# Humidity retention phenomena inside porous boron carbide pellets

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**Résumé**

Boron carbide (B4C), with its high melting point (2400○C), its excellent mechanical properties, its chemical resistance and its high neutron absorption cross-section, is very used in the nuclear industry as the main component of control rods in Pressurized Water Reactors (PWR). Therefore, as part of an essential component of the nuclear core, the characteristics of the boron carbide pellets are highly controlled. In addition to their mechanical resistance, another important parameter is their water level as an abnormal humidity would imply a shorter average life for the control rod. Unfortunately, it was found that some batches of boron carbide pellets have been oxidized and have unusual humidity retention abilities. However, the difficulty relies on the establishment of the link between the manufacturing process of the pellets and the oxidation mechanism.
The oxidation of boron carbide has already been investigated1 and the following equations were established to explain the oxidation of boron carbide:

Boron oxide (B2O3) is a very hygroscopic molecule, therefore explaining that an oxidized pellet has a high humidity level.

The previous equations show that the oxidation of boron carbide happens according to two steps: first the oxidation of boron carbide into boron oxide, which becomes volatile around 900○C and then the reaction of boron oxide with water vapour into gaseous boric acid (B(OH)3) or metaboric acid (HBO2).

Boron carbide (B4C) pellets are prone to oxidation during their manufacture. Four samples, with various levels of oxidation, were obtained. To characterize these different oxidation states, infra-red spectrometry, X-Ray diffraction, scanning electron microscopy as well as nitrogen adsorption were used. In order to precise the oxidation mechanisms involved, thermogravimetric analysis were conducted under dry (80% N2, 20% O2 or 80% He, 20% O2) or wet conditions (80% N2, 20% O2, 10 mbar H2O or 80% He, 20% O2, 10 mbar H2O), at temperatures ranging from 600○C to 1000 ○C, to artificially oxidize B4C pellets. The oxidized samples were characterized by scanning electron microscopy, X-Ray diffraction and nitrogen adsorption.

The aim of this study is to investigate the oxidation mechanism of boron carbide and to understand the influence of different oxidizing atmospheres and temperature on the formation of boron oxide (B2O3) and boric acid (B(OH)3).

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The oxidation of boron carbide is a complex mechanism. Many factors can influence the formation of boric acid: the duration of the oxidation, the shape of the sample, the nature of the atmosphere (nitrogen or helium-based).

1Viricelle *et al.,* 2001. Oxidation behaviour of a boron carbide based material in dry and wet oxygen. *Journal of Thermal Analysis and Calorimetry,* v. 63, p.507-515.