


title

INAMULLAH BHATTI
Chemical Engineering Department,
Mehran University of Engineering and Technology-Jamshoro-Sindh
PAKISTAN
Bhatti_inam@yahoo.com

KHADIJA QURESHI
Chemical Engineering Department,
Mehran University of Engineering and Technology-Jamshoro-Sindh
PAKISTAN
Qureshi.khadija@yahoo.com

HOSSAM ADEL ZAQOOT
Institute of Environmental Engineering and Management
Mehran University of Engineering and Technology Jamshoro, Sindh
PAKISTAN
hanreen@yahoo.com

Abstract - Increasing rate of auto mobiles around the world has augmented the demand of tires and as well increased the rate of waste scrap tires day by day. The existing system of waste tires disposal, incineration and thermal decomposing in the open areas generating toxic gases, which is depleting environment rapidly. The major composition of tire is based on the carbon material and its compounds therefore it is possible to recover petroleum oil in complex crude form in the reversing method. This study was carried out in the Chemical Engineering department at Mehran University of Engineering and Technology-Jamshoro, Pakistan. The decomposition unit was designed and fabricated locally and FTIR tests were carried out in the Institute of Chemistry at Sindh University-Jamshoro. Experiments were carried out at various temperatures (299, 305, 308 and 309°C) and pressure (500, 650, 750 and 800 psi) for 30 gm sample of tire. By measurement of the residual solids weight and further chemical analysis the percent decomposition and decomposition characteristics were evaluated with respect to temperature and pressure. Also by GC analysis of decomposed oil, the major components of oil and their molecular weight were confirmed. Approximately 94.2 % of tire was decomposed at 308°C by applying pressure 750 psi. This study also showed that the hydrocarbon oil with molecular weight below 300 was obtained from automotive tire by supercritical decomposition with toluene. We hope that this work will help and assist the local authorities and decision makers in designing policies and plans to protect the environment from further pollution with respect to scrap tires waste.

Key-words:- Scrap tires, Supercritical decomposition, Pressure, Temperature, Toluene

1 Introduction
Waste tires are currently being treated by conventional methods such as incineration [Sholeh 1995] and by chemical methods such as thermal decomposition [Crane and kay 1975, Crane et al 1978]. There is need to develop new methods which may recover some products and be environmental friendly. Automotive tires are composed of 50 % rubber, 30 % carbon black and reinforcing...
materials and 20% adhesives, cord and steel wires [Seung 2001]. Many researchers have worked on low temperature decomposition of tires by using supercritical solvents such as toluene, cyclohexane, n-pentane, methanol and water etc. This method is helpful in recovery of hydrocarbon as well minimizes the discharge of toxic gases. Supercritical toluene, n-pentane and nitrogen has been used to find out the extraction rate and efficiency of spent tires [Funazukuri et al 1985]. Also water has been used as supercritical solvent for the extraction of oil, and the reaction kinetics and activation kinetics was found to be 170 kJ/mol [Funazkuri,1987]. Hydrocarbon having low molecular weight was also recovered from automotive tires by using water as solvent [Lee 1996]. Oxidation treatment of PVC was as well reported by using the same solvent. Supercritical methanol was also used for the treatment of PET [Sako 1997]. The decomposition of SBR, polyisoprene was reported using toluene as solvent [Dhawn 1991, 1993].

In this study waste tires of light vehicles were used to recover hydrocarbon oil using toluene as supercritical solvent.

2 Methodology and experimental work
In primary phase the decomposition unit was designed and fabricated as shown in fig. 1 for the recovery of Hydrocarbon oil. After the decomposition of applied sample the recovered liquid was physically processed. Using the Gas Chromatography method, the recovered material was analyzed to accomplish the objective.

