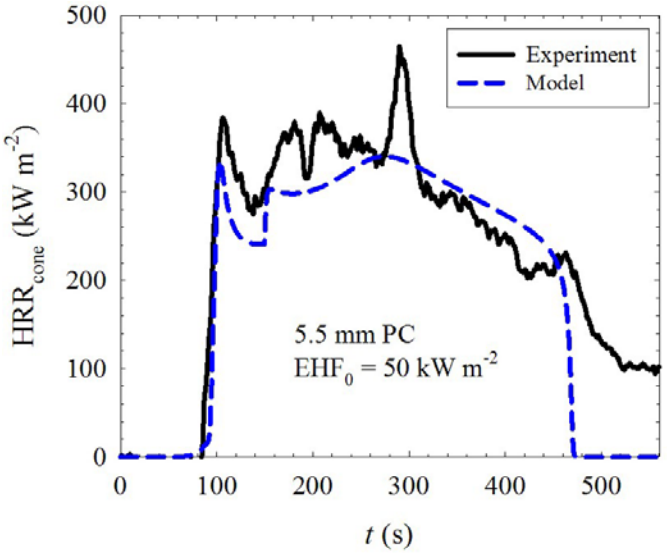
Model of Char

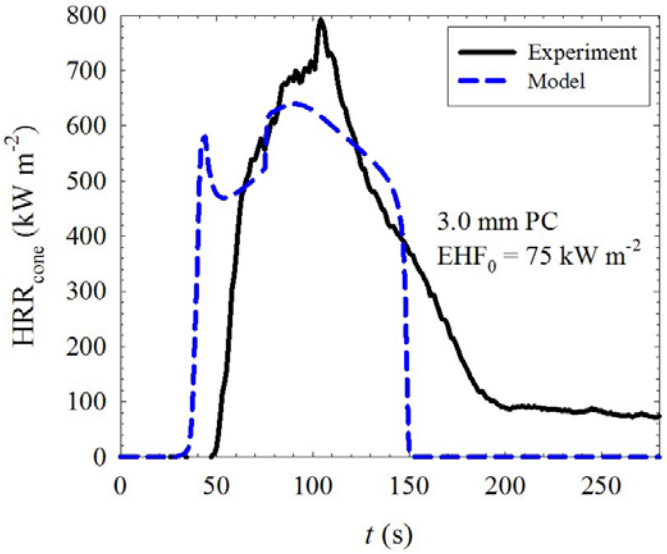


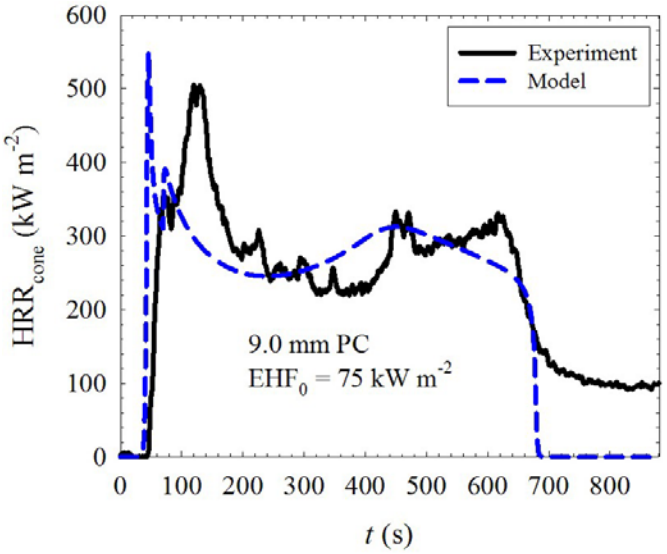
If the char layer is a stack of graphitic plates, which exchange energy via radiation, the layer thermal barrier efficiency depends only on the number of plates in this layer.

