

NISTIR 6242

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

Kellie Ann Beall, Editor

Building and Fire Research Laboratory
Gaithersburg, Maryland 20899

NIST

United States Department of Commerce
Technology Administration
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The Influence of Surface Silica on the Pyrolysis of Silicones

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ABSTRACT

Silicones encompass a wide variety of novel materials that find applications in virtually every major industry sector. The dominant polymer in the silicone industry is polydimethylsiloxane (PDMS). The combustion of long chain PDMS exhibits a low heat release rate and the unique characteristic that the heat release rate does not increase significantly with an increase in external applied thermal radiant flux [1] or pool size [2-5]. The deposition of amorphous silica ash (a major combustion product of silicones) on the fuel surface is believed to play a significant role in mediating the fuel formation rate of silicones in fire scenarios. The objective of this study was to document and quantify the influence of surface silica on the pyrolysis rates of PDMS.

For this study, the gasification apparatus developed at NIST-BFRL by Steckler and others was used. An earlier study on the gasification of silicones by Austin et. al., provides complete details on this unique apparatus [6]-both operational and data analysis. A range of silica types and fluids were studied.

The influence of silica on the pyrolysis rates of PDMS fluids was assessed by incrementally adding amorphous fumed silica in a uniform thin layer to the surface of the test fluid sample (100 g) and measuring their pyrolysis rates in the gasification apparatus. Pyrolysis rate data for incremental silica additions are given in Figure 1. The silica additions are estimated to be representative of the quantity of silica deposited on the surface of silicones during the earliest stages of burning. Note the continuous reduction in pyrolysis rate with silica additions. Average pyrolysis rates were obtained following Austin's procedures [6]. These data are given in Figure 2 for external heat flux conditions of 50 and 70 kW/m². A pyrolysis rate of 0.04 g/s corresponds to a heat release rate of 125 kW/m² which is in good agreement with values measured for these polymers [1-4].

The use of silica based additives to mediate the burning rate of thermoplastics was demonstrated by Romenesko et.al. [7]. The potential utility of other inorganic fumed oxides was briefly assessed following the procedures used for silica. These data are summarized in Figure 3. Oxides of aluminum, zirconium and titanium were evaluated. The latter two oxides are effective in mediating the pyrolysis of PDMS similar to silica.

In the course of this investigation, a variety of PDMS polymers were pyrolyzed which resulted in new interesting insights into their high temperature behavior, i.e. the subtle influence of process chemistry and the influence of various additives used in formulating silicones. Data illustrating the influence of polymer molecular weight (I,H-intermediate or high molecular weight), residual catalysts (RCx = chemical form, UC = ultra clean, TCx = trace catalyst levels) and other polymer variables (V, M = polymer chain terminal endgroups) on the high temperature pyrolysis of PDMS are given in Figure 4. Note the profound influence of several of these parameters on the high temperature pyrolysis of PDMS under the thermal conditions in the gasification apparatus. The role and importance of these polymer parameters in the actual fire performance or fire test performance of formulated products have not been determined. However, an awareness and control of them in studies such as this is readily apparent. These findings and their implications regarding fire performance along with several unresolved observations will be discussed.

In summary, the NIST gasification apparatus provides a unique capability for both measuring fundamental fire parameters of materials and providing new insights into the high temperature behavior of polymers and formulations thereof.

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Figure 1. SURFACE SILICA-PYROLYSIS MEDIATION

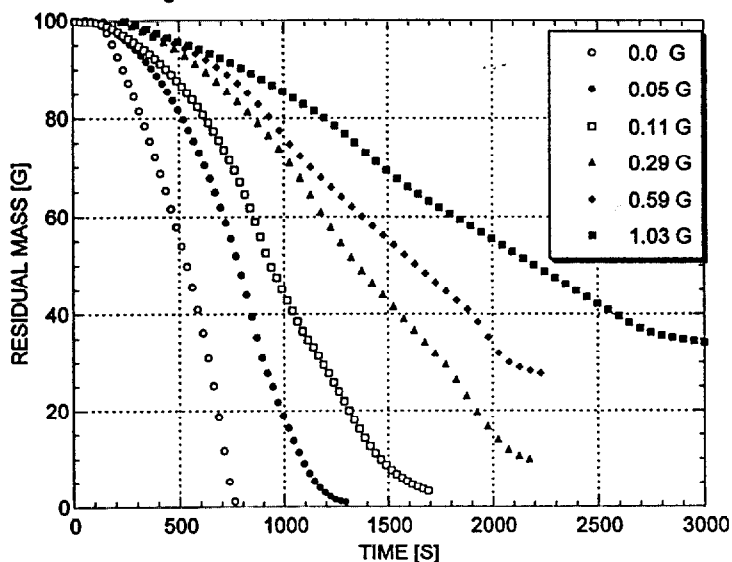


Figure 2. MASS PYROLYSIS RATE vs SURFACE SILICA

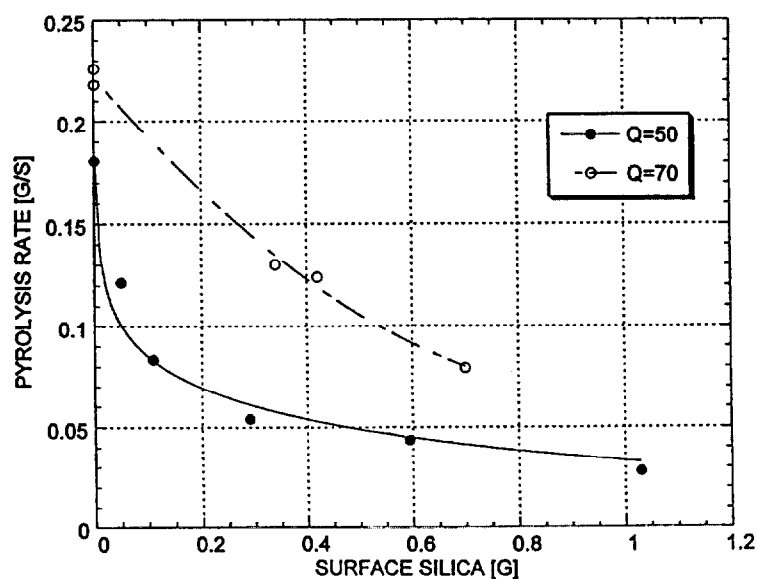


Figure 3. FUMED OXIDES-PYROLYSIS MEDIATORS

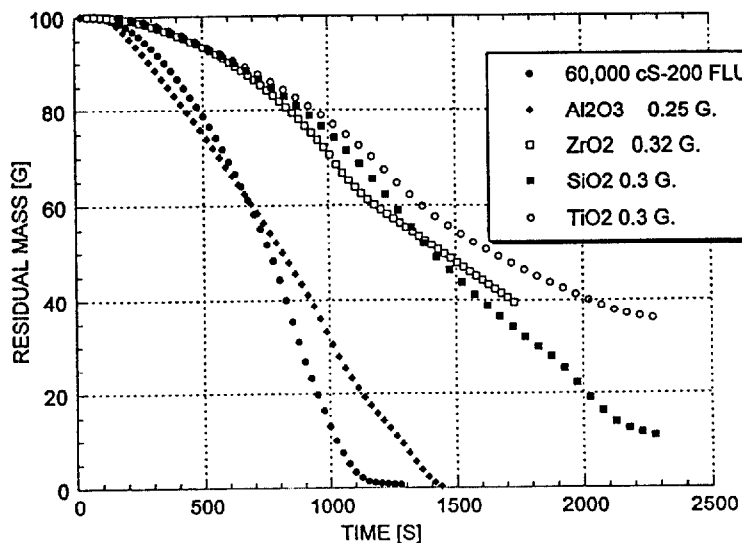


Figure 4. POLYMER VARIABLES

