CHAPTER – VI

CONCLUSIONS
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Under present studies work has been carried out on modification of two binder pitches. These have been analysed for physical, thermal and optical properties. Raw pitches have been stabilized in air and nitrogen at different temperatures for different time intervals. By using these modified pitches, composites were fabricated with high strength carbon fibers. Various conclusions have been made from these studies are given in this chapter.

From the present studies it is concluded that modification of binder pitches, by air-blowing, at temperatures between 350°C & 400°C for periods of 1 hrs. to 10 hrs. results in significant increase in carbon yield and softening point. The solubility of pitches in Benzene shows that coal tar pitches have better binding properties than petroleum pitch. Coke yield is also higher in coal tar pitch as compared to petroleum pitch. In presence of air the rate of polymerization of pitch gets enhanced. The low molecular weight components are evolving out due to heating while some of these are getting polymerized. As the time of modification increases, the Haro/Hali ratio was found to increase. After 5 hours, it get decline. For thermally treated pitch, this ratios is found to be lower than that for air stabilized pitches.

C/H ratio has been found to increase with heat treatment temperature and time in presence of air. This confirms that aromaticity increases with heat treatment in
presence of air. Heat treatment of pitches in air at temperature, more than 350°C result in low yield and high softening point. This suggest that pitch of required fluidity, pitches air-blown at 350°C may be the most suitable conditions for matrix precursor.

From the work carried-out under the present studies, it is concluded that stabilization in nitrogen or air of pitch used as matrix precursor strongly influences the development of the carbon matrix structure in carbon/carbon composites. In fact, stabilization of pitch in air induces major changes in the porosity amount and the size and shape of voids. In particular, the debonding between fibers is less pronounced in the case of stabilized pitch which results in a smaller pore fraction at the inter tow level. TPD of C/C composite indicates that the devolatilization process of the matrix precursor is less complete up to 1000°C. This is attributed to the development of an internal and closed porosity, which is particularly important in the case of a composite based on stabilized pitch.

The reactivity of C/C composites and their constituents, carbon fibers and matrix was compared. The final heat treatment temperature of the composite has been found to significantly influence their oxidation behaviour. In particular, the reactivity of the composites decreases as the final temperature of the heat treatment of the composites reaches 2000°C. For composites heat-treated at 1000°C, it clearly appears that the use of a carbon matrix originated from air-stabilized pitch results in a lower reactivity of composite. Like for the carbon fibers, the reactivity of the composite heat-treated at 1000°C is higher in wet air than in dry air. Therefore, it can be deduced
that the nature of the carbon matrix and the oxidizing environment strongly influence the reactivity of the composites heat-treated at 1000°C, but for composites annealed at 2000°C and 2500°C, this influence is not really marked.

Oxidation of the composite is due to the oxidation of carbon fibers and carbon matrix as well and the fraction of carbon fibers taking part in the oxidation process is higher than the one of coke matrix. Moreover, this fraction is also larger for an oxidation in wet air compared to dry air. The results are in agreement with those obtained by the study of the oxidation of carbon fibers and coke taken separately. The same trend has been found for composites made with stabilized pitch compared to the one made with unstabilised pitch.

The mechanical properties of the composites have been found to decrease with extent of oxidation. The decrease is not appreciable upto 5% burn off. For extended oxidation, the strength is found to decrease rapidly. This is due to onset of oxidation of the carbon fibers. The influence of oxidation on mechanical properties is less pronounced in case of composites made with air stabilized pitch than for composites made with as such pitch as matrix precursor.

As a major conclusions of the studies it is deduced that:

Air stabilization of coal tar pitch under optimum conditions (around 350°C for one hour) result in a processable matrix precursor for carbon/carbon composites.
Using air stabilized pitch as matrix precursor, high density carbon/carbon composites can be made with lower impregnation cycles than with as such pitch.

Water vapours enhance oxidation rates.

Oxidation resistant of carbon/carbon composites can be increased by controlling the carbon matrix structure though use of air stabilized pitch as matrix precursor and higher heat treatment temperature of the composites can increase oxidation resistant of carbon/carbon composites.