2.1 Supercritical fluid decomposition
Light vehicles waste tire were obtained from the local market and treated primarily. Tread part of the tires was separated from the steel wires and cords and plied for experiment. Samples were sliced and crushed into small particles to utilize. Toluene of analytical grade was used as supercritical solvent. 30 gm mass of treated tire sample was placed in the reactor and sealed. The reactor was purged with nitrogen for half hour to create nitrogenous environment of reactor to evacuate the air from it. The solvent was pumped into the reactor by high pressure injection system. The heat energy was added to the reactor with PID controller at 5 K/min until the temperature reached a designated point. During heating the pressure was controlled by discharging some amount of solvent in the reactor. When the reactor conditions reached at designated pressure and temperature the reaction was continued for 1 hour. After the completion of reaction the reactor was cooled to room temperature to reduce the temperature. The decomposed waste tire material was filtered with Watman filter paper and recovered substance was analyzed by GC.

2.2 Analysis on GC
The major constituents of the recovered oil were analyzed on GC. The residual solid was dried in an oven and its weight was measured to calculate the decomposed mass percent. Using this data the decomposition at each experimental condition was calculated applying the following equation.

\[ \text{Decomposition} \% = 1 - \frac{W_f}{W_i} \times 100 + W_c \% \]

where \(W_f\) denotes weight of residual solid after drying, \(W_i\) the initial weight of sample tire and \(W_c\) the weight % of carbon black and inorganic materials in the sample tire.

3 Results and discussion
3.1 Optimization of amount of solvent

10 g of tire was heated at temperature 308 C and pressure 750 psi by varying the amount of solvent (200ml, 400ml, 600ml, 700ml, 770ml of toluene). Decomposition was proceeded for an hour for every sample. The percent decomposition was calculated by equation 1. The results are summarized in Table 1. It was observed that the highest decomposition 90.67 % was found when 770 ml toluene was used.

The percent decomposition was calculated by using equation 1. The results obtained are reported in Table 2. It was observed that when 30-40g of tire was used highest decomposition 94.2 % was achieved.

<table>
<thead>
<tr>
<th>S. NO</th>
<th>Solvent (ml)</th>
<th>Tire (gm)</th>
<th>Amount of solvent (ml)</th>
<th>Decomposition %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Toulene</td>
<td>10</td>
<td>770</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>Toulene</td>
<td>20</td>
<td>770</td>
<td>92.3</td>
</tr>
<tr>
<td>3</td>
<td>Toulene</td>
<td>30</td>
<td>770</td>
<td>94.2</td>
</tr>
<tr>
<td>4</td>
<td>Toulene</td>
<td>40</td>
<td>770</td>
<td>94.2</td>
</tr>
<tr>
<td>5</td>
<td>Toulene</td>
<td>50</td>
<td>770</td>
<td>92</td>
</tr>
</tbody>
</table>

Table 2: Optimization of quantity of tire used

3.3 Effect of Temperature and Pressure on decomposition:

For a 30 gm sample and 1 hour retention time supercritical decomposition of tires was carried out at different temperatures (295, 299, 304, 305, 306, 308, 309 C) and different pressures (400, 500, 600, 650, 700, 750, 800psi) as shown in Table 3.

<table>
<thead>
<tr>
<th>S. NO</th>
<th>Temperature °C</th>
<th>Pressure (psi)</th>
<th>Decomposition %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>295</td>
<td>400</td>
<td>85.3</td>
</tr>
<tr>
<td>2</td>
<td>299</td>
<td>500</td>
<td>87.3</td>
</tr>
<tr>
<td>3</td>
<td>304</td>
<td>600</td>
<td>88.2</td>
</tr>
<tr>
<td>4</td>
<td>305</td>
<td>650</td>
<td>90</td>
</tr>
<tr>
<td>5</td>
<td>306</td>
<td>700</td>
<td>92.3</td>
</tr>
<tr>
<td>6</td>
<td>308</td>
<td>750</td>
<td>94.2</td>
</tr>
<tr>
<td>7</td>
<td>309</td>
<td>800</td>
<td>93.2</td>
</tr>
</tbody>
</table>

Table 3: Effect of temperature and Pressure on decomposition %
The highest decomposition 94.2% was achieved at 308 °C and pressure 750 psi which is in agreement to previous reported work 573 k at which 100 % decomposition was achieved.

4 Conclusion
It was concluded that at temperature 308 °C and pressure 750 psi the highest decomposition 94.2 % was obtained. Supercritical decomposition is a low temperature method and also environmentally friendly.

References