New precursors for plasma-facing carbon-based materials

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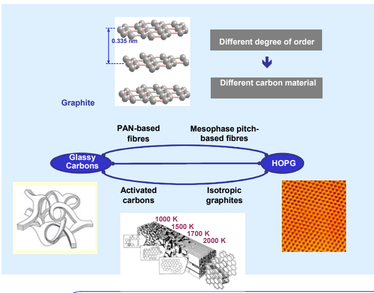
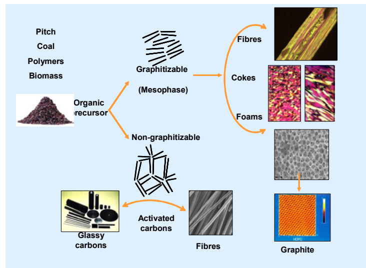
Introduction

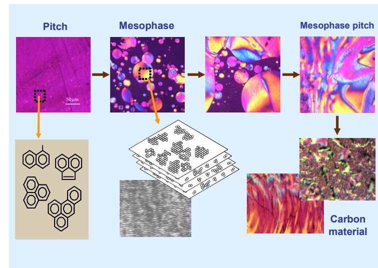
Structure of carbon materials



Liquid-solid precursors



Transformation of pitch into carbon

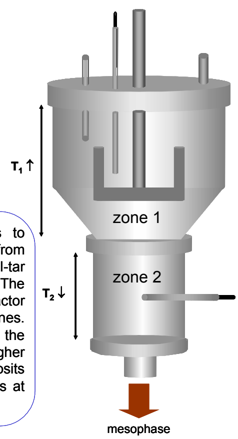


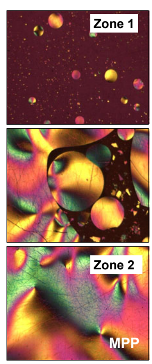
Carbon materials are good candidates for new applications in extreme environments. They offer many of the desired requirements for plasma-facing materials: low atomic number, good thermo-mechanical properties, high thermal conductivity, high melting temperature and low coefficient of thermal expansion. However, the properties of these carbon-based materials still need to be improved.

Mesophase is a liquid crystal phase that forms during the conversion of pitch into carbon material. The use of mesophase as precursor of carbon materials usually yields materials of improved properties, as a result of the pre-graphitic structure present in the mesophase. In this study, the development of a new process to obtain mesophase pitch is explored.

Development of mesophase pitch

A single stage process to obtain mesophase pitch from a petroleum or a coal-tar pitch is being developed. The system consists of a reactor divided in two zones. Mesophase is formed in the upper one, at higher temperatures, and it deposits in the lower one, which is at lower temperatures.





After 6 h of reaction, in the upper part of the reactor (zone 1), very little mesophase is observed. In the middle part, the mesophase content increases significantly. The diameter of the spheres is much larger than in zone 1.The lower part (zone 2) contains a highly pure mesophase pitch, fully coalesced, proving the viability of the method. Moreover, the process has the potential to extract the mesophase continuously from the reactor.

Properties of the mesophase pitch developed and a commercial one (AR24)

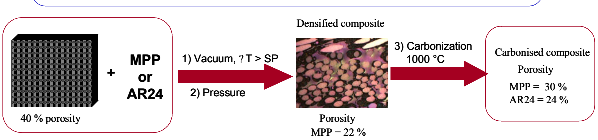
	MC	CY	SP	C/H	TI	NMPI
AR24	100	77	292	1.6	75	46
MPP	97	77	330	1.8	78	68

MC, Mesophase content (vol. %)
CY, Carbon yield at 1000°C (wt. %)
SP, Mettler softening point (°C)
C/H, atomic ratio
TI, toluene insoluble content (%)
NMPI, N-methyl-2-pirrolidone (%)

The carbon yield is very high for both mesophase pitches. However, the softening point of the commercial mesophase pitch is significantly lower than that of the mesophase pitch developed, which makes the processing of this last pitch more difficult.

Preparation of carbon-carbon composites

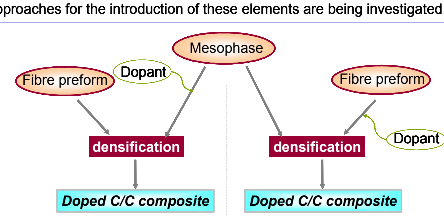
The use of mesophase pitch as carbon matrix precursor in the preparation of carbon-carbon composites would allow a reduction of number of the densification cycles (due to its high carbon yield). However, processing of mesophase pitch is not easy due to its high softening point and high viscosity.



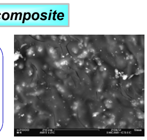
The use of the commercial mesophase pitch results in a higher densification degree. However, after carbonisation, both pitches yield materials with not so different porosity. The introduction of an oxidatively stabilization step before carbonization would promote a decrease in porosity.

Preparation of Ti doped composites

The introduction of metals into the composite would contribute to enhance the oxidation resistance and chemical erosion of the materials. Different approaches for the introduction of these elements are being investigated.



Preliminary studies are being made with Titanium butoxide, mixed with the pitch in a molten stage. The dispersion degree and size of the particles (TiO_2) seems to be suitable. The next stage is to infiltrate the carbon preform with this Ti-doped precursor.



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