Burning Rate of PC

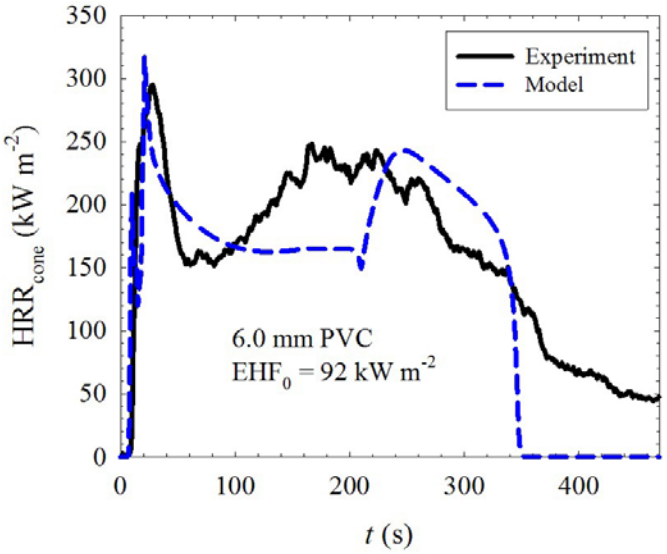


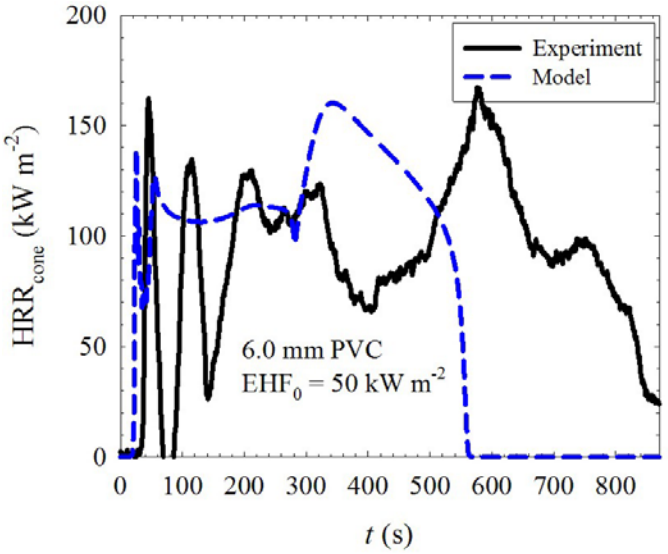


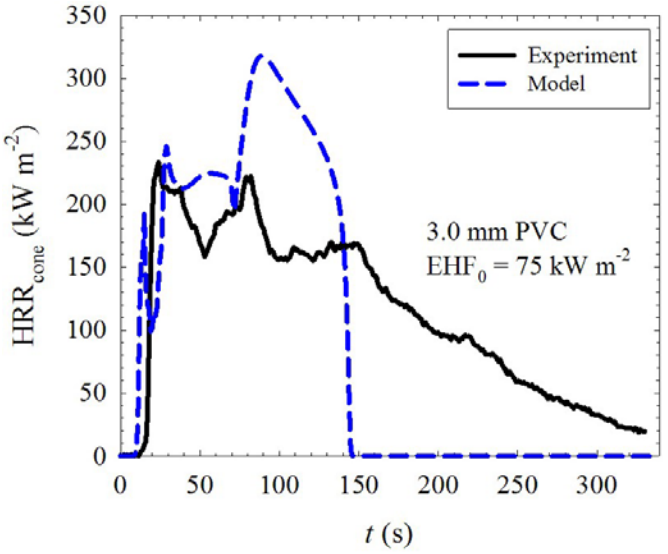


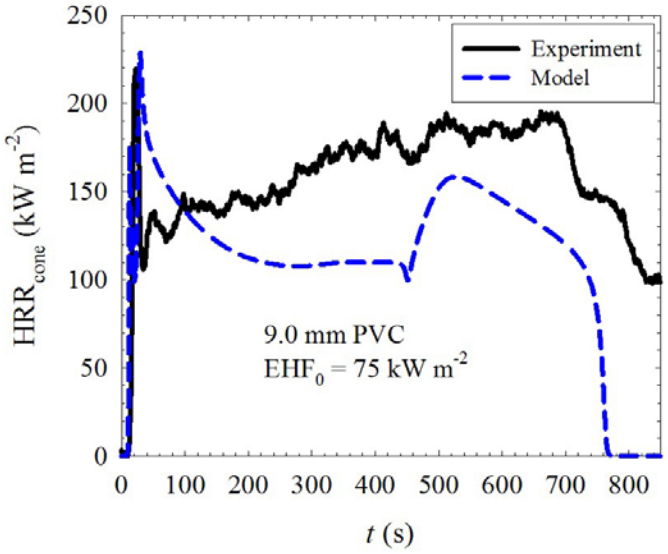


Burning Rate of PVC

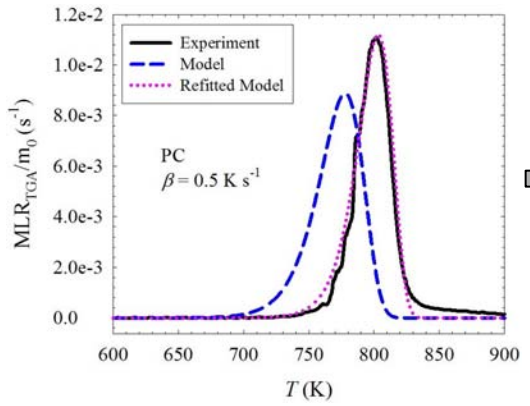


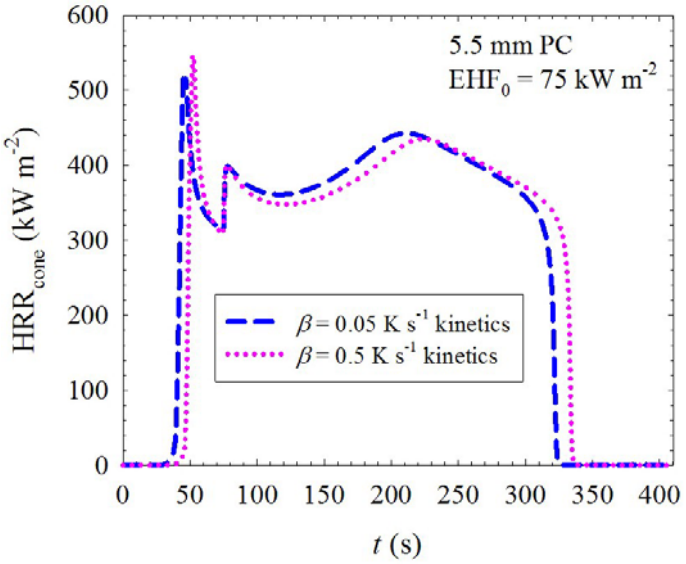


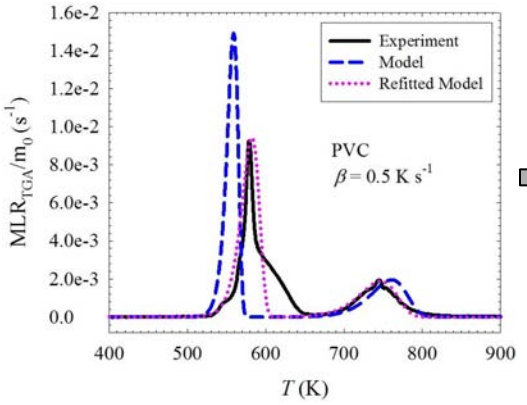


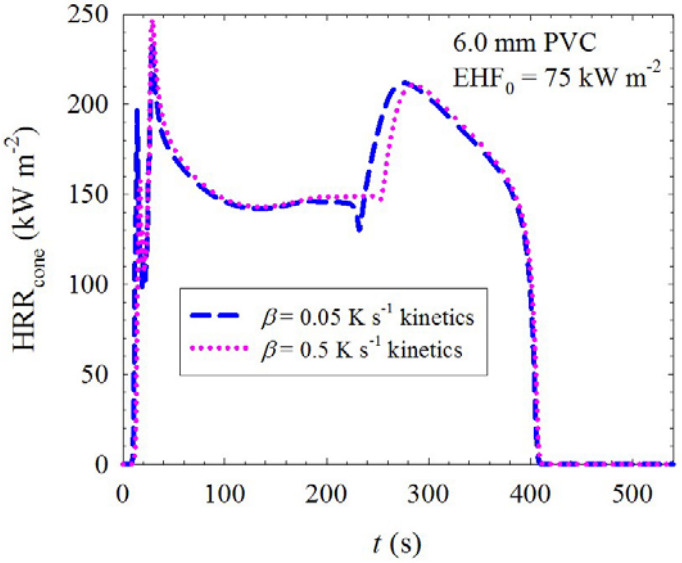


