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**ANNUAL CONFERENCE ON FIRE RESEARCH**  
**Book of Abstracts**  
**November 2-5, 1998**

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Kellie Ann Beall, Editor

Building and Fire Research Laboratory  
Gaithersburg, Maryland 20899

**NIST**

United States Department of Commerce  
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# Condensed Phase Phenomena in Commodity Polymers Undergoing Degradation/Gasification

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## ABSTRACT

A series of degradation/gasification experiments has been conducted to better understand the condensed phase processes during burning of commodity polymers such as polypropylene (PP), polyethylene (PE), and polystyrene (PS). Understanding the molten behavior of these thermoplastics is the first step. Although none of the polymers in this test series had flame retardants, future work will include flame-retardant materials. Indeed, understanding the action of these retardants in this molten polymer context is a goal of this study.

Most experiments were conducted in the gasification rig shown in Fig.1 using specimens in the form of 100 mm diameter disks. On the basis of direct observation, initial results for 25 mm-thick specimens of PP exposed to 40 kW/m<sup>2</sup> in nitrogen suggested that the bulk of the gasification layer might be rendered isothermal by the bubble motion, therefore, be simpler to model. To further investigate this, the gasification rig was equipped with a lamp to illuminate a portion of the specimen's surface with white light. This lighting, in combination with a new close-up lens, provided a very good camera view of the illuminated surface area. The bubbles, which at the beginning of the experiment were large and isolated (Fig. 2), eventually formed a froth of very small bubbles, very similar in appearance to that of a beer "head" (Fig. 3). The bulk of the gasification process (over time) was dominated by this behavior. Similar results were obtained for PE. In the case of PS, however, the melt viscosity appeared to be greater and the bubbles in the "froth" were somewhat larger than observed for PP and PE.

In subsequent experiments, sheathed thermocouples (0.25 mm dia.), supported by hypodermic stainless-steel sleeves were installed at positions 3, 6, and 9 mm below the original surface. The temperature traces for PP (Fig. 4) increased fairly steadily with time. Similar traces were obtained for PE and PS. Also, during this series of experiments, the thicknesses of the PP and PE froths were examined by blowing the froth aside with short bursts from a nitrogen nozzle. For both materials the thickness was judged to be one to a few bubble diameters. Consequently, these new results suggest that the idea of a deep, well-stirred (isothermal) vaporization layer is not likely to be appropriate for modeling.

Additional experiments on PE and PP specimens in the cone calorimeter (i.e. flaming conditions) revealed the same bubbling phenomena that were observed in the gasification (nitrogen) experiments.

The appearance of the froth suggests two points relevant to modeling the gasification rate: (1) the incoming radiation must be absorbed over a depth of at least a few bubble diameters; (2) the bubble breakage process which actually releases the polymer degradation vapors very near the surface is probably controlled in large measure by the surface tension of the polymer melt, coupled with thermal degradation of the bubble "windows".

A series of radiation-absorption experiments was conducted on PP specimens exposed to 40 kW/m<sup>2</sup> in the

gasification rig. The intent was to measure the attenuation by the bubbles. The center of the foamed-glass insulator, on which the specimen rests, was drilled-out to accommodate a 6.4 mm diameter heat flux gauge. The face of the gauge was recessed to provide an air gap of about 1.6 mm between the gauge and the lower surface of the specimen. Specimens approximately 12.7 mm, 6.4 mm, 3.2 mm, and 1.6 mm thick were tested. Unfortunately, a significant heat conduction flux developed across the air gap before bubbles were formed, and only the first few seconds of data, representing the non-degraded materials, were valid. Those data, corrected for reflections at the two air-specimen interfaces, show that over a distance of 1.6 mm, 80 percent of the radiant flux was absorbed, and over 12.7 mm, 98 percent was absorbed.

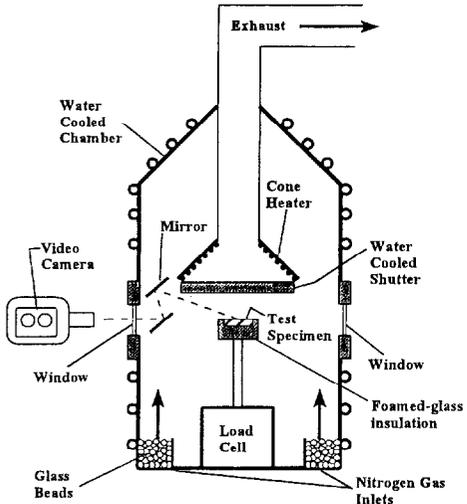


Fig. 1. Schematic of gasification rig.

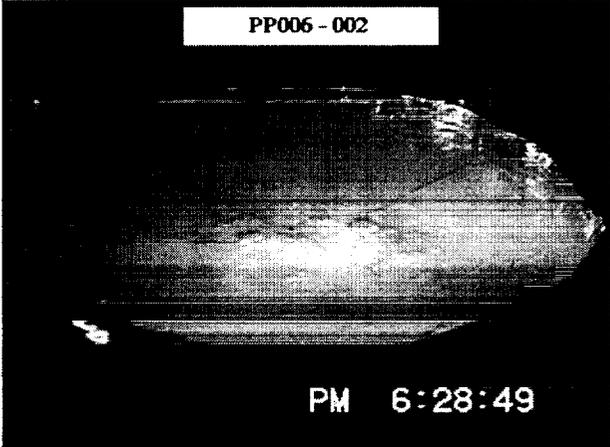


Fig. 2. PP specimen showing large isolated bubbles.

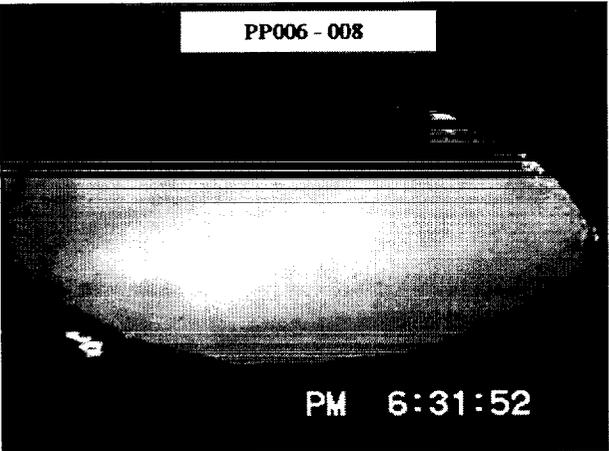


Fig. 3. PP specimen showing froth of very small bubbles.

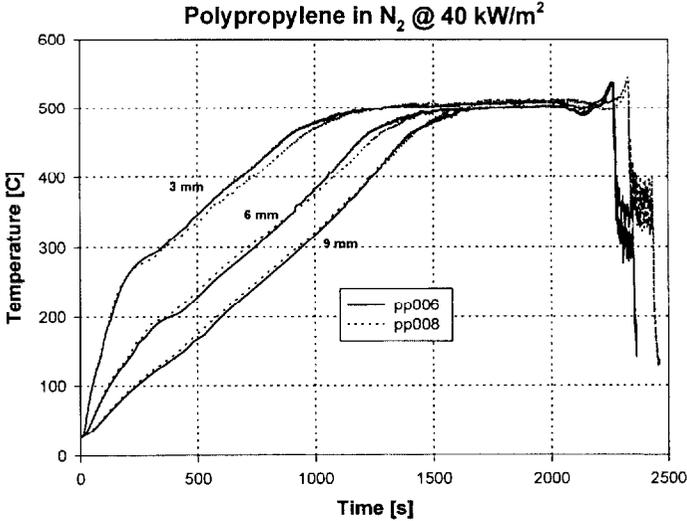


Fig. 4. Temperatures measured at various depths in PP specimens.