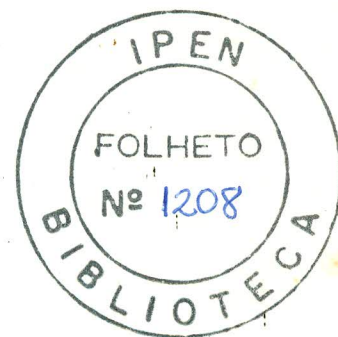


NON-OXIDE CERAMICS: ACTIVITIES IN BRAZIL



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INTRODUCTION

In this work an overview of the activities related to non-oxide ceramics in Brazil is presented. These activities are research and development as well as industrial production. The main topics to be discussed are raw materials and processes for fabrication and characterization of the final products. Finally, some of the research work done by Brazilian scientists in Brazil and at foreign laboratories are listed.

RAW MATERIALS

There is only one group doing research work on the process for obtaining silicon nitride and sialons from the reaction of hydrated aluminum silicates with carbon and nitrogen. Their work, at the Federal University of S. Carlos, has been able to produce $\text{Si}_{6-x}\text{Al}_x\text{O}_x\text{N}_{8-x}$ compounds with different Al/Si ratios starting from several silicates. These silicates and the approximate formulae of the sialons are shown in tables 1 and 2.

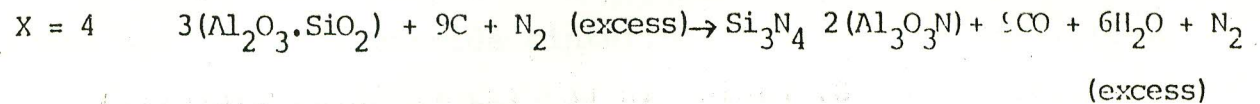
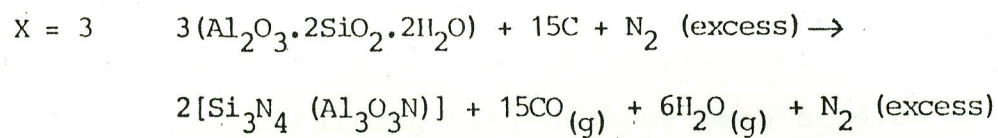
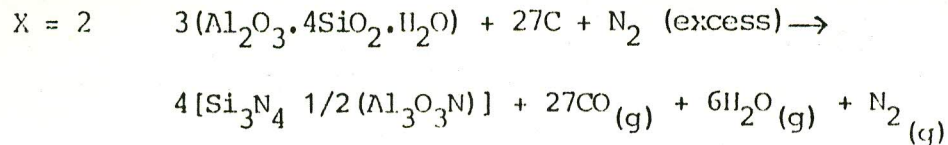
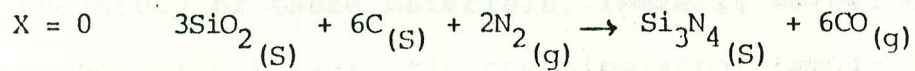
TABLE I

Silicate	Formula	Ratio Al/Si in Equivalents
Silica	SiO_2	0
Pyrofilite	$\text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2 \cdot 1\text{H}_2\text{O}$	1/2
Kaolinite	$\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$	1
Kyanite	$\text{Al}_2\text{O}_3 \cdot \text{SiO}_2$	2

TABLE II

Al/Si	X Value	SiAlON Composition
0	0	Si_3O_4
1/2	2	$\text{Si}_4 \text{Al}_2\text{O}_3 \text{N}_6$
1	3	$\text{Si}_3 \text{Al}_3\text{O}_3 \text{N}_5$
2	4	$\text{Si}_2 \text{Al}_4\text{O}_4 \text{N}_4$

The corresponding carbothermic reaction are the following:



The main conclusions of their work is that their method is a low cost one and leads to highly reactive sialon compounds.

Besides their work, nothing worthwhile has been done on research for obtaining non-oxide ceramic powders.

On the industrial side, we could mention the silicon carbide production by Carborundum, using the electrofusion process.

PROCESSES FOR FABRICATION; CHARACTERIZATION

As the study of the processes for fabrication of non-oxide ceramics requires sophisticated equipments there is almost no involvement of Brazilian researchers in this area. There is a small number of furnaces and hot presses suitable to the study of these materials. There is no evidence of the existence of hot isostatic pressing apparatus in research laboratories in Brazil.

Only two institutions have done research work on processing and characterizing of non-oxide ceramics: the Federal University at S. Carlos and the Institute for Energy and Nuclear Research at S. Paulo. In the former, some sintering parameters for obtaining sialons have been studied as already described before. In the latter, research work is being carried out on boron carbide sintering, on the crystallization of the amorphous phase of beta-sialon with yttria additions, and on the polymorphism in silicon carbide; these studies are a continuation of the doctoral thesis programme followed by two researchers at the Max-Planck Institute at Stuttgart in the Federal Republic of Germany in the period 1980-1984 (pl. see attached publications list). In 1987 two other institutions started a programme for non-oxide ceramics research work: the National Institute of Technology (Instituto Nacional de Tecnologia - INT) in Rio de Janeiro and the Institute for Technological Researchers (Instituto de Pesquisas Tecnológicas - IPT) in S. Paulo. The INT ceramics group is oriented to research and development of non oxide ceramics. Their

programme goes from the production of the starting ceramic powders to the characterization of the non oxide ceramic pieces. On the other hand, the IPT ceramics group directed their efforts to the study of processes for fabrication of AlN substrates. The same kind of research work is being pursued by the Federal University of S. Carlos.

On the industrial side, only some refractory materials, resistive elements, and wear resistant pieces for mining applications are available. Carborundum, Coors and Combustol are the main plants. None of the ceramic pieces available in these industries have high mechanical strength. Some small and medium industries show interest in investment in the fabrication of silicon nitride and silicon carbide high mechanical strength pieces. Significant involvement has not appeared so far.

CONCLUSIONS

Our main conclusion is that either in the research area or in the industrial production area, Brazil has not performed satisfactory development. We should also mention that in the last few years some research institutions as well as some small and medium industries have shown intentions for investment in the non oxide ceramic area. This is due to the worldwide progress in the advanced ceramic area, having Japan as one of the leading countries. Several barriers have to be overcome, the most important one being the lack of suitable laboratory facilities and enough well trained scientific staff.

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