Effect of Uncertainties in Arrhenius Parameters

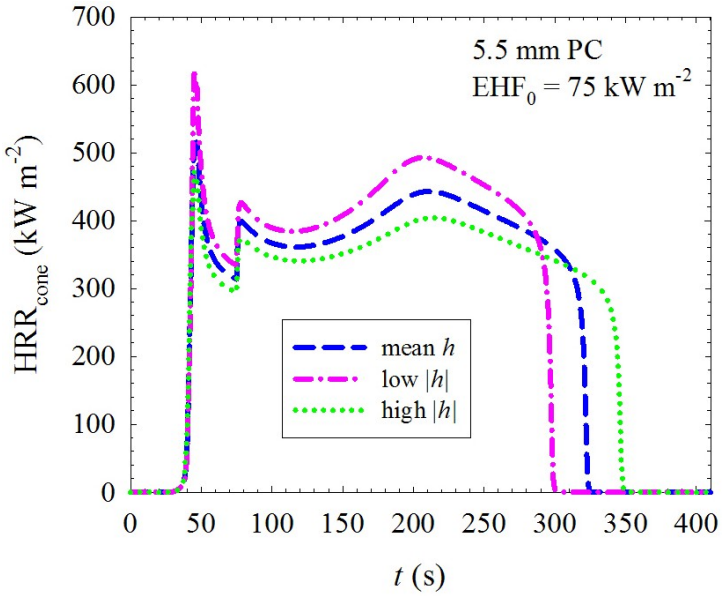


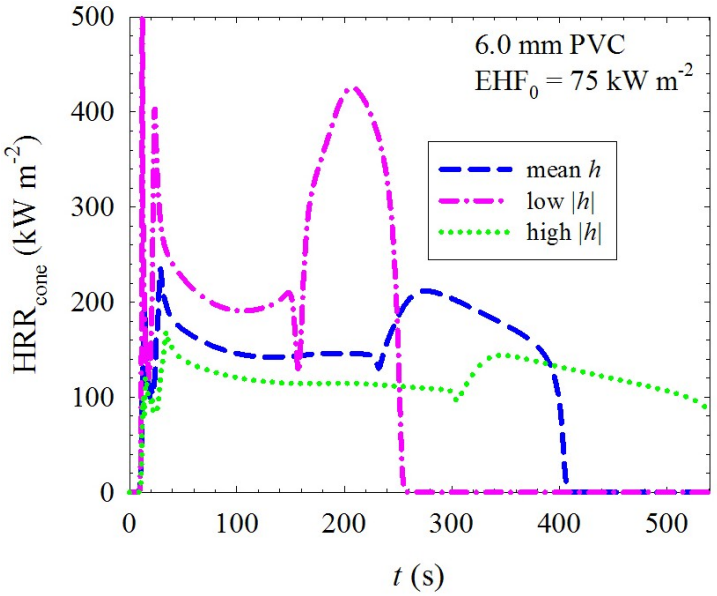






Effect of Uncertainties in Heats of Decomposition





Conclusions

- One-dimensional numerical pyrolysis model can be used to predict the outcome of cone calorimetry experiments performed on a charring and intumescing polymer.
- Char can be represented by a simple submodel based on the properties of graphite and a single adjustable heat transfer parameter, the value of which is determined using the results of one cone calorimetry experiment.
- A considerable improvement in the consistency of the model can be achieved by increasing the accuracy of the heat of decomposition values.