1. INTRODUCTION

Wood is the most important and major forest product. It is one of the oldest known raw materials and from the pre-historic period man used it for fuel, tools, boat making and house construction. It is biological in origin, renewable and biodegradable.

Wood is also a modern raw material as well. Huge timber vaultings and precious furniture exemplify its glory. Besides solid wood applications, wood has become a valuable material in reconstituted forms such as plywood, particle board, fibre board, etc. It forms the basic substance for pulp and paper, films, fibres, additives, chemicals and many other products.

About one third of the world’s land surface is covered by forests which contain a total growing stock of about 300 billion m³ of wood (Steinlin 1979). Hence it is one of the most important products of nature. The global consumption of wood increased drastically since the early part of this century and further rapid increase in consumption is predicted for the future (FAO 1981). The world’s total annual requirement of round wood by 2000 A.D. is estimated to vary between 3800 and 6200 million m³. The demand for industrial round wood and pulp wood is increasing day by day. The consumption of the most important product of chemical conversion of wood, pulp, is also increasing day by day. The decrease in the internal sources of supply and a growing concern for environmental protection in the developed countries resulted in an increased exploitation of tropical forests in the developing countries culminating in the fast depletion of tropical hardwoods and the resultant increase in price. FAO (1992) reported a substantial raise in the prices of various forms of wood.
One of the primary and historic reasons for the continuous decrease in the forest wealth of India is the increasing demand for fuelwood with the growing population. A further burden was from the excess demand for timber during the two world war periods for ship building and railways. The post world war period witnessed major agricultural expansion activities which resulted in a significant loss of forest cover, causing a further decrease in timber production. The demand for timber for construction, joinery, furniture and for the manufacture of modern construction materials like plywood, fibre board, etc. increased over the years. All these developments exerted pressure on the limited timber resources resulting in a rapid increase in timber prices. In India, the projected demand for wood is 63 million m³ by 2000 A.D. (Govt. of India 1976).

In Kerala State, the imbalance between demand and supply of wood has been on the increase due to factors like growth of population and increased demand for timber with the increase in standard of living. Also, the negligence of sustained yield management practices of the forests led to loss of forest cover. The rapid rate of declining forest wealth created more environmental awareness which resulted in the stoppage of clearfelling of natural forests, and consequent shortage of timber supply. This has led to a further increase in timber prices in the State.

Krishnankutty (1990) reported that the effective demand for industrial timber in Kerala during 1987-'88 was 2.5 million m³ round wood equivalent. The long term trend in timber prices, as reported by Krishnankutty (1989 a), gives a clear indication of scarcity of timber resources in the State. Projections for the future indicate that the likely supply-demand disparity can be neutralized to some extent by economizing the timber use.

1.1 WHY RUBBER WOOD?

It is clear that timber plays a significant role in the economy of Kerala. Development of wood-based industries is therefore of great importance to the
State. But with the current rate of dwindling timber resources, there is uncertainty over the availability of raw material for timber industries. This critical situation calls for drastic changes in the pattern of raw material supply and utilization. One approach to partially solve the problem is to evolve appropriate technologies for the utilization of non-conventional timbers.

Rubber plantations are an important non-conventional source of timber. Rubber plantations ensure a sustained supply of rubber wood as the plantations are managed on a rotation of 25-30 years. Utilization of this resource can indirectly contribute to the conservation of natural forests. The major rubber growing ASEAN countries have the potential of producing 19 million m³ of rubber wood logs per annum based on an annual replanting rate of 3% and an estimated yield of 100 m³ per hectare (Ser 1990).

India is one among the leading rubber growing countries in the world. According to the estimates of the Rubber Board of India (RRII 1992), the total annual wood production is about 1.27 million m³, out of which 60% is stem wood and the remaining 40% branch wood. Kerala State accounts for about 86% of the total area under rubber cultivation in India (Mannothra 1993, George and Joseph 1993).

A study conducted by Krishnankutty (1989 b) showed that rubber wood accounted for around 65% of the total consumption of industrial wood, excluding sawmilling in Kerala, indicating the significant contribution of rubber wood in the industrial economy of the State.

The consumption pattern of rubber wood in India, as reported by the Rubber Board of India is given below (RRII 1992):
<table>
<thead>
<tr>
<th>Consuming sector</th>
<th>Quantity consumed (million m³)</th>
<th>Relative share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packing case</td>
<td>0.49</td>
<td>64.5</td>
</tr>
<tr>
<td>Safety matches</td>
<td>0.13</td>
<td>17.1</td>
</tr>
<tr>
<td>Plywood</td>
<td>0.10</td>
<td>13.1</td>
</tr>
<tr>
<td>Processed wood</td>
<td>0.03</td>
<td>3.9</td>
</tr>
<tr>
<td>Others</td>
<td>0.01</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.76</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

This clearly shows the need for more value addition and more efficient utilization, as is evident from the insignificant share of processed rubber wood in the total consumption.

It is estimated that about 50% of the demand-supply imbalance of wood can be resolved by rubber wood (Mannotha 1993). Thus rubber wood can play a very important role in the timber scenario of the State. Conversion of this perishable wood into value added products through chemical treatments warrants attention since it is available at comparatively low cost and the plantations are likely to become one of the most promising sources of wood in the state. Because of the acute timber scarcity, the stem wood of rubber tree now finds many applications. Effective utilization of this wood will relieve pressure on our forests to a significant extent.

1.2 NATURE OF THE PROBLEM

Perishable nature of rubber wood - its susceptibility to fungal and insect attack - limits its wider utilization. Rubber wood will continue to be under-utilized if it is not treated with preservative chemicals for protection against fungi and
insects. It is because of this reason that rubber wood has been traditionally used for firewood, packingcases and match veneers and splints. Only through developing appropriate techniques for the protection, wood from rubber tree can be effectively and efficiently utilized. The protection can be approached in two different angles, one with the use of conventional toxic preservatives and the other by non-conventional method using environmentally friendly non-toxic chemicals, like chemical modification.

1.2.1 Biodegradation

Rubber wood is classed under the category of perishable timbers. It is highly susceptible to the attack of biological organisms such as fungi, insect borers, termites and marine borers. Through the cut ends of the logs, soon after felling, fungal infection starts. The sapstaining fungi causes a bluish black stain and the aesthetic value of the timber gets affected. Along with this, the infestation of decay fungi causes deterioration of the wood which affects its physical and mechanical properties. Also rubber wood is highly susceptible to the attack of insect borers during the air-drying period. Heavy infestation of insect borers can lower its mechanical strength. Under marine conditions rubber wood is affected by the intense attack of marine borers.

1.2.2 Natural durability

The high susceptibility of rubber wood to the attack of biological organisms makes it to be grouped under the 'durability class 3 type' of timbers, whose average life in ground contact is less than 60 months (BIS 1982). Balasundaran and Gnanaharan (1990 a) reported rubber wood as 'non-resistant' to decay fungi. Varma and Gnanaharan (1989) recorded it as highly susceptible to termite attack in ground contact. Santhakumaran and Srinivasan (1989) and Rao et al. (1993) found that rubber wood was easily degradable in marine conditions. All these studies clearly indicate that rubber wood is not naturally durable.
1.3 OBJECTIVES OF THE STUDY

Preservative treatment is the most important aspect to be taken care of for the effective utilization of this perishable timber. Appropriate preservation techniques suitable for small scale industries as well as medium to large scale industries need to be developed/standardised. Diffusion treatment, suitable for both sectors, and vacuum-pressure impregnation (VPI) treatment, suitable for the latter, have to be standardized. Even though conventional wood preservative chemical composition such as copper-chrome-arsenate (CCA) is more effective, due to the increased environmental concerns emphasis has been given in the present study for the use of environmentally safer chemicals like boron compounds.

To ensure the availability of raw material throughout the year, rubber wood will have to be stored for few months. Because of its acute susceptibility to biodegradation, the method of storage is very important. Under-water storage is an effective way to protect timber from the attack of biological organisms. This method of storage needs to be evaluated in the case of rubber wood. It is also important to assess the effect of under-water storage on the physical and mechanical properties as well as on the treatability.

As environmental concerns are becoming more and more important these days, the possibility of using non-toxic compounds for wood preservation needs to be explored. Chemical modification of wood structure is a novel and environmentally friendly method of wood preservation. This can be achieved by blocking the confirmational sites required for the highly specific enzyme-substrate reactions, thereby modifying the wood so that the attacking microorganisms do not recognize it as a food source. Further, replacing the polar hydroxyl groups with less polar groups results in reduction in hygroscopicity which means increased dimensional stability.
It was decided to develop and standardize the optimum treatment conditions for the production of 'modified' or 'improved' rubber wood through chemical modification by acetylation technique. Another aspect of the study was to evaluate the effect of acetylation on the physical and mechanical properties of rubber wood for different end-use applications. The utilization potential of modified rubber wood fibres for the preparation of medium density fibre board (MDF) and the effect of acetylation on the dimensional stability and strength properties of MDF were also included as part of the study.

Thus the broad objective of the study was to develop appropriate techniques for converting the highly perishable rubber wood into durable, value-added products; thus to effect saving of our valuable natural forest from the pressure for timber.