CHAPTER 3

TURPENTINE A BIOFUEL

3.1 INTRODUCTION

This chapter briefly discusses about the sources, types, tapping methodology, physical and chemical properties, chemical composition and reactivity of the biofuel turpentine that was used in the work. It also provides a brief insight to the physical and chemical properties of this substance and its potential as a future biofuel.

3.2 TURPENTINE

Turpentine is a kind of volatile essential oil obtained from oleoresin exuded from the various species of pine tree when subjected to mechanical injury. Oil of turpentine is a colourless, oily, odorous, flammable, water-immiscible liquid. Its chemical formula is $\text{C}_{10}\text{H}_{16}$.

3.3 SOURCES OF TURPENTINE

Pine trees are the world's known tallest, biggest, oldest and most populated trees (even 5000 year old trees are known to exist!). Genus Pinus is one of the most widely distributed genera of trees in the northern and southern hemisphere, extending from the polar region to the tropics. It is one of the most widely planted exotics because of its large-scale use for timber and pulp.
Pine trees (coniferous trees) naturally has a kind of resin, which is rich in chemical compounds such as terpenes, fatty acids, waxes, tannins and phenolics. The main function of the resin is to protect the tree against insect, pests and diseases, and as energy reserves. This resin is identified as oleoresin, which the tree may exude when subjected to stressors. The crude oleoresin exudates are converted into its primary fractions such as gum rosin and turpentine by steam distillation process.

Pine trees can be easily cultivatable in wastelands and they need very little or no water and human effort. Turpentine can also be obtained from pines needles (leaves of pine trees) by steam distillation.

Figure 3.1 to 3.5 shows the picture of resin exudation from pine tree, resin tapping operation, resin rosin turpentine, molecular structure of turpentine (Occupational Safety and Health Guideline for Turpentine), TG oil and terpene oil respectively.

Figure 3.1 Resin exudation from pine tree
Figure 3.2 Resin tapping operation in pine tree

Figure 3.3 Resin rosin and turpentine
3.4 TYPES OF TURPENTINE

There are three distinct types of Turpentine

- **Gum Turpentine**
  
  It is obtained by tapping from living pine trees.

- **Sulfate Turpentine**
  
  It is recovered during the conversion of pine wood chips into pulp by the sulfate (craft) pulping process.
Wood Turpentine

It is obtained from resin-saturated pine wood kept long period after the tree has been felled.

3.5 RESIN TAPPING METHODS

3.5.1 Bark Chipping Method

This is a conventional method of resin tapping operation. This method involves chipping of bark upto 5 cm wide along one-third the tree’s circumference. The resin exudates from the chipped portion are collected in open cups affixed to the tree. The mixture of sulfuric acid and the plant growth regulator called ethephon are applied to the freshly wounded cambium layer of the tree to enhance oleoresin yields and to prolong the duration of flow. This treatment process is repeated at intervals of 3 to 4 weeks proceeding longitudinally along the stem to expose fresh resin ducts and remove resin tissue to renew the flow of oleoresin.

3.5.2 Borehole Method

Borehole method is a new method of oleoresin tapping from pine tree. It was developed in an attempt to overcome some of the limitations of bark chipping. A key feature of the system is that a closed collection apparatus captures the volatile oleoresin and prevents premature solidification of the resin acids, thereby maintaining the flow for an extended period of time. Labor requirements and costs for borehole tapping are significantly lower than conventional bark chipping method. Also, product quality is higher due to reduced oxidation and gross contamination, and recovery of volatiles (turpentine) is about 50 percent greater.

The oleoresin thus obtained from the above processes is finally steam distilled to obtain turpentine oil.
3.6 CHEMICAL COMPOSITION

Turpentine is a mixture of organic compounds mainly terpenes and its composition can vary considerably according to the species of pine tree from which it was derived. Oil of turpentine consists of hydrocarbons (terpenes) of the formula C_{10}H_{16}.

3.7 PHYSICAL AND CHEMICAL PROPERTIES OF TURPENTINE

The physical and chemical properties of turpentine are presented and compared with gasoline and diesel fuel in Table 3.1. The properties of turpentine are obtained from ‘Occupational Safety and Health Guideline for Turpentine’.

Table 3.1 Physical and chemical properties of turpentine

<table>
<thead>
<tr>
<th>Properties</th>
<th>Gasoline</th>
<th>Diesel</th>
<th>Turpentine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula</td>
<td>C_nH_{1.87n}</td>
<td>C_nH_{1.5n}</td>
<td>C_{10}H_{16}</td>
</tr>
<tr>
<td>Molecular Weight</td>
<td>105</td>
<td>200</td>
<td>136</td>
</tr>
<tr>
<td>Composition % Wt</td>
<td>Carbon 88% Hydrogen 15%</td>
<td>Carbon 87% Hydrogen 16%</td>
<td>Carbon 88.2% Hydrogen 11.8%</td>
</tr>
<tr>
<td>Density kg/m^3 @ 20ºC</td>
<td>780</td>
<td>830</td>
<td>860-900</td>
</tr>
<tr>
<td>Specific Gravity @ 20ºC</td>
<td>0.78</td>
<td>0.83</td>
<td>0.86-0.9</td>
</tr>
<tr>
<td>Boiling Point ºC</td>
<td>30-220</td>
<td>180-340</td>
<td>150-180</td>
</tr>
<tr>
<td>Viscosity cSt @ 20ºC</td>
<td>0.4</td>
<td>3-4</td>
<td>2.5</td>
</tr>
<tr>
<td>Latent Heat of Vaporization kJ/kg</td>
<td>350</td>
<td>230</td>
<td>305</td>
</tr>
<tr>
<td>Lower Heating Value kJ/kg</td>
<td>43,890</td>
<td>42,700</td>
<td>44,000</td>
</tr>
<tr>
<td>Flash Point ºC</td>
<td>-43</td>
<td>74</td>
<td>38</td>
</tr>
<tr>
<td>Auto Ignition Temperature ºC</td>
<td>300-450</td>
<td>250</td>
<td>300-330</td>
</tr>
<tr>
<td>Flammability limit % Volume</td>
<td>1.4-7.6</td>
<td>1.0 – 6.0</td>
<td>0.8 - 5.8</td>
</tr>
<tr>
<td>Cetane Number</td>
<td>15</td>
<td>45-50</td>
<td>20-25</td>
</tr>
</tbody>
</table>
3.8 **REACTIVITY OF TURPENTINE**

**Instability:** Heat, exposure to air in a confined space, and sources of ignition causes instability.

**Incompatibilities:** Contact of turpentine with oxidation catalysts or with strong oxidizing agents (especially chlorine) may cause fires and explosions.

**Hazardous decomposition products:** Toxic gases and vapors such as carbon monoxide and the partial oxidation products of terpenes may be released in a fire involving turpentine.

**Special precautions:** Turpentine attacks some coatings and some forms of plastic and rubber. So these materials are avoided while handling turpentine.