

Carbon Foams; Precursors, Properties and Applications

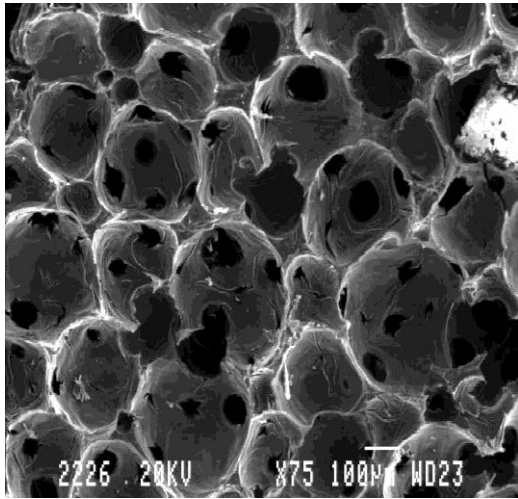
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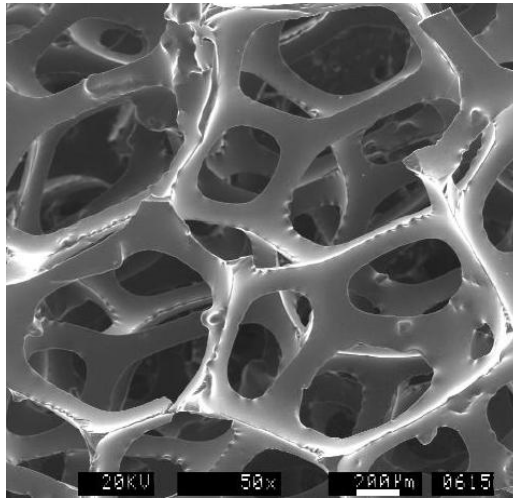
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Carbon foam is a structural material, which has unique properties such as low density, high compressive strength, and high thermal conductivity. With these properties carbon foams has a potential to be use as an alternative material for various applications. The main application including aviation space industry, automotive industry, lightweight mirrors, thermal protection systems, heat transfer systems, lightweight antennas, lightweight armor, battery and fuel cell electrodes, brake disks, engine components, catalytic converters, heat exchangers, energy absorbing crash barriers, structural insulated panels, high temperature insulation, fire doors and bone surgery material.

Carbon foams were first developed in the late 1960s by Walter Ford [1]. Carbon foams can be produced from a variety of precursors. The precursor and the process, process conditions determine the properties of the foam. Some of these precursors are synthetic mesophase pitch [2], coal tar and petroleum pitches, coal , Polyacrylonitrile (PAN), polyurethane vinylidene chloride polymer, phenolic polymer and pyrolyzable organic compounds such as sugar or cellulose. Figure 1 shows scanning electron microscope photographs of carbon foams produced from Mitsubishi AR pitch (a) and reticulated vitreous carbon foam RVC (b)



a



b

Figure 1 SEM photographs of carbon foams (a) from Mitsubishi AR pitch (b)Reticulated vitreous carbon foam RVC [3]

Generally, on pitch and coal based carbon foam formation together with viscosity bubble growth is an effective mechanism affecting foam formation. As the temperature is increased under high pressure, more volatiles are evolved. They may remain in bulk phase or form cells by

coalescence as pressure is reduced more volatiles are released to affect the foaming process. When the pressure is released the volume of the cells expand, the structure and interconnection between the cells are established in which reduction of viscosity plays an important role. Figure 2 a shows the terminology used for carbon foam and Figure 2 b shows schematic representation of cell formation.

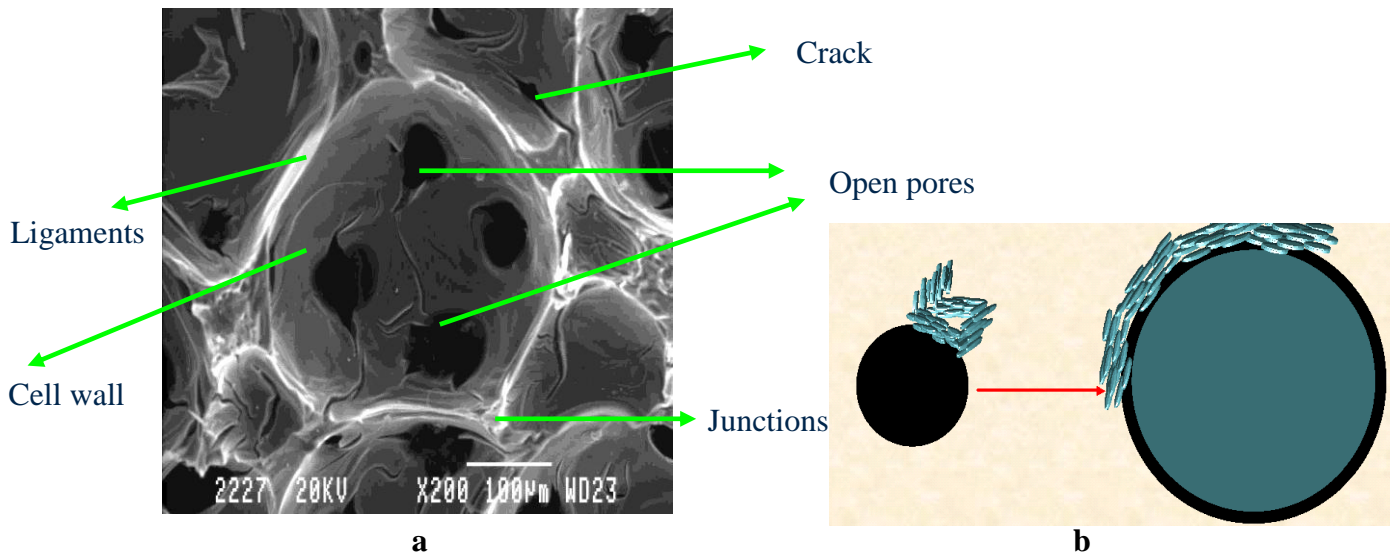


Figure 2 a Terminology used for evaluation carbon foam SEM photographs and Figure 2 b shows schematic representation of cell formation.

There are various techniques for the manufacture of carbon foams. Researchers from the US Air Force Materials Laboratory developed a production process by applying a ‘blowing’ technique to mesophase pitches to form a carbon foam. The foam is then oxidatively stabilized prior to carbonization and graphitization. A process that does not require blowing and stabilization steps was developed at Oak Ridge National Laboratory (ORNL). Modified version of both processes is used by Istanbul Technical University Carbon Group in order to produce carbon foams from Mitsubishi AR pitch and Turkish asphaltites.

The effect of process parameters such as temperature, pressure and pressure release time are investigated in these studies. The results shows that; increase in process temperatures resulted in more homogeneous, interconnected, better structured, higher density, higher compressive strength and higher porosity carbon foams. Higher density, increased compressive strength and a more interconnected open celled porous structure are obtained at higher pressures. A more interconnected open-celled porous structure is formed for shorter pressure release times. For carbon foams were produced from original and deashed asphaltites deashing improved the structures of the foams.

References

- [1] Ford W. Method of making cellular refractory thermal insulating material. US patent 3121050, 1964.
- [2] Klett JW. Process for making carbon foam US. Patent 6033506, 2000.
- [3] ERG Materials and Aerospace Corporation. 900 Stanford Avenue, Oakland, CA 94608, USA. Reticulated vitreous carbon datasheet.