Innovative porous SiC ceramics from natural precursors

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Silicon carbide (SiC) belongs to the materials known as advanced ceramics which emerged as a consequence of the limitations of metal alloys for certain structural applications or in aggressive environments at high temperatures[1,2]. It is a low dense material (3.21g/cm^3) composed by a covalent bond, covalence degree of 88%, and a similar structure to diamond. Both properties are the reasons for presenting a value of hardness of 13 in Mohr scale (being 15 for diamond[1]) as well as a great mechanical strength to both thermal shock and chemical attack[3]. At the same time, due to its electron configuration it acts as a semiconductor material. Silicon carbide can be obtained by different traditional methods as hot pressing sintering, pressureless sintering, chemical vapor deposition etc. The main drawbacks of the prior techniques are the complexity in the reproducibility of the pieces and the difficulty to obtain complex shapes, which reduces the range of applicability of the ceramics, the need for final machining and high temperatures requiring of expensive technology (high cost of manufacture) and the decrease of mechanical properties due to the use of additives[1, 3].

In 2001 a new method for the obtaining of SiC was developed[4]. This process met the requirements for all industrial manufacturing processes that are low cost and simplicity and, included the novel use of biological plant precursors as the carbon source[4]. It consists on the pyrolysis, or thermal decomposition, of the cellulose-based precursor to obtain a piece of porous carbon that preserves on it the interconnected vascular system of the plant. This piece of carbon is then subjected to a reactive infiltration with silicon (up to 1550ºC). The molten silicon will flow through the entire piece by means of the interconnected pores reacting with carbon, resulting in a porous SiC ceramic, also called Biomorphic® SiC [1]. The use of silicon powder of high purity or additives are not necessary and, due to the use of an open-porosity structure, the velocity of the synthesis increases together with the ability to produce pieces with complex shapes by modeling the carbon preform[1].

Different cellulose-based precursors as trees (*Entrandrophragma cylindricum*, *Eucalyptus* spp and *Pinus* spp), marine plants (*Juncus maritimus* and *Zostera marina*) or macroalgae species (*Laminaria ochroleuca*) have been successfully used for the obtaining of these porous SiC ceramics. The fact that the final ceramic retains the biological porosity and interconnectivity is one of the reasons for the great potential of this material, as traditionally it has been "printed" on the different materials the specific needed microstructure. With the use of these plant precursors, that costly process is avoided given that the desired microstructure has been already developed on the materials by nature[6], providing the ceramics with macro- and micro-patterning on their surfaces, ranges of porosity from nano to macro-scale... that will make it possible to select one over another depending on the final application[5]. Thus, it has been introduced in industrial processes as a compound resistant to abrasion and corrosion (mechanical valves), to friction (brake pads), to temperature (receivers of solar radiation, engines, turbines), also in structural reinforcing concretes, acoustic and thermal isolation... or even as a biomaterial for bone prosthesis[1,5,7]. As a semiconductor material it is also attractive for blue light emitting diodes, ultraviolet and high-temperature sensors, radiation-hardened electronics, high-power electronics...This work pretends to summarize the great variety of materials with a range of microstructures and porosities that these biological precursors have provided to the ceramics field.

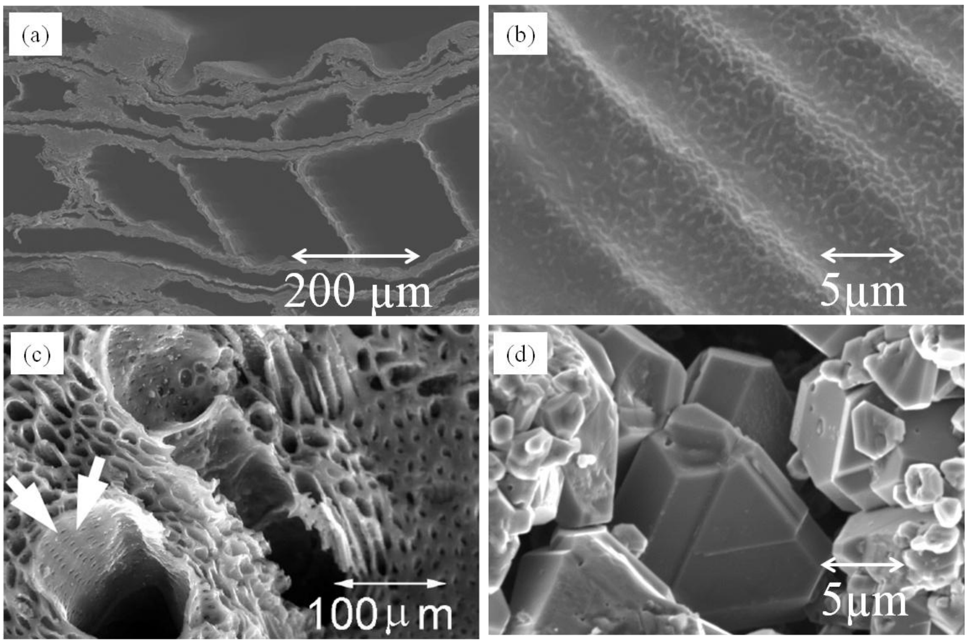

Fig. 1 Scanning electron micrographs presenting porosity (a, c), surface patterning (b) of different cellulose-based precursors and a crystal of silicon carbide (d).

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