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AUTHOR(S): Richard C. Oldenborg, CHM-4
Steven L. Baughcum, CHM-4

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Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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GAS-PHASE OXIDATION OF ATOMIC BORON AND BORON MONOXIDE

Richard C. Oldenborg and Steven L. Baughcum
Chemistry Division
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

ABSTRACT

Rate constants for the reactions of $B + O_2$ and $BO + O_2$ have been measured over the temperature range 298-1180 K using the laser photolysis/laser-induced fluorescence technique. The rate of the $B + O_2$ reaction increases slightly with increasing temperature. In contrast, the $BO + O_2$ reaction has a negative temperature dependence and is believed to proceed via a stable intermediate complex.

INTRODUCTION

The emphasis in much of the previous boron slurry rocket fuel research has been on particle ignition, yet roughly half of the potential energy content of boron fuels is released in the gas-phase oxidation of BO(g) to B_2O_3(g). We are investigating the kinetics of the key gas-phase boron oxidation reactions over a wide temperature range so that a comprehensive reaction scheme can be assembled and evaluated. Our initial effort has concentrated on the $BO + O_2 \rightarrow BO_2 + O$ reaction, which is considered to be the key BO oxidation step in dry atmospheres.

EXPERIMENTAL

Volatile boron compounds such as BCl_3 are photolyzed with an excimer laser to provide an essentially instantaneous source of boron atoms. These quickly react with O_2 to yield BO molecules,

$$B + O_2 \rightarrow BO + O$$

which in turn react with additional O_2 to produce BO_2.

$$BO + O_2 \rightarrow BO_2 + O$$

The time histories of the B, BO, and BO_2 are monitored using laser-induced fluorescence (LIF) and chemiluminescent techniques.

Systematic variation of O_2 pressure yields the desired rate constants. Experiments are conducted in a high-temperature cell capable of 298-1500 K operation. All experiments are in an argon diluent at 25 torr total pressure.

RESULTS AND DISCUSSION

The $B + O_2$ reaction rate constant was measured to be 7×10^{-11} cc/molecule-s at 298 K and increases slightly with increasing temperature. In contrast, the $BO + O_2$ reaction rate constant is somewhat slower at 298 K, i.e., 2×10^{-11} cc/molecule-s, and decreases with increasing temperature in a non-Arrhenius fashion. The reaction may proceed via a stable BO_3 intermediate

$$BO + O_2 \rightleftharpoons BO_3 \rightarrow BO_2 + O \quad ,$$

which may help account for this interesting temperature dependence. Experiments are in progress to better establish the functional form of this temperature dependence and to test the role of third-body collisions at both high and low gas pressures. Other key boron oxidation reactions are also presently under investigation